electronics today international

APRIL 1975

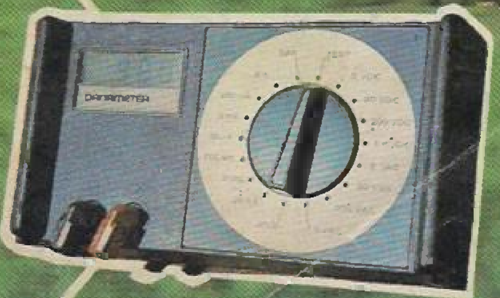
25p

ETI SPECIAL PROJECT

ELECTRONIC IGNITION

FEATURES: SUPER-RELIABILITY, BUILT-IN REV LIMITER & TACHO

FREE COMPETITION
3 DANAMETERS MUST BE WON!



- MODERN XTAL OSCILLATORS
- MAIL ORDER CATALOGUES
- CMOS BURGLAR ALARM
- FLIP FLOP FLASHER
- TAPE SPEED ICs

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

electronics today international

APRIL 1975 Vol. 4. No. 4.

main features

HIGH TEMPERATURE BATTERIES . . . 14
Revolutionary new designs have applications for transport and power storage.

MODERN CRYSTAL OSCILLATORS . . . 23
Up-to-date guide to crystal oscillator circuits.

TAPE SPEED IC'S . . . 30
How to use the TCA600/TCA900 and the TCA610/TCA910.

MAIL ORDER CATALOGUES . . . 38
Review of the commonest mail-order catalogues.

UNDERSTANDING COLOUR TV – PART 3 . . . 45
Get to know colour TV. This month, the PAL System.

ELECTRONICS–ITS EASY – PART 14 . . . 57
The sources of power.

projects

ELECTRONIC IGNITION SYSTEM – PART 1 . . . 10
Reliable CDI, tachometer and rev-limiter - all in one unit.

FLIP–FLOP FLASHER . . . 42
A simple, effective unit that could save your life.

CMOS BURGLAR ALARM . . . 51
Modern technology used in ETI's new alarm system

news & information

NEWS DIGEST . . . 6

PREVIEW OF MAY'S ETI . . . 36

INPUT GATE . . . 37

TECH–TIPS . . . 64

THREE DANAMETERS TO BE WON . . . 35
Enter our free Cross-Number Competition and you could win a digital Multimeter worth over £100!

Cover: The latest ETI Electronic Ignition System is almost certainly the most sophisticated ever published – see Part 1 on page 10.

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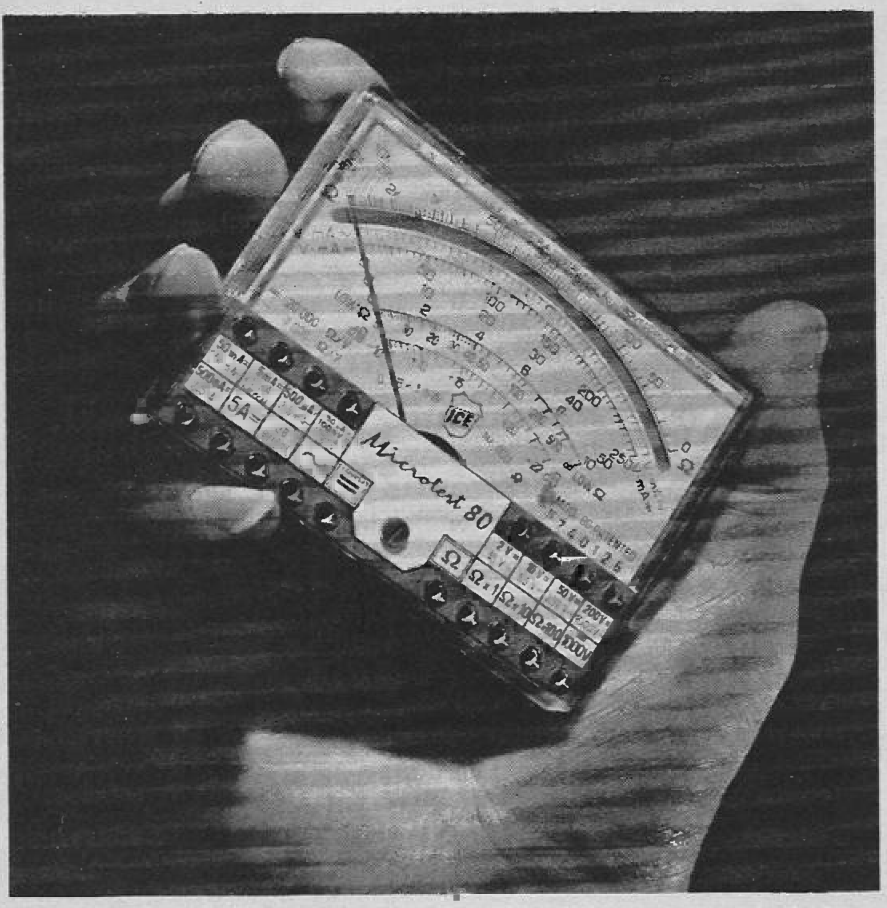
SPECIAL SUBSCRIPTION/ PROJECT BOOK OFFER SEE PAGE 33

news digest



POCKET SIZED TEST METER

The new ICE Microtest 80 test meter combines several unique features in an accurate instrument no bigger than a pack of cigarettes. The meter covers 8 fields of measurement in 40 ranges, with a 20,000 ohm per volt sensitivity (4kΩ/V on AC), giving 2% accuracy on voltage scales.

Design of the meter incorporates special automatic electronic regulation for zero ohms, and the movement is protected against an overload of 1,000 times in the ohmetric ranges before automatic cut out. Protecting the low ohmetric ranges is an internal fuse unit, easily repaired by winding on a new fuse from a minute, internal bobbin. The shockproof movement, with a compensated magnetic core, provides a closed magnetic circuit screened against all external magnetic fields. The 20 components are housed on a printed circuit board, making part replacement easy, quick and without re-soldering the board.

Power is from a special 1.35V mercury battery which, in normal usage, will last up to 3 years, and a complete range of accessories is available with the meter to extend its performance. The Microtest 80 uses the latest manganine and metallic film resistors to give high stability and 0.5% precision. The mirror scale gives an accurate reading. Each meter is supplied with an instruction manual and a protective case incorporating the leads. The size is 90mm x 70mm x 18mm. Electronic Brokers Ltd., 49 Pancras Road, London NW1 2QB, will supply the meter for £12.91 including VAT.

ATOMIC FREQUENCY STANDARD

Two new miniature atomic frequency standards, each contained within the dimensions of a four inch cube, have been introduced by Racal for the accurate generation of frequency and time signals. Both models use the atomic resonance of rubidium to control the frequency of a quartz crystal oscillator. This technique gives particularly low ageing characteristics several orders better than even the best conventional crystal oscillators. In the case of model FRK-H long term stability is better than 1 part in 10^{11} per month.

Both models feature small size, low weight, modest power consumption, near instant warm-up, and operation over a wide temperature range. Excellent spectral purity coupled with a high signal-to-noise ratio make the 10MHz output ideal for multiplication into the microwave bands.

£15 DOLBY RADIOS SOON?

Even the cheapest of domestic radio receivers may soon have Dolby circuitry inbuilt according to Alan Gregory of the Signetics Corporation, manufacturers of the NE545 Dolby IC chip.

Gregory believes that the inclusion of the chip (which will be sold to manufacturers for less than a dollar will increase the price of domestic receivers by a pound at the most.

ELECTRONIC GUIDE FOR THE BLIND

Germany's Ernst Leinz GmbH are currently developing a lightweight optical device to enable blind people to detect obstacles in front of them.

The prototype units is about the size and shape of a torch. It converts optical signals into electrical signals the strength and frequency of which 'describe' the obstacle encountered.

At present the unit is in prototype form, but Leitz hope to have the devices in production by 1976. Prices it is hoped will not exceed £150 or so.

AUDIO IC LEAFLET

Chromasonic Electronics have a new eight page leaflet showing pin connections and circuits for 26 Audio ICs. The leaflet is available free to customers spending over £1, or for 10p otherwise.

Other leaflets currently available on the same basis are one for the Motorola IC's for decoding the CBS four channel SQ system and one for the ZN414. Chromasonic are at 56, Fortis Green Road, London, N10 3HN.

MICRO-LASER

A microscopic laser designed for powering optical communication systems has been built by scientists from California Institute of Technology and Japan's Hitachi Limited.

The laser - 1/60 inch long and 1/250 inch thick - incorporates an artificial periodic corrugation built into the crystalline substance, providing for oscillation and eliminating the need for conventional end-mirrors. The laser is constructed by growing five alternate layers of gallium arsenide and gallium aluminium arsenide, with the process interrupted after growth of the third, central layer to produce the corrugations.

A new range of scientific construction kits for young people is being introduced to the UK from Canada by Patterson Edwards Ltd. The toy in the picture is a miniature computer. The computer, which works on the same principle as a real one, comes complete with 112-page manual containing fifty programs. It is also possible for youngsters to make up their own programs. The computer comes in the form of a kit which retails for approximately £18.

TEXAS INSTRUMENTS CLAIM ROYALTIES FROM JAPAN

Texas Instruments are demanding retrospective royalty payments from Japanese calculator manufacturers.

The claims relate to the one-chip MOS IC's that most calculators now use. Industry observers are puzzled by the claim for whilst Texas have patented the process in the USA, as far as is known, it has no such patents in Japan.

ENZYME-POWERED BATTERIES SOON?

An enzyme battery for cardiac pacemaker implants appears to be in the offing, according to one of its developers, Dominic C. Avampato of South Central Connecticut Community College, New Haven, U.S.A. The enzyme process produces a seven microamp current from five grams of maleic acid and five micrograms of NAD malate dehydrogenase.

NEW SUPERCONDUCTOR

A new superconductor that has zero electrical resistance at cryogenic temperatures and retains this ability in intense magnetic fields has been developed at the Massachusetts Institute of Technology's Magnetic Laboratory.

A combination of one part lead, five parts molybdenum and six parts sulphur remained superconducting in a magnetic field of 510,000 gauss at the temperature of liquid helium (−268°C). At absolute zero, MIT scientists say, the material might withstand a field of 600,000 gauss.

NOVUS INTO SCIENTIFIC CALCULATORS

Ten new scientific and special-purpose calculators are about to be introduced by the Novus Division of the National Semiconductor Corporation.

Prices are believed to range from $75 up to $170. The new range is based on an IC technology in which all the basic scientific and computational functions are built onto a single p-channel chip. A second chip is used for the programmable functions.

DIGITIZED TV VIA FIBRE OPTIC LINK

Digitized TV pictures have been successfully transmitted via a 4km fibre-optic link. The experiment was conducted by West Germany's Heinrich-Hertz Institute using equipment developed by Siemens AG.

The TV picture was conventional PAL 625-line, 5MHz bandwidth, it was converted to binary-difference pulse-code modulation (24 megabits/second) and transmitted via multi-mode fibre by a special light emitting diode.

The receiver was an avalanche diode connected to the monitor via a pulse decoder.

US COLOUR TV SALES DROP

US sales of colour TV receivers fell drastically in November. Final sales were 30.6% down compared with the same month in 1973. The decline for the first eleven months of 1974 was approximately 14%.

FIRST GEOSTATIONARY SCIENTIFIC SATELLITE FOR EUROPE

Work goes ahead on the Geostationary Orbital Satellite (GEOS) development 'model' at the Electronic and Space Systems Group of the British Aircraft Corporation in Bristol. GEOS is being developed by the Satellites for Technology Application and Research (STAR) consortium of companies for the European Space Research Organisation under the prime contractorship of BAC.

The development model brings together for the first time the many sub-systems from the STAR consortium, together with the on-board experiment apparatus from the nine scientific groups in this multi-national programme. Its purpose is to resolve problems of functioning and electronic compatibility in advance of building the satellite flight model.

GEOS is due for launch in the autumn of 1976 and will probe the nature of the electric, magnetic and particle fields in the Earth's magnetosphere.

In operation, data from the satellite's attitude in orbit is derived from on-board sensors and transmitted to the ground control station. Computed instructions sent to the satellite command its attitude and orbit control sub-system to release controlled bursts of hydrazine through small jet thrusters, the reaction from which is used to manoeuvre the satellite in attitude and position. To meet the needs of the scientists whose apparatus is carried by GEOS, it will be moved between positions of 15°W and 40°E while maintaining a constant geostationary orbit 35900 km above Earth.

news digest

ELECTRONICS OUTLOOK FOR 1975

The Chase Manhattan Bank's annual outlook for selected industries is being circulated for the first time in the UK. The document tells the tale of the recession in the US economy. However our readers might find it useful to draw parallel forcasts for electronics in the UK! Here are some excerpts from the electronics section of the report:

In 1974, the electronics industry was strong through the first quarter of the year, continuing the upward trend of 1972 and 1973. Since then, however, many sectors, most notably semiconductors and consumer electronics, have weakened considerably. Total U.S. factory sales of electronics equipment remained flat (at $31 billion).

The industry's strongest and most consistent growth sector during 1974 was electronic data processing, which grew approximately 8% to $9 billion. Especially strong were all forms of data entry and process control systems, with growth estimated at 20%. The semiconductor sector showed growth of 12%, although most of this increase occurred in the first part of the year.

In the consumer product sector, calculator sales were up for the year, but by year-end the trend was down with severe price-cutting. The electronic digital watch market is becoming significant. Worldwide retail sales in 1974 totalled $1·20 million with an average selling price of $150. By 1980, sales are projected at $1.5 billion worldwide at an average selling price of $40.

The overall outlook for the electronics industry in 1975 generally is unfavourable, both in the U.S., in Europe and in Japan - the three major electronics markets. Increasingly, these markets tend to move concurrently rather than in separate cycles.

Although at the moment the electronic data processing industry remains relatively strong, a leveling trend should occur in 1975, and European computer equipment manufacturers in particular may be adversely affected. Minicomputer shipments are slowing, and a slowdown in capital spending will affect large system installations. Data entry and process control should be less affected, but a general decrease in the growth rate will be evident.

Some communications systems and equipment such as satellites, microwave links, and data networks should continue to show steady growth through 1975. Facsimile is becoming a more important method of communication.

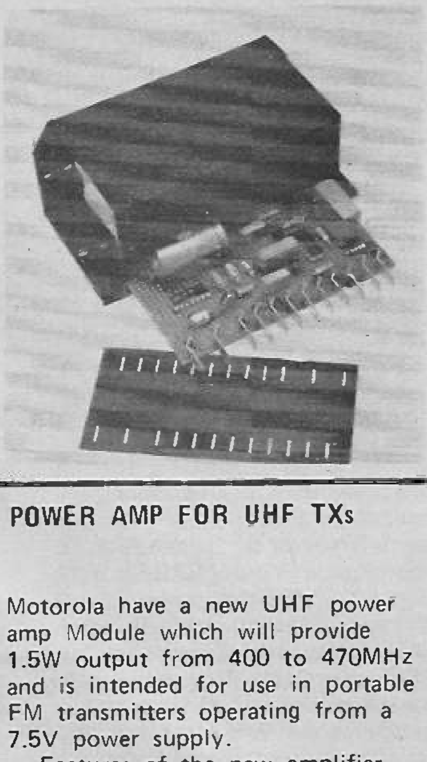
Sales of inexpensive consumer items (black and white TV sets, radios, and calculators) and inflation-fighting appliances such as small home freezers should continue to be relatively strong, although profit margins will remain under pressure.

Overall, the electronics industry should show little growth through the first six to nine months of 1975, with some possible recovery in the last quarter. Less inflation, an upturn in housing starts, improved consumer confidence, and increased capital spending will be the necessary ingredients for renewed strong growth.

NEW HOUSINGS

A new component housing suitable for automotive or general use has been announced by Mentor Electronics. The 'Housing 300' can carry one or two printed circuit boards (106 x 60mm) with a maximum of twelve ¼" flat terminals on each.

No special plugs and sockets are needed to connect to the printed circuit board. Mountings are available externally on two faces. The unit is made from black polypropylene with external size 130 x 65 x 55mm. The box costs 49p (inc. p&p) from Mentor Electronics Limited, Ryefield Crescent, Northwood, Mddx.



DISTORTION-FREE AMPLIFIERS

For a long time negative feedback has been used to reduce distortion in amplifiers; this is effective but under certain conditions oscillation can occur.

A new approach to reducing amplifier distortion is currently being researched by the Royal College of Surgeons.

The technique involves two amplifiers, in the first the output is subtracted from the input. The noise and distortion signal is amplified in a second unit and again subtracted from the output in the first. The resultant output is virtually noise and distortion free.

POWER AMP FOR UHF TXs

Motorola have a new UHF power amp Module which will provide 1.5W output from 400 to 470MHz and is intended for use in portable FM transmitters operating from a 7.5V power supply.

Features of the new amplifier are a minimum efficiency of 40%, a minimum power gain of 40dB and an input impedance of 50ohms. All harmonics are at least 30dB down and other spurious outputs are a minimum of 70dB down. Motorola, York House, Empire Way, Wembley, Middlesex.

MICRO TV CAMERA

A colour TV camera less than four millimeters in diameter has been developed by Philips!

The camera has been produced for medical use and is so tiny that it can be threaded through human veins. It can even obtain pictures from inside the brain.

Within the camera 3.5mm diameter synchronous motor drives a mirror and prism/lens combination. This rotating assembly scans the target area.

The target area is illuminated via glass fibre leads. Similar glass fibre connectors pick up the scanned data and feed it out to associated photomultipliers.

The camera is not just a state-of-the art prototype - pre-production units have been built by Philips' Laboratoires d'Electronique et de Physique Aplique and satisfactorily tested in hospitals in France. As a result the cameras may soon be commercially available.

OUTDOOR LIQUID CRYSTAL DISPLAYS

A liquid crystal display that can be read in bright light - even outdoors - has been developed by Tekelec (Oxnard, California).

The displays are field-effect devices with both transmissive and reflective properties. A small bulb is used to assist readability when ambient lighting is poor.

Continued on page 68.

ELECTRONIC IGNITION SYSTEM

PART ONE

Reliable CDI, tachometer and engine speed limiter — all in one unit!

by Barry Wilkinson.

THE CONVENTIONAL electro-mechanical engine ignition system has been with us virtually unchanged since its development by Charles Kettering over fifty years ago.

It is simple in concept and fairly reliable in operation, but even if maintained in impeccable working order it's performance is only *just* adequate in vehicles of average performance used in moderate climates.

The Kettering system has characteristics that are very far from ideal. The voltage supplied to the spark plugs, for instance, is low during starting and also at high engine speeds — just when high output is most needed. Contact breaker point and distributor cam wear is quite rapid and cause efficiency to fall off alarmingly.

Even when new, it is rare indeed to find a Kettering system that is working correctly, (that is the reason why many people obtain better results than should otherwise be expected when they fit a CDI or other electronic system to their car).

Now the system's deficiencies have become more serious — our world has too little oil and too much pollution. Good fuel economy and low engine emission have become of greater importance than original engineering cost.

At first sight it seems a relatively simple job to convert a Kettering system to electronic operation. But there is far more to it than that, as many have found to their cost. And whilst there has been a plethora of electronic systems on the market for the past ten years, few indeed can even remotely match the conventional system's reliability.

As recently as August of last year, one of our leading motoring magazines tested ten electronic systems made by leading European manufacturers. Incredibly, five of those systems failed within an hour and a half of installation! The reasons for the failure of these systems is discussed later in this article.

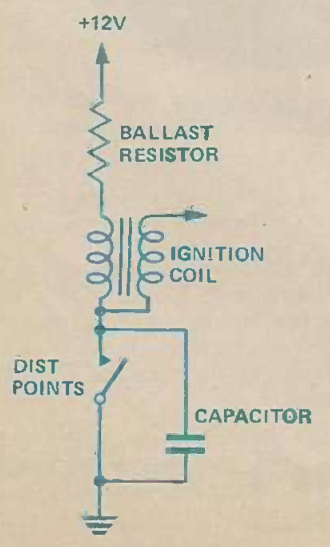
Nevertheless though, it *is* possible to design and construct sound reliable electronic ignition systems and these do have many advantages over Kettering systems.

At this point we might as well debunk a few myths — and probably lose the odd advertiser or two as well!

Unless your original ignition system is grossly maladjusted, there is no way in the world that an electronic system will improve power or fuel consumption by the 20% plus that many of their manufacturers claim.

What you can *realistically* expect is about three to five per cent better consumption and about the same increase in top end power — especially with small high revving engines. There is rarely any measurable difference with big lazy V8s, except that starting may be easier on cold mornings.

Distributor point life is greatly extended, spark plugs will last longer and the system will remain in tune for much longer periods.



Normal (Kettering) ignition system.

EARLY ELECTRONIC SYSTEMS

The first transistor systems came into use about ten years ago. These were rudimentary systems in which a transistor was used to switch the main current — so that a control current only passed through the contact breaker points.

These systems were effective in that they prevented point burning but were just as adversely affected by high-speed point bounce as the systems they replaced. Apart from that, only low-voltage rating (100 V) transistors were generally available so special high ratio ignition coils were required. These special coils drew heavy current — as much as 12 amps was not uncommon.

The systems just described were not really electronic ignition systems — rather they were transistor-assisted.

CDI

Capacitor Discharge Ignition (CDI) was introduced some three years later.

In this system a capacitor (normally between 1.0μF and 1.5μF) is charged to 400 V or so, and, when triggered, is discharged into the spark coil thus inducing the required high voltage by transformer action.

CDI systems can be made to work very well indeed, they have excellent characteristics, such as low current drain and almost constant voltage output.

But whilst they *can* be very effective, many CDI systems are very unreliable due mainly to designers not appreciating that many of the components are being run way beyond their design limits.

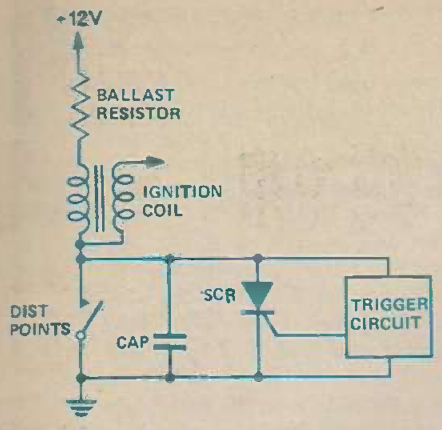
DWELL EXTENDERS

A simple device called a dwell-extender made a brief appearance a few years ago. This operated by using an SCR to 'close' the points about half a millisecond after they opened thus allowing greater current build up in the coil. In effect, dwell extenders extended the 'effective rev range' of an ignition system by about 20%.

At present the transistor assisted system is making a comeback and is just as common as CDI systems. There is also a trend towards breakerless (no contact points) systems — thus eliminating point bounce and ideally ensuring that each cylinder is fired precisely at the correct time — something that rarely happens with Kettering systems due to manufacturing errors in the distributor cam.

THE ETI SYSTEM

Many readers have asked us to design and publish a reliable up-to-date CDI system, so over the past year we have investigated very many different types to see which would provide the optimum in performance and cost combined with total reliability.



Typical dwell-extender circuit

Since electronic components can fail suddenly and unexpectedly (usually at the most inconvenient times) we opted out of a contact-breakerless system or any system which could not be changed rapidly back to standard.

This latter constraint ruled out transistor assisted systems since these normally require a low inductance ignition coil which cannot be used with standard points.

Eventually we came back to the CDI technique, but then set about eliminating those aspects of earlier designs that compromised reliability.

Our starting point was to study existing CDI systems — to see just why they fail.

The circuit diagram of a conventional CDI system is shown in Fig. 1.

In this circuit the most likely component to fail is the discharge capacitor since peak currents of 10 to 20 amps flow during each cycle. Few capacitors will withstand this sort of treatment for long. To make matters worse, the charging voltage may under certain conditions reach 500 volts or more. Since 300-350 volts is really all that is required, this higher voltage causes the capacitor to operate at twice the energy density needed — thus stressing the capacitor unnecessarily.

The SCR is also subjected to high current peaks and unless of adequate rating (as few are) it too may soon fail.

The inverter used to provide the high input voltage required by the CDI system is normally a self-oscillating saturating core circuit of the type shown. This type of circuit too has inherent failings. High currents are drawn at the moment of switching, thus causing high peak power dissipation in the transistors themselves, and as the output from the inverter is a square wave the rectifier diodes are subjected to very rapid changes in polarity.

Diodes such as the 1N4001 or the IN4007 (which are commonly used) need 10 microseconds in which to turn off, so that in the inverter circuit shown, opposite pairs of diodes may be on simultaneously, thus creating a momentary short circuit across the output every half cycle.

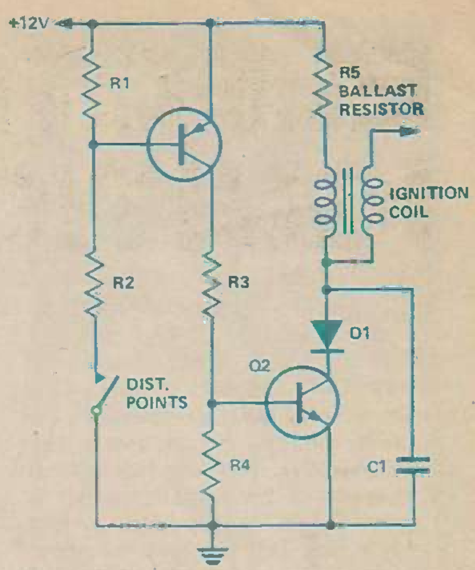
Another failing common to many commercial units is that if the inverter is sufficiently powerful to deliver full power up to 5000 rpm to a V8 engine (i.e. operating frequency of plus 2 kHz) the power dissipated in the diodes may eventually destroy them.

A final most annoying characteristic of otherwise satisfactory CDI systems is the hard-to-quieten whistle from the inverter transformer.

The new ETI unit is more complex than most CDI's currently available — but all the above problems have been eliminated — and it has two further features that make it (we believe) unique.

Besides being a very good CDI unit, the circuit includes a tachometer output and an adjustable rev-limiting circuit.

The tacho has been included because most electronic tachos cannot be used in conjunction with a CDI system (to use the tacho function all that is



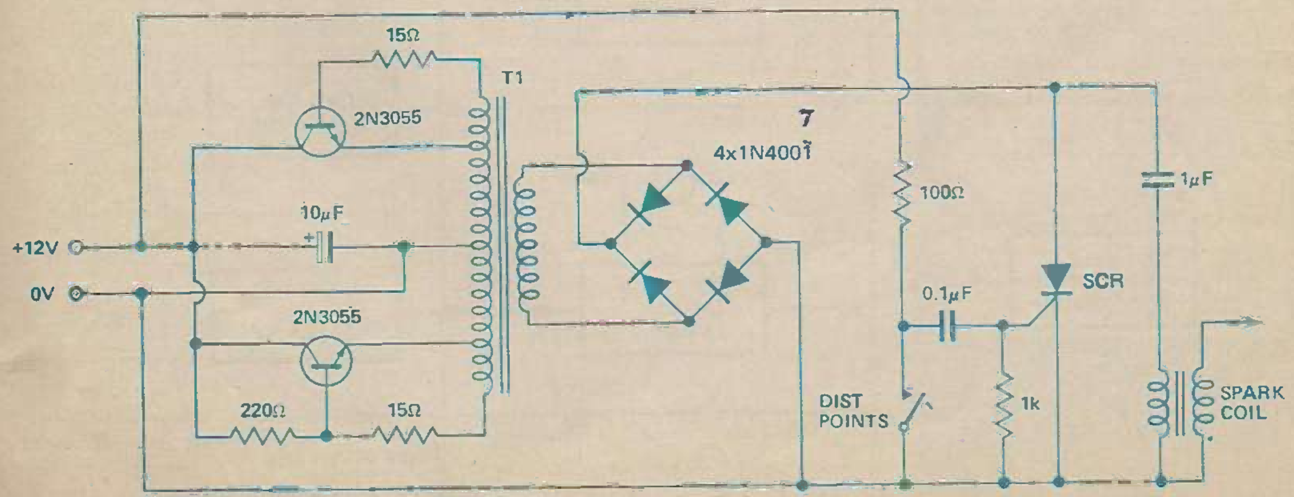
Transistor assisted ignition

needed is a suitably calibrated 0—1 mA fsd meter).

The rev limiter circuit is intended for engine overspeed protection only. It is of particular value with sporting cars in which safe engine rpm may be inadvertantly exceeded — and also in high power motor boats which frequently suffer engine damage due to the propellor jumping out of the water, thus unloading the motor sufficiently for engine speed to exceed a critical level.

Engine speed limiters are already fitted to a few vehicles (some Lotus cars for example) but these usually consist of a mechanically controlled electrical ignition cut-out. They work quite reliably but are prone to a 200 rpm or so hysterisis. If they cut out at, say 6500 rpm, then ignition will not be switched on again until the engine speed has fallen to 6300 rpm. In the meantime unburnt fuel has collected in the silencer where it will be ignited (with a bang) when ignition re-occurs.

The ETI electronic unit has virtually no hysterisis and operates smoothly and effectively.



ELECTRONIC IGNITION SYSTEM

A full description of how the ETI unit operates will be published in the second (and final) part of this article next month. Briefly however the tacho/rev limiting circuit uses a dual timer (NE556). The first half of this IC operates as a monostable which is triggered when the ignition contact points open. This provides the tacho drive.

When the first delay period ends, the second monostable is triggered and this sets the limiter. If the next pulse from the points occurs before the completion of the second delay, the SCR is inhibited thus switching off ignition until the speed has fallen below the preset limit.

As the limiter has no real hysterisis, the motor will usually fire every second or third cylinder.

Any back firing that may occur takes place in the exhaust pipe near the cylinder head — not in the silencer.

We would like to emphasise once again that the limiting circuit is intended for motor protection only. It should not be used as a road speed limiter or governor.

EARLY IGNITION SYSTEMS

The very earliest gas and oil engines used a flame or hot tube ignition system. The systems were basic yet reliable and effective. When ignition was required, a port in a reciprocating slide valve provided a passage between the burning flame and the mixture in the combustion chamber. Once the mixture was ignited, the port was mechanically closed.

The first electrical ignition system was devised by Sir Dugeld Clerk in the mid-1800's. The principle was similar to that of flame ignition except that an electrically heated platinum wire replaced the flame or hot tube. (This system is described in Sir Dugeld Clerk's classic work 'The Gas, Petrol and Oil Engine, Vol II.)

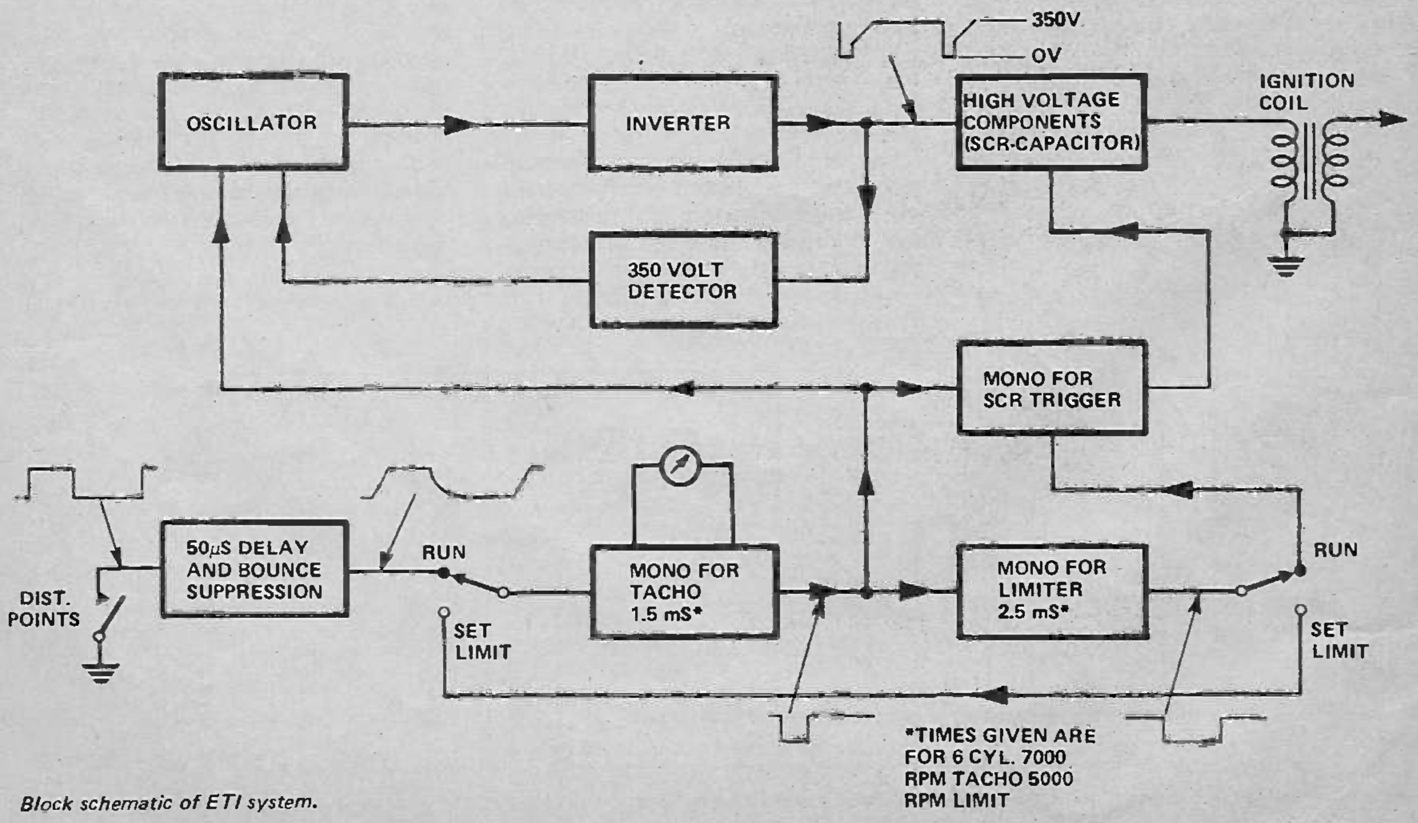
Break-spark ignition was used for a short time in the early days of motoring. In this system, a low voltage generator produces current in an inductive circuit. A spark is established within the combustion chamber at the required moment simply by mechanically separating two normally closed contacts. (This system is still used in a number of slow-speed stationary engines.)

The first high tension spark gap ignition was developed in France by Lenoir in 1860. Ten years before, a French mechanician, Ruhmkorff, had started to produce induction coils on a commercial scale. Lenoir based his system on the Ruhmkorff coil. His circuit was virtually identical to present day practice except that he used a trembler make and break on the primary side of the induction coil, instead of the mechanically operated synchronous switch used today.

The so-called 'trembler' ignition system was fitted to early Model 'T' Fords, and a few other (mainly American) vehicles, prior to 1920 or so. In this system, sixteen or so magnets were located around the engine flywheel. When the flywheel revolved, the magnets caused an alternating flux change in sixteen coils fixed to the engine main flywheel housing.

All sixteen coils were connected in series and provided an ac input to four separate trembler coils which in turn provided a high tension output, via a rotating distributor, to the spark plugs.

The system was not very reliable and later models used an orthodox Kettering system.



Block schematic of ETI system.

HOW THE ETI UNIT WORKS

The block schematic drawing shows all functions of the ETI system.

The oscillator is based on a TTL device and runs at approximately 36 kHz. The output is frequency divided down to 9 kHz and can then be gated on or off by either of two control lines.

The output of the oscillator is used to drive an inverter which is simply a set of power transistors driving a centre-tapped transformer (no feedback windings are used).

The output of the transformer is rectified by high-speed diodes to provide about 500 volts with 14 volt input. This output is monitored by a detector. If the voltage rises above 350 volts the oscillator output is gated off which in turn shuts off the inverter. The oscillator restarts when the voltage drops below 325 volts. This circuit ensures that the output voltage (i.e. across the capacitor) is maintained at a constant level for input voltage changes from eight to 16 volts.

High voltage components consist of a 1μF or 1.5μF capacitor and a 16 amp SCR. Due to the closely controlled drive voltage from the inverter, stress on these high voltage components is greatly reduced.

When the distributor points open, a 50μsec delay is initiated. This approximates the delay inherent in the normal mechanical system, thus the original distributor timing is maintained.

At the end of this 50μsec period, a monostable (half a NE556) is triggered. Its output is used for several purposes. The complete pulse is used to drive the tachometer (1 mA fsd) and the leading edge of the pulse triggers the SCR via a short monostable and signals the oscillator to switch off and remain off for a period long enough for the SCR to discharge the capacitor and turn off again. This prevents the inverter looking into a short circuit.

The trailing edge of this monostable output pulse triggers a second monostable comprising the second half of the NE556. This latter monostable is used for the rev limiting function. If its output has not returned to 'normal' before the contact breaker points re-open, the firing pulse to the SCR will be inhibited.

The rev limiting function is adjusted by simply connecting the output of the second monostable to the input of the first. The tacho meter will now indicate the maximum rpm before limiting occurs. Then, by adjusting the second delay, the desired rpm limit can be set.

To be continued with the second (and final) part next month.

HIGH TEMPERATURE BATTERIES

Batteries using liquid electrodes and electrolyte have been under development for the past ten years. Their very high temperature operation has caused problems but now they are about to be made commercially.

Here, Dr. Sydenham reports on European and American developments in the design and projected use of high-temperature batteries for transportation and power system storage.

A LARGE PROPORTION of our energy needs can be met with direct heating — coal, oil and gas being burned to produce heat — nevertheless the flexibility of energy in electrical form takes some beating. Electricity, being easily controlled, suits a large variety of needs better than the other basic forms of energy. Electricity, however, suffers one great disadvantage: it is generally uneconomic to store. This problem has been with us since the dawn of electrical knowledge and has still not been solved entirely adequately.

When very large amounts of energy are involved, the only really satisfactory storage method is to use the electricity to pump water to a higher elevation. When the energy is needed again, the water is used to drive turbines as it descends, thus regaining the electricity available earlier (but with some loss in the overall process).

Clearly, although on economic grounds pumped-storage *is* the cheapest and most efficient way to store electric power, it is only practical where the amount of energy is extremely large and where suitable geographical places exist to store water at two levels.

On the face of it, it would seem better to generate power only as it is needed — but economic factors dictate that power generators should run at quite high outputs all the time. Unfortunately the demand for electric power fluctuates widely throughout the day and season. To obtain cheapest operation of the system, power system operators ideally desire economic storage facilities to absorb and smooth out fluctuations, and with (virtually) only pumped-storage being feasible at this time they are generally forced to make do with machine switching and variable loadings.

A better solution, if it could be found, would be to add electrical storage batteries to the transmission system at the points where the load needs smoothing. As yet this is not done in any significant way because the cost of storage batteries is prohibitive, nevertheless some developments have been made and the concept is now well worth serious consideration.

The advantages of such a scheme are manyfold, modules of batteries could be placed just where the load problem exists; the capacity can be changed with comparative ease by adding or removing units. A second and quite relevant parameter in favour of battery energy storage is that a battery can be manufactured very rapidly, contrasting sharply with the time needed to build a pumped-storage installation. Batteries can also be moved around at will to suit changing conditions; pumped-storage plants cannot. Direct electrical storage would also be compatible with many of the various forms of generation. It produces no pollution, contains little hazard and is straight-forward in concept.

If a cheap battery with high specific energy (measured in watt-hours per kilogram of weight) were devised, this concept of power storage could be implemented. However, battery designs have, until now, not been suitable. The common lead-acid battery used in cars, industrial electric vehicles and the like, costs around £15 per kW/h stored and has a life of around three years. Experts have assessed that the economic battery for power system use would have to be producable at around £5 per kW/h. and have a five year life. This cost point is just being approached with new battery forms.

No storage battery is made as prolifically as the lead-acid unit. Its design has been continually improved and its cost reduced to the minimum. However a major breakthrough would be needed in lead-acid design to provide the much less expensive units required. We can, therefore, expect little improvement with the traditional cells. The cost of lead and its relatively scant supply precludes it for massive use on power systems.

A second major use for storage batteries is as the power source for electric transportation. Battery vehicles are already used extensively in mines, warehouses, ships, submarines and on roads in the form of milk carts and other small delivery vehicles.

With the interest in reduced-pollution transportation considerable effort has been expended in the attempt to produce an economic non-polluting road vehicle for general use — to replace the oil-driven motor car, bus and train. Electric cars are not new — Porsche built one at the end of the last century — but the cost and weight disadvantages of currently available storage batteries have always existed to dampen the case for electric drives, except, of course, in cases where low-pollution levels are a must.

Electric golf buggies, boats, courtesy cars, bicycles, to name a few of the

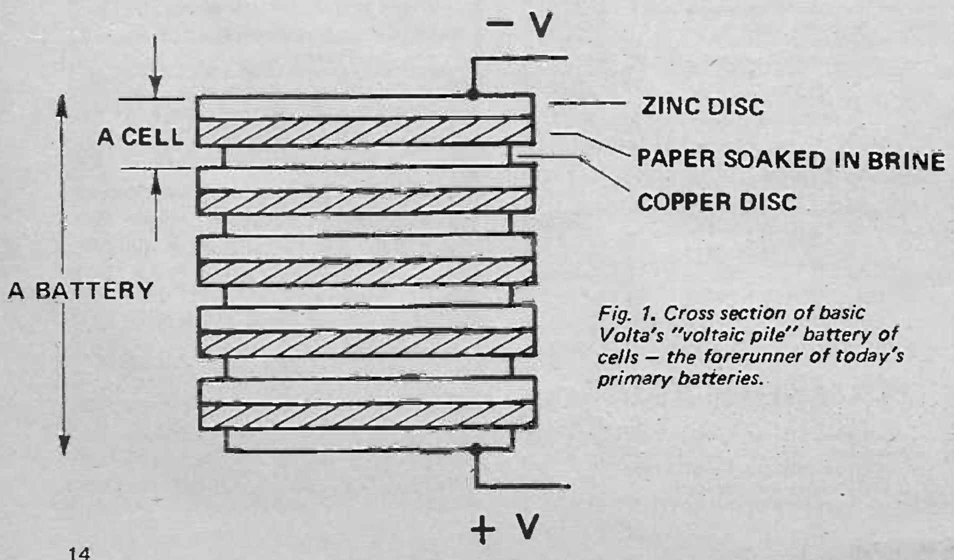


Fig. 1. Cross section of basic Volta's "voltaic pile" battery of cells — the forerunner of today's primary batteries.

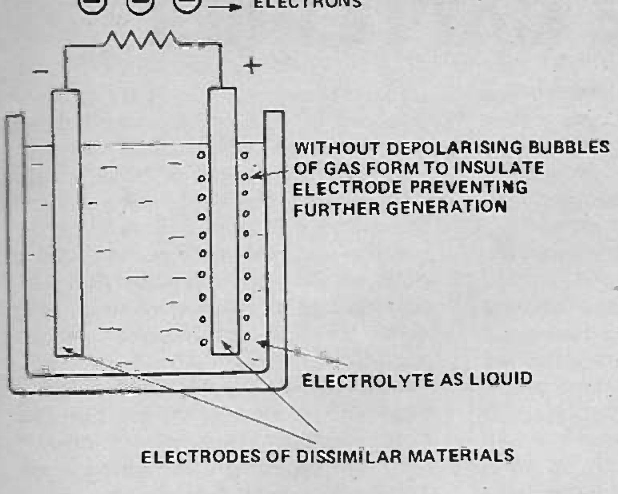


Fig. 2. Electrical cells can also be made with liquid electrolyte but means are needed to depolarise the electrode if it is to work for long.

vehicles where low cost is not vital, are now available but the main problem still holding up serious consideration of electric transportation with inboard storage is the cost of the battery, and its sheer weight.

Each year the margin by which stored electricity fails to be economic in transport is reduced a little further. Lighter batteries resulted when more exotic materials — silver-zinc, nickel-cadmium, for instance, are used, but the cost has risen sharply to achieve this. If you can afford ten times the price of a lead-acid battery you can gain a very considerable reduction in weight — but only military and other vital needs where cost is not the prime factor can afford this solution.

A new generation of storage batteries is however emerging. These operate at high temperatures (up to 400°C in design) but offer about four times as much storage as lead-acid batteries whilst retaining the same weight and price.

High-temperature arrangements tried to date include lithium and sulphur electrodes, sodium and sulphur, and lithium and chlorine. Of these the sodium-sulphur Na-S combination appears to be gaining favour now that one group has produced large-size cells that can be made and used commercially. Before we look into the technology of these recently developed storage cells we need to understand how an electrical cell produces electricity.

Electrochemical batteries come in different forms

The discovery and invention of the first electrochemical battery was the result of Alessandro Volta's work of 1800. Volta was inspired by the findings of Galvani who had previously demonstrated that chemistry and electricity were compatible concepts. Volta first discovered that two dissimilar metals touching together produced a voltage difference across them. Later he realised the very significant fact that certain solutions (he used brine and acidulated water) placed between the two different metals greatly increased the potential. Armed with this new knowledge he went on to build a battery of cells (depicted in Fig 1), made from zinc and copper disks which were separated with common-salt solution soaked paper. These were stacked to form a 'pile' of disks. This seems simple to us now, but in Volta's time it had not yet been fully appreciated that electricity could be produced by any other means than by frictional generation . . . the invention of a battery revolutionised man's thinking.

Volta also built cells (we do call a single cell a battery but strictly a battery is a collection of cells) using metal plates (the electrodes) placed in solution (the electrolyte) in the manner shown in Fig 2. It was not until later, however, that the true significance of the electrolyte was appreciated: originally it was regarded merely as a separating fluid.

Cells that produce electricity from electrochemical action without charging are denoted primary cells. They produce electricity as the result of the chemical reaction taking place between the electrodes and the electrolyte. Eventually the reactants run out and electrical generation ceases. Certain combinations of electrodes and electrolyte can be 'recharged' by passing electricity through them, a condition which recycles the reactants back to their initial state. In practice there is a limit to the number of times this recycling can be achieved with reasonable efficiency and only certain electrode-electrolyte combinations will recycle in a worthwhile manner. Cells that are made deliberately as rechargeable units are called storage or secondary batteries.

To illustrate what happens inside a typical battery let us look at the electrochemical behaviour of Volta's wet cell — zinc and copper electrodes in dilute sulphuric acid. The electrolyte in this case is dilute sulphuric acid and, as is the case with all electrolytes by definition, it consists of molecules that are individually charged because of additional or removed electrons. Such charged molecules (and atoms) are known as ions. Normally the overall nett charge of the solution is neutral but, when electric current is passed through the electrolyte, or allowed to flow in an external circuit, from the electrodes, the ions move freely in the solution travelling to whichever electrode for which they have charge affinity. In this particular battery, at the zinc electrode, sulphate ions combine with zinc from the electrode to produce zinc sulphate liberating electrons at the zinc electrode. This negative charge, if the external circuit is completed, flows around to the copper electrode and back into the electrolyte to neutralise free hydrogen ions of the solution forming non-ionised hydrogen gas. The process continues in this way until the hydrogen gas completely clouds the copper electrode with an insulating coat of bubbles and electric current ceases. This effect is known as "polarisation" of the cell. It prevents the simple cell from producing electricity for long, and successful primary cell designs employ means whereby a *depolarising* action is included to absorb the gas as it is produced. The electrochemical process

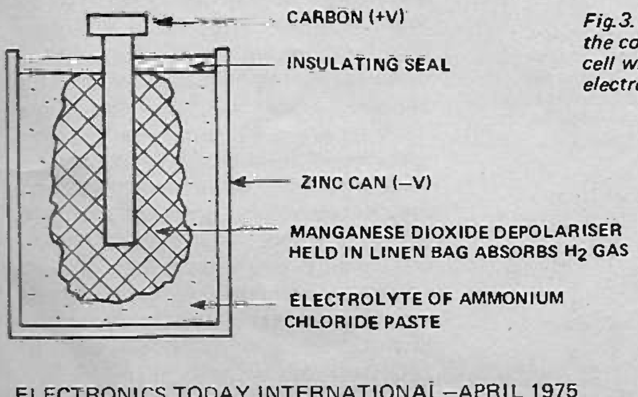


Fig.3. Cross section of the common tubular dry-cell which uses a paste electrolyte.

HIGH TEMPERATURE BATTERIES

also results in the material of one electrode being plated upon the other – zinc onto the copper in the Voltaic cell. Consequently, even though depolarising a cell enables the reaction to continue longer, the cell eventually stops producing electrical energy due to the lack of material on one electrode.

The so-called dry-cell that is used commonly in a flash-light or transistor radio is similar to the wet cell. The difference is that the electrolyte is used in a paste form. A central carbon rod (see Fig 3), surrounded with a manganese dioxide depolariser, is placed into a zinc cylinder filled with ammonium chloride paste. This is a modified form of a cell originally devised by Georges Leclanche in the latter part of the nineteenth century.

Other forms of battery cell exist – the Daniell cell (which is a Voltaic cell with added copper sulphate to depolarise the hydrogen), the Clerk cell (that uses zinc, mercury sulphate and mercury), and the Weston Standard cell are each historically important.

Cells incorporating depolarisers are not usually rechargeable in an efficient way because the depolarising action is not reversible. If a secondary rechargeable cell is desired, the design consists generally of little else than the two suitable electrodes immersed in an electrolyte. The lead-acid storage battery shown schematically in Fig 4, uses lead and lead-dioxide plates with dilute sulphuric acid as the electrolyte. The negative plate is made of a spongy form of lead to increase its surface area; the positive plate is coated with lead dioxide. When the cell is discharging, the lead and lead dioxide plates combine with the sulphuric acid to form lead sulphate, liberating water to the electrolyte, and removing sulphuric acid from the electrolyte. Eventually both plates become totally coated with lead sulphate and energy production ceases. The process is reversed in recharging – lead and lead dioxide reform on the plates and sulphuric acid is remade in the electrolyte.

Another commonly used storage battery is the nickel-iron cell invented by the Edison company. Its plates are oxides of nickel and iron immersed in potassium hydroxide electrolyte. Its advantages are lighter weight for a given energy stored and it is more robust than the lead-acid battery. Another feature is that its chemical cycle can be sealed – no vents are needed to allow gases to escape. It is, however, more expensive.

The lead-acid battery is so common that it is easy to assume that batteries of all forms would be similar. Nothing is further from the truth now that the high temperature batteries have been developed. They must operate at high temperature (300 – 500°C), are sealed and can have a solid electrolyte with liquid electrodes – an inside-out battery by the standards we have grown to accept over the past century of battery use.

Enter the high temperature storage battery

Just what prompts designers to breakaway from traditional ideas is always hard to define, but the idea to try storage batteries running at greater than ambient temperature probably arose out of experience with thermally regenerative calls which began back in 1961 in the U.S. Atomic Energy Commission, (AEC). It is also known that improved chemical reaction occurs at higher temperatures. Standard Oil, Ford Motor Co., General Motors and Argonne National Laboratory were each actively involved in high-temperature battery development from 1966 onward. These, plus a number of other groups who entered the field later, invested considerable finance into research for ways to provide more punch from a given weight and size of battery with the view to power-system smoothing and vehicle transport power applications.

A number of early design ideas were reported in glowing terms but few have resulted in continued interest right through to the marketing stage. Today the only battery now being considered seriously appears to be the sodium and sulphur electrode arrangement – it is the only one developed, rigorously tested in an electric vehicle, and about to be commercially produced at this time.

Most, but not all, high-temperature cells are electro-chemical arrangements involving chemical reactions but there is one approach – that of ESB Inc. in the U.S., for instance – that makes use of porous carbon plates to form a very large capacity capacitor when fused salts are run between the plates. Each specially made carbon plate, measuring about 150 by 300 mm, has an effective area of $10^5 m^2$! This design runs at around 250°C in order to keep the electrolyte (really a dielectric material) fluid in order that mobile ions are available.

The main contenders for large-scale battery storage are the traditional ambient temperature lead-acid units, nickel-cadmium, silver-zinc and zinc-air, and the sodium-sulphur, lithium-sulphur and lithium-chlorine high temperature designs. Figure 5 shows the theoretical merits of each type. Although there seemed the possibility that batteries using relatively exotic and specially compounded materials might provide a greater economic yield – lithium-selenium cells with sulphur and thallium additives in the cathode plates is one example – the cell that appears to have made it turns out to be one that is straightforward and uses abundant and easily refined elements; sulphur which is mined in an almost pure state and sodium that is extractable from sea water at a mere 12p per kilogram.

The lithium sulphur cell

Originally the greatest emphasis was on lithium-sulphur battery research. This was largely because on theoretical grounds it can pack the greatest amount of energy on a weight for weight basis. Estimates of the need for raw materials to make the batteries

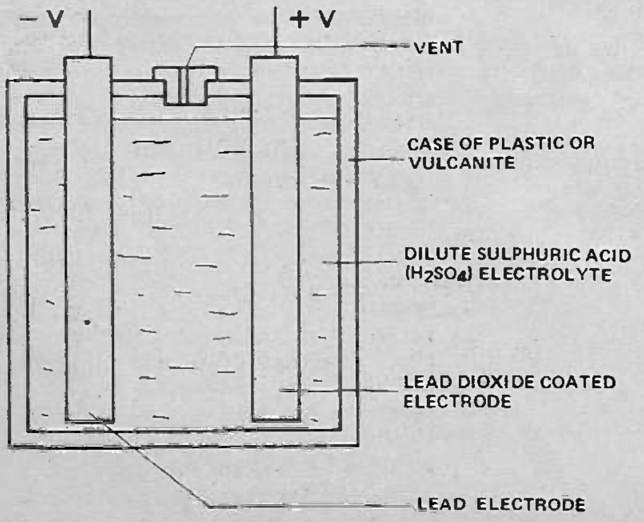


Fig.4. Schematic of the common lead-acid storage cell. They are made in flat parallel plate and tubular forms depending on the application.

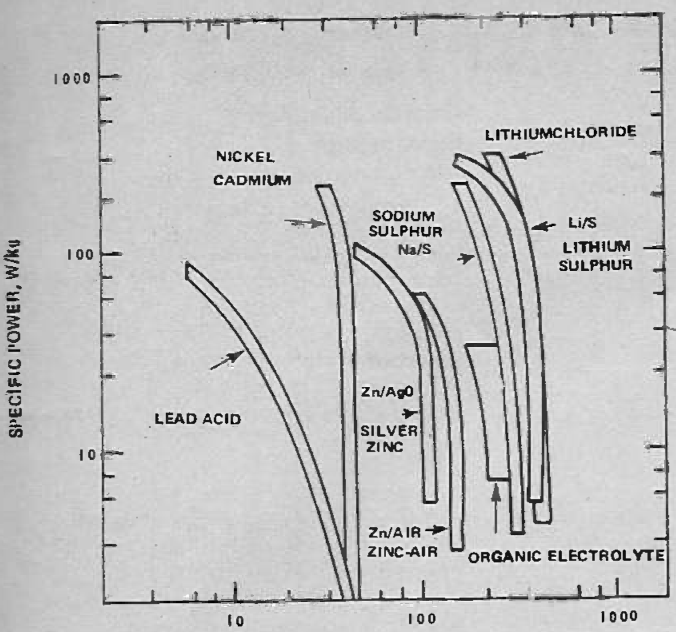


Fig.5. Comparative chart of the main forms of high-temperature battery designs.

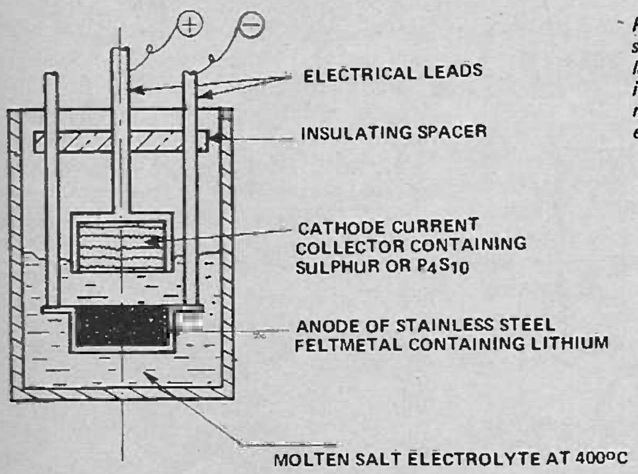


Fig.6. Rudimentary lithium-sulphur cell design for use in laboratory test chambers — it is unsealed and lithium reacts with moisture explosively. (Argonne Lab.).

required ran to 180 000 tonnes of lithium against a known supply of 24 million, so there would be no supply problem. It must, however, be extracted from rock mineral and current supply runs at only 3000 tonnes per year.

A typical early Li-S experimental cell is shown in Fig 6. Its design uses a molten salt electrolyte and special electrodes that are designed to hold the electrode materials when they become molten at the elevated 400°C temperature used.

Another design of so-called "super battery" with these electrodes is shown in Fig 7. It is how the production version might look.

An Argonne National Laboratory advanced design of cell is shown in Fig 8. It is a sealed cell, a must in practice — for lithium reacts explosively with water vapour — in which the lithium cathode is enclosed in a quite complex electrolyte. It shows the sophistication that was found necessary to obtain a workable cell with long life and close to theoretical power storage ability.

Plans currently exist to use these cells in mammoth arrays to act as mains power back-up supplies.

Chlorine cells

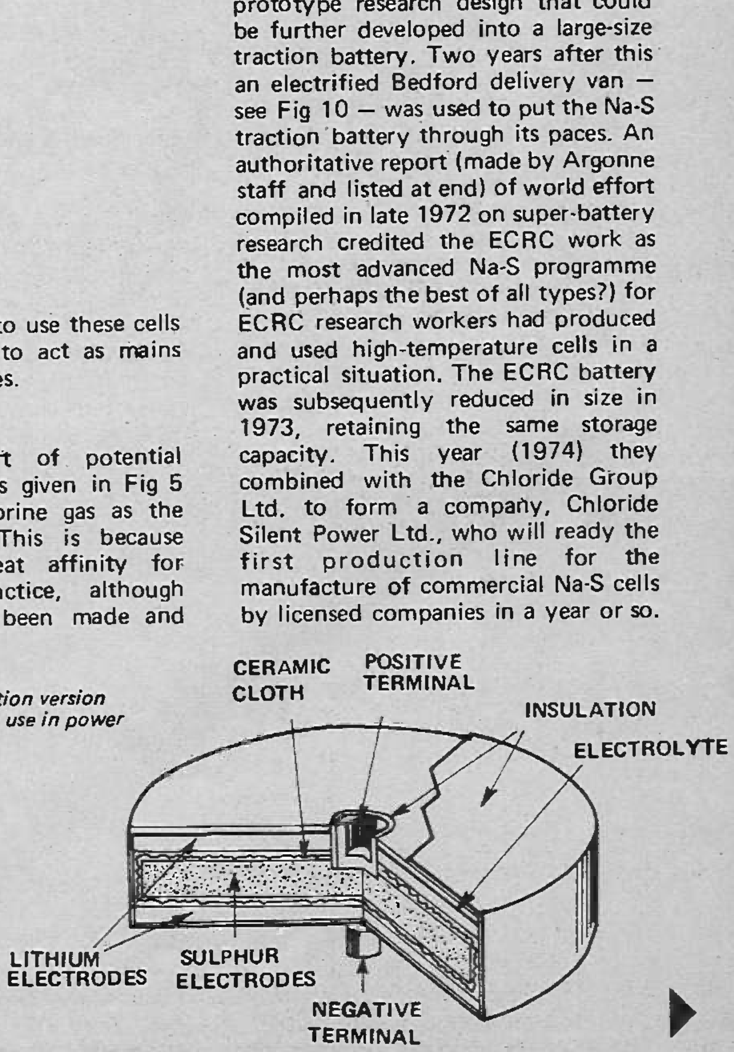
Heading the chart of potential high-temperature cells given in Fig 5 are those using chlorine gas as the positive electrode. This is because chlorine has a great affinity for electrons. In practice, although chlorine cells have been made and demonstrated — such as in the Vega Hatchback test car which used the Udylite Co. system shown in Fig 9 — chlorine is particularly nasty to handle due to its toxicity. Pumps and other ancillary equipment are also needed to circulate the gas through the zinc plates and this considerably adds to the cost and spoils the modular concept that is enjoyed with the lead-acid battery.

Sodium sulphur wins through

Although the Na-S cell combination is, in theory at least, less attractive to chlorine or lithium electrodes, the practice has now yielded a cell that will be cheap to build — the same cost for a lead-acid cell of the same weight but with as much as four times the storage capability. It uses cheap materials — stainless steel, sulphur, fibrous carbon and sodium.

In 1966 Ford Motor Co. reported that a Na-S cell had been produced in a laboratory glassware form. The following year the Electricity Council Research Centre, ECRC, situated near Liverpool, began its own programme of research leaning somewhat on what Ford had found. By 1970 their efforts had produced a prototype research design that could be further developed into a large-size traction battery. Two years after this an electrified Bedford delivery van — see Fig 10 — was used to put the Na-S traction battery through its paces. An authoritative report (made by Argonne staff and listed at end) of world effort compiled in late 1972 on super-battery research credited the ECRC work as the most advanced Na-S programme (and perhaps the best of all types?) for ECRC research workers had produced and used high-temperature cells in a practical situation. The ECRC battery was subsequently reduced in size in 1973, retaining the same storage capacity. This year (1974) they combined with the Chloride Group Ltd. to form a company, Chloride Silent Power Ltd., who will ready the first production line for the manufacture of commercial Na-S cells by licensed companies in a year or so.

Fig.7. Envisaged production version of Li-S cells for modular use in power system load-levelling.



HIGH TEMPERATURE BATTERIES

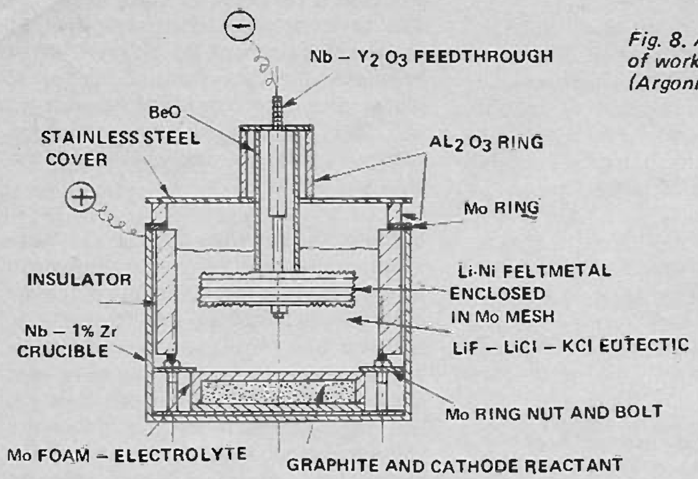


Fig. 8. An advanced form of workable Li-S cell (Argonne Laboratory).

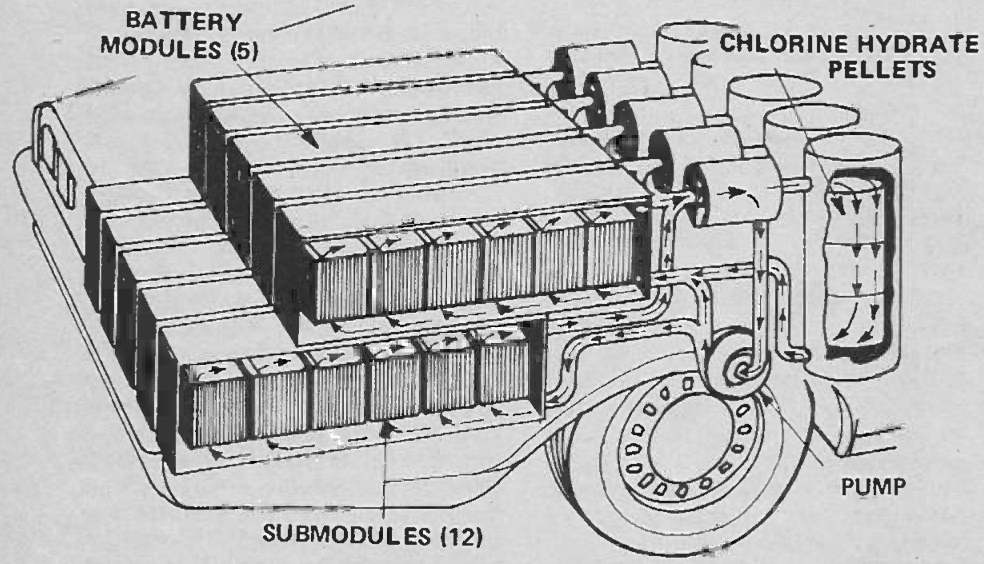


Fig.9. Layout of chlorine-zinc battery installation in a vehicle.

Fig.10. This modified Bedford van was run around the streets of London to prove the first large battery of Na-S high temperature cells.

Chloride Silent Power design is inside-out

Most batteries use a liquid electrolyte and solid electrodes. Not so the Na-S batteries to be marketed by Chloride Silent Power. Figure 11 shows a schematic cross-section of the cell. A stainless-steel case, the current collector, contains sulphur which is absorbed in fibrous carbon material. In the middle of this is a tube of Beta-alumina ceramic which contains pure sodium.

The ceramic tube serves to separate the sodium from the sulphur and performs as an electrolyte enabling ions to be transferred between the electrodes and preventing the electrode liquids mixing. Although the highest melting point of either of the electrodes is only 119°C the unit must be operated at at least 250°C to ensure that the reactant product (sodium sulphide) remains molten. If this is not kept fluid the electrical action ceases due to onset of polarisation because of the solids formed on the electrode surface.

Porous carbon is used to contain the molten sulphur (sulphur is a good insulator) and provides better electrical contact.

Another practical problem to be considered was that the amount of sodium needed requires more volume for a given amount of sulphur so a reservoir has been engineered to accept the excess sodium as it is liberated back from the sulphur on discharge. Figure 12 shows a typical cell used to drive the Bedford van. An efficient seal is vital for sodium is also explosive when contaminated by moisture.

The open-current voltage is 2.08 volts falling to 1.75 volts with an average load. The cell shown weighs 330 gm and stores 30 Ah (52.5 Wh). Discharging at 10 amps it holds up at 1.75 volts for close to 3 hours.

In the first demonstration battery 24 (later up to 48 in the same space) such individual cells were packaged into a module, as shown in Fig 13. Forty modules were then wired together to provide a unit delivering 100 V with 50 kW/h capacity in a volume of 1.52 m^3 (including heaters and insulation). The all up weight was 800 kg. The unit thus provided 63 W.h/kg and 33 $kW.h/m^3$.

At the time of our visit to Chloride Silent Power (August 1974) some details of a new projected design had just been released. It will use larger individual cells that lie horizontally as shown in Fig 14. It is envisaged that this unit (for which many of the details are closely under wraps) will store the same 50 kW/h but with a weight of 250 kg and a volume of 0.25 m^3.

Keeping the batteries hot

Maintaining these batteries at the 250°C-400°C needed may seem a formidable waste of power. In practice, however, the heating only consumes 500 W of the 50 kW available. Quite thin thermal insulation is adequate.

Once the unit is hot and operating, its own losses provide enough heat to keep the temperature up (and even provide some external heating if need be). To get the system going, however, an auxiliary heater is needed inside the insulated container. This is used to heat up the unit from the mains, usually via the charger provided to charge the cells. When the cells go cold the electrical action ceases without defect. Upon heating the energy again becomes available. A newly made cell is a primary cell and, therefore, can provide the current on demand once heated – eliminating the need to precharge it before use.

Although there was some initial concern that the cells in a module would not share the heat loss evenly, tests have since shown that there is no fear of thermal instability and that the cells can be packed as close as is electrically convenient. Interconnections are made using series paths for safety reasons: cells can fail in the short circuited condition which could damage the bank.

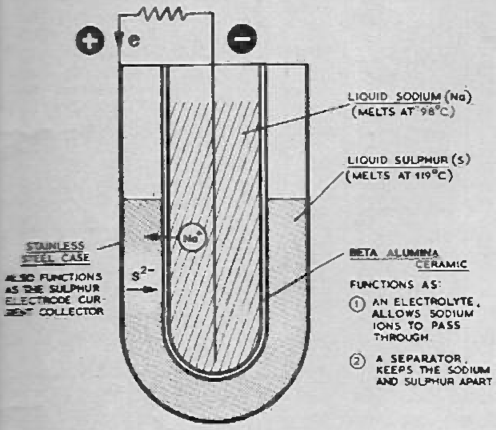
Safety

Due to the high temperature and toxic nature of sodium the designers have been careful to study the various mechanical failure mechanisms of a unit. Although risk does exist – as it also does with the lead-acid unit – the Na-S cells appear safer than currently acceptable lead-acid units. The main safety risk of a car battery is not considered to be the material toxicity but the sheer mass of the battery in high-g collision conditions.

The future

The projected design of this battery reaches the 200 W.h/kg estimate needed for economic power-system purposes so we might well see the new batteries being deployed on power systems in the not too distant future. The case for the electric car is also made stronger. Once the production volume rises the cost of a given energy capacity will fall to less than for lead acid batteries.

Clearly, high temperature batteries offer little for small energy needs, especially where the demand is for infrequent on-off use, but in transport and power uses the potential is vast.



SODIUM SULPHUR CELL

LIQUID REACTANTS, SOLID ELECTROLYTE

CURRENT IS CARRIED BY SODIUM IONS (Na^+) WHICH GIVE UP ELECTRONS (e) TO THE EXTERNAL CIRCUIT, PASS THROUGH THE SOLID ELECTROLYTE AND REACT WITH SULPHUR (S)

Fig. 11. Cross section schematic of the inside-out Na-S-cell.

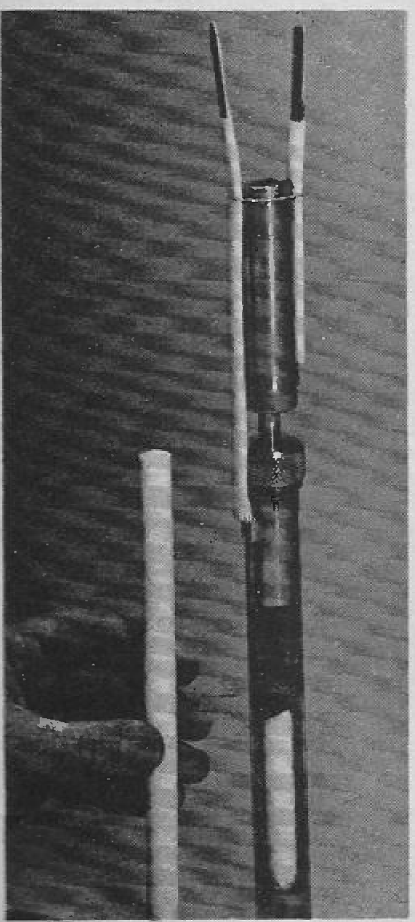


Fig. 12. Actual cell of ECRC Na-S cell showing the Beta-alumina tube used as a solid electrolyte.

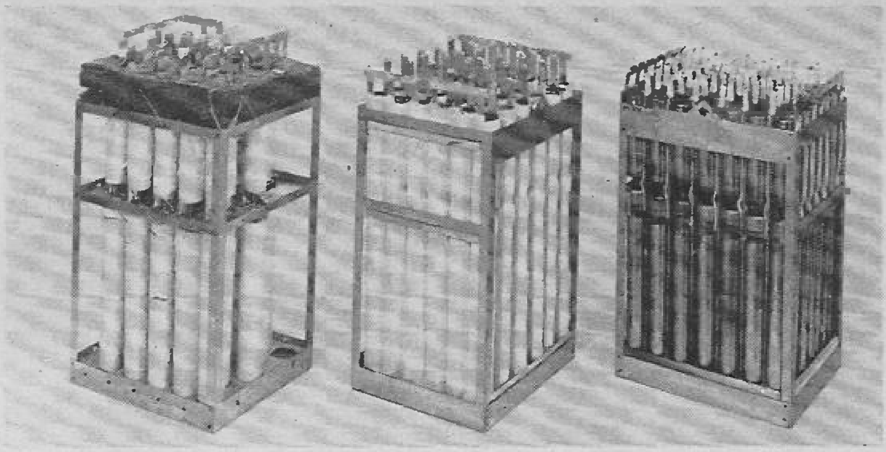


Fig. 13. Three stages of development increased packing density of the ECRC cells into the battery module. They must be electrically insulated from each other at an operating temperature of around 350°C.

Further reading.

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"Battery power for electric vehicles." M. Barak "Electric Vehicles" part 1, Dec. 1973, part 2, March 1974.

Fig. 14. Design model of projected 50 kWh Na-S module.

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AC117K	0·32
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AC132	0·16
AC134	0·16
AC137	0·16
AC141	0·20
AC141K	0·32
AC142	0·20
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AC151	0·17
AC154	0·22
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ACY44	0·39
AD130	0·42
AD140	0·53
AD142	0·53
AD143	0·42
AD149	0·55
AD161	0·39
AD162	0·39

AD161 & AD162(MP)	75
ADT140	0·55
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AF115	0·27
AF116	0·27
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AF118	0·39
AF124	0·32
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AF181	0·55
AF186	0·35
AF239	0·41
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AL103	0·72
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BCY70	0·16
BCY71	0·22
BCY72	0·16
BCZ10	0·22
BCZ11	0·28
BCZ12	0·28
BD115	0·68
BD116	0·68
BD121	0·66
BD123	0·72
BD124	0·75
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	0·83
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	0·82
BD190	0·82
BD195	0·94
BD196	0·94
BD197	0·99
BD198	0·99
BD199	£1·05
BD200	£1·05
BD205	0·83
BD206	0·83
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	0·24
BF176	0·39
BF177	0·39
BF178	0·33
BF179	0·33
BF180	0·33
BF181	0·33
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	0·83
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	0·32
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
MJE2955	0·95
MJE3055	0·69

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	0·65
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	0·26
OC204	0·22
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
TIP29	0·48
TIP30	0·56
TIP31A	0·60
TIP32A	0·73
TIP41A	0·73
TIP42A	0·88
TI843	0·34
UT46	0·30
ZN414	£1·20
2G301	0·21

2G302	0·21
2G303	0·21
2G304	0·27
2G306	0·44
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	0·23
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	0·18
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	2N3053	0·19	2N4058	0·13
2N2147	0·79	2N3054	0·51	2N4059	0·11
2N2148	0·63	2N3055	0·45	2N4060	0·13
2N2160	0·66	2N3391	0·16	2N4061	0·18
2N2192	0·39	2N3391A	0·18	2N4062	0·13
2N2193	0·39	2N3392	0·16	2N4284	0·19
2N2194	0·39	2N3393	0·16	2N4285	0·19
2N2217	0·24	2N3394	0·16	2N4286	0·19
2N2218	0·22	2N3395	0·19	2N4287	0·19
2N2219	0·22	2N3402	0·23	2N4288	0·19
2N2220	0·24	2N3403	0·23	2N4289	0·19
2N2221	0·22	2N3404	0·31	2N4290	0·19
2N2222	0·22	2N3405	0·46	2N4291	0·19
2N2368	0·19	2N3414	0·17	2N4292	0·19
2N2369	0·16	2N3415	0·17	2N4293	0·19
2N2369A	0·16	2N3416	0·31	2N5172	0·13
2N2411	0·27	2N3417	0·31	2N5294	0·50
2N2412	0·27	2N3525	0·83	2N5457	0·35
2N2646	0·58	2N3614	0·74	2N5458	0·35
2N2711	0·23	2N3615	0·82	2N5459	0·44
2N2712	0·23	2N3616	0·82	2N6221	0·75
2N2714	0·23	2N3646	0·10	28301	0·55
2N2904	0·19	2N3702	0·13	28302A	0·46
2N2904A	0·23	2N3703	0·13	28302	0·46
2N2905	0·23	2N3704	0·14	28303	0·61
2N2905A	0·23	2N3705	0·13	28304	0·77
2N2906	0·17	2N3706	0·13	28305	0·86
2N2906A	0·20	2N3707	0·14	28306	0·86
2N2907	0·22	2N3708	0·09	28307	0·86
2N2907A	0·24	2N3709	0·10	28321	0·62
2N2923	0·16	2N3710	0·10	28322	0·46
2N2924	0·16	2N3711	0·10	28322A	0·48
2N2925	0·16	2N3819	0·31	28323	0·62
2N2926(G)	14	2N3820	0·55	28324	0·77
2N2926(Y)	10	2N3821	0·39	28325	0·77
2N2926(O)	11	2N3823	0·31	28326	0·77
2N2926(R)	11	2N3903	0·31	28327	0·77
2N2926(B)	11	2N3904	0·33	28701	0·46
2N3010	0·77	2N3905	0·31	40361	0·44
2N3011	0·16	2N3906	0·30	40362	0·50

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AA119	0·09	BY128	0·17	OA10	0·16
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	BZY18	0·39	SD10	0·06
BA173	0·16	BYZ19	0·31	SD19	0·06
BY100	0·17	CG62		1N34	0·08
BY101	0·13	(OA91 Eq)	0·06	1N34A	0·08
BY105	0·19	CG651—		1N914	0·06
BY114	0·13	(OA70-79)	0·07	1N916	0·08
BY124	0·13	OA5	0·39	1N4148	0·06
BY126	0·16	OA5 short		IS021	0·11
BY127	0·17	leads	0·23	IS951	0·07

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200	0·27	0·32	0·54	0·54	0·62	0·67	0·67	1·76
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100	0·05	0·07	1N4002	0·06	0·10	0·17	0·23	0·75
200	0·06	0·10	1N4003	0·07	0·12	0·22	0·25	£1·00
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MODERN CRYSTAL OSCILLATORS

Roger Harrison looks at Circuits for Radio Amateurs

CRYSTAL OSCILLATORS, in one form or another, are fundamentally associated with virtually all transmitting and receiving equipment. Basic circuitry and circuit techniques, and the fundamentals of quartz crystals are discussed at various length by both the ARRL and RSGB handbooks, Pat Hawker's 'Amateur Radio Techniques', the various VHF handbooks by Jessop (RSGB) and Tilton (ARRL) as well as 'The Radio Handbook' by Bill Orr (Editors and Engineers). A useful, and more recent discussion on the subject of crystals and crystal oscillators is contained in the 'Ham Notebook' from the editors of the American journal 'Ham Radio'. For a deeper appreciation of the subject, references (1) to (4) are recommended.

Basic solid state crystal oscillator circuit techniques are by now well established, most circuits being adaptations of the well-known vacuum tube technology such as the Pierce, Hartley, Clapp and Butler oscillator and use both bipolar and FET devices. Whilst these circuits basically fulfil their intended purpose, there are many applications which require something different or where performance needs to be reliably characterised.

Presented here are a variety of circuits, for a range of applications from LF through the VHF range, that are not commonly found in current amateur use or literature.

MODES OF OPERATION

A point not often appreciated, or just forgotten, is that quartz crystals can oscillate in a *parallel* resonant mode *and* a *series* resonant mode. The two frequencies are separated by a small amount, typically 2-15 kHz over the frequency range. The series resonant frequency is *lower* in frequency than the parallel. A crystal specified and calibrated for use in the parallel mode may be satisfactorily used in a series resonant circuit if a capacitor equal in value to its specified load capacitance (usually 20,30, 50 or 100 pF) is connected in series with the crystal. Sadly, you can't invert the process for series resonant crystal in parallel mode circuits. The series mode crystal will oscillate higher than its calibrated frequency in this case and it may not be possible to capacitively load it down sufficiently.

Overtone crystals operate in the *series* mode usually on the third, fifth or seventh overtone, and the manufacturer normally calibrates the crystal *at the overtone frequency*. Operating a crystal in the parallel mode and multiplying the frequency three or five times produces quite a different result from operating the same crystal in the series mode on its third or fifth overtone. When ordering overtone crystals avoid confusion and specify the frequency you want, *not* the apparent fundamental frequency. Reference (4) makes this point quite clear.

Fundamental crystals in the range 500 kHz to 20 MHz are usually specified for parallel mode operation but series mode operation can be requested. For low frequency crystals, up to 1 MHz, either mode can be specified. Overtone crystals generally cover the range 15 MHz to 150 MHz.

WIDE RANGE or APERIODIC OSCILLATORS

Oscillators that do not employ tuned circuits can be very useful, whether they are simply used as 'crystal checkers' or some other purpose. Particularly for LF crystals, tuned circuits can be bulky. However, they aren't without their traps. Some crystals are prone to oscillation on unwanted modes, particularly the DT and CT cut crystals used for LF quartz oscillators. It is wise to check that the output is on the correct frequency and no mode instability is evident. Reducing feedback at the higher frequencies usually cures this. In extreme cases, the idea has to be abandoned and an oscillator having a tuned circuit used instead, (LF crystal oscillators are discussed later).

The first circuit is an emitter-coupled oscillator, a version of the Butler circuit. The basic circuit first appeared in VHF Communications in 1970 (p.240) as portion of a VHF-UHF calibration spectrum generator. Versions have subsequently been published in the 'VK5 Bulletin' (S.A. Div. WIA) in 1972 and 6UP, August issue, 1974. Lane (3) discusses a variation of this circuit (Fig. 2).

The output of the circuit in Fig. 1 is

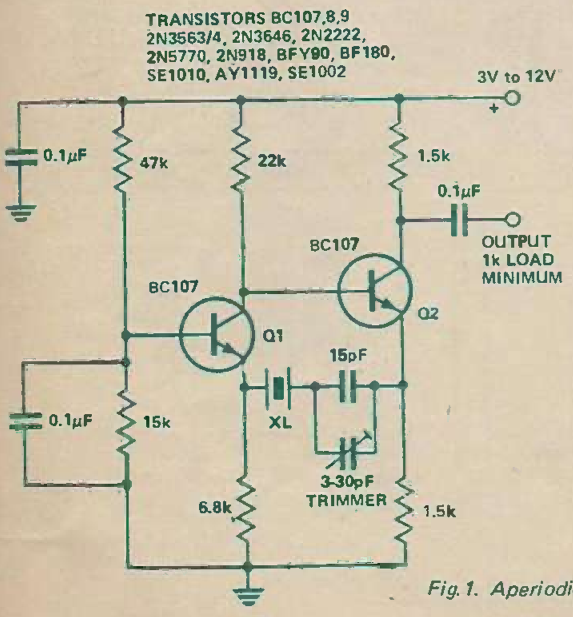

Fig. 1. Aperiodic Butler oscillator (series mode)

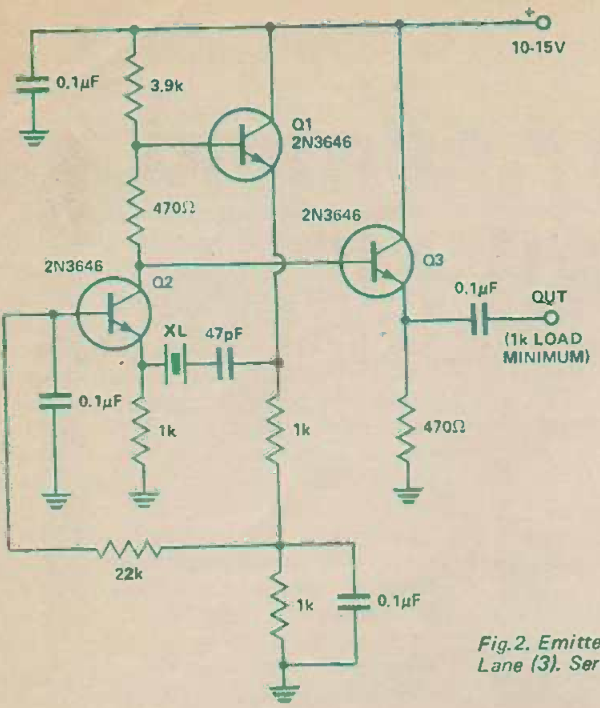

Fig.2. Emitter-coupled oscillator – after Lane (3). Series mode.

essentially sine wave; reducing the emitter resistor of Q2 increases the harmonic output. By doing this, a 100 kHz crystal produces good harmonics through 30 MHz. It is a series mode circuit.

A variety of transistors may be used. For crystals above 3 MHz, transistors with a high gain-bandwidth product are recommended. For crystals in the 50 kHz to 500 kHz range, transistors with high LF gain, such as the 2N3565 are recommended. Also, for crystals in this range, permissable dissipation is usually less than 100 microwatts and amplitude limiting may be necessary. Low supply voltage, consistent with reliable starting, is recommended. Modifying the circuit by the addition of diodes – as shown in Fig. 3 – is a better method, and starting performance is improved. The circuit will oscillate up to at least 10 MHz with appropriate transistors and emitter resistor values. An emitter follower or source follower buffer is recommended. Similar comments to the above apply to Fig. 2. An emitter follower buffer is included in this circuit. Both circuits are slightly frequency sensitive to power supply voltage changes and load variations. A load of 1 k or greater is recommended.

TTL IC can be used in crystal oscillator circuits but many published circuits have poor starting performance or suffer from non-repeatability owing to wide paramater spreads in IC's. The circuit in Fig. 4. is by K1PLP from QST, Feb. 1974 (5) and is after Weggeman (6). This circuit has been tried by the writer over the range 1 MHz to 18 MHz and can be recommended. It is a series mode oscillator and suits AT-cut crystals. The output is about 3 volts peak to peak, square wave up to about 5 MHz beyond which it is becomes more like half-sine pulses. Starting performance is excellent, often a critical factor with TTL oscillators.

LOW FREQUENCY CRYSTAL OSCILLATORS

Crystals in the range 50 kHz to 500 kHz require special considerations not encountered with the more common AT or BT cut HF crystals. The equivalent series resistance (which determines 'activity' – that figure of merit of days of old) is much greater and their permissable dissipation is limited to less than 100 microwatts, preferably 50 microwatts or less.

The circuit in Fig. 5. is a series mode oscillator described by Lane (3). It has the advantage of ot requiring a tuned circuit, and has a choice of sine or square wave output. For crystals in the range 50-150 kHz, 2N3565 transistors are recommended although the author has found BC107's satisfactory. Either type will suffice for crystals in the range 150 kHz to 500 kHz. If you find the crystal will not start reliably, most likely the crystal has a very high equivalent series resistance, in which case increase R1 to 270 ohms and R2 to 3.3 k (as recommended by Lane). For square wave operation, C1 is 1 uF (or a value close to, or above it). For sine wave output, C1 is not in circuit. Amplitude limiting is unnecessary. Sine wave output is about 1 V rms, square wave output about 4 V peak to peak.

The circuit in Fig. 6 is also described by Lane (3) and can be recognised as a modified form of the Colpitts oscillator, with the addition of resistor Rf to control feedback (it works the same way as Eno's). Capacitors C1 and C2 should be reduced by preferred values as the frequency is increased. At 500 kHz, values for C1 and C2 should be around 100 pF and 1500 pF respectively.

The circuit as shown gives sine wave output with the second harmonic

Continued on page 27.

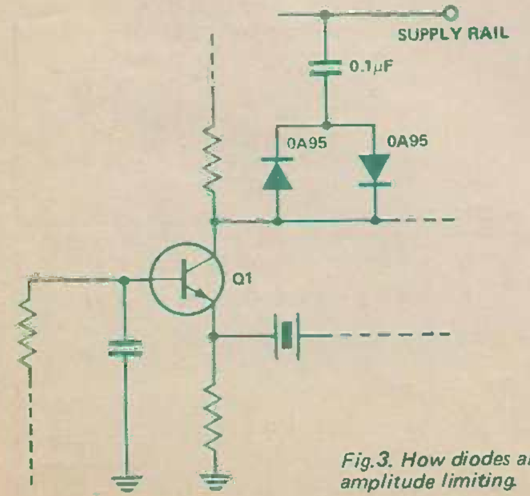

Fig.3. How diodes are used for amplitude limiting.

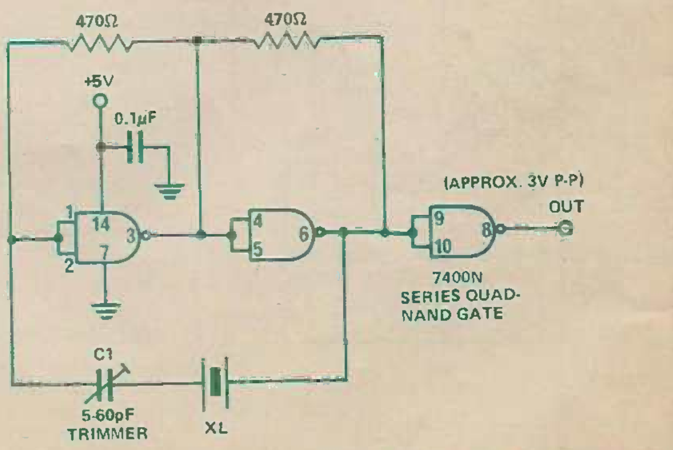

Fig.4. Reliable TTL crystal oscillator.

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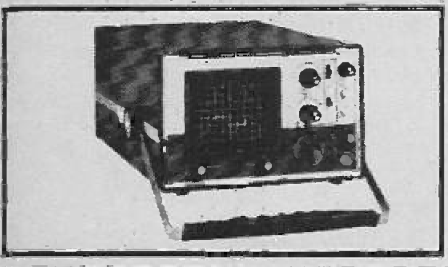

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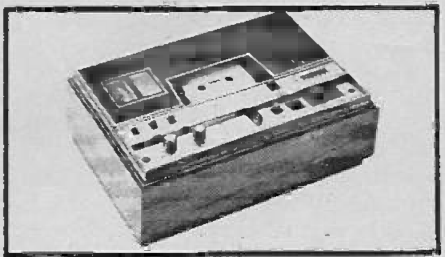

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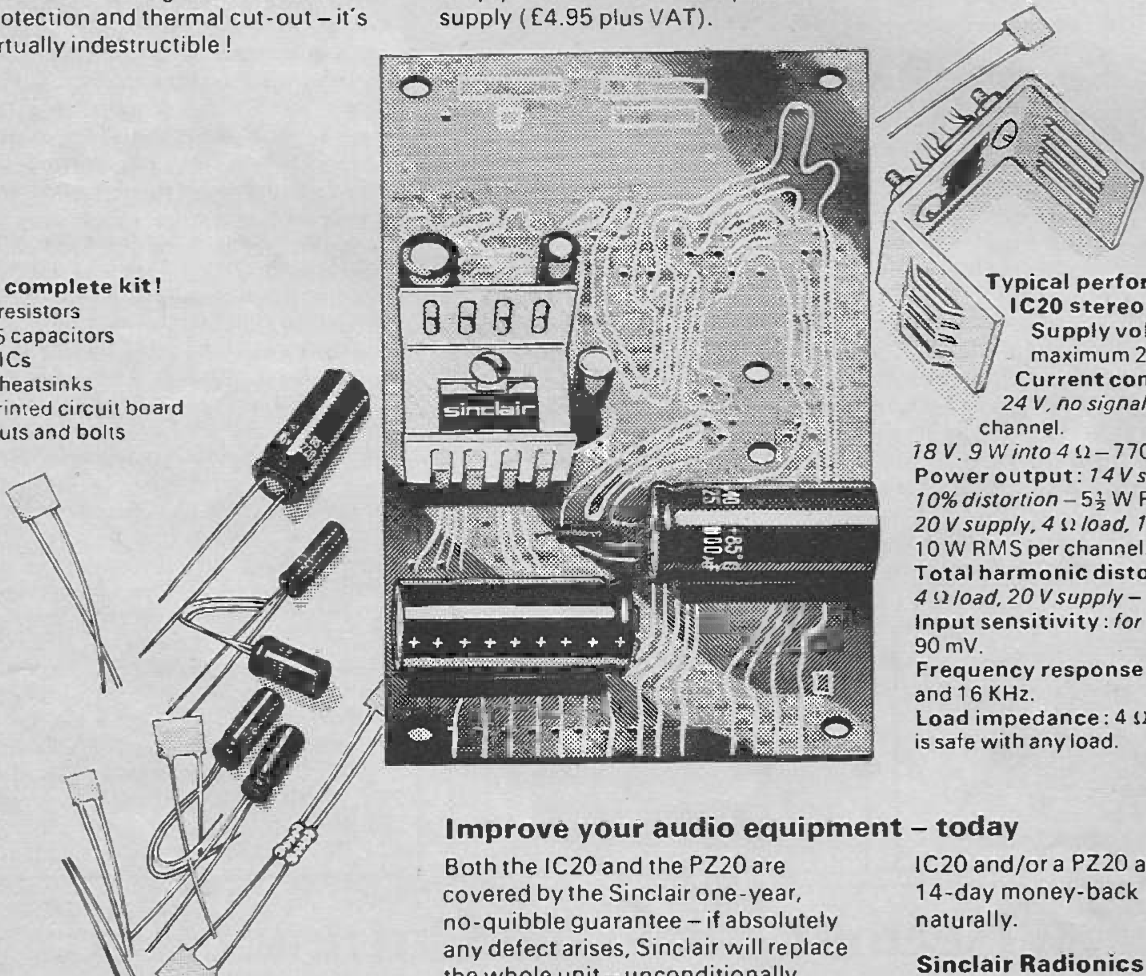

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MODERN CRYSTAL OSCILLATORS

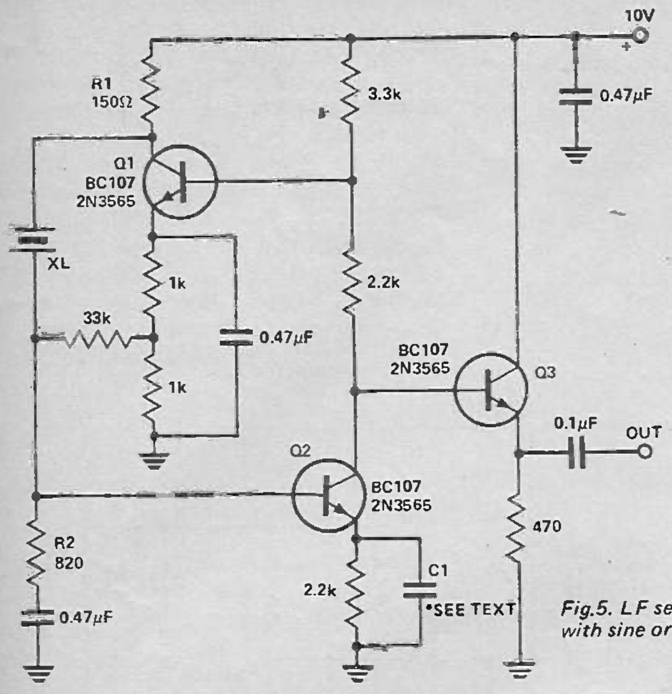

Fig.5. LF series mode oscillator with sine or squarewave output.

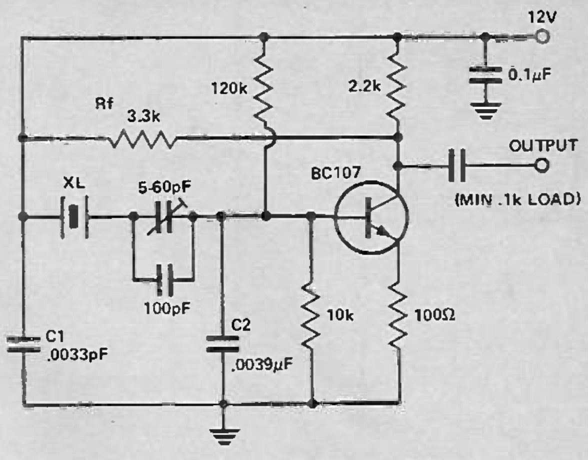

Fig.6. Parallel mode LF oscillator.

about 40 dB down (or greater). This can be reduced by careful trimming of Rf and C1. Note that, at the reduced level of feedback necessary to achieve this, it takes some 20 seconds for the oscillator to reach full output. Output is about 2 to 3 volts peak to peak.

If you need an output rich in harmonics, the simple addition of a 0.1 uF capacitor across the emitter resistor will achieve this. Output then rises to about 5 V peak to peak. Power supply voltage can be reduced in this case to lower crystal dissipation.

Other transistors can be used, but bias and feedback may have to be adjusted. For cantankerous crystals determined to oscillate in modes other than those you wish, the circuit of Fig.7 is recommended. Feedback is controlled by tapping down the collector load of Q1. Amplitude limiting is necessary to keep the crystal dissipation within limits. For 50 kHz crystals the coil should be 2 mH and its resonating capacitor 0.01 uF. Output is about 0.5 V rms, essentially sine wave. The use of an emitter follower or source follower buffer is recommended. If a parallel mode crystal is used the 1000 pF capacitor shown in series with the crystal should be changed to the crystal's specified load capacitance (usually 30, 50 to 100 pF for these crystals).

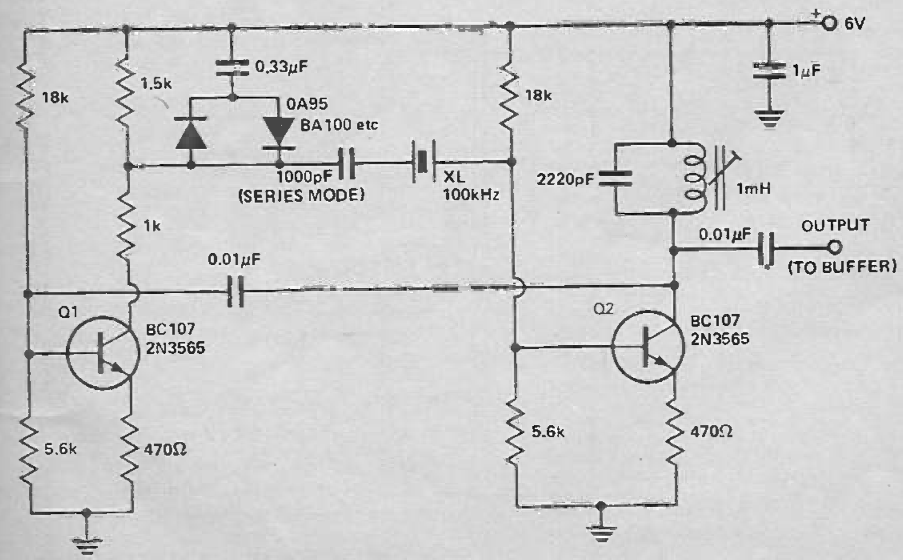

Fig.7. 100 kHz crystal oscillator (with tuned circuit).

HF CRYSTAL OSCILLATOR CIRCUITS

Solid state circuits for the popular AT-cut HF crystals are legion. However, results aren't always what one would expect. Most fundamental crystals up to 20 MHz are ,usually specified for parallel mode operation. However, such crystals can be used in series mode oscillators by putting the specified load capacitance in series with the crystal as mentioned previously. Both types of circuit are detailed here.

A useful oscillator for the range 3 to 10 MHz that does not require a tuned circuit is given in Fig. 8 (a). It is, of course, the same circuit as Fig.6. The circuit can be used down to 1 MHz if C1 and C2 are increased to 470 pF and 820 pF respectively. It can be used up to 15 MHz if C1 and C2 are reduced to 120 pF and 330 pF. Respectively. This circuit is recommended for non-critical applications where high harmonic output is wanted, or not a consideration.

The addition of a tuned circuit as in 8(b) reduces harmonic output considerably. A tuned circuit with as high a Q as possible is recommended. In a 6 MHz oscillator, I have obtained the following results. With a coil Q of 50 the 2nd harmonic was 35 dB down. With a Q of 160, it was −50 dB! Resistor Rf can be adjusted (increase slightly) to improve this. The output is also increased with a high Q coil. As previously noted, with reduced feedback it takes some tens of seconds to reach full output from switch on, however, frequency stability is excellent.

Operation at other frequencies is accomplished by changing the capacitors and coil appropriately.

This circuit (Fig. 8) can also be turned into a very effective VXO. A small inductance is placed in series

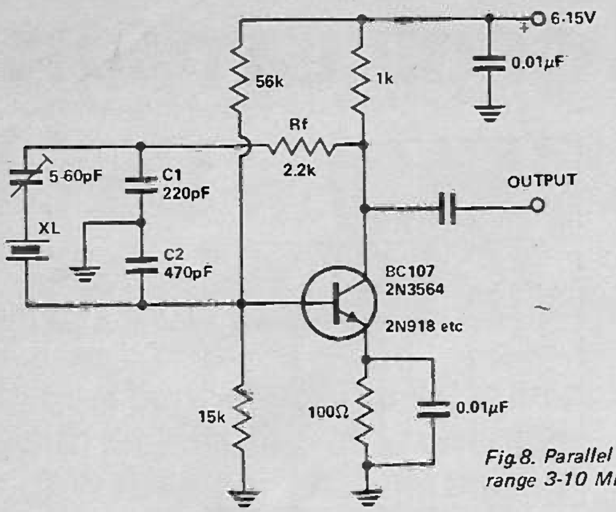

Fig.8. Parallel oscillator for the range 3-10 MHz.

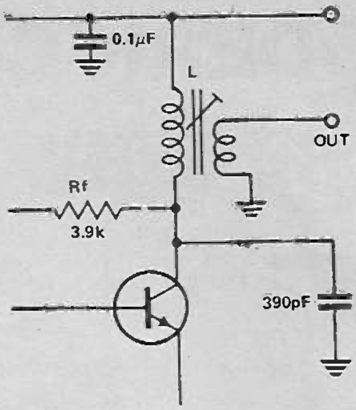

Fig.8b. Adding a coil to the circuit shown in Fig.8.

with the crystal and one of the capacitors in the feedback circuit is made variable. An ordinary two-gang 10-415 pF (or thereabouts) broadcast tuning capacitor will do the job nicely. Both gangs are paralleled. The tuning range depends on the crystal used, the inductance of L1 and the frequency. A greater range is usually obtainable with the higher frequency crystals. Stability is excellent, approaching that of the crystal.

Another variation of this circuit is shown in Fig. 10. This circuit may allow more 'pull' on the crystal, but stability is poorer. For both Fig's 9 and 10 the trimmer is to set the nominal frequency at some position of the tuning capacitor. For both circuits also, especially for Fig.10, the output varies across the tuning range.

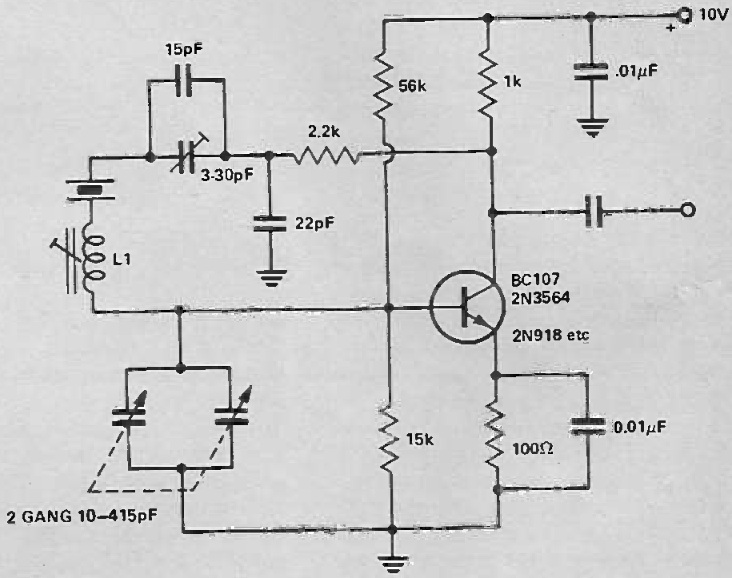

Fig.9. VXO

A VHF OSCILLATOR-MULTIPLIER

The circuit in Fig.11 is a modification of the 'Impedance Inverting' overtone oscillator discussed by Rankin (4), who also describes a similar circuit. Normally, with the impedance inverting circuit, the collector is either untuned or grounded for RF. The collector can be tuned to twice or three times the crystal frequency To reduce the output at the crystal frequency, a double tuned circuit is recommended. DO NOT tune the collector to the crystal frequency, otherwise the circuit will oscillate at a frequency not controlled by the crystal. It is advisable to keep the collector lead as short and direct as possible.

Results with this circuit are excellent. All outputs other than the wanted output were at –60 dB or greater. Noise output is at least 70 dB below the wanted output. It makes an excellent conversion oscillator for VHF/UHF converters. Almost 2 V of RF is available at the hot end of L3

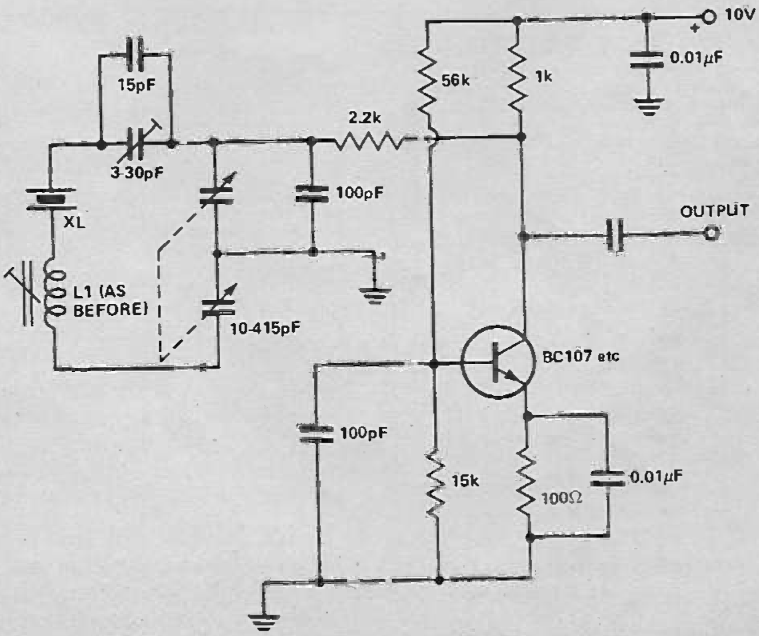

Fig.10. Alternative version of circuit shown in Fig.9.

MODERN CRYSTAL OSCILLATORS

(author's prototype at 30 MHz). A Zener regulated supply is recommended. As indicated on the diagram, different circuit values are necessary for different transistors. Strays in individual construction may also necessitate variations. **L1** can be used to pull the crystal onto frequency.

Slight variations in frequency (about 1 ppm) occur when tuning L2 and L3 and also with load variations. However, in practise, these turn out to be of no consequence.

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(3) 'Transistor Crystal Oscillators to Cover Frequency Range from 1 kHz to 100 MHz' by M. Lane, Australian Post Office Research Laboratories, Report No. 6513.

(4) 'Overtone Operation of Quartz Crystals' D. Rankin (VK3QV), Amateur Radio, March and May 1967.

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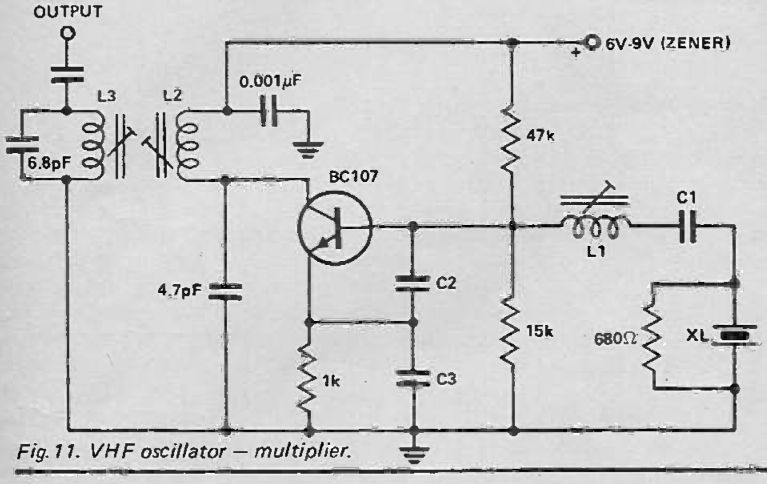


Fig. 11. VHF oscillator — multiplier.

65 MHz Xtal 130 MHz OUTPUT
L1 = NEOSID AZ ASSEMBLY (4mm FORMER & F29 SLUG) WOUND WITH 12 TURNS OF 4.55 mm ENAMEL WIRE, CLOSEWOUND

L2/3 = NEOSID, DOUBLE ASSEMBLY 7300 CAN, TWO 722/1 FORMERS, F29 SLUGS, WOUND WITH 5 TURNS, 0.63mm ENAMEL, CLOSEWOUND

C1 = 33 OR 39 pF

43 MHz Xtal 130 MHz OUTPUT
L1 = 20 TURNS 0.4mm AS ABOVE
L2/3 = AS ABOVE
C1 = 56pF

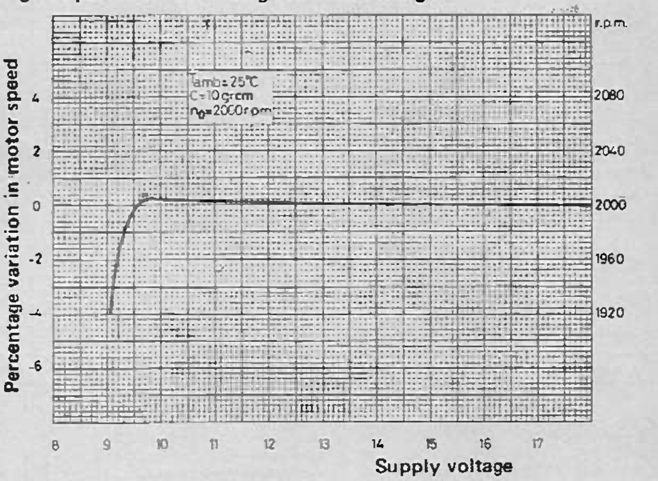
38MHz Xtal 116 MHz OUTPUT
L1 = 24 TURNS 0.4mm AS ABOVE
L2/3 = 9 TURNS 0.63mm AS ABOVE
C1 = 68pF OR 100pF

XL	C2	C3	
65mHz	8.2pF	5.6pF	BC107
43mHz	15pF	10pF	BC107
38mHz	22pF	18pF	BC107
65mHz	18pF	12pF	2N3564
43mHz	33pF	18pF	2N3564
38mHz	56pF	39pF	2N3564

Cassette Speed Regulator I.C's

by Brian Dance

Fig 1: Speed Variation using the circuit in Fig 3.



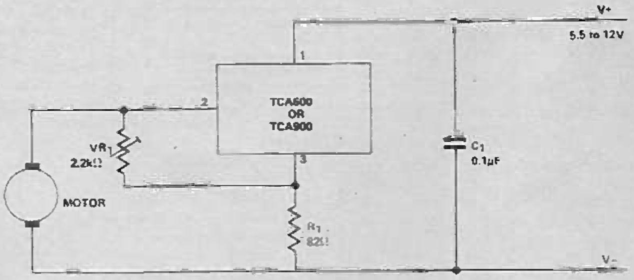


Fig 2: Typical Speed Control circuit of a cassette player running from batteries or mains.

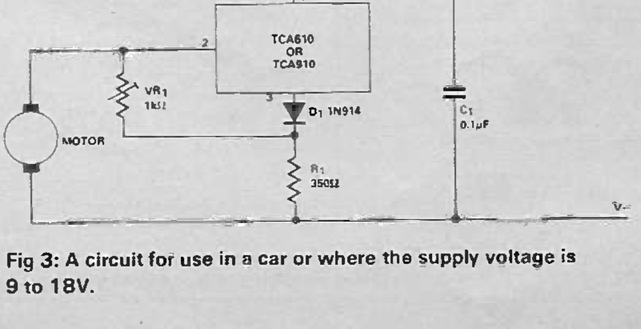


Fig 3: A circuit for use in a car or where the supply voltage is 9 to 18V.

The speed of a small cassette recorder can vary with the supply voltage, with the ambient temperature and with the torque applied by the tape to the motor spindle. Such variations of speed can produce a considerable effect on the sound reproduction.

The extremely simple circuits described in this article can be used to stabilize the motor speed against variations caused by any of these effects. They can also be employed for the stabilization of the speeds of small dc motors used for other purposes.

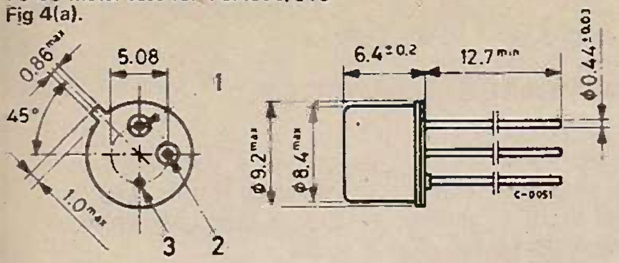
THE INTEGRATED CIRCUIT

The circuits to be described employ one of four similar types of integrated circuit manufactured by the S.G.S.-Ates Company.

The devices coded TCA600 and TCA900 are suitable for use in portable cassette players operating from power supplies in the range of 5.5 V to 12 V. The types TCA610 and TCA910 are most suitable for the speed control of motors driven from a car battery, since they can operate from power supplies in the range of 9 V to 18 V. (The absolute maximum supply voltage is 20 V, but the normal maximum of 18 V allows a safety margin.)

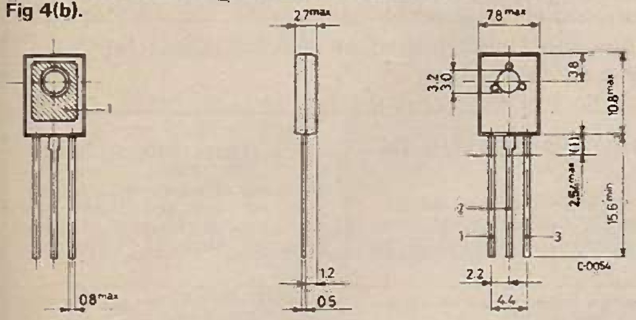
The TCA600 and TCA610 are encapsulated in TO-39 circular metal cans, whilst the TCA900 and TCA910

TO-39 metal case for TCA600/610
Fig 4(a).



Pin 3 connected to case.

TO-126 (SOT-32) plastic package for TCA900/910
Fig 4(b).



Pin 3 connected to metal part of mounting surface.

are in flat plastic packages known as the TO-126 type. Each of these devices has three connections which are numbered in Fig 4 and in the circuits to be discussed.

The maximum power dissipation of the TCA900 and TCA910 (0.8 W) is greater than that for the other two devices (0.55 W). A heat sink can be fitted if a greater power dissipation is required.

LOW VOLTAGE CIRCUIT

A circuit suitable for use in a typical battery or mains powered cassette player is shown in Fig. 2. The speed of the motor can be varied by the adjustment of RV1.

The power supply for the motor is obtained from pin 2 of the device. The output from this pin shows negative resistance characteristics. That is, if the motor takes an increased current (owing to an increase in the force resisting the rotation of the motor), the driving voltage from pin 2 will increase in proportion.

The maximum motor operating current is 150 mA, although approximately 400 mA can be supplied when the circuit is first switched on.

CAR BATTERY OPERATION

A circuit suitable for operation from power supplies in the range 9 to 18 V is shown in Fig. 3. The motor should produce a back emf of about 6 V, the internal resistance of the motor being typically 44 ohms.

The diode used in this circuit reduces variations of the motor speed with changes in the ambient temperature. However, this system of compensation can be used only with motors producing a back emf greater than 4 V.

The typical variation of motor speed with the supply voltage when using this circuit is shown in Fig. 1.

PERFORMANCE

The variations of the motor speed with temperature are around 2% for a 25°C temperature change in the circuit of Fig. 2. If, however, the diode is used in the circuit of Fig. 3, the speed variation is very small below 20°C and is about 1% for a rise in temperature from 25°C to 50°C.

The variation of the motor speed with torque is typically little more than 2% when the torque changes by a factor of two; this applies to both the circuits of Fig. 2 and Fig. 3. This variation can be reduced by increasing the value of R1, but care must be taken to ensure that oscillations do not occur.

The minimum permissible back emf from the motor varies linearly from about 2.9 V when R1 is 40 ohms to 3.7 V when R1 is 290 ohms.

The capacitor C1 can be omitted if the power supply is well decoupled.

ADVANTAGES

These motor speed control circuits employ only four or five components. They are much smaller and simpler than speed stabilizing circuits which employ discrete components and this reduces the assembly costs. The circuits provide a high starting torque from the motor even at very low ambient temperatures.

It must be made quite clear that these circuits can be employed only to control dc motors; ac motors require a different type of speed control circuit.

BIRTHDAY SPECIAL

This issue marks the start of eti's fourth year. We've grown a lot since April 1972 and are growing faster now than ever before. This, unfortunately, means problems for some of our readers. As more and more people buy eti the quicker the newsagents sell their copies, so people are dissapointed.

Fortunately there is an easy solution for those who want regular copies . . . they can take out a subscription and receive their magazine through their letterbox as soon as it is published. If you want a subscription just fill in the coupon at the bottom of the page and send it to eti with a cheque for £4.25 (or £4.75 overseas) which will cover postage, too.

And as it is our birthday we are going to be especially generous. Those of you who send in for a Top Projects book as well as a subscription will only have to pay the subscription fee. THE PROJECTS BOOK WILL BE FREE! Just send in the voucher attatched to your coupon.

This offer expires on 30th April 1975 and applies only to new subscriptions taken out before then and using the special coupon. This offer is also being made to existing subscribers whose renewals fall within the offer period.

ETI TOP PROJECTS

ON SALE AT YOUR NEWSAGENTS FOR

75p

MAY BE OBTAINED FROM ETI USING THE COUPON ON PAGE 62 FOR 75P PLUS 10P POSTAGE

THIS VOUCHER IS WORTH **75P**

TO READERS BUYING A TOP PROJECTS BOOK & TAKING OUT A SUBSCRIPTION TO ETI WITH THE ADJOINING COUPON

VALID TO 30th APRIL WHEN ATTACHED TO COUPON

ETI SUBSCRIPTIONS

SEND A CHEQUE FOR £4.25 (OR £4.75 OVERSEAS) WITH THE COUPON TO RECEIVE YOUR ETI DIRECT FROM US AS SOON AS IT IS AVAILABLE

YOU WILL BE ASSURED OF EACH ISSUE FOR THE NEXT TWELVE MONTHS.

If you already have a Projects Book, send in the coupon without the special voucher.

Send to:
ETI BIRTHDAY SPECIALS,
36 EBURY STREET,
LONDON, SW1W OLW.

To Subscriptions Department,
OR, for a free Top Projects book, To 'ETI BIRTHDAY SPECIALS', 36 Ebury Street, London SW1W OLW.

Please find enclosed £4.25 (£4.75 for overseas), which includes postage, for my annual subscription to ETI starting with the next available issue.

NAME...

ADDRESS...

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April 1975

THREE DANAMETERS MUST BE WON

OUR RECENT CROSS-NUMBER competition was such a success that we are setting you another one. Again we are offering three prizes, but this time every winner gets first prize! These are three digital multimeters which were launched earlier this year by Dana Electronics, and are selling for £107.46 each (inc. VAT).

Look at the spec. on the right and you will see what a professional instrument the Danameter is. It comes in a 4"x7¼"x2¼" plastic case which will protect it if it falls off the bench. It is electrically rugged too — overloads like 250V on the ohms ranges will not hurt it! It is such a beautiful little meter and so simple to use that you will probably spend many hours playing around with it before you put it to any serious use.

SPECIFICATIONS

DC Volts Ranges: 2V,20V,200V, and 1kV with 1mV resolution. Overload protection is 1000V DC or peak AC, any range. Accuracy: ±½% to ±¾%. Automatic polarity and 10Mohms input resistance.

AC Volts Ranges: 2V,20V,200V, and 1kV with 1mV resolution. Overload protection is 1000V peak AC, 250V DC, any range. Input resistance 2Mohms and input capacitance 40pF.

DC Current Ranges: 20µa,2mA,200mA and 2A with 0.01µa resolution. Accuracy ±2% to ±4%. Overload protection is 250V DC or RMS.

OHMS Ranges: 200Ω,20kΩ,2MΩ and 200MΩ with 0.1Ω resolution. Accuracy ±3½%,±1½%,±3½% and ±8%. Overloads up to 250V DC or RMS.

Battery: one 9V dry battery, Est. battery life: 1 year at normal usage. Test leads: included. Weight: 1 lb.

For further details from Dana Electronics Ltd., Collingdon Street, Luton, Beds.

ACROSS

1. Well known '2N' transistor number with suffixes of colours.
5. When it's 2100 hours in Moscow, whats the time in Guyana?
8. FM IF
10. Traditional date of founding of Rome.
11. One radian in degrees.
13. Four foot two inches in millimetres.
16. TTL decade counter.

DOWN

2. Resonant frequency of 1µF and 27.48mH (to nearest hertz)
3. Fahrenheit of 16°C.
4. 1000111
6. CABBAGE 3122175; DICE?
7. didididit, dahdahdididit dididahdahdah, didididahdah.
8. Earliest 'air' crossing of the Atlantic?
9. Marconi's famous radio patent.
12. Hi-Z op. amp for low level applications.
14. $\sqrt[3]{}$(625-line TV line frequency)
15. Bond loses nothing

RULES

This competition is open to all U.K. and Northern Ireland readers of Electronics Today International except employees of the magazine, their printers and distributors and employees of Dana Electronics Ltd.

All entries must be on the coupon cut from the magazine, photostats are not acceptable. As long as the correct coupon is used, readers may submit as many entries as they wish.

The prizes will be awarded to the first three correct entries drawn after the closing date. No correspondence can be entered concerning the competition. It is a condition of entry that the judges decision in all matters is regarded as final.

The winners will be notified by post. The answers and a list of prizewinners will appear in a future issue of ETI.

Entries should be sent to: ETI/Danameter Competition, 36 Ebury Street, London SW1W 0LW to reach us by April 30th, 1975.

HOW TO ENTER

Solve the clues shown and enter them on the form alongside as though it were a crossword but you will be entering numbers. All figures, (where applicable) should be rounded off to the number of decimal points for which there is space. Decimal points need not be entered and are not applicable in the other direction. For numbers less than 1, ignore the first zero. Therefore 0.025 will appear as 025.

Some of the clues are tough — but they are not tricks and those which you cannot answer from your head will be available in common reference books.

Cut

TO: ETI/DANAMETER COMPETITION
36 EBURY STREET,
LONDON SW1W 0LW.

Please find attached my competition entry. I agree to abide by the rules and judges decision.

NAME ....

ADDRESS ....

....

....

....

Entries must be received by April 30th 1975.

1	2		3	■	4	■
■		■	5	6		7
8		9	■		■	
	■	10			■	
	■		■	11	12	
13	14		15	■		■
■		■	16			

INPUT GATE

LETTERS FROM OUR READERS

ETI 100W GUITAR AMP

I would be pleased if you could give me some information on how I could obtain certain parts for the guitar amplifier (in your Top Projects Book, ETI 413). These are the transformer - 56 volts CT at 1.5A (Repanco 0722) and the resistors 0.25 Ohm 2W.

— R.C.F., Newcastle.

A suitable transformer is available from Doram (see the reply to the Stereo Amp letter) and Doram can also supply 0.27Ω, 2.5W resistors which are okay for this circuit.

ETI's DODGEY WIREGAUGE

Re the "Colour Organ" project in the February issue of ETI could you confirm the gauge and type of wire used to wind the choke and pulse transformers. You quote 0.40mm (30swg) and 0.63mm (26swg). My wire gauge does not agree with these figures, for enamel wire 0.40mm = 27swg and 0.63mm = 23swg.

— R.K.M., Harrow.

The diameter of the wire we recommend in our projects is the correct figure. The SWG reference is worked out afterwards and in this case we made an error.

ETI 50W STEREO AMP

I have partly completed the ETI Stereo Amplifier (in ETI, August 1974) but I am having difficulty in obtaining the Mains transformer, 56V CT, and the transistors, PN3643. Could you please tell me where these components are obtainable from?

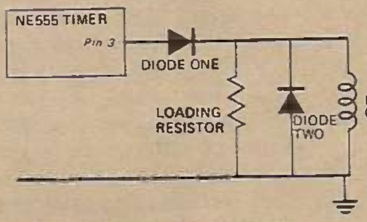
— B.G., Glasgow.

A 30V - 25V - 0 - 25V - 30V transformer rated at 1.5 amps is available from Doram (order code 196-139) for £4.75 plus VAT. This will do if you use it as a 60V CT transformer.

A common equivalent of the PN3643 is the 2N3643 (available from Marshall's, amongst others).

LATCH UP WHEN DRIVING AN INDUCTIVE LOAD

With reference to the circuit in your feature concerning the NE555 timer chip, Figure 10 on Page 27 of the February ETI, it will be found that on the NE555 integrated circuit timer a negative voltage at pin 3 can cause a latch up. The solution is to add two diodes and a resistor as shown below; this circuit prohibits a negative voltage from reaching pin 3.



— A. C. Lewis, Nottingham.

ELECTRONICS IN CRIME

I am writing to correct and clarify some of the impressions given by your December issue on the subject of burglar alarms with particular reference to Volumetric devices.

It is true that there are many types of alarm systems which may signal either local audible alarms or a remote central station or police station. In any circumstance the prime objective of the alarm system is to deter and prevent crime, which is done by demonstrating to the potential intruder that the premises are protected by means of the outside bell unit with the alarm company's name on it. Without inside information the criminal then has no knowledge of the alarm nor the method of signalling and may well be deterred.

DETECTION AND DISARMING

The possibility of overcoming or bypassing the modern alarm is very much more difficult than the article suggests. In the first place all professional systems operate with a standby battery facility to remove the problem of mains failure or disconnection. The most usual form of power supply today is the rechargeable gel cell or nickel cadmium battery which is left permanently "on line", with the mains prime source for recharging. There is no switching as such and fluctuations or interference of the mains supply presents no problems. Second, the method of wiring used today employs double pole wiring throughout and either cutting or shorting of wires will create an alarm condition.

It will always be possible to overcome individual items of the "hard wired" or conventional type but it would take an amount of inside information plus considerable technical ability which would be as rare as someone attempting to pick a security lock - the more usual method being to kick in or jemmy the frame or weakest point.

The greatest weakness in the "hard drawn" or conventional system is that it is a method of protecting individual points and access routes, such as windows, doors, skylights etc., and these can be bypassed by coming through a ceiling, wall or floor which would not be cost effective to prevent by conventional methods. Also in large buildings conventional systems can become unwieldy by virtue of the number of access routes and therefore switched points to be protected. The situation is further aggravated by modern building methods e.g. asbestos clad roofs and walls, louvre windows, ceiling lights of poor construction and large expanses of glass.

VOLUMETRIC SYSTEMS

A great deal of research has gone into the development of devices which protect by volume (hence volumetric) to overcome these problems and raise the level of security. In the early days many of these devices were underdeveloped and highly unstable leading to an unacceptable level of false alarms.

For several years now the writer's company has been dealing with an ultrasonic system known as Unisec. Each area to be protected has a transmitter and receiver head which are connected to a central control which contains the logic circuitry, control function, power supply and rechargeable gel cell. The receiver heads "see" any change in the transmitted frequency caused by movement of a person within the area but will not see any external or electrical noises. This change in frequency (the "Doppler Shift") can be accurately measured and provides the alarm signal. The protection is 100% by volume (not by a beam). The system is accurate and dependable giving a false alarm ratio below that of conventional systems, with the further advantage that all the components of the system are within the protected areas and therefore not accessible for tampering.

I trust that this fills in some of the gaps and provides a fuller picture of this aspect of Electronics in Crime.

— T.A. Hack., Wessex Intruder Alarms Limited.

Mail Order Catalogues

EVEN READERS living in major cities usually have to buy some of their components by Mail Order. All companies who market components by mail order advertise (how do they get hold of their customers otherwise) but only a tiny fraction of the items stocked can possibly be listed.

At ETI we consider that a selection of mail order catalogues is as essential to the constructor as a soldering iron or a screwdriver. Mail order companies almost always have a far greater stock of components than local shops and as there is considerable competition between outlets, the prices are often lower.

When checking component availability, we at ETI make use of a number of catalogues and we publish here details of ten of the major ones.

We have not included the catalogues of companies who stock only specialised components or only surplus equipment and only those which have a good range.

We often hear objections from readers about the cost of some catalogues. Most catalogues (even the dearest) cost far more to print than their selling prices and a charge has to be made to recover part of the cost. Some of the companies provide vouchers so that the catalogue costs nothing or very little to regular customers.

We give details about what the catalogues contain, which items listed that are hard to obtain elsewhere, etc. We have not set out to compare merits as this is highly subjective but we have listed details of 'extras' that customers get. By this we mean details of circuits etc., that are nothing to do with the sale of components directly.

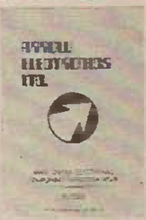
We consider a couple of pounds spent on mail order catalogues is money well spent. Even those catalogues not included here are excellent value, at least we have yet to come across one which has not been.

Good range of transistors and I.C.s with adequate listing of passive components. Listings and specifications are clear and well thought out. Large numbers of photographs illustrate the components but the reproduction is poor on some. The catalogue covers nearly all categories though the range is not always large, for instance there are only three transformers.

Some unusual items: RAMs, Mullard FM modules, for example. Few r.f. components. Arrow are part of a group which holds franchises for RCA, Siemens and Newmarket and can usually supply any components from these companies.

ARROW ELECTRONICS LTD.
7 Coptfold Road,
Brentwood,
Essex, CM14 4BN.

Cost: 10p to cover despatch
Size: 210x150mm, 45 pages.



Bi-Pak are of course semiconductor specialists, so it is not surprising that over half their catalogue is devoted to transistors and IC's with much of that space carrying details of the 74 series digital devices.

Only two capacitors are listed and resistors are only available in 'Paks' but there are chassis, pots and some connectors with a good selection of slide switches.

BI-PAK,
P.O. Box 6,
Ware,
Herts.

Price: 10p
Size: 208x148mm, 36 pages.

A good range of 'Paks' covering both new and surplus equipment is one feature of the catalogue from Bi-Pre-Pak. There is a moderate range of transistors of the most popular types and listings of diodes etc. with a few IC's.

Details of the company's Stirling Sound range of audio equipment and modules are given. Also listed are books and some unusual surplus items.

BI-PRE-PAK LTD,
222-224 West Road,
Westcliff-on-Sea,
Essex SS0 9DF.

Price: S.A.E. with 5p stamp
295x210mm, 22 pages.

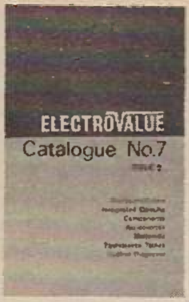
Very well though out range, well illustrated. The items covered have been deliberately selected to cover the components used by amateur constructors. Very wide range of capacitors and resistors all of which are very clearly presented. A limited, but well chosen range of transistors with full spec. given for each device. Few integrated circuits.

Good range of cases, tools and switches including push-button switch kits. Excellent range of various connectors.

Except for semiconductors, this catalogue has as complete range as any, all extremely well presented and easy to use.

DORAM ELECTRONICS LTD.
P.O. Box TR8,
Wellington Road Industrial Est,
Wellington Bridge,
Leeds, LS12 2UF.

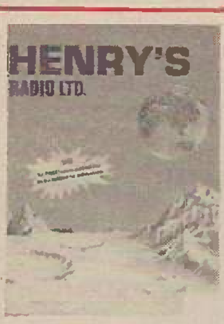
Cost: 25p.
Size: 295x208mm, 64 pages.



ELECTROVALUE LTD.
28 St. Judes Road,
Englefield Green,
Egham,
Surrey,
TW20 0HB.

Price 30p: (includes 25p voucher for use on orders over £5.00).
Size: 209x134mm, 108 pages.

A catalogue which doubles as a reference book. The transistor listings are unique and extremely useful. Semiconductors are listed conventionally with price but this cross-indexes to 63 charts which give spec and lists devices in the same group. For instance, *Low Power Output, Medium Current Switching, NPN, Silicon* is one such category which has seven types which can be compared for spec and price. A 'Near Equivalents' list is also given. Two pages of very clear semiconductor outlines are included.
Fair to good range of IC's but mainly in the 74 series. Good range of pots, resistors and capacitors. Nine pages are devoted to Siemens pot cores, including specs. Several transformers are listed covering a good range. Some unusual items: Speaker fabric and Hall effect probes.
Good value for money even if you ignore the mail order aspect.



HENRY'S RADIO LTD.
303 Edgware Road,
London W2 1BW.

Cost: 75p
NOTE: Due for printing Spring 1975. Details are based on previous catalogue (not currently available) and plans made available to ETI.

An enormous catalogue covering a vast range of new and surplus equipment. Well illustrated with quite a number of circuits, etc., which in some cases are almost constructional articles.
A good range of semiconductors, though these are even better covered by their separate listings (available free).
Good range of test equipment and Hi-Fi gear as well as kits and components. Good range of r.f. components. Main criticism is poor index and bitty presentation making reference difficult. Henry's tell us that this is being much improved in the new edition.
Apart from this, there may be weak points in this catalogue, we just haven't found them!

HOME RADIO (COMPONENTS) LTD.
240 London Road,
Mitcham,
Surrey,
CR4 3HD.

Price: 65p plus 33p post etc.
(70p worth of vouchers included)
Size: 288x200mm, 244 pages.

This catalogue can best be judged by the postage charge - we've checked the weight and at 33p, Home Radio are not making a profit out of that. 244 pages, crammed with components. Price list is separate making double reference necessary.
A very wide range of almost all components with the notable exception of semiconductors and IC's. Both are included but the range is small. Excellent range of chassis and cases, also of built test equipment. Good for r.f. components.
Apart from the weakness of semiconductors, this is perhaps the most comprehensive catalogue with a good index.

MAPLIN ELECTRONIC SUPPLIES.
P.O. Box 3,
Rayleigh,
Essex SS6 8LR.

Price: 35p (Feb. 75 issue).
Size: 245x178mm, 132 pages.

The catalogue from Maplin is unlike any other. The first 70-odd pages are fairly conventional in that they list stock and prices but the remainder is technical data sheets, circuits and other useful information making it almost a combined catalogue/book.
Firstly the catalogue section. This covers a very wide range of most types of components such as semiconductors and passive components. There is also a good selection of hardware, connectors etc. — in fact, apart from r.f. items, there are few gaps. Also included is a selection of organ components.
The other half of the catalogue gives 9 complete circuits and 40 application circuits, all with detailed notes. In addition there is a good transistor equivalents list and formulæ.

A. MARSHALL (LONDON) LTD.
42 Cricklewood Broadway,
London NW2 3ET.

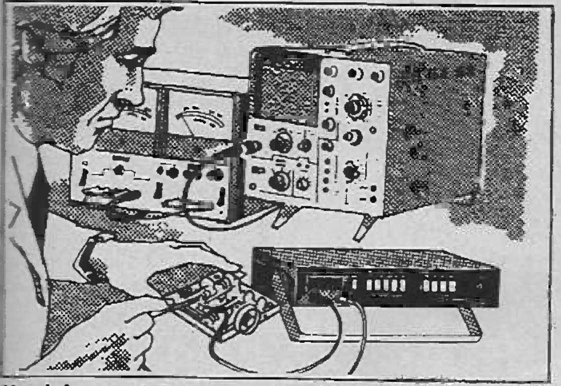
Price: 25p.
Size: 208x108mm, 100 pages.

Unlike many other mail order catalogues, the one from Marshalls is not all-embracing: there is practically no hardware, no chassis, few tools etc., BUT this is made up for by the outstanding range of semiconductors including IC's, thermistors, triacs etc. The range of capacitors, resistors nd transformers is also good.
Little spec is given for the devices but there are some useful tables such as one for selecting a diode for various voltage/current combinations. Few illustrations but those that are included are well chosen.

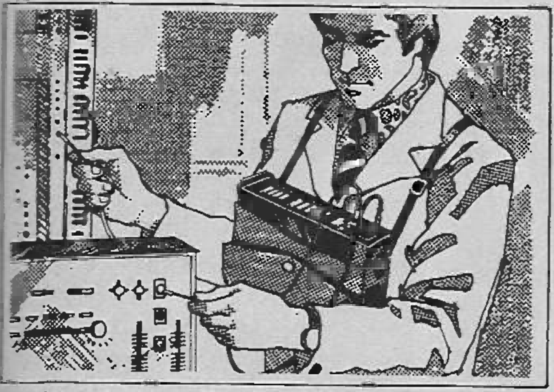
S.C.S. COMPONENTS: Price List 1.
Northfield Industrial Estate,
Beresford Avenue,
Wembley,
Middlesex HA0 1YY.

Price: Free
Size: 210x150mm, 122 pages.

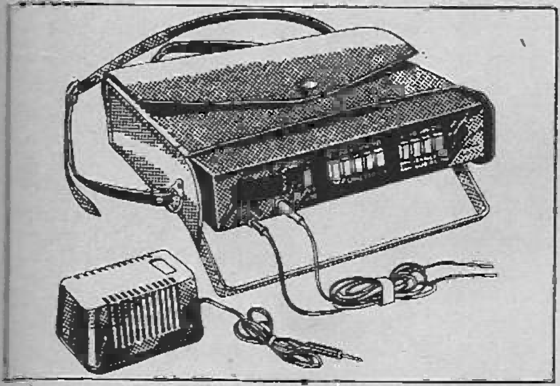
SCS make no claims to this being a catalogue - they refer to it as a Price List. Virtually all that is included is a list of transistors and IC's - but what a list! A quick tally shows that about 1200 different devices are included. Other items include a good selection of MOS and LED components.
We haven't actually counted, but this catalogue is possibly the most complete one on semiconductors available to the amateur.



Use it in your laboratory. The DM2 sits rigidly on its combined carrying handle/stand.



Use it on the move. Keep the DM2 in its carrying case – it's always ready for use.



All you need to use the DM2 . . . anywhere. Mains adaptor . . . carrying case . . . multimeter . . . you're ready for quick, efficient metering – whatever the situation.

The Sinclair DM2 Multimeter: full technical story

DC Volts

Range	Accuracy	Input Impedance	Resolution
1 V	0·3% ± 1 Digit	> 100 MΩ	1 mV
10 V	0·5% ± 1 „	10 MΩ	10 mV
100 V	0·5% ± 1 „	10 MΩ	100 mV
1000 V	0·5% ± 1 „	10 MΩ	1 V

Maximum overload – 350 V on 1 V range
1000 V on all other ranges.

AC Volts

Range	Accuracy	Input Impedance	Frequency Range
1 V	1·0% ± 2 Digits	10 MΩ/40 pF	20 Hz–3 KHz
10 V	1·0% ± 2 „	10 MΩ/40 pF	20 Hz–3 KHz
100 V	2·0% ± 2 „	10 MΩ/40 pF	20 Hz–3 KHz
1000 V	2·0% ± 2 „	10 MΩ/40 pF	20 Hz–1 KHz

Maximum overload – 300 V on 1 V range
500 V on all other ranges.

DC Current

Range	Accuracy	Input Impedance	Resolution
100 μA	2·0% ± 1 Digit	10 KΩ	100 nA
1 mA	0·8% ± 1 „	1 KΩ	1 μA
10 mA	0·8% ± 1 „	100Ω	10 μA
100 mA	0·8% ± 1 „	10Ω	100 μA
1000 mA	2·0% ± 1 „	1 Ω	1 mA

Maximum overload – 1A (fused).

AC Current

Range	Accuracy	Frequency Range
1 mA	1·5% ± 2 Digits	20 Hz–1 KHz
10 mA	1·5% ± 2 „	20 Hz–1 KHz
100 mA	1·5% ± 2 „	20 Hz–1 KHz
1000 mA	2·0% ± 2 „	20 Hz–1 KHz

Maximum overload – 1A (fused).

Resistance

Range	Accuracy	Measuring Current
1 KΩ	1·0% ± 1 Digit	1 mA
10 KΩ	1·0% ± 1 „	100 μA
100 KΩ	1·0% ± 1 „	10 μA
1000 KΩ	1·0% ± 1 „	1 μA
10 MΩ	2·0% ± 1 „	100 nA

Overload protection – 50 mA (fused).

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FLIP-FLOP FLASHER

eti project

by A.J. Lowe

This simple effective unit could save your life

A MOST DANGEROUS situation for a motorist is changing an offside wheel at night on a dark road. The FLIP FLOP FLASHER provides protection by flashing a 'bouncing' red light warning signal to other drivers. As can be seen from Fig 1, two red accessory tail lamps are mounted on an aluminium tripod about 500 mm high. They are fed through a long lead from the car's cigarette lighter socket.

The tripod may be folded for easy stowage as shown in Fig 2.

The flashing action is provided by a simple astable multivibrator timed to give a flashing rate of about 60 flashes for each lamp per minute.

As one side of each tail lamp is connected to the metal tripod and may be stood on the vehicle, it is necessary to provide two circuits – one to suit cars with a positive earth system, and one for cars with a negative earth.

The circuit for positive earth systems uses NPN transistors and is shown in Fig 3. The other uses PNP transistors and is shown in Fig 4.

From these it will be seen that there is no danger of a short circuit if the tripod is in contact with the vehicle metal work.

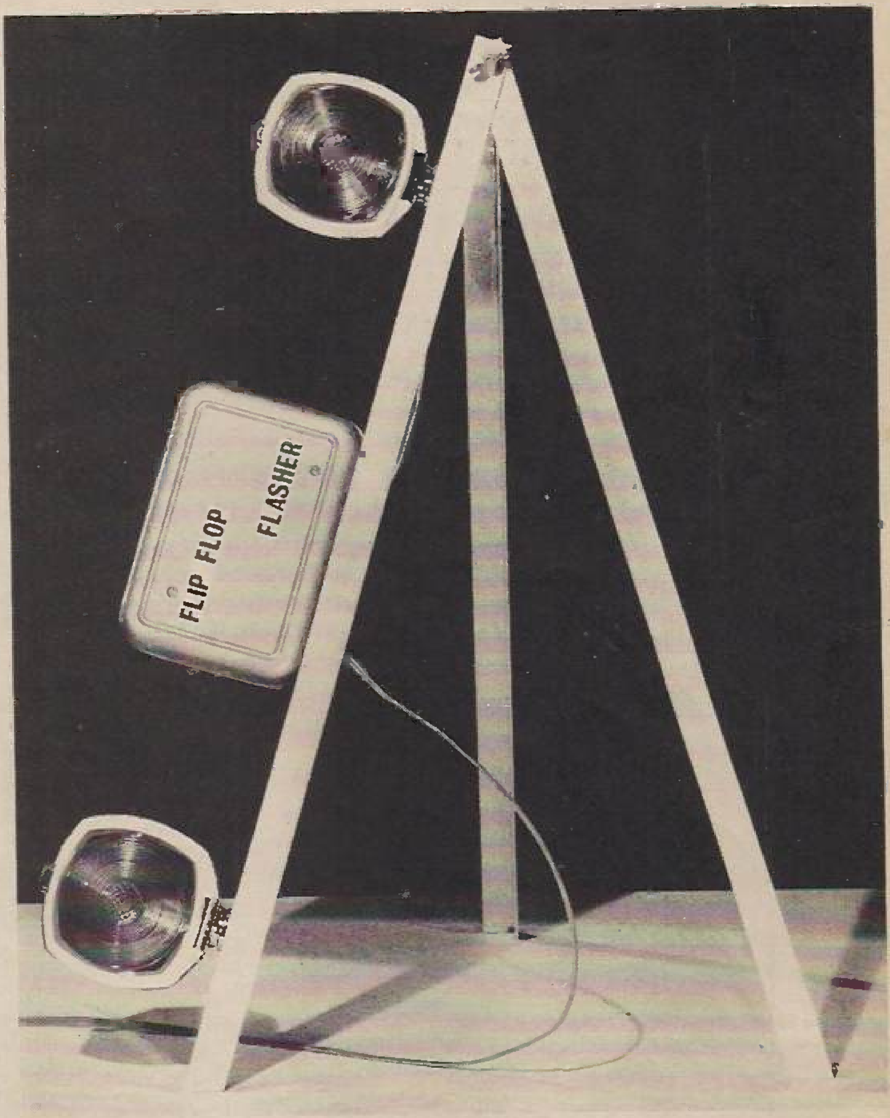
CONSTRUCTION

The few components of the electronic part of the device can be easily attached to a single tag strip as shown in Figs 5 and 6 for the positive earth system, and in Figs 7 and 8 for the negative earth system.

The tag strip may be mounted in a suitable tin box attached to one leg of the tripod. Toffee tins, or other tin boxes with tight fitting lids are ideal for this purpose. The mounting of the prototype using the negative earth tag strip is shown in Fig 9.

The tripod is constructed from three strips of 20 mm aluminium angle. The front legs are bolted together with a bolt and wing nut. The rear leg of the front pair is shaped at the top corner so that, with the bolt in position, the legs can separate by an angle of only about 32 degrees. The third leg is attached to a small bracket made from the same aluminium angle, and shown in Fig 10. The bracket is attached to the front legs by the bolt and wing nut which holds them together. The rear view arrangement is shown in Fig 11, and from this it can be seen how the rear leg is kept central.

N.B. There are certain legal limitations governing the use of flashing lights on cars. Do not use them on a moving vehicle.



The lamps used were inexpensive accessory tail lamps available from motor accessory shops. They are fitted with 12 volt 6 watt lamps. If you wish to fit more powerful lamps then the

Main text continued on Page 44

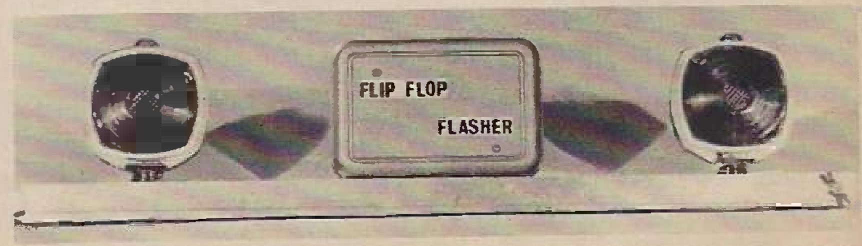


Fig. 2 The unit with its legs folded

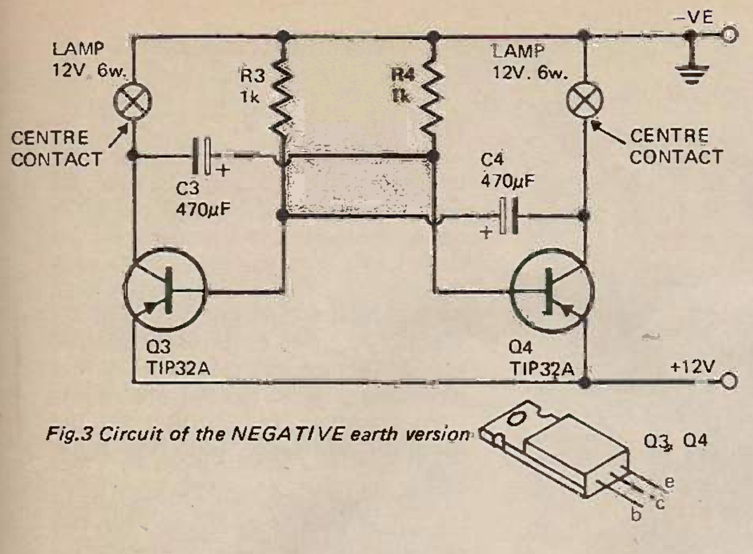


Fig.3 Circuit of the NEGATIVE earth version

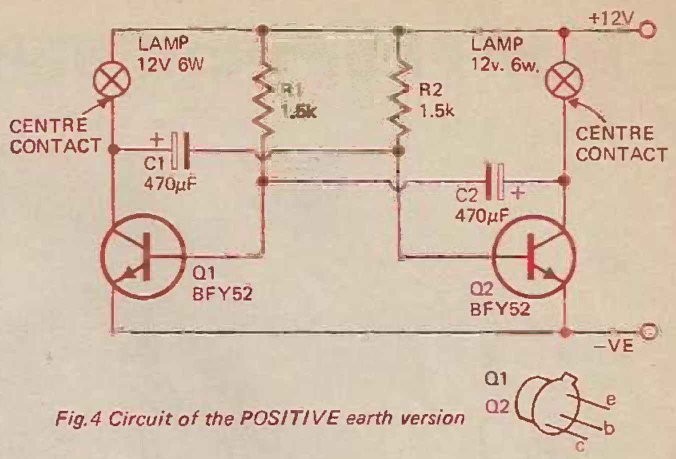


Fig.4 Circuit of the POSITIVE earth version

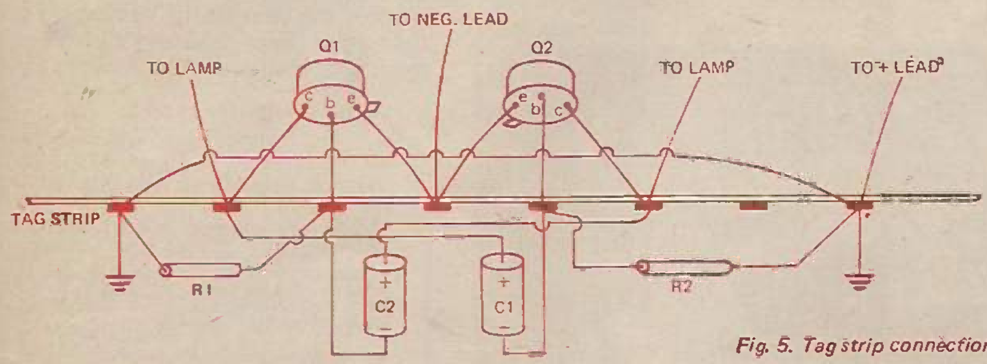


Fig. 5. Tag strip connections of positive earth version.

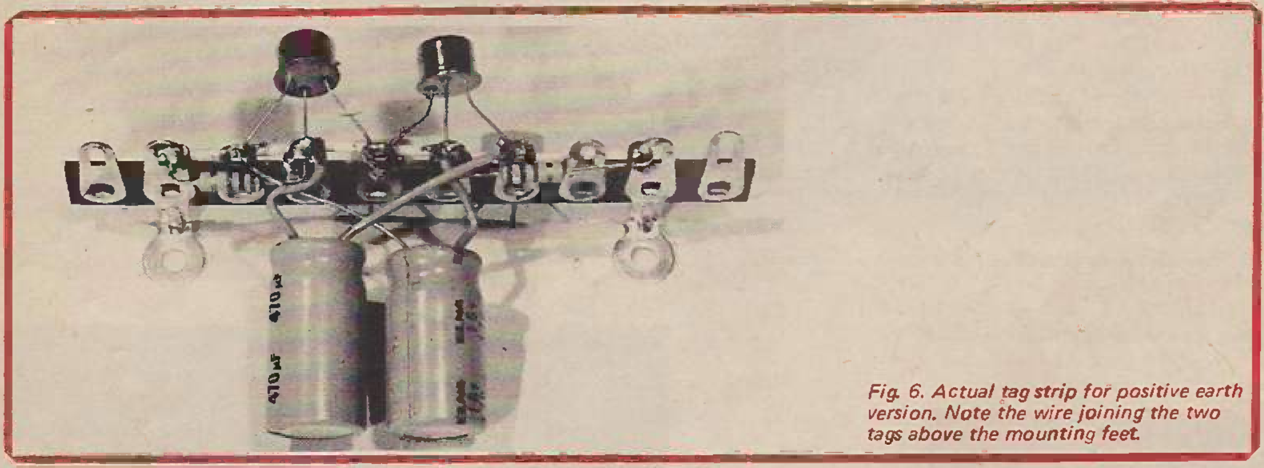


Fig. 6. Actual tag strip for positive earth version. Note the wire joining the two tags above the mounting feet.

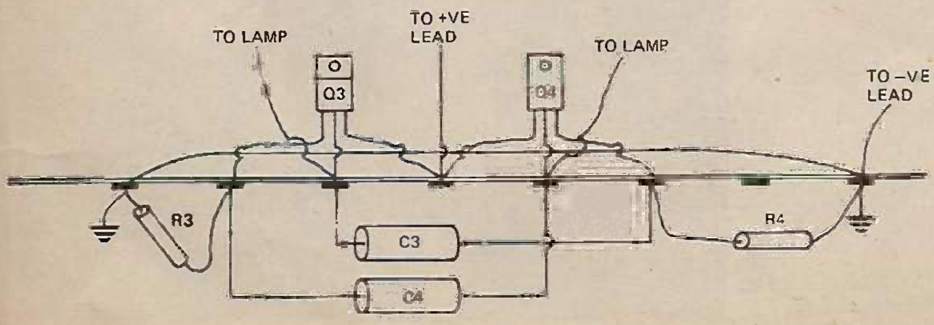


Fig. 7. Tag strip connections of negative earth version.

FLIP-FLOP FLASHER

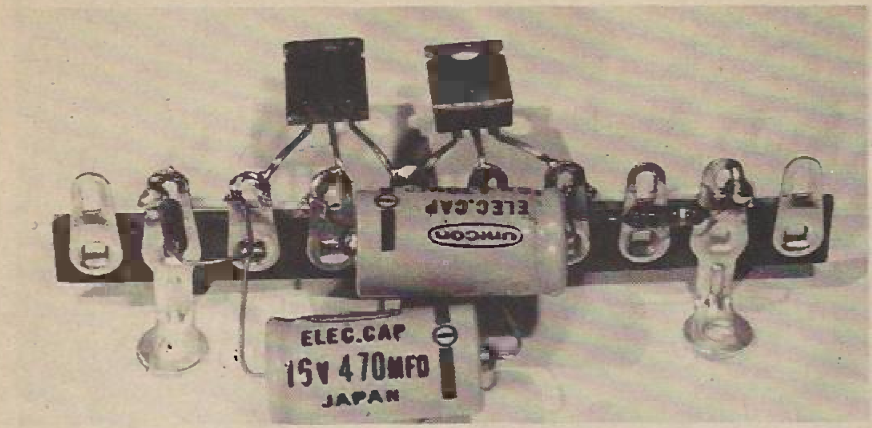


Fig. 8. Actual tag strip for negative earth version. Note the wire joining the two tags above the mounting feet, and also the use made of the lower holes in the tags.

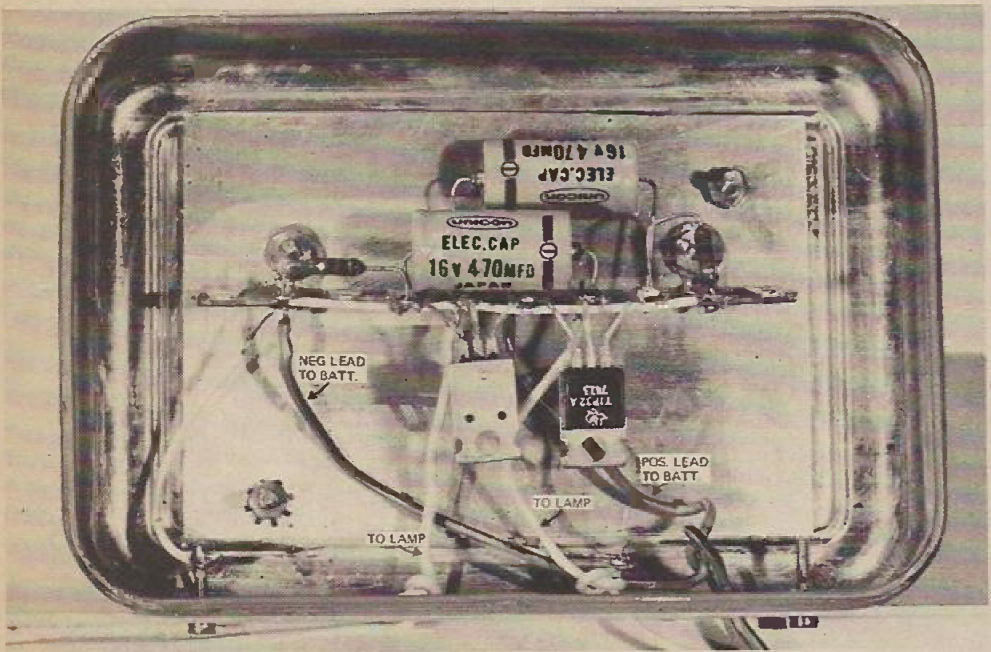


Fig. 9. The negative earth version mounted in a tin box.

circuits would need redesigning to cope with the extra current.

TESTING

It is important that, when the transistors are 'on', they should be fully on, i.e. saturated. This limits power dissipation to a proper level. To check this the voltage across each transistor in its on condition should be measured. It should not exceed about 1 volt. To keep a transistor on long enough to measure the voltage, all that is necessary is to remove one of the lamp bulbs. This holds on the transistor associated with the other bulb.

If you have a very low gain sample of transistor then the voltage may be excessive. In this case the base resistor of that transistor should be reduced until the voltage is satisfactory. If this changes the evenness of flashing, then the other base resistor should be reached to the same value. ●

PARTS LIST

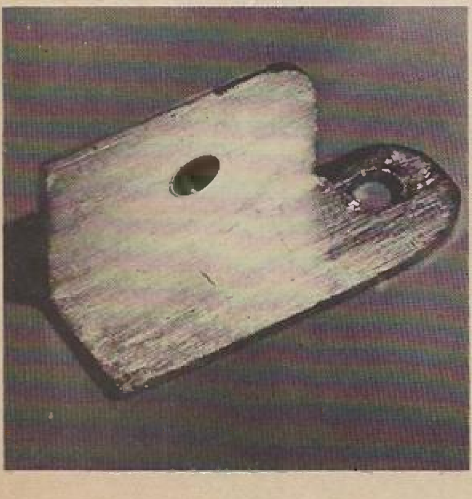
POSITIVE EARTH VERSION
R1 R2 Resistors 1500 ohms ¼ watt
C1 C2 Capacitors electrolytic 470 µF 16 volt
Q1 Q2 NPN Transistors BFY52 or equivalent.
Tap strip — 10 lug as shown
Lamps — two 12 volt 6 watt bulbs
Aluminium angle about 1.7 m

NEGATIVE EARTH VERSION
R3 R4 Resistors 1000 ohms ¼ watt
C3 C4 Capacitors electrolytic 470 µF 16 volt
Q3 Q4 PNP transistors TIP32A or equivalent
Other parts as above.

TRANSISTORS

The BFY52 is listed by several suppliers and should present no problem. The TIP32A is listed by Electrovalue and Marshalls.

Fig. 10. The bracket for mounting the rear leg. ▼



▶ *Fig. 11. Rear view of the the tripod joint.*

UNDERSTANDING COLOUR TV

by Caleb Bradley

PART 3 The PAL System

THE SUBCARRIER which is added to the conventional monochrome television signal to convey colour information has to carry *two* streams of colour-difference information: ($E_R - E_Y$) and ($E_B - E_Y$). This is achieved in the PAL colour television system, invented in Germany by Dr. Bruch of Telefunken as an improvement on the American NTSC system, by 'synchronous modulation in quadrature' of the subcarrier by the colour difference signals.

SYNCHRONOUS MODULATION

Like amplitude or frequency modulations, this is a way of using a high frequency carrier to convey a signal which might be speech, music, a television waveform or in this case the colour difference signals.

Synchronous modulation is achieved by feeding the carrier and the modulating signal into a balanced modulator or signal multiplier. The output of this is at any time the algebraic product of the two input voltages. If either voltage is zero, e.g. when the carrier wave crosses zero or when there is zero modulating signal, the modulator output is zero hence the modulation is balanced or suppressed-carrier type. When the modulated carrier arrives at the receiver, the signal can only be properly recovered by demodulating the carrier in a second modulator, using a locally generated oscillation of exactly the same frequency and corresponding phase to the carrier source used at the transmitter. Although the frequency can be duplicated accurately by using a quartz-crystal oscillator, some form of synchronisation signal must be transmitted to ensure correct phase.

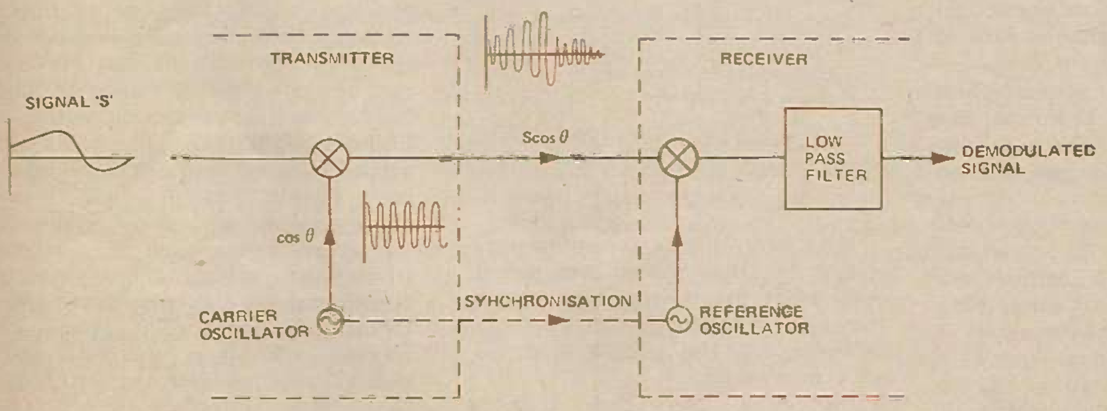
A simple system of synchronous modulation and demodulation is shown in Fig.15. The carrier oscillator at the transmitter produces a sinewave whose instantaneous value we can call 'cos θ' i.e. the cosine of the angle θ whose value grows from 0^o to 360^o during each period of oscillation. This signal can be represented by a vector pointing upward on a vector diagram. This type of diagram is an easy way of showing phase differences between oscillations of the same frequency. Amplitude is represented by the length of a vector.

If the synchronisation between transmitter and receiver is effective the receiver's reference oscillator also produces (cos θ) and the original signal (S) is correctly recovered. Before accepting the statement it is worth seeing the trigonometry which describes the process:

Modulated Carrier = Scos θ

local oscillator = cos θ

$\therefore$ demod product = S cos θ x cos θ



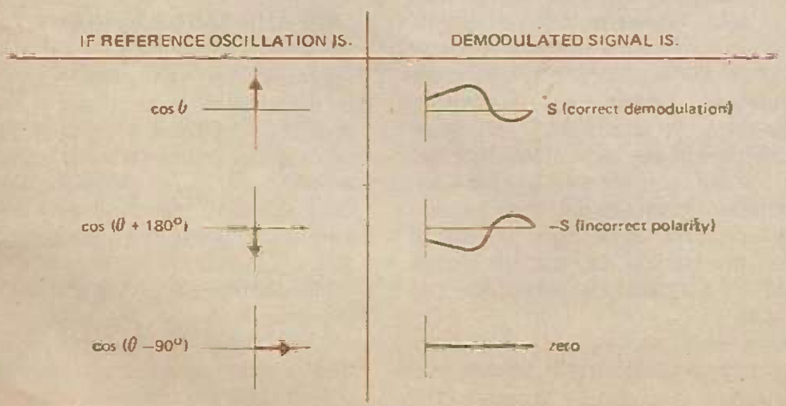


Fig. 15. Principle of synchronous modulation and demodulation. Correct demodulation is only obtained if the receiver's reference oscillator is synchronised in frequency and phase to the transmitter's carrier oscillator.

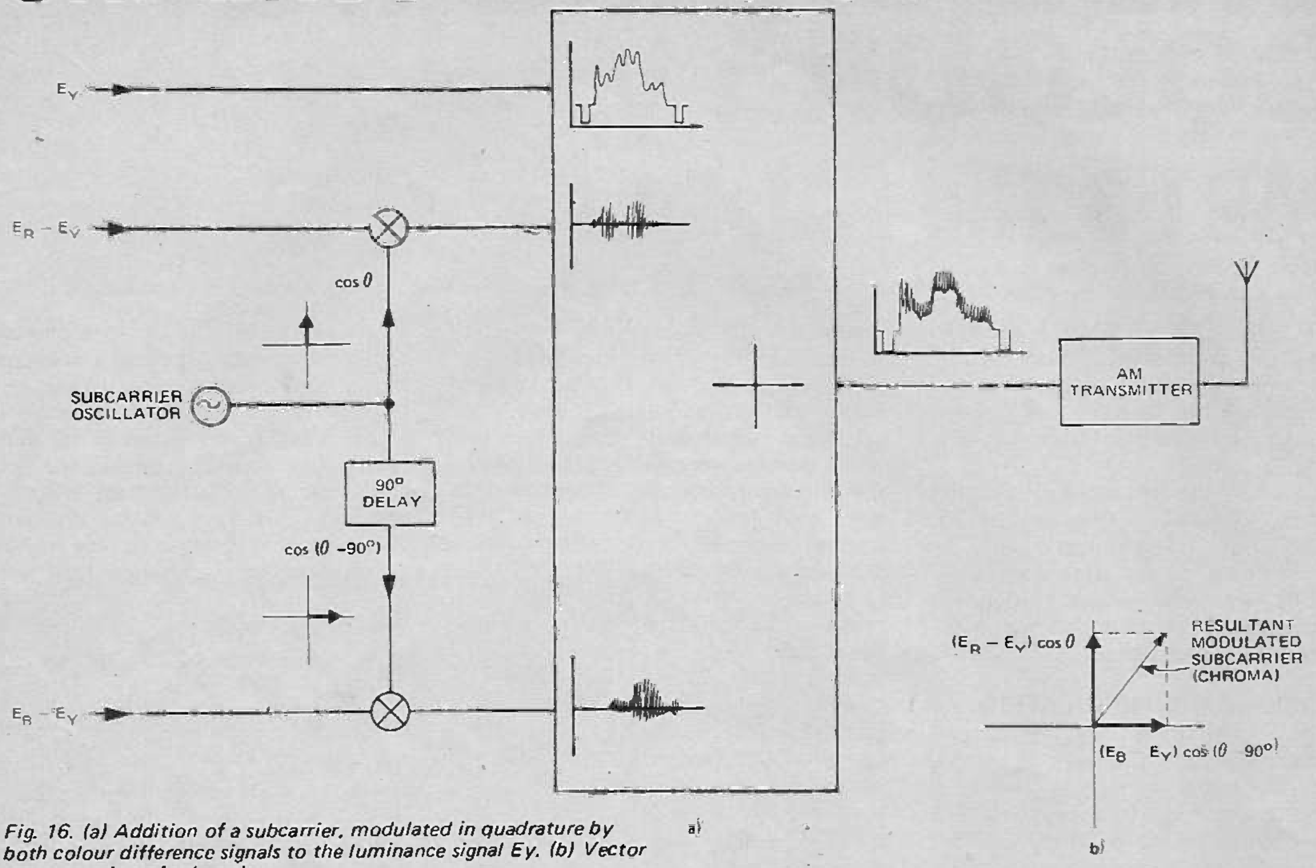


Fig. 16. (a) Addition of a subcarrier, modulated in quadrature by both colour difference signals to the luminance signal Ey. (b) Vector representation of subcarrier.

$$= ½S \cos 0° + ½ S \cos 2\theta$$

But as Cos 0° = 1

$$= ½S + ½ S \cos 2\theta$$

Thus we have the original signal (½S) plus an unwanted component at twice carrier frequency (½ S cos 2 θ).

This reveals an unwanted high frequency output from the demodulator which has to be suppressed by the low-pass filter in Fig.15.

It is particularly interesting to see what happens if the reference oscillator is *not* in correct phase.* Suppose it were out of phase by a whole 180°, i.e. generating cos (θ − 180°). This is the same as −(cos θ), a vector pointing downwards at 180° to the cos θ vector, and the signal would just be demodulated with wrong polarity. This would have disastrous effect on a colour difference signal, e.g. if ($E_R - E_Y$) is inverted, red colours (positive values) swap places with blue-green or cyan colours (negative values). This fault can occur!

* *The phase delay along the transmitter-receiver path is ignored throughout on the assumption that it is the same for the carrier and the synchronisation signal.*

Alternatively suppose that the reference oscillator is exactly 90° out of phase i.e., cos (θ − 90°) = sin θ. Again using trigonometry:–

Modulated carrier = S cos θ
Local Oscillator = sin θ
∴ demodulation product = S cos θ x sin θ

$$= ½S \cos 90° + ½ S \cos (2\theta - 90°)$$

But as cos 90° = zero

$$= ½ S \cos (2\theta - 90°)$$

Thus only the twice frequency component is generated and this is removed by the low pass filter. Hence there is no output if the reference oscillator and the modulated carrier are in quadrature.

This gives the clue that a synchronously modulated carrier can carry two different colour signals without interference if the cos θ and cos (θ − 90°) phases are separately modulated, known as *quadrature modulation*. It is easiest to think of two carriers of the same frequency but 90° phase difference which are separately modulated, then added together. This is shown in Fig.16 where, to remind us, the luminance signal E_Y is also brought into the addition.

When two signals of the same frequency but different phases and amplitudes are added together the result is a signal of the same frequency with new phase and amplitude. This happens when the two parts of the modulated subcarrier are added together, and for any instantaneous values of the colour difference signals the amplitude and phase of the sum can be found by extending parallel lines (dotted) on a vector diagram as in Fig.16 b). The quadrature-modulated subcarrier is called the *chroma* signal and appears as a fine 'fuzz' superimposed on the luminance waveform. Although the colour difference signals may seem inextricably mixed in the chroma-plus-luminance signal, a receiver with synchronous colour demodulation, as shown in Fig.17, can recover them perfectly.

HUE AND SATURATION

Returning to the vector representation of the chroma in Fig.16 b, it can be seen that since ($E_R - E_Y$) and ($E_B - E_Y$) can each have positive or negative values i.e. each vector may point either way along its axis, the chroma vector can have any phase or amplitude. Some examples to illustrate this are shown in Fig.18.

The phase angle of the chroma vector depends only on the ratio between (E_R-E_Y) and E_B-E_Y) but this ratio also defines a particular *hue* in the colour triangle described in Part 1.

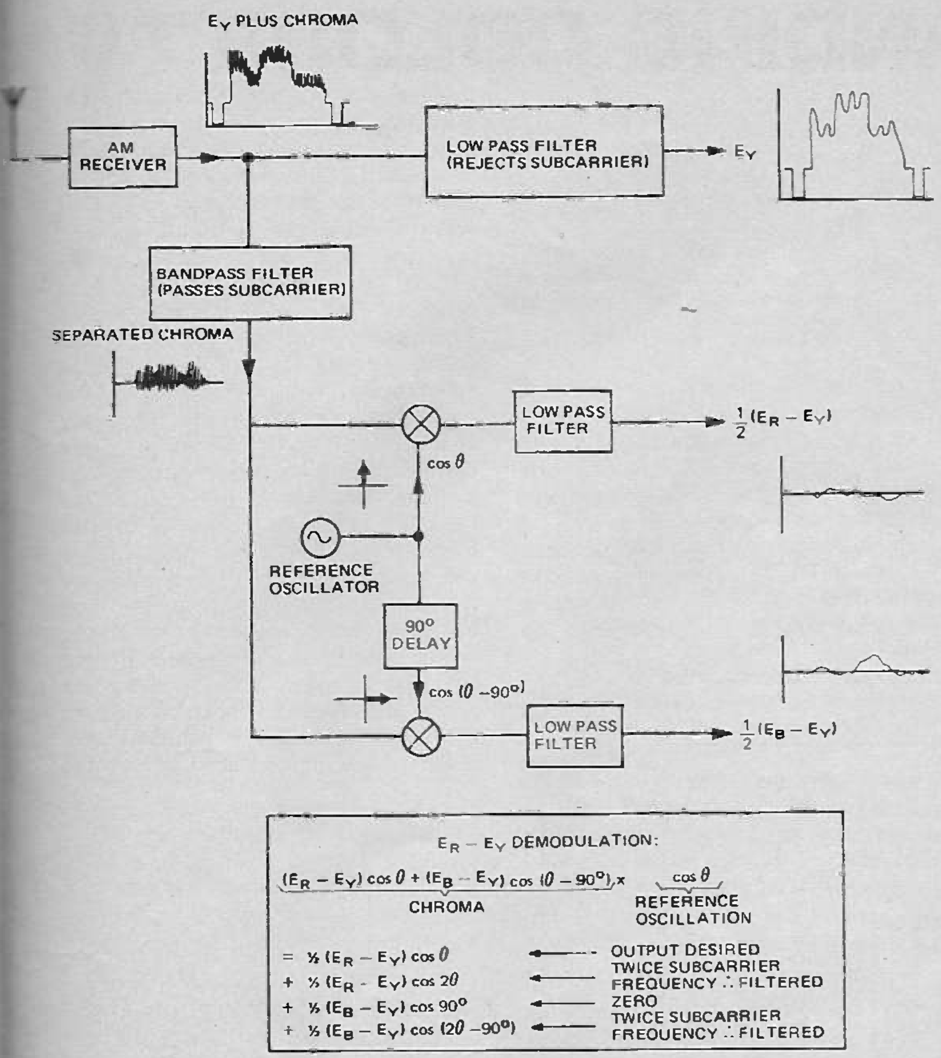


Fig. 17. A suitable receiver for the signal produced by Fig. 16. For correct colour demodulation the reference oscillator must be precisely phase-locked to the transmitter. The insert shows a full description of the $(E_R - E_Y)$ demodulator; the $(E_B - E_Y)$ demodulator works similarly.

Further, the length (amplitude) of the chroma vector can only be large if one or both $(E_R - E_Y)$ or $(E_B - E_Y)$ are greatly positive or negative, which implies colours far from white in the colour triangle i.e. strongly saturated colours. Thus a consequence of quadrature modulation is that the *hue* and *saturation* of a colour is directly defined by the *phase* and *amplitude* respectively of the chroma signal. The actual phase and amplitude values for the primary colours are shown in Fig.19. From the foregoing one would expect blue to lie exactly along the horizontal axis but in practice it is necessary to multiply $(E_R - E_Y)$ and $(E_B - E_Y)$ by reducing factors of 0.877 and 0.493 respectively to prevent overmodulation of the subcarrier by certain saturated colours. These 'weighted' colour difference signals are referred to as V and U in the PAL system and cause some rotation of the colour phases from their expected positions.

PHASE SYNCHRONISATION

The system of simultaneous colour modulation of a subcarrier or *colour coding* so far described was used for the first regular colour television broadcasts. It is the basis of the NTSC system developed by Radio Corporation of America and is still used there and in Japan. Provided the reference oscillators in receivers are accurately phase-locked to the transmitter's subcarrier oscillator, the colour difference signals are accurately decoded. This phase lock is provided by transmitting a short burst of unmodulated subcarrier just before each picture scanning line. Colour receivers use this burst to correct the phases of their reference oscillators. Unfortunately experience has shown that unless the receiver is sufficiently close to the transmitter to receive a very high quality signal, propagation effects can upset the accuracy of the phase lock. When this happens the effect on the viewer's picture is disastrous since all the chroma vectors are in effect rotated clockwise or anticlockwise by the angle of the phase error. People find these hue errors especially unpleasant when flesh tones veer towards blue or green!

When colour television was about to be introduced in Europe in the mid-60s the opportunity arose to standardise on a different colour system giving better colour under poor reception conditions. Unfortunately power politics prevented complete international agreement and a minority of countries, primarily France and USSR, opted for a system in isolation called SECAM. This has its own history of development and is briefly described in the insert; it is

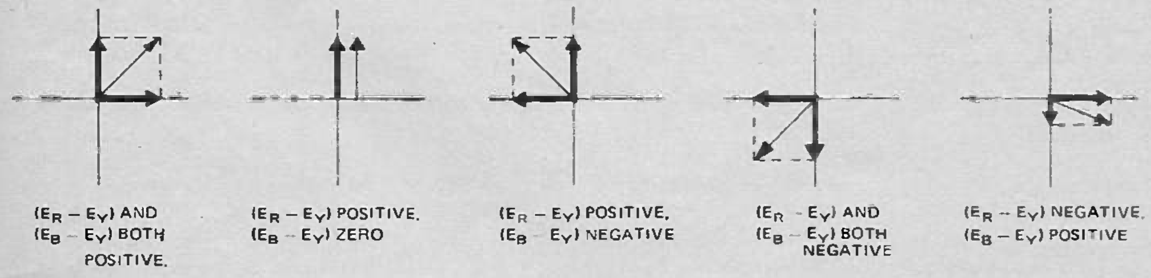


Fig. 18. Typical chroma vectors (thin arrow) produced by various values of $(E_R - E_Y)$ and $(E_B - E_Y)$ modulated as in Fig.16.

UNDERSTANDING COLOUR TV

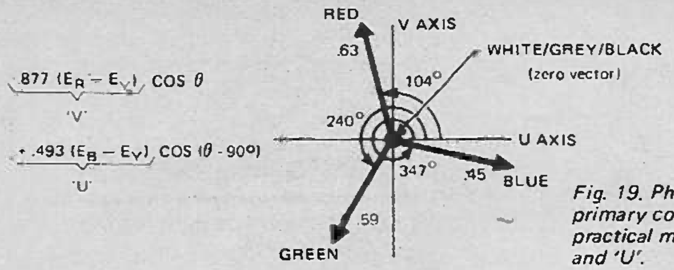


Fig. 19. Phases and amplitudes of primary colour vectors using practical modulation signals 'V' and 'U'.

unlikely to be chosen by many other countries.

PAL (Phase-alternate-line)

This is the colour system adopted by most of Europe, Australia and South Africa, and is most likely to be chosen by other countries in the future. It uses the same synchronously colour-modulated subcarrier as the NTSC system but with a simple trick added by Dr. Bruch which prevents phase errors causing incorrect hues. The trick is to send the V signal with *reversed Phase (polarity) on Alternate Lines* — hence 'PAL'. The arrangement to do this is shown in Fig.20.

The significance of this switching can be seen in Fig.21 where for simplicity both U and V have positive values. Demodulation is straightforward on the lines where U and V are modulated normally. On the alternate lines where V is inverted, the U demodulation is unaffected but −V needs to be reinverted in the receiver to +V. One way of doing this is to use a phase reversing switch similar to the one in Fig.20 to invert the reference oscillator feed to the V demodulator. This switch in the receiver must change at the start of every line in synchronism with the switch at the transmitter, i.e. at half-line frequency (7.8 kHz). This frequency is easily derived from the scanning circuits by a bistable. However it is necessary for the composite colour signal to contain information from which the receiver can ensure that its 'PAL bistable' is working in the right phase — if it happened by chance to start off on the wrong foot, V would be demodulated with the wrong polarity on every line giving grotesque colour errors. In fact the synchronisation is achieved as a result of the method used to lock the

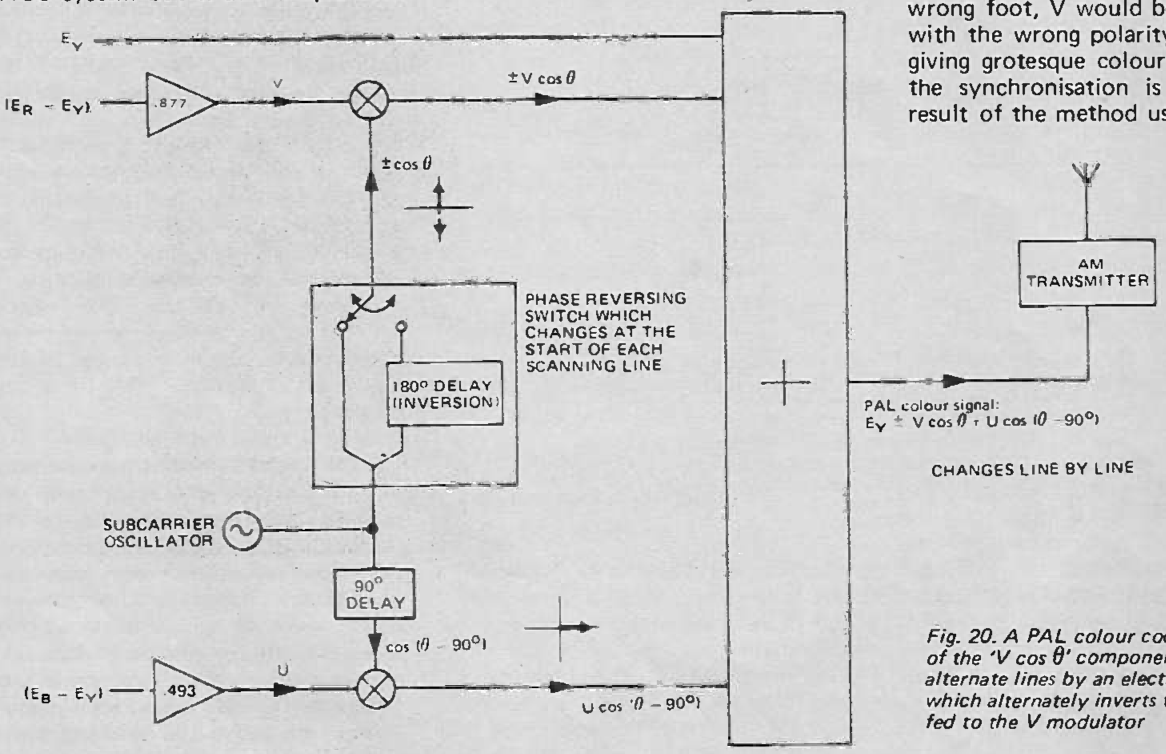


Fig. 20. A PAL colour coder. The polarity of the 'V cos θ' component is reversed on alternate lines by an electronic switch which alternately inverts the subcarrier fed to the V modulator

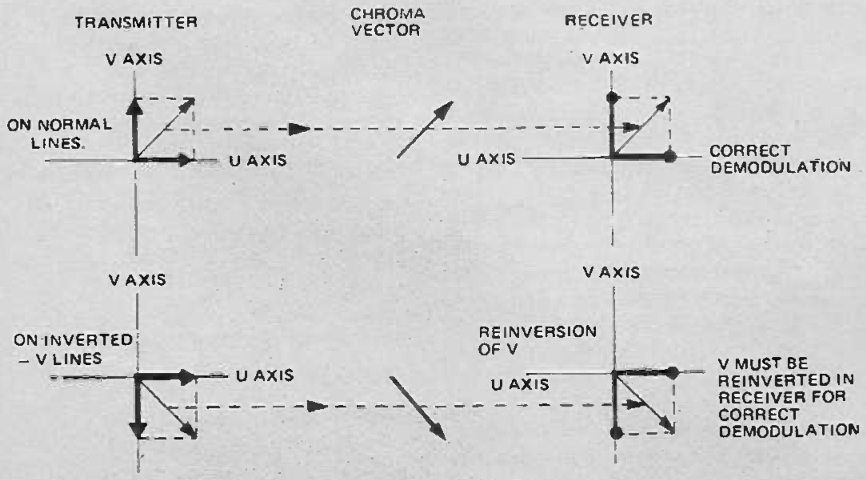


Fig. 21. Inversion of V signal on alternate lines in the PAL system.

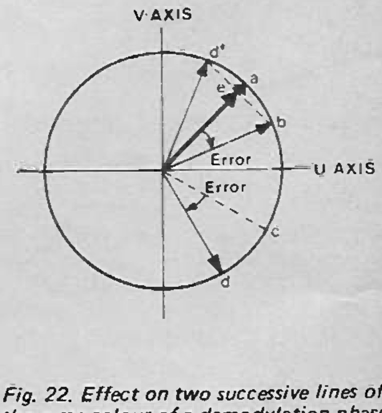


Fig. 22. Effect on two successive lines of the same colour of a demodulation phase error in the receiver. For explanation see text.

receiver subcarrier oscillator to the right phase, to be explained next month.

PHASE ERROR CANCELLATION

Why does this extra complexity of alternate-line V reversing make the colour subcarrier immune to phase errors? The vector diagram in Fig.22 shows why.

Suppose a picture contains two successive lines of a particular colour whose hue and saturation are represented by the chroma vector a. Suppose there is a phase error present such that all colours are demodulated with slightly leading phase. Thus on the line of the pair where +V is transmitted, the receiver demodulates the vector b. On the next line where −V is transmitted the receiver, instead of demodulating c the V−inverted version of a, demodulates d which it V-inverts to d'. Therefore there are hue errors on both lines since neither b nor d' correspond with a. But note that they are at equal angles either side of a. A person viewing a television from a reasonable distance cannot resolve the colours of small areas (the property of the eye which makes low definition colour signals adequate) and in particular tends to see the *average* colour of a adjacent scanning lines. This colour-integrating action of the eye can be represented by taking the average of the vectors b and d'. The viewer sees the colour e. This has exactly correct hue (angle) but is a little shorter than a. Thus phase errors cause only a slight loss of saturation of the coloured parts of the PAL picture and viewers are unlikely to notice this.

If phase errors are really gross, a critical viewer inspecting the picture will notice the line-by-line errors. The interlaced scanning of two fields in each frame causes a stroboscopic effect such that pairs of differently coloured lines appear to crawl up the screen. These are known as Hanover blinds, named after the exhibition where they were first demonstrated. They can be completely eliminated by using a receiver decoder circuit with a refinement which integrates the colour of adjacent lines electrically instead of relying on eye resolution.

To be continued . . .

SECAM

This system also uses a subcarrier to convey both colour difference signals but to avoid the need for phase-sensitive demodulation the subcarrier is *frequency* modulated. Only one colour difference signal can be sent at a time in this way so $(E_R - E_Y)$ and $(E_B - E_Y)$ are sent on alternate scanning lines. The absent colour signal on each line is replaced in the receiver by the colour signal sent on the previous line (by means of a one-line delay unit) thus vertical colour resolution is halved. This does not matter and the system provides good pictures under reception conditions that would ruin NTSC colour.

Objections to the SECAM system are its incompatibility with other systems, the small number of countries using it, and the highly specialized equipment needed to handle and record SECAM signals at the transmitter.

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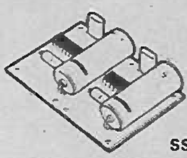
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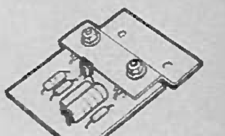
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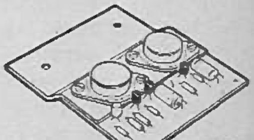
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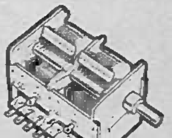
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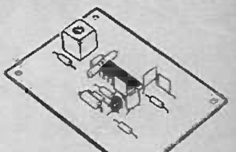
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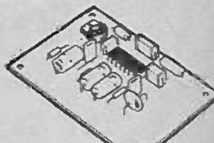
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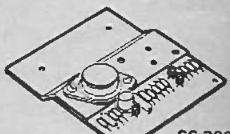
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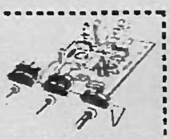

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INTRUDER ALARM

A simple burglar alarm with superior performance.

ETI project

AT THE beginning of this century there were only three crimes a year for every one thousand people. By 1971 there were three for every one hundred — ten times as many. In the UK, statistics have shown that from 1964 to 1970 the number of indictable offences rose by 50% — and the rate is steadily increasing.

This increase in crime rate is common to the entire western world, and seems to be related to affluence rather than to poverty as was previously thought by many.

Hence, these days, the chances of your home being burgled are high indeed, and getting higher. Each householder should therefore give serious consideration to protecting his home by an effective alarm system.

A burgler alarm for the home should preferably be battery operated (as it is quite easy to switch off the power from outside most houses), should be reliable over long periods and should not be subject to false alarms.

In the ETI Alarm the CMOS IC has sufficiently low power drain (less than 1 mA) to make battery operation feasible. And by virtue of the high noise immunity of CMOS (half supply voltage) the unit is not susceptible to false alarms due to lightning flashes etc. Add to this the inherent reliability of integrated circuits and you have the basis of a very simple, but very effective, system.

Three modes of operation are built in to the unit which functions as follows:

ALARM MODE

Microswitches or reed relays fitted to each window and door are arranged to have closed contacts when the door, etc, is shut. All contacts are wired in a series loop such that if any door or window is opened, the loop will be broken activating the alarm. The series loop should be wired between the 'external loop' and 'common' terminals shown in Fig. 4.

SILENT ENTRY

This mode of operation allows the owner, when leaving the premises, 30 seconds to open and close the front door before the alarm mode is activated. Additionally it allows the owner 30 seconds to disable the alarm after entering through the front door. Thus the front door microswitch is not included in the normal alarm loop but to its own 'silent entry' loop. The silent entry switch should be wired between 'silent entry' and 'common' — see Fig. 4.

EMERGENCY

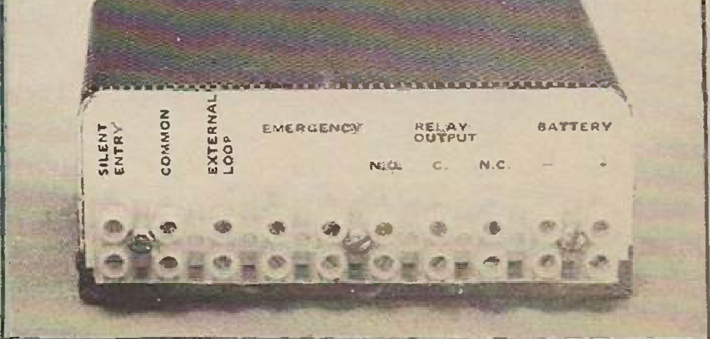
In this mode, any contact closure from a switch or sensor (eg fire, smoke or gas detector) will immediately sound the alarm. Wire switch/s across 'emergency' terminals (Fig. 4).

CONSTRUCTION

Assemble all components to the printed circuit diagram in accordance with the component overlay diagram, Fig. 3. *Do not* fit the CMOS IC until all other components are in place. Make sure that the diodes, the transistor and the tantalum capacitors are all orientated correctly before

SPECIFICATIONS

Power requirements	12 volts
Current consumption	1 mA
Silent entry delay	30 seconds approx.
Alarm circuits	Normally closed
Emergency circuits	Normally open
Alarm output	Relay change over contacts



INTRUDER ALARM

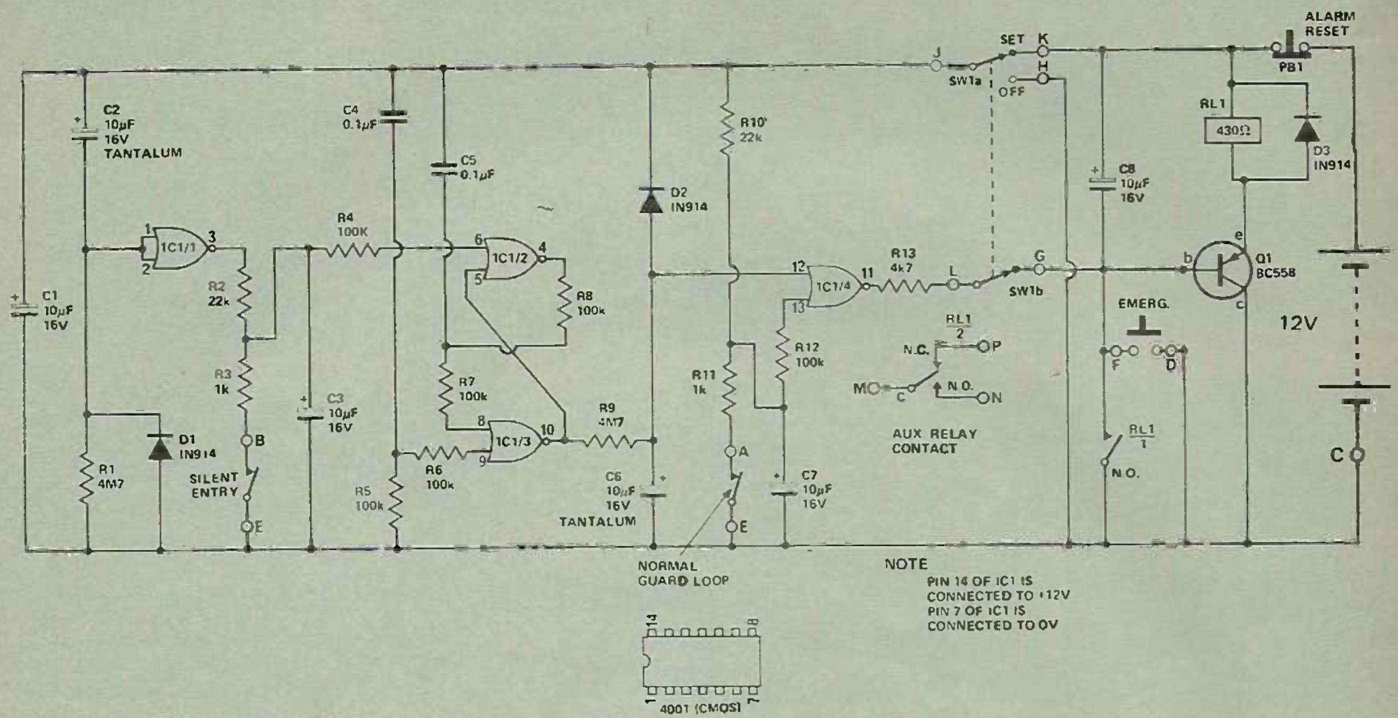


Fig. 1. Circuit diagram of the ETI Burglar alarm.

Fig. 3. Component overlay for the alarm.

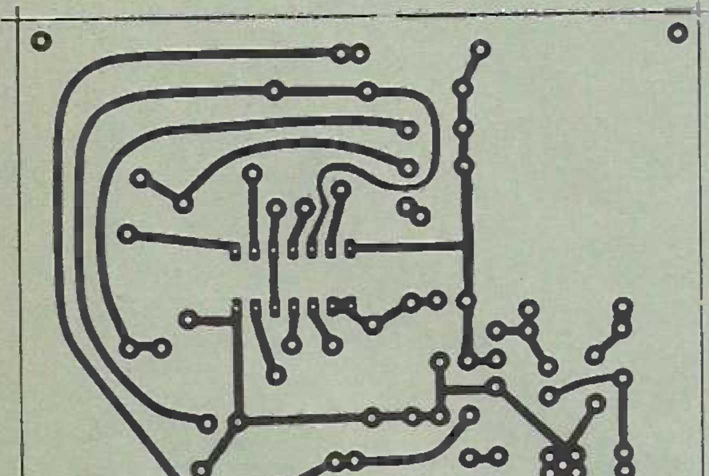
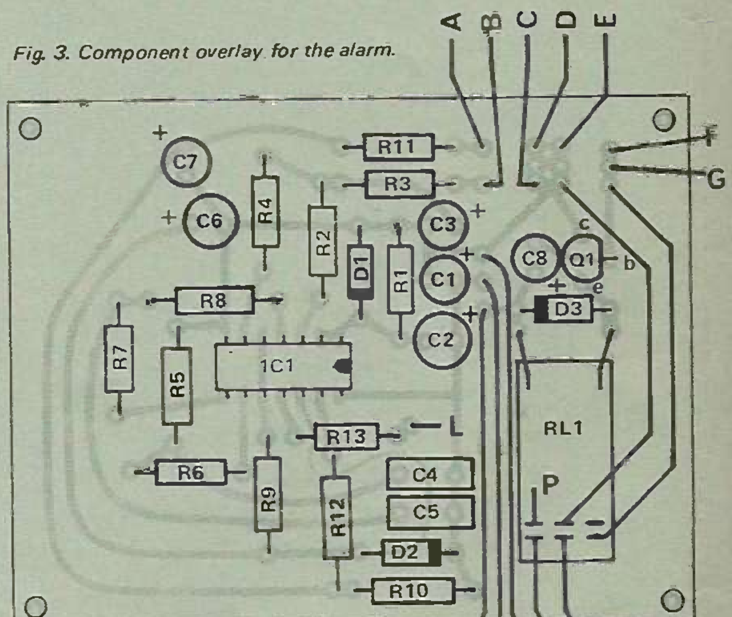


Fig. 2. Printed circuit board lay-out for the alarm. Full size 90 x 70 mm.



soldering. The relay should be cemented in position on the board with a little contact cement or 5-minute epoxy.

CMOS integrated circuits are supplied with their pins inserted into black conductive foam. The ICs should be left in this foam, which protects them from damage due to static electricity, until you are ready to insert them into the printed circuit board. On no account should the devices be stored in ordinary polythene foam (the static electricity generated by withdrawing the device may well destroy it).

To insert the device into the printed circuit board, first check the orientation of the device, avoid touching the IC pins and insert as quickly, and with as little fiddling, as possible. Then using a lightweight soldering iron (with a clean tip) solder pins 7 and 14 first. These pins are the supply rails and their connection allows the internal-protection diodes to safeguard the gates against electrostatic damage. The remaining pins may then be soldered.

The completed printed circuit board should then be assembled into the box, together with the switches and terminal block, and the complete unit wired with reference to the component overlay and the wiring diagram Fig. 4.

The completed alarm unit should be located in a reasonably well concealed position close to the 'silent entry' door.

The alarm bell is best located in a high, well concealed and not readily accessible position. As very high voltages are generated across the bell 'make and break' contacts it is preferable to use a separate bell battery of suitable voltage rather than to connect it across the main system battery.

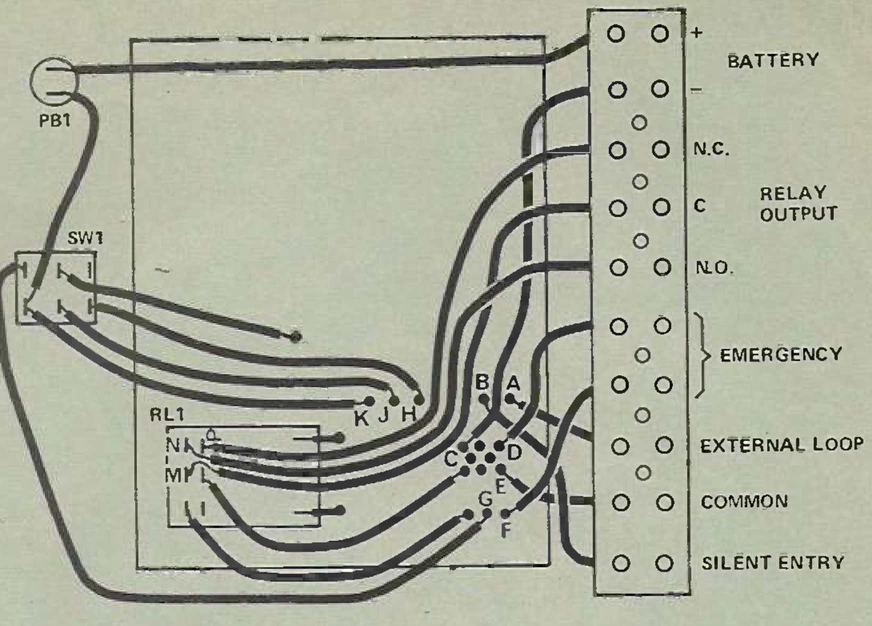


Fig. 4. Wiring diagram showing connections from printed circuit board to switches and connector strip.

HOW IT WORKS

The alarm has three different modes of operation as described in the text.

When power is first applied, i.e. normal alarm mode enabled, capacitor C2 initially has no charge. This momentarily lifts the inputs of IC1/1 to +12 volts. The capacitor then charges slowly via R1 and the voltage presented to IC1/1 falls exponentially to zero. The output of IC1/1 will be zero if the input is over 7 volts, and at +12 volts if the input is less than 5 volts. There is a small linear region, around 6 volts, in which the output changes from zero to +12 volts. With the values given to C2 and R1 a delay of 30 seconds is provided which may be altered, if required, by changing C2. During this delay opening or closing the silent entry door will not affect the level presented to pin 6 of IC1/2.

An RS flip-flop is formed by IC1/2 and IC1/3 in which the control inputs (pins 6 and 9) are normally low (zero volts). On first switch-on pin 9 is pulled up momentarily to +12 volts by C4 before returning to zero. This presents a "1" to the input of IC1/3 and therefore its output will be low (see Table 1). Since pin 7 is at zero, and pin 5 is also at zero, (connected to pin 10) the output of IC1/2 will be high. Since this is coupled to the input of IC1/3 the flip-flop will be locked into the state where IC1/3 output is low.

The only way the flip-flop can be reversed is for the input to pin 6 to go high. However during the first 30 seconds, as explained above, the output of IC1/1 is low. Hence, opening or closing the silent entry door during this time will not set the flip-flop and activate. the alarm.

After this 30 second period, opening the silent entry door will present a "1" to pin 6 which will cause the flip-flop to change state. Closing the silent entry door will now have no effect and the flip-flop will remain set.

The high output of IC1/3 will allow C6 to charge slowly to +12 volts via R9. When this voltage reaches 6 volts (about 30 seconds) it will cause the output of IC1/4 to go low (assuming the normal alarm loop is closed). The low output of IC1/4, via emitter follower Q1, pulls in relay RL1 activating the alarm. When the relay closes contacts RL1/1 cause it to latch on, and only removing power by pressing PB1 will reset it.

If at any time the normal guard loop is broken, when the alarm is activated, a "1" is presented to pin 13 of the IC1/4 causing the output to go low and the relay to close.

When the emergency switch is closed the base of Q1 is taken to zero and the relay closes and latches. This action will take place regardless of whether the alarm is enabled or not.

Diodes D1 and D2 discharge capacitors C2 and C6 respectively via SW1 when it is in the "off" position, thus ensuring that the 30 second delay is always obtained. Resistors R6, 7 and 12 protect the CMOS IC against voltages in excess of the supply rails. Capacitors C3, 5, 7 and 8 add further protection against false triggering due to lightning etc.

INPUT		OUTPUT
A	B	
0	0	1
1	0	0
0	1	0
1	1	0

TRUTH TABLE FOR 2 INPUT NOR GATE 4001 (CMOS)

NOTES
INPUT
1 means >55% supply voltage
0 means <45% supply voltage

INTRUDER ALARM

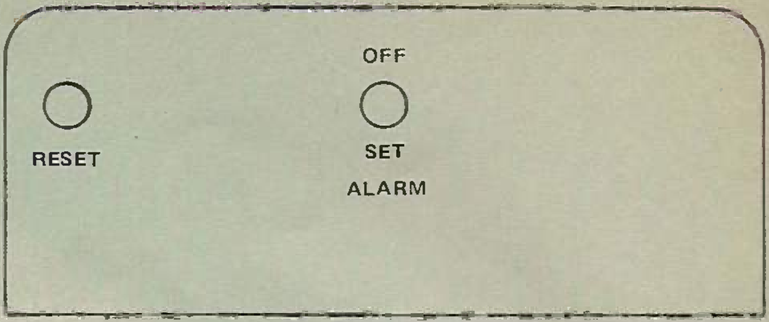
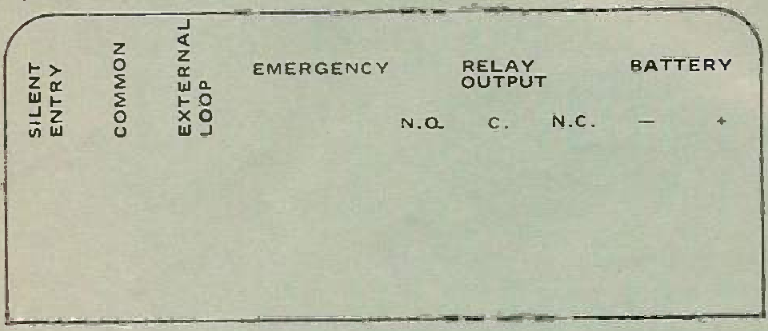
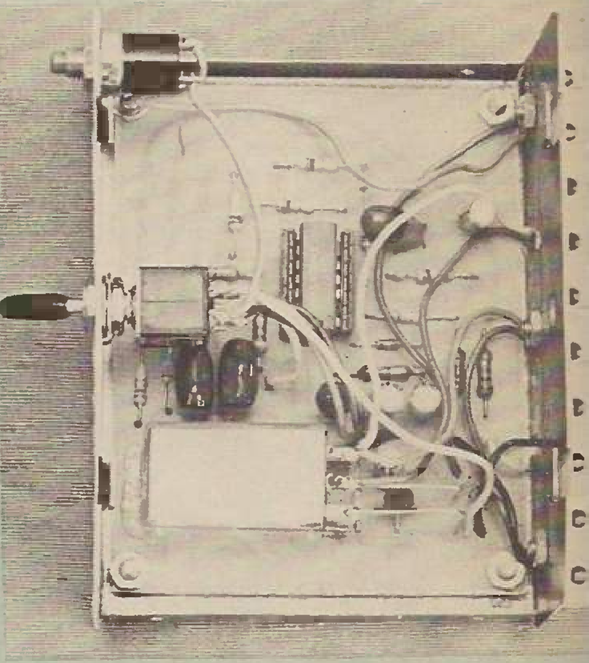


Fig. 5. Front panel artwork.

Fig. 6. Rear panel artwork.





ETI INTRUDER ALARM PARTS LIST

R1, R9	Resistor	4M7 ohm ¼W 5%
R2, R10	"	22k ohm ¼W 5%
R3, R11	"	1k ohm ¼W 5%
R4, R5, R6, R7, R8, R12	"	100k ohm ¼W 5%
R13	"	4k7 ohm ¼W 5%
C1,C3,C7,C8	Capacitor	10μF 16v electrolytic
C2,C6	"	10μF 16v tag tantalum
C4,C5	"	0.1μFpolyester.
D1,D2,D3	Diode	IN914
Q1	Transistor	BC 558, BC 178 or equivalent
IC1	Integrated Circuit	SCL4001A, MC14001, etc.
SW1	Switch	DPDT subminiature
PB1	Switch	Push button switch NC.
RL1	Relay	Miniature relay, 150Ω to 1k coil, two c/o contacts.

PCB, box, 10way terminal block, two 6V lantern cells, hookup wire, etc.

WHERE TO GET THE COMPONENTS

IC
SCS list the MC14001CP in their catalogue (55p).

TRANSISTOR
The BC178 is fairly easy to find (15p Marshalls; 16p SCS; etc.).

RELAY
Anything with a resistance of 150Ω to 1k will do, as long as it two changeover contacts (DPDT).

Doram do a suitable 290Ω PCB-mounting relay for £2.40, coded 349-197.

SWITCHES
Miniature DPDT Toggle switches are available from Electrovalue for 48p; Doram for 94p (code 316-715) and Marshall's 40p.

Miniature Push Button switches come from Doram at 44p and Electrovalue at 23p.

SCS, Northfield Industrial Estate, Beresford Avenue, Wembley, Middlesex, HAO 1YY (add VAT & 20 p&p).

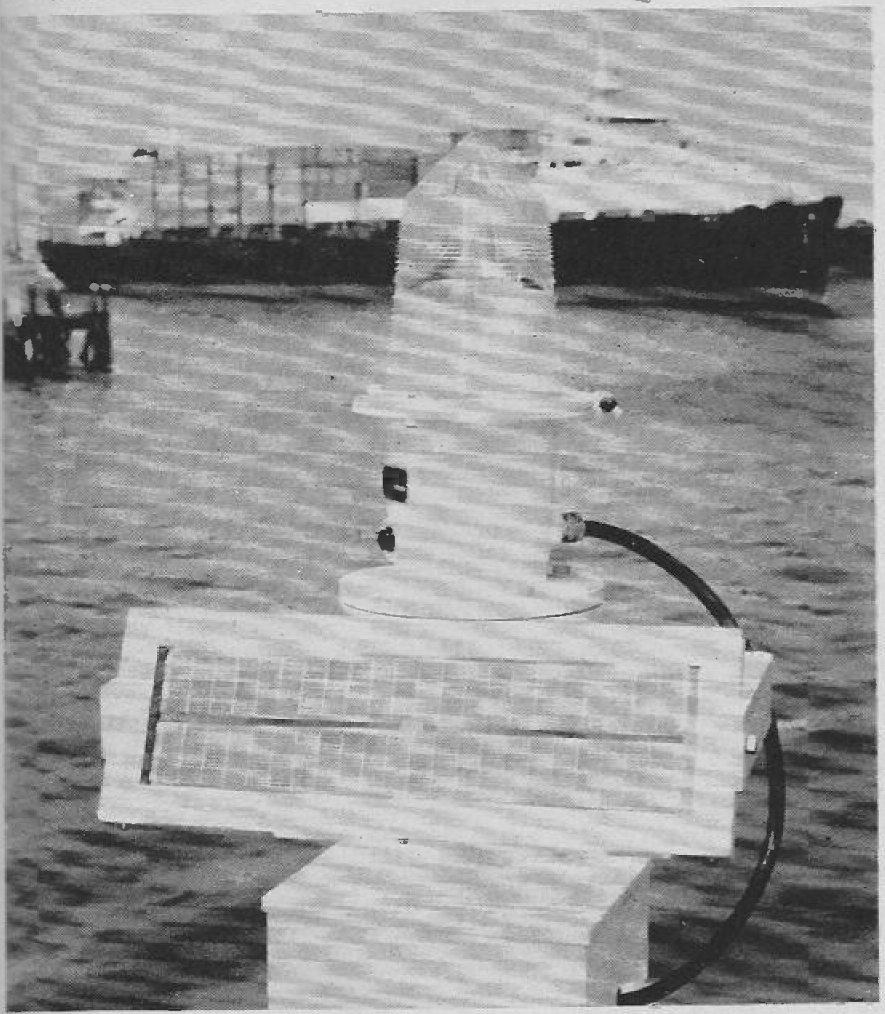
Marshall's, 42 Cricklewood Broadway, London, NW2 3ET (add VAT and 15p p&p).

Doram, P.O. Box TR8, Wellington Road Industrial Estate, Wellington Bridge, Leeds LS12 2UF (p&p 20p; add VAT to both price and p&p charge).

Electrovalue, 28 St. Judes Road, Englefield Green, Egham, Surrey, TW20 0HB (add VAT & 10p).

ELECTRONICS —it's easy! Part 14

The sources of power.



Solar-cell powered buoy.

OUR COURSE, so far, has concentrated on developing basic electronic system blocks from combinations of passive and active components. You will have seen that, with each type of circuit, there is a requirement for some sort of power supply, although, there are some very rare circuits that may be powered by signal energy alone.

The provision of power for electronic circuits, is hence of primary importance. In the circuit illustrations used so far, power supplies have been of a very simple kind, but, in some circumstances, they may be quite complex and expensive. Hence, before developing our circuitry still further we must gain a better understanding of the types of supply and the methods of implementing them.

The most commonly used source of electrical energy is that provided by the power mains and this, as we know, is alternating current (ac). However electronic circuits, in the majority of cases, need direct current (dc) supplies. Hence a discussion of power supplies for electronic systems must cover firstly the production. and secondly the stabilization of dc voltages.

PROVISIDN OF DC

The source of dc power for electronic circuits, at any particular voltage, must be convenient, economic and easily started and stopped as required.

A wide range of basic power supplies is available to choose from — see Fig. 1 They range from tiny batteries to huge engine-driven generators. Each application has to be considered individually and the appropriate means chosen to suit the requirements of the circuit and the way it is to be used. Can the supply provide enough power. Does it provide the desired conditions of portability? — (in the field the weight of the supply may be critical). Is the method used economic? (batteries may be simple to use but their replacement can be costly). Is a non-portable supply already available for use? (such as the electricity mains). Sometimes a power supply already operating on some existing equipment may have adequate spare capacity.

There are many known methods of producing dc power. Batteries use electro-chemical action; rotating generators move conductors in a magnetic field to generate electricity; the mains supply (derived by rotating generators) is rectified to produce dc, fuel cells combine chemicals (still an exotic way to produce energy); thermo-electric systems generate electricity from thermo-couples or solar cells.

However the two most common sources of dc are firstly from batteries and secondly transformer/rectifier systems driven from the mains ac supply.

BATTERIES

In 1792 Italian anatomist Luigi Galvani, whilst working on dead frogs, discovered that the frog's legs twitched when touched with two dissimilar metals. The same phenomena occurred when the frog's legs were attached to an electrostatic generator. He (wrongly) attributed this to an effect which he called "animal electricity".

However, another Italian professor, Alessandro Volta, investigated the effect in 1800 and, showed that it did not depend on the animal tissue, but upon electrical generation due to two dissimilar metals being separated by a conductive solution. He thus showed two important things — that animal muscle was activated electrically, and that electricity could be generated chemically. (Previously only static electricity was known.)

Volta produced the first practical battery, called at that time a voltaic pile, by placing moistened paper sheets

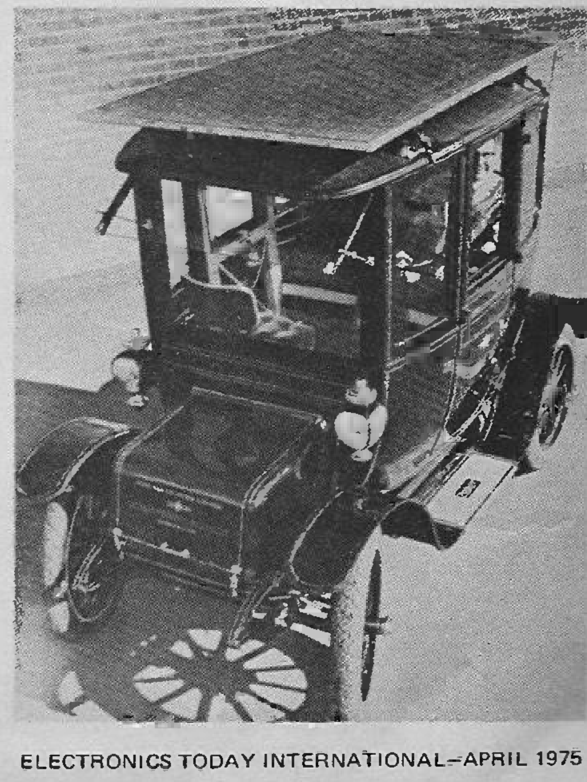
Fig. 1. Power sources for electronic systems may vary from dry batteries, engine driven generators, thermo-electric (as the solar-cell powered buoy p. 57) — *to specialised laboratory power units deriving their energy from the mains.*

between alternate sheets of copper and zinc as shown in Fig. 2a. He also made cells in which the separating fluid (now called the electrolyte) was a liquid. His wet-cells used rods of zinc and copper, placed apart, in a diluted solution of sulphuric acid (Fig. 2b). Volta thought that the solution merely separated the electrodes without playing any vital role. We now know differently.

The fluid (it can also be a paste or solid) acts as an electrolyte. That is, the dissolved compound dissociates into positive and negative ions, however, the electrolyte has overall electrical balance.

When the copper and zinc electrodes are inserted an electric field is set up in the boundary layer between each electrode and the electrolyte. With the copper/zinc cell the copper is at a lower potential than the acid and the zinc is at an even lower potential.

The cell thus has an electromotive force between the electrodes which



This 1912 Baker Electric is now driven by solar energy! An array of 10 640 silicon solar cells mounted on the vehicle's roof charge intermediate storage batteries. Final drive is via the Baker's original dc electric motoı

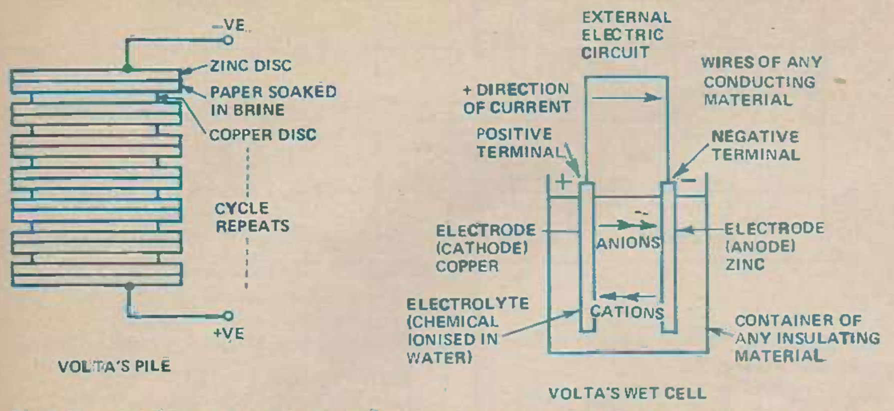


Fig.2. Cross sectional diagrams of the first electrochemical cells — VOLTA'S pile and wet cell.

depends on the difference in potential between the copper and the zinc.

When the electrodes are connected to allow electrons to flow, the dissociated ions move towards the electrode of opposite polarity. For example, in Volta's wet cell, the zinc electrode combines with the negative sulphate ions leaving the zinc electrode with an excess of electrons. These electrons flow through the external circuit to the copper electrode where they combine with the hydrogen ions to produce free hydrogen.

Many combinations of electrodes and electrolytes may be used to form cells in a similar manner. Some arrangements are more useful than others by virtue of higher energy capability, and hence many of the original systems developed have now been discarded as inefficient.

DEPOLARIZATION OF CELLS

The formation of gas on an electrode (hydrogen in the voltaic cell) becomes an effective insulator and may cause the cell to cease working efficiently or even completely. If the gas (or other product, eg solid in some cells) can be chemically removed, as it is formed, the cell will continue to produce power until the negative plate material has been used up — it redeposits on the other plate. Such an additive, which maintains full cell efficiency, is known as a depolarizer.

PRACTICAL BATTERIES

The electrochemical process just described can be optimized to either *produce* electricity or to *store* it for reuse. Cells providing power from an initial chemical charge are called primary cells. Those that are made intentionally to store power are called secondary cells (also called accumulators in earlier literature). Some combinations and designs will act as both, but usually a primary cell is a throwaway item. A secondary cell usually requires charging (the process of storing electrical energy) after manufacture, and may be recharged as often as is necessary.

PRIMARY CELLS

The most commonly used primary cell is the well-known dry-cell (or more correctly, the Leclanche cell, after the original developer who introduced it in 1877). It is made, as shown in Fig. 3, from a zinc can containing a central carbon rod surrounded by, firstly, a depolariser (manganese dioxide) and then the electrolyte which is in paste form (ammonium chloride, zinc chloride, water and a filler material). The basic cell is made in many sizes and is also packaged as groups of cells connected in series and/or parallel to provide either greater capacity at the 1.5 V delivered per cell — or increased voltage. For example 90 V batteries (constructed from sixty 1.5 volt cells) were extensively used in the days of valve-circuit portable radios.

There are many alternatives to the basic Leclanche cell. All have characteristics which make them suitable for low power, portable applications. The characteristics of the different primary cells are given in Table 1.

The mercury cell, developed in the 40's, is far more rugged than the Leclanche cell and retains its voltage better over long periods of light use or storage — several years is typical. These use zinc and mercuric oxide (or graphite) electrodes with alkaline hydroxide electrolyte. A typical arrangement is shown in Fig. 4. They can be made extremely small in size and are ideal for powering very small equipment, such as hearing aids, or for equipment used intermittently such as photographic light meters.

Another cell available today is the alkaline-manganese battery. Its interior design consists of pellets of anode and cathode materials; zinc and carbon are used. The manganese dioxide depolariser is arranged to be more efficient than in the common dry-cell and the electrolyte is potassium hydroxide. This battery has an excellent shelf-life and is capable of sustaining a high discharge rate.

Several other primary cells will be encountered in electronic instrumentation — The Daniell cell 1836 (copper, zinc and sulphuric acid), the Clark cell 1872, and the Weston cell 1892 (mercury, cadmium amalgam and cadmium sulphate solution, as

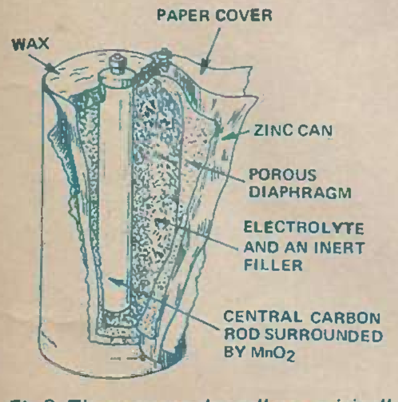


Fig.3. The common dry cell was originally developed by Leclanche in 1877. It produces power for a limited period ana is then discarded.

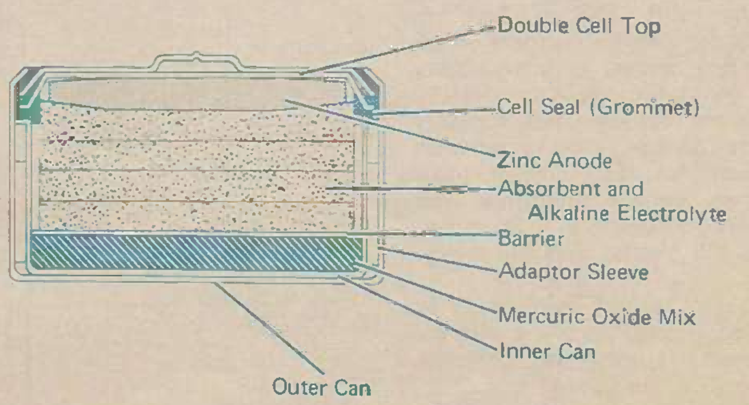


Fig.4. Cross sections of a typical mercury cell.

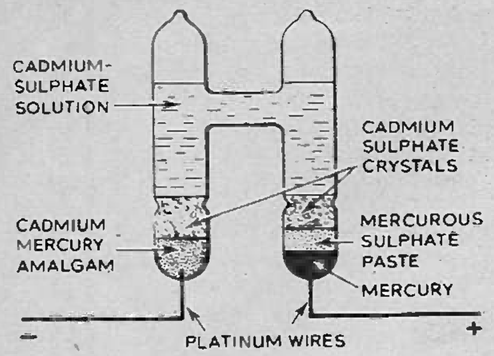


Fig.5. The Weston standard cell delivers 1.0186 volts provided the load is minimal. It has found extensive use as a standard of the voltage unit.

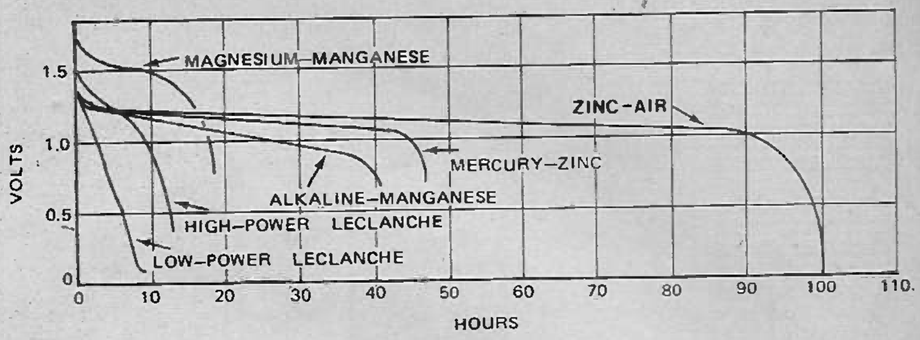


Fig.6. Comparative chart showing voltage characteristics of similar size units of various types of dry cell battery.

shown in Fig. 5) are the three cells which were used internationally at various times to define the standard of voltage. The latest voltage standard has recently been changed to use the so-called Josephson solid-state effect, but the Weston cell is adequate for many voltage calibration tasks (1.086 volts). Standard cells are used only to provide accurately-known and time-stable voltage, but only at low current. They are not intended for power use.

A more recent development are zinc-air cells. These use a zinc powder anode in contact with potassium hydroxide electrolyte. The cathode is a porous arrangement that breathes to atmosphere making use of oxygen, via an intermediate process and a catalyst, to produce hydroxyl ions which enable current flow to occur.

The silver-zinc primary cell has high energy density and discharge rate but because of high cost, is restricted to exotic applications such as spacecraft electronics.

Each type of cell has its own particular merits. Figure 6 shows the voltage-time curves for an ideal loading condition along with comparative figures for the commonly used cells. Leclanche cells operate best in intermittent service, where high currents are needed, or continuously for low drains. Mercury cells especially suit low current demands for very prolonged periods. Zinc-air batteries work best for high current loads maintaining voltage uniformly over considerable periods. Silver-zinc provides the highest available energy density.

The relative cost of each should be considered in selection along with the requirement. It may well be more economical, in the not too long a run, to use the more expensive alternatives.

SECONDARY CELLS

We have seen that the electrical energy provided by a primary cell is derived from a chemical process. From school chemistry we know that, when zinc is dissolved in sulphuric acid, a large amount of energy is released as heat. In the voltaic cell this energy is released as electricity rather than as heat. If the reaction is *not* reversible the cell is a primary cell and is thrown away when exhausted.

There are however others in which the reaction *is* reversible and these are known as secondary cells. For the system to be reversible the electrolyte and electrodes must be capable of being converted back to their original state after discharge. This reversal is *not* spontaneous. The cell must have the electrical energy pumped back into it. That is – it must be charged.

The commonest arrangement (in use since the last century) is the lead-acid battery, such as is used to start cars and to power the auxiliary circuits. The second most commonly used is the nickel-iron cell.

The lead-acid battery consists basically of a plate of lead (negative electrode) and a plate of lead dioxide (positive electrode) immersed in dilute sulphuric acid – as shown in Fig. 7. As the cell discharges, the lead electrode and sulphate ions in the electrolyte combine to produce lead sulphate plus electrons, and the lead-dioxide combines with sulphate ions, hydrogen ions and electrons to produce lead sulphate plus water. The insoluble lead sulphate adheres to the plates, finally shielding them from further electrochemical reaction – the cell is then discharged. The recharging process reverses the reactions, rebuilding the electrode material as the lead sulphate is removed from solutions to produce sulphuric acid and electrode. The nominal voltage produced is 2.0 V. As water is liberated the cell is usually vented but it can be made as a sealed cell.

The nickel-iron cell, invented by the Edison Company at the turn of this century, uses oxides of iron and nickel as the electrodes together with potassium hydroxide electrolyte. The electrochemical action is similar to the

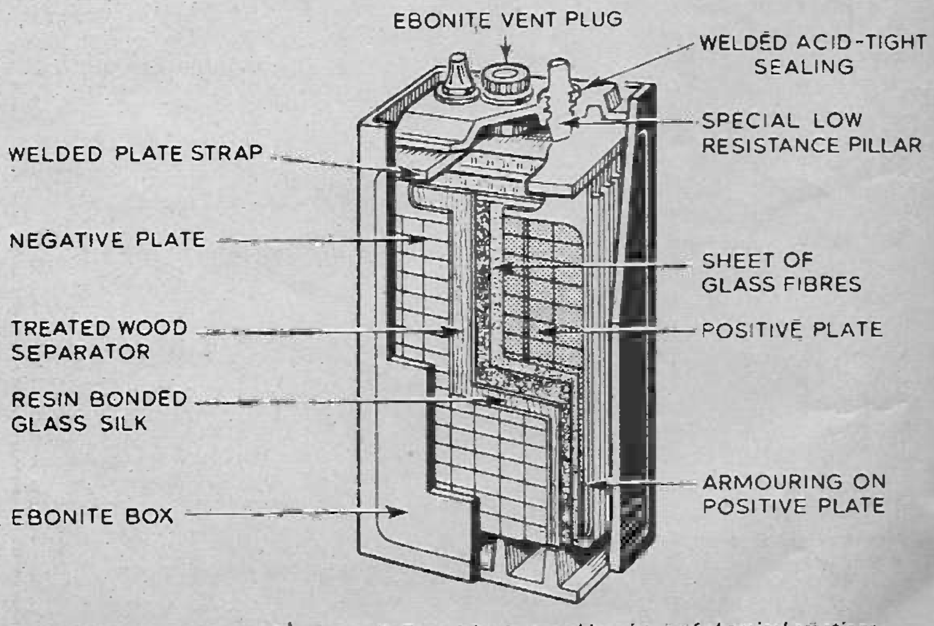


Fig.7. Interior of lead-acid storage cell. Electricity is stored by virtue of chemical reactions induced by charging the cell with electricity.

ELECTRONICS –it's easy!

lead-acid battery — electrodes and electrolyte combine releasing electrons and the process is reversible. These cells can be sealed without difficulty, they are more rugged, give a longer life than lead-acid cells, but cost more.

In the search for more storage capacity for unit volume and weight, research has yielded some exotic battery designs. Silver and zinc are used in a design originated by Andre in the 1930s. Clearly the cost is higher but the considerable gains in weight reduction may make them attractive where weight is a major cost factor — missiles, satellites and man-packed equipment.

As it is now clear that a new kind of storage battery will be in extensive use within this decade we include a brief description of the high-temperature batteries now approaching market production. These cells, also use electrodes and electrolytes, but run at temperatures up to 400°C, and can provide at least four times the storage capacity at the same cost and weight as lead-acid cells. The need for high-temperature operation does, however, exclude them from low power applications. The two main contenders are the sodium/sulphur battery that uses liquid sodium and sulphur electrodes with solid alumina electrolyte (the more developed to date) and the lithium/sulphur battery that uses liquid lithium and sulphur electrodes with molten salt electrolyte (the more theoretically efficient cell). This latter type, will probably be more costly to produce. Both of these types, plus severa' other high temperature arrangements, have been used in prototype situations — powering electric cars is the dominant requirement, but large scale mains-power, system-float storage will be the main usage in the future.

The range of storage cell available for powering electronic circuits is therefore broad, and the type must be chosen to suit the application. For circuits having only medium demands, electronic flash units, calculator supplies — small rechargeable nickel-cadmium cells are best. These are made in the same shape as mercury or Leclanche cells allowing them to replace primary cells and be recharged when needed.

Continued overleaf with Table 2

Table 1—Primary Batteries

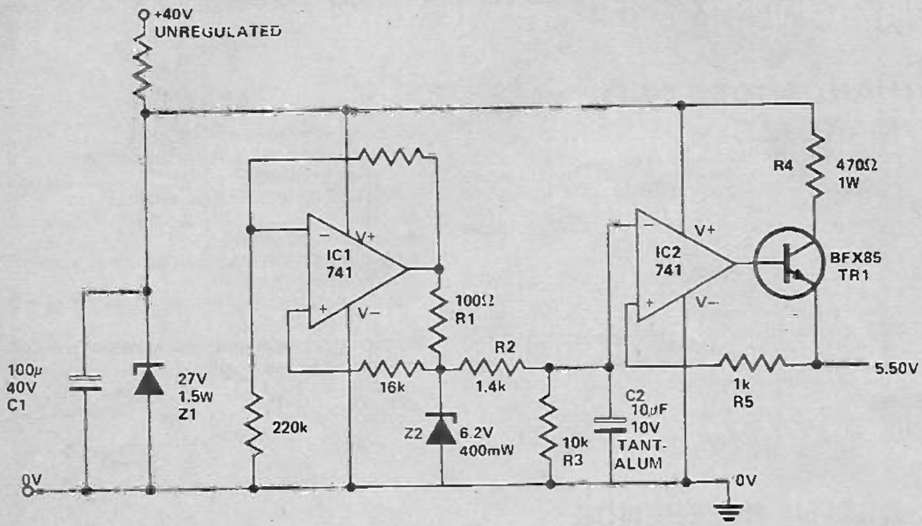
	Leclanché (Dry Cells) Cylindrical	Alkaline-Mercuric Oxide: Mercuric Oxide	Alkaline-Mercuric Oxide: Mercuric Oxide Manganese Dioxide	Alkaline Manganese Dioxide	Magnesium-Manganese Dioxide	Zinc-Air	Solid State	Silver-Zinc
Cap. Avail. (Ah)	0.350 - 21	0.075 - 14.0	0.036 - 3.6	0.580 - 10.0	2.0 - 9.0	3 - 25	0.010 - 1.5	1.5 - 220
Open Circuit Voltage (V)	1.55 - 1.70	1.35	1.40	1.50	2.0	1.45	0.66	1.86
Nom. Operating Voltage (V)	1.25	1.25	1.25	1.25	1.55	1.1	0.55	1.45
Recom. Dischg. Temp. (°F)	65 - 85	65 - 130	65 - 130	65 - 115	65 - 130	50 - 100	40 - 120	50 - 90
Recom. Storage Temp. (°F)	−40 - 75	−10 - 80	−10 - 80	−40 - 80	−40 - 120	−80 - 100	−65 - 120	32 - 90
Self-Dischg. Rate/Mo. at R. T. (%)	1.0 - 1.5	0.8 - 0.9	0.8 - 0.9	0.8 - 0.9	0.5 - 2.0	0.2 - 1.0	0.02 - 0.25	N/A
Watt Hr./Lb	15.5 - 34	37 - 48	34 - 52	33 - 38	55 - 60	80 - 150	5 - 10	40 - 80
Watt Hr./Cu. In.	0.9 - 2.7	4.7 - 6.0	4.5 - 7.5	3.8 - 3.9	3.30 - 3.70	10 - 15	0.6 - 1.2	2.37 - 6.51
£/Watt Hr. (approx)	0.02 - 0.09	0.08 - 2.70	0.10 - 2.20	0.02 - 0.20	0.04 - 0.10	0.01 - 0.02	0.15 - 15.00	0.30 - 4.00
Characteristic Features	Inexpensive, available in a large variety of sizes & battery volt.	Excellent shelf life, High energy density	Excellent shelf life, High energy density	Excellent shelf life, High-rate discharge cap.	High Operating voltage, High storage cap.	High energy density	Excellent shelf life, Low temp. operating cap.	High energy density, High-rate cap but very expensive.

Table 2—Practical Secondary Systems

	SEALED NICKEL-CADMUIM			SILVER-ZINC			LEAD-ACID SYSTEMS					
									STATIONARY			
	Cylindrical	Button	Rectangular	Low Rate SZR(L)	High Rate SZR	Fast Activating SZFA	Auto	Motive Power	Antimony	Calcium	Planté	Sealed Gelyte
Cap. Avail. (Ah)	0.100 - 7.0	0.02 - 0.50	11 - 23	1 - 140	1 - 150	1 - 180	33 - 340	180 - 2175	10 - 8000	50 - 2550	8 - 996	6 - 9
Open Circuit Voltage (V)	1.30	1.30	1.30	1.86	1.86	1.86	2.10	2.12	2.06	2.06	2.06	2.10
Nom. Operating Voltage (V)	1.25	1.25	1.25	1.45	1.45	1.45	1.98	1.94	1.94	1.94	1.94	1.97
Nom. End-of-Chg. Voltage (V)	1.48	1.48	1.48	2.05	2.05	2.05	2.53	2.55	2.17 @ Float	2.17 @ Float	2.17 @ Float	2.55
Recom. Dischg. Temp. (°F)	65 - 85	65 - 85	65 - 85	50 - 90	50 - 90	50 - 90	70 - 90	70 - 110	70 - 90	70 - 90	70 - 90	70 - 90
Recom. Storage Temp., Wet Chg'd (°F)	-40 - 80	-40 - 80	-40 - 80	32 - 90	32 - 90	32 - 90	-40 - 115	30 - 77	-40 - 80	-40 - 80	-40 - 80	0 - 50
Recom. Storage Temp., Dry Chg'd (°F)	N/A	N/A	N/A	32 - 90	32 - 90	32 - 90	-40 - 115	32 - 100	-40 - 115	-40 - 115	-40 - 115	N/A
Self-Dischg. Rate/Mo. at R. T., Wet Chg'd (%)	10 - 15	5 - 8	5 - 8	2 - 5	2 - 5	5 - 10	5 - 11	7 - 10	7 - 12.5	1.0	3.0	7 - 12
Watt Hr./Lb.	8.3 - 19.0	10 - 12	7.4 - 9.2	32 - 60	38 - 66	36 - 73	12.7 - 21.8	8.6 - 11.0	4.8 - 9.7	5.7 - 9.7	3.9 - 6.5	14.5
Watt Hr./Cu. In.	0.85 - 2.20	0.64 - 0.90	0.62 - 0.73	1.66 - 4.20	1.95 - 4.61	2.20 - 5.22	0.79 - 1.6	1.08 - 1.37	0.27 - 0.84	0.43 - 0.84	0.22 - 0.58	1.16 - 1.50
Cycle Life (nom. cycles expectation)	250 - 10,000	250 - 10,000	250 - 10,000	25 - 50	10 - 20	2 - 5	150 - 250	1000 - 2000	N/A	N/A	N/A	100 - 1000
Calendar Life (nom. yr expectation)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	~15	15 - 24	~24	N/A
£/Watt Hr. (approx)	0.45 - 5.0	1.75 - 26	0.55 - 0.72	0.37 - 5.5	0.4 - 5.5	0.32 - 5.5	0.006-0.012	0.02 - 0.04	0.04 - 0.21	0.04 - 0.14	0.05 - 0.27	0.11 - 0.15
£/Watt Hr./Cycle (approx)	0.002-0.02	0.007-0.1	0.002-0.003	0.015-0.22	0.04-0.55	0.18 - 2.25	0.00004 - 0.00008	0.000025 - 0.00004	N/A	N/A	N/A	0.0011 - 0.0015
Characteristic Features	Operative in any position, no maint.	Operative in any position, no maint.	Operative in any position, no maint.	High rate capability, High energy density	High rate capability High energy density	High rate capability, High energy density	Inexpensive Excellent high-rate capability	Excellent cycle life, Rugged const.	Rugged Const. Wide range of available cap.	Lowest float current, Excellent life	Long life, High Reliab.	No Maint. Inexpensive

tech-tips

STABLE REFERENCE-VOLTAGE SUPPLY



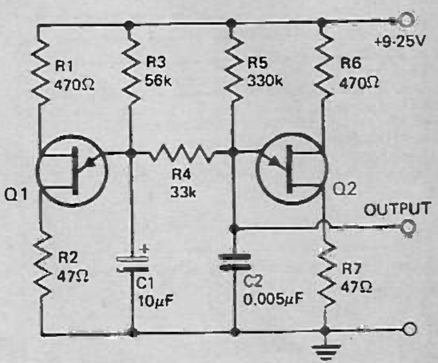
This circuit was evolved to provide a highly stable and ripple-free voltage to act as the reference for the stabilised power-supplies of an electronic music synthesiser; the stability of its voltage-controlled oscillators depended directly on the constancy of supply-rail voltages.

The 40V unregulated supply is derived from conventional full-wave rectification and smoothing of the ac from a 25Vrms transformer winding, and pre-regulated by Z1; C1 provides some further smoothing. IC1 and IC2 are powered from the 27V rail thus generated. IC1 drives a constant current of 5mA through Z2 by acting as a differential amplifier sensing the voltage-drop across R1. Z2 is a 6V zener since diodes of about this voltage have the lowest voltage/temperature coefficient.

The stable voltage across Z2 is then reduced to the desired value by the potential divider R2, R3. This network has a fairly high output impedance and so C2, although fairly small, has a large smoothing effect. C2 must be tantalum as a conventional electrolytic may inject more noise than it removes, in this application. The voltage across C2 is then buffered by IC2 and TR1; R4 forms a simple but foolproof protection against short-circuits. The prototype was designed for a maximum rated output of 30mA.

The reference voltage provided by the circuit as shown above is 5.5V. Different values may be obtained by altering the value of R2; if a voltage above 6.2 is required then R5 must be connected to a potential divider across the output.

STEP FREQUENCY OSCILLATOR

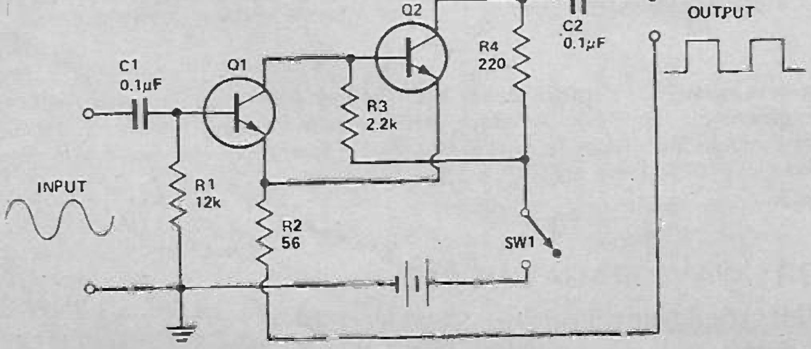


This circuit will produce a continuous sequence of increasing frequencies (in steps) until the highest is reached. The system then resets itself and starts again.

Two unijunction relaxation oscillators are cross-coupled together. On switching on capacitors C1 and C2 start to charge up through R3 and R5. The time constant C2-R5 is shorter; Q2 fires first and discharges C2. As C2 charges up again it will draw current through R5 and R3-R4. This will shorten the Q2 time constant, and in progressive cycles, as C1 charges up slowly, the Q2 time constant will keep shortening till Q1 fires, at which stage C1 will discharge and the whole cycle begins again.

Various sound effects can be obtained by varying R3, R4, C1 and C2.

SINE/SQUARE WAVE CONVERTER



Many audio generators only give a sinusoidal output. However a square-wave output is often useful too.

This circuit will square any sinusoidal input over the range of 20 Hz to 30 kHz with an output of about one volt, input signal should be about 400 mV.

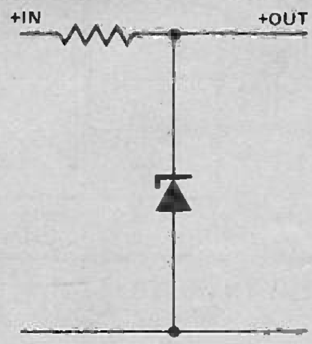
The waveform obtained is of much better purity than obtained by a diode squaring circuit. The circuit is in fact suitable for use where square waves with a fast rise-time are required.

Transistors are germanium NPN types such as AC 127.

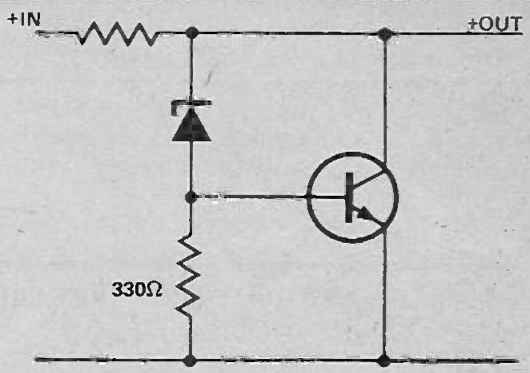
The power supply is 1.5 V and consumption is in the region of one to 2 mA.

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.

ASSIST THAT ZENER



(1)

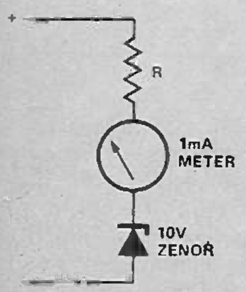


(2)

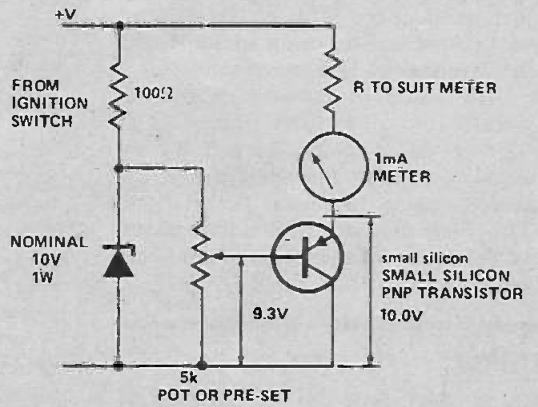
The simple zener shunt of diagram (1) may not handle sufficient current if the zener available is of low wattage. A power transistor will do most of the work for the zener in circuit (2).

The output voltage is increased by 0.7V but it is stabilisation rather than exact voltage which is often required.

SUPPRESSED ZERO VOLTMETER FOR THE CAR



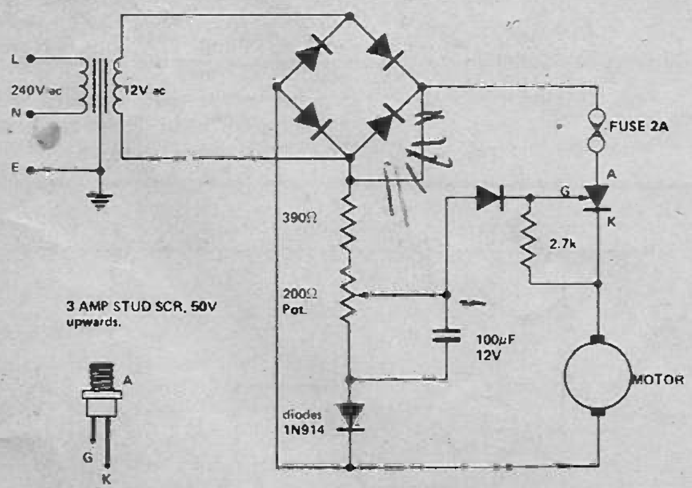
(1)



To make a meter cover the range 10 to 15V or 10 to 20V over its whole scale, then circuit (1) is often used.

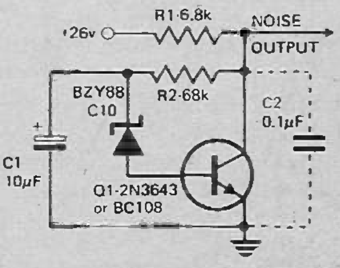
The zener must be exactly 10.0V and may not be available. In this case use the arrangement shown in (2).

SPEED CONTROL FOR MODEL TRAINS OR CARS



The following is a low voltage adaptation of the type of speed control popularly used to regulate power drills. It gives very good starting torque and excellent speed regulation of the model. A reversing switch may be incorporated in the leads to the motor.

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.

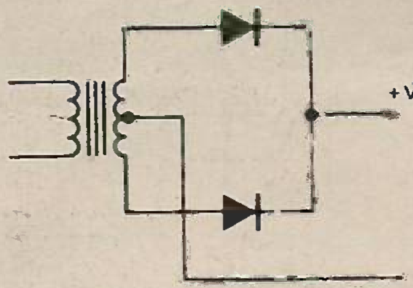
SHARING THE LOAD

If two diodes are used in series to increase the voltage rating, then it is advisable to add two resistors as shown. In practice one diode would be found to be taking most of the voltage, but the resistors prevent this situation.

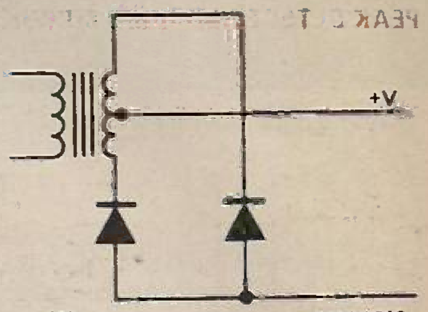
tech-tips

AVOIDING INSULATED HEAT SINKS

If a fairly heavy current is to be taken from the type of power supply shown in (1), then the diodes will be of the stud type on insulated heat sinks. By choosing stud anode diodes, and using arrangement (2), the chassis may be the heat sink without the need for insulation.

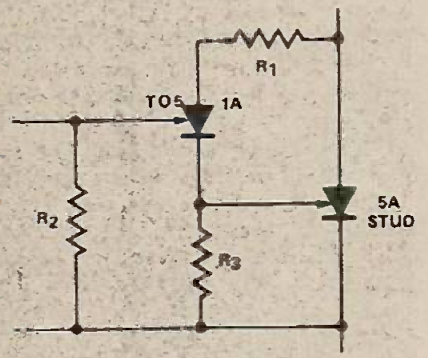


(1) CHASSIS



(2) CHASSIS

INCREASED SENSITIVITY FOR HEAVY CURRENT THYRISTORS

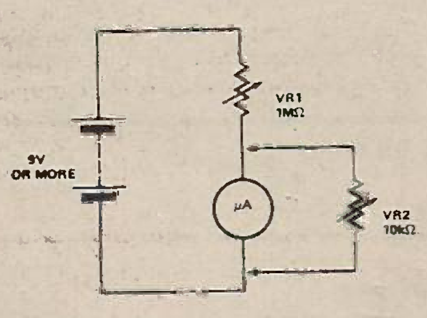


A typical stud thyristor of 5A rating will need 10mA or more for triggering into conduction. This can be reduced to 1mA or less by using an additional 1A thyristor of T05 construction.

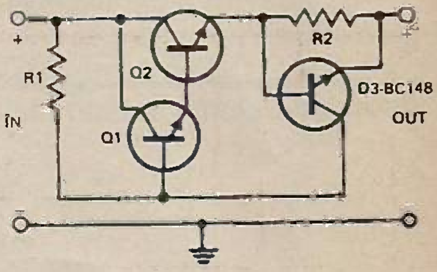
The value of R_1 will depend on circuit voltage, ranging from 47Ω at 12V to 1k at 240V R_2 and R_3 are equal, and normally specified in the circuit, being typically 1k or more. The small thyristor should have exactly the same voltage rating as the larger one.

MEASURING MICRO- AMMETER RESISTANCE

When it is required to measure the unknown resistance of a micro-ammeter, then an ordinary multimeter on the necessary ohms range will send too much current through the meter coil, with the chance of causing damage. To avoid this, set up VR1 to give full scale deflection on the meter. Then shunt the meter with VR2 and adjust so that the meter reads exactly half scale. Remove the measure VR2, which, to a good degree of accuracy, will be equal to the meter resistance.



ELECTRONIC FUSE



Imax	R1	R2	Q1	Q2
5.0A	100Ω	0.12Ω	BFY50	2N3055
0.5A	1k	1.0Ω	BC107	BFY50
0.1A	4.7k	3.7Ω	BC107	BFY50

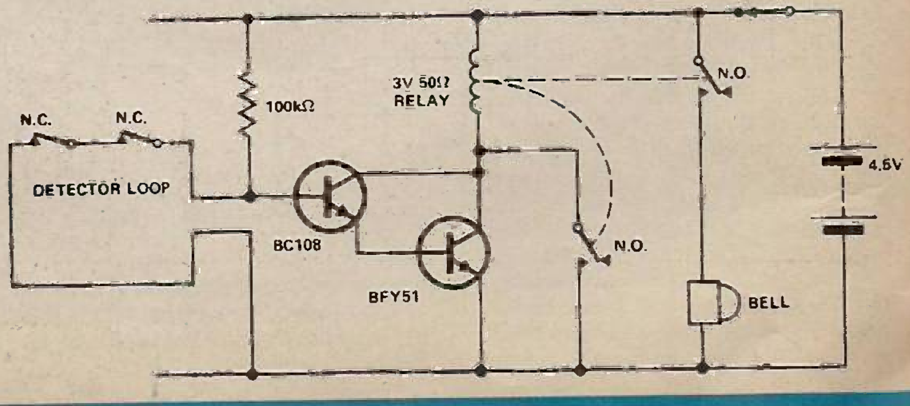
Here is a circuit for protecting modern transistorised gear which requires a faster action than can be provided by an orthodox fuse.

Transistor Q2 is saturated by base current supplied by Q2, which is itself turned on by R1. The overall voltage drop between input/output is in the region of 2V. If a momentary surge in current or a short circuit in the load appears then the voltage drop across R2 will increase and when it reaches about 0.7V, Q3 will begin to conduct and its collector emitter voltage will drop to about 0.3 V. This in turn cuts off Q1 and Q2 thus breaking the supply current.

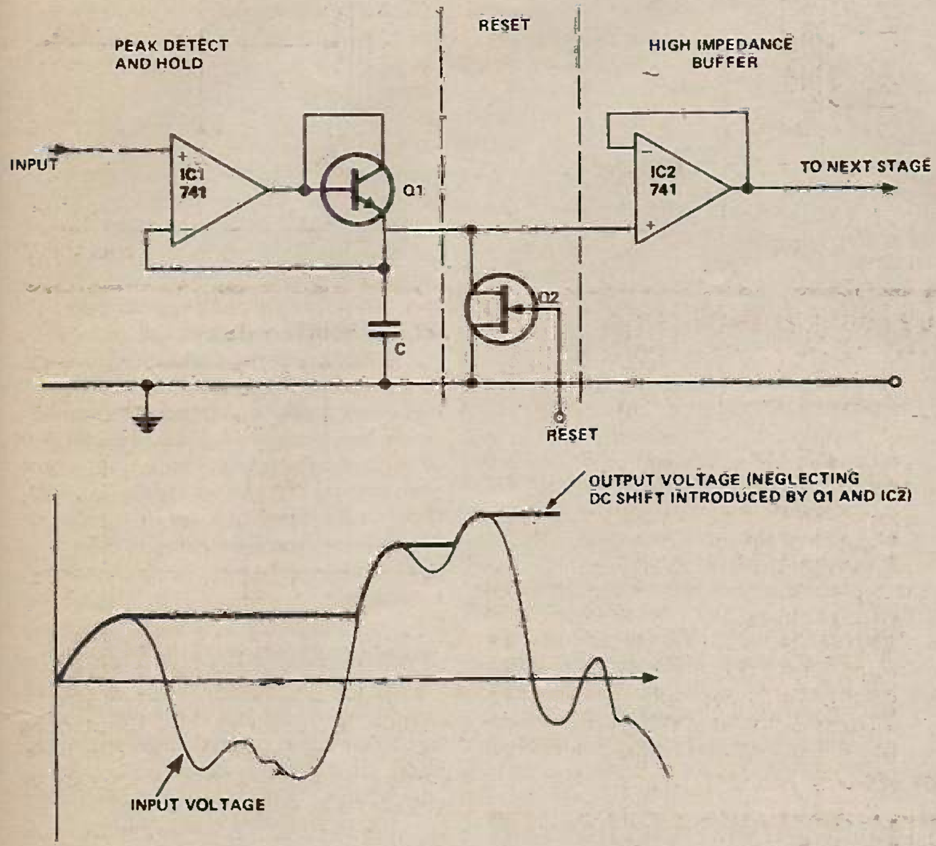
The tables gives circuit values for various currents. These are suitable for supply voltages up to 45 V.

BASIC ALARM

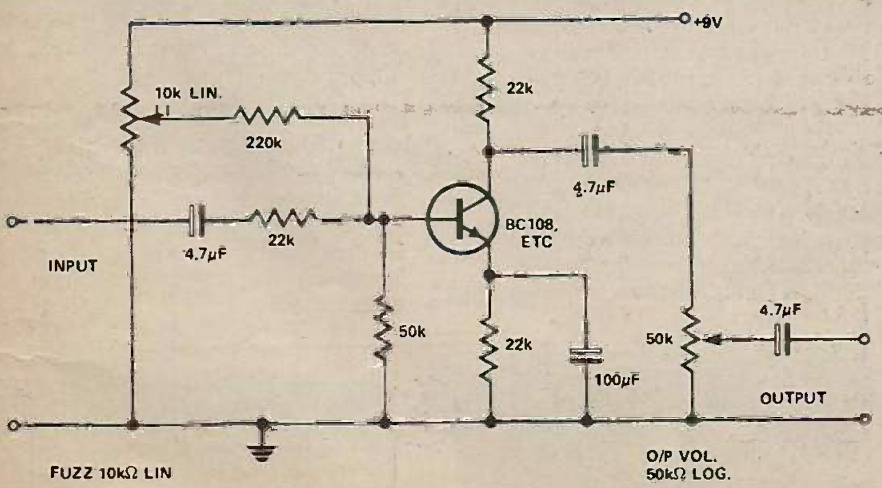
The basic alarm circuit uses the minimum of components, has a very low standing current (less than 50µA) and thus may be operated from small dry batteries. The circuit has a lock-out system which prevents the alarm being stopped, except by disconnecting the battery. Any break in the detector loop allows the current through the 100kΩ resistor to switch on the transistors, pulling in the lock-out relay and sounding the alarm.



PEAK DETECT AND HOLD CIRCUIT



If the voltage at the input becomes bigger than the voltage on the capacitor, then the output of the 741 goes positive, the diode conducts, and the capacitor is charged up to the input voltage-forward voltage drop of diode. When the voltage at the input is less than that on the capacitor, the output of the 741 goes negative, and the diode cuts off. To prevent the capacitor from discharging through the input resistance of the next stage, a high input impedance buffer stage (IC2) is used. The circuit can be reset by means of a FET or similar high impedance device connected across the capacitor.



Fuzz Box

QUICK JFET TEST

A quick test of an N or P-channel JFET is possible using only a standard mulitmeter ohmmeter.

With the ohmmeter connected between source and drain (polarity unimportant) the channel resistance (about 200Ω) will be read. If the gate is now touched with a finger once or twice, the channel resistance should rise to about 10MΩ indicating pinch off. If this does not happen the FET may be assumed not working. Electrostatic pickup from the "mains" charges the gate capacitance and pinches off the FET. The time it takes for the channel resistance to return to normal gives an indication of the gate leakage resistance of the FET.

The relatively low gate leakage resistance, and the high resistance between the finger and the mains helps to prevent destruction of the FET whilst it is being tested in this way.

FUZZ BOX

A quick look at a commercial one will show that fuzz-boxes are grossly overpriced for what they are. This general principle is that the input is split, and one part of it is distorted, then the two signals are mixed, variably, providing variable "fuzz". But why not cut costs again by simply varying the distortion of a one-transistor stage.

None of the components are particularly critical in value or quality, as distortion is the sole object!!

The transistor could be BC107-8-9, 2N2926, etc. A PP3 battery completes the "fuzz-box" which fits easily into a small plastic box with two jack sockets for the input and output and an on-off switch. The unit could be made easier to operate by reducing the value of the "fuzz" control and adding two series resistors.

The unit costs around £1 to £2, depending what components the constructor has available, the case and sockets seem to be the most expensive items.

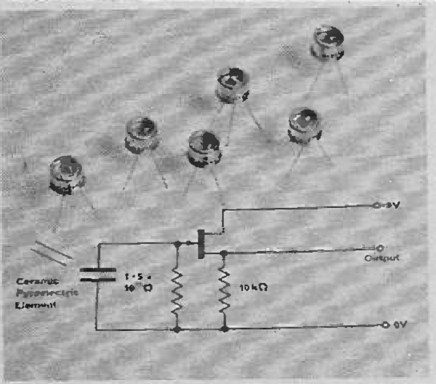
 Continued from page 8.

PICTURE-FRAME SPEAKERS

A picture which oscillates within its own frame, reproducing sounds as efficiently as most conventional speaker systems, has been launched by Omal. The speakers are made in Japan and are 1½ inches thick. They are designed for wall mounting in matching pairs.

A choice of over 60 different pictures handle 10W and cover the range 40Hz to 12KHz through 180°.

The price is about £50 per pair, from Omal House, North Circular Road, London NW10 7UF.



The new Plessey PPC 522 low-cost broadband ceramic pyroelectric infra-red detector which comprises a detector element and J.F.E.T. preamplifier encapsulated in a TO5 transistor can, with a suitable cell window according to the required application. These devices are specifically designed for intruder detection, fire alarm and pollution monitoring applications.

MIRRORS FOR LASERS

Rofin Ltd., of Alston Road, Barnet, Herts, announce the introduction of a new range of super performance mirrors for use in CO_2 high power laser systems. The mirror surfaces are based on a copper nickel substrate which is polished, pin-hole free and carefully etched and ultrasonically cleaned. A high reflectivity very hard gold coating is then put over the substrate. This yields a high damage threshold for both CW and pulsed CO_2 laser beams.

The standard radii of curvature are 2,4,6,10,20 metres concave and flat. Standard diameters are 25, 38 and 50mm. Prices vary from £19 - £27.

BALANCED MIXER/MODULATOR/ PHASE DETECTOR

Lithic Systems have introduced a much improved version of the 1596 Balanced Mixer, with guaranteed matching characteristics to permit untrimmed operation. The useful frequency range has been improved to 250NHz and the device comes as a monolithic integrated circuit encapsulated in a 10 pin T0-100 package.

Applications include balanced modulation and demodulation, frequency heterodyning and multiplication, multiplexing and demultiplexing, and phase detection in SSB, DSB, AM, FM and audio communication systems.

The LS1596A, which guarantees 2% internal matching is priced at £3.22 and the 1% matched LS1596B at £4.05 each for quantities of 100 and over. Both types are available from Adrian Electronics Limited, 28 High Street, Winslow, Buckingham MK18 3HF.

SILVER-COATED GLASS SPHERES FOR CONDUCTIVITY

Microscopic solid glass spheres coated with pure silver are being used for electrical conductivity in a wide range of polymer products with advantages in cost and processing. The spheres are produced and coated by Potters-Ballotini for use in such applications as electrically-conductive adhesives, gaskets, caulking compounds, in conductive inks, electroplating, printed circuit repair, component lead termination, in electro-magnetic shielding, and in the manufacture of prototype circuits and molding of conductive plastic parts.

Use of silver on a glass core provides excellent conductivity at relatively low cost. In processing, the spheres are easy to handle, easy to mix, and permit high loadings with minimal increase in viscosity. Potters-Ballotini Ltd. are in Pontefract Road, Barnsley, Yorks, S71 1HJ.

TWO NEW SOLDER PRODUCTS

Multicore's new solder-wick absorbs solder from tags and printed circuits when used with a 40 or 50W soldering iron. It is quick and easy to use and desoldering takes only a few seconds.

The solder-wick is packed in a 5 foot length on a handy plastic dispenser. Each dispenser comes on a card with full instructions printed on the reverse. There are 10 cards packed in a carton for a recommended retail price of 97p.

You will be able to buy solder in new packages too. A coil of 40/60 alloy is 18 gauge Ersin Multicore Five Core Solder is packed in handy to use dispensers with full directions for use printed on the side. The solder is suitable for general purpose soldering of all types of electrical joints and household metal repairs (except aluminium). When the dispenser is held in the hand the solder can be easily directed to the area where the solder joint is to be made. The cap has been designed with a hanging hole for convenient storage or display. 25 dispensers are packed in a carton for selling at a recommended retail price of 19½p.

A new range of calculators has just been announced by Plustronics. The 908 (with accumulating memory) costs £21.95. The 508 (5-function, with % key) costs £15.94. The 808 (with stored memory) costs £19.95 The 308 is the four-function model for £14.50. The quoted prices are based on the average selling prices. The calculators are available from dealers.

TWO NEW SOCKET SETS

Hi-Way (Automotive) Ltd., of 226 Mary Street, Birmingham B12 9RJ, is offering two useful Socket Sets.

The first set is a 17-piece, ¼" drive Socket Set covering BA sizes and includes 11 sockets, from 0BA to 10BA, two extension bars and one each ratchet handle, flexible handle, cross bar, and sliding bar. The carrying case of plastic has an integral carrying handle.

The second set, a 39-piece ¼" drive Socket Set, comprises 33 sockets from 0 to 10BA, 4mm to 12mm, and 5/32" to ½" AF sizes. In addition there is a ratchet handle two extension bars, a sliding T bar, a flexible handle and one Tommy bar. The carrying case is of metal and is secured by two snap-on latches.

Prices, including VAT, are £4.49 for the 17 piece set and £6.99 for the 39-piece set. Postal Orders are 35p extra to cover carriage and packing. Hi-Way Automotive give you a "you break it, we replace it", guarantee with each set.

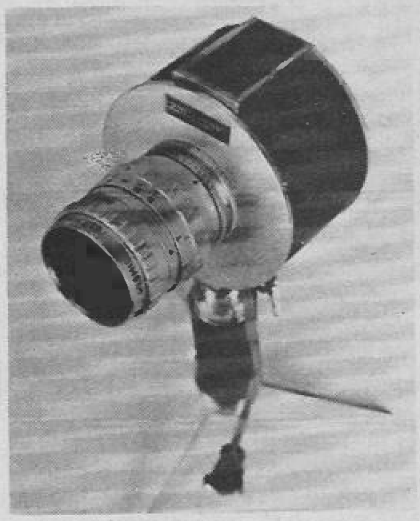
MINIATURE SOLID-STATE TV CAMERA

Use of charged-coupled-device technology allows the bulky Vidicon tube normally used in TV cameras to be replaced by a compact solid-state image-sensing device which contains 10,000 photosensors on a standard 24-pin dual-in-line integrated-circuit unit. Fairchild have just introduced the MV101 which has a cylindrical body 3 inches in diameter and 1 7/8 inches deep. The weight of the camera is 11 ounces.

The power consumption of the camera is 1.5W. It responds to illumination levels as low as 2 lux (0.2 foot candles), making it suitable for low-light applications such as night security and surveillance. Other applications are made possible by the camera's small size, such as remotely piloted vehicles, space systems, periscopes and process control. The accurate registration of the CCD system allows its use in scientific measurement, medical instrumentation and microscopy.

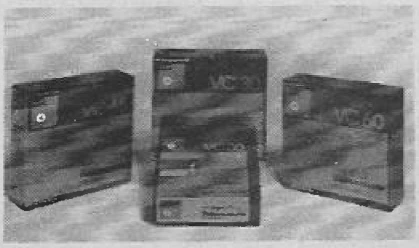
The spectral response extends into the near infrared range. The camera has a 100-line horizontal resolution and a bandwidth of 1MHz.

A 5-inch TV monitor adapted to the 123 frames/sec sweep rate is supplied with the camera.



The camera can operate at a distance of up to 100 feet from the monitor. An optional battery pack is available when complete portability is required. The standard lens of the MV101 is a 25mm f/1.4 C-mount type. Information from Fairchild Camera and Instrument Corporation, 464 Ellis Street, Mountain View, California 94042 USA.

VIDEO CASSETTES

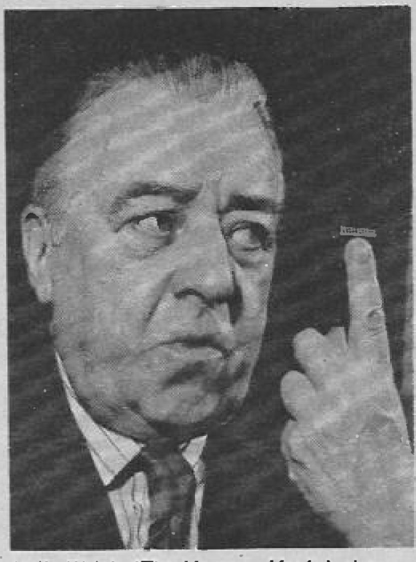


Three video cassettes have been released in the UK by BASF. They are VC30, VC45 and VC60 cassettes (with 30, 45 and 60 minutes' playing time respectively). The VC cassettes are made in Germany using high density chromium dioxide tape.

At present the supplies are limited, and, prices are £11.00, £14.50, and £17.00 plus VAT.

ELECTRONICS TOMORROW

Due to circumstances beyond our control we regret it has not been possible to include our Electronics Tomorrow feature in this issue. It will be back as usual next month.



Leslie Welch, 'The Memory Man', is shown here, face to face with the latest competition – a 1K CMOS RAM from Intel. The device, which draws only 15 microamps from a single 5 volt supply, incorporates fully DC stable circuitry in a 22-pin package.

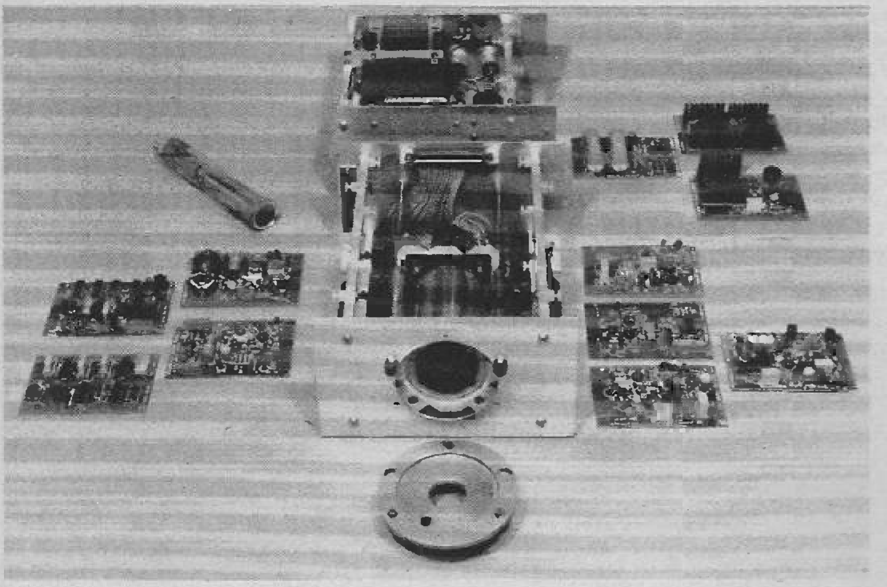
TELEX COMPATIBLE VDU

Automation and Technical Services Ltd (Bridge Road, Haywards Heath, Sussex) have introduced a VDU designed specifically for applications where direct compatibility with existing telegraph networks is necessary.

It has a 64 character per line, 16 line display. Information is generated in ASCII and is converted to CCITT Alphabet No.2 (Telex) code before transmission to line. The unit is complete with a solid state bi-polar telegraph interface (80V - 0 - 80V) for both transmit and receive. Line protection is also provided and the unit is approved for direct connection to Post Office lines. A hard copy printer output is fitted for local verification.

A special feature of the unit is the Phrases and Word generating keyboard, which in addition to the standard (teletype) ASR33 keyboard has 16 keys which generate a preselected word or phrase from each single key operation.

The facilities offered on this visual display make it suitable for a wide range of applications such as compilation, recording and editing of telegraph messages before line transmission; automatic or semi-automatic password and phrase generation for terminal installations; common phrase storing for computer programming and for emergency services where data retention in the event of a power failure is vital.



BUILDING BLOCK CAMERA

As a cost-effective solution to the problem of widely differing requirements of industrial TV camera users, Marconi have developed a system of modules which produces the V327 family.

The skeleton is made up of the Camera Control Unit and the Camera (as shown in the 'photo in the back and foreground respectively), which can be remotely located or mounted together in an integral unit. The other modules are plug-in or screw-on and can be chosen from a wide range.

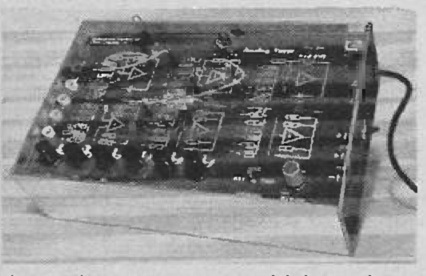
The tubes can be vidicon, lead oxide or silicon diode. The silicon diode tube provides for infra-red surveillance but requires auto-gain which comes on an optional pcb. The camera carries eight main boards which are low-mass types so that plug-in mounting gives sufficient rigidity. There is spare capacity for two extra pcbs.

One of these could be used for camera ID; a plug-in module will generate an alphanumeric code to show up in the corner of the picture (useful in multi-camera systems). Other special boards carry such features as gamma correction and aperture correction. The camera can be supplied for mounting in the user's housing or in one of the wide Marconi range. The lens and its mount form another building block and this can hold most types of lens.

To facilitate the plug-in method of design and maintenance the equipment needs very little setting up. Feedback and stabilisation circuitry overcome the need for internal adjustments (such as scan-linearity). Automatic black level control is another feature.

In its simplest form the camera will cost £650 (from Marconi-Elliott Electro-optical Division, Christopher Martin Road, Basildon, Essex, SS14 3EL).

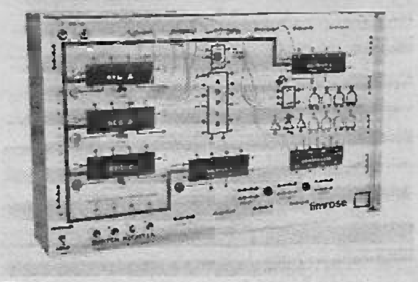
ANALOG TUTOR



An analogue computer which can be used in schools for teaching the basic principles of analogue and hybrid computation has been developed by Limrose Electronics.

An instruction book dealing with the subject from first principles accompanies the Analog Tutor which costs (from) £99.

DIGITAL ARITHMETIC TUTOR



This advanced logic trainer has been designed for teaching the principles of binary arithmetic and four-bit data word manipulation.

Prices, which include the Instruction Book, start at £150. From Limrose Electronics, 8 Kingsway, Altringham Cheshire, WA14 1PJ.

INFRARED DIODES FOR HEADPHONES

The wearers of headphones are chained to their radios and record players by trip cords that have caused many a domestic tangle. Siemens have tackled this problem by introducing a diode for cord-less transmission of entertainment sound in the home. Amplifier and headphones are linked by invisible infrared light, transmitted and received by these new diodes. The basis of the system is a new photodiode (BPW34) with an active area of $9mm^2$ which is installed in the headphones and picks up the frequency modulated signals (over 100kHz max.). The transmitter comprises a maximum of eight luminescent diodes (LD241) capable of supplying a total power of 120mW, which is adequate even for large rooms.

On account of its physical characteristics, infrared light is particularly suitable for the electronic "flooding" of rooms. Neither dark nor rough areas can absorb the radiation or distort the impressed intelligence signals. Protruding edges of furniture also remain without effect on the high fidelity quality of the reproduction. The infrared light is diffuse and stochastically distributed throughout the room. The headphones do not have to be trained in any particular direction.

CONDUCTIVE PLASTIC POTENTIOMETERS

Two new ranges of conductive plastic potentiometers are now available in the U.K. The P4100/4200 is rated at 1.8 watts and offers high resolution (0.003%), large electrical angle (352°), long life (50.10^6 operations), good linearity (0.2%), and low operating torque (0.2 cmg).

The second range designed is a lower cost version known as the P4400. It has virtually the same specification as the other model, with a smaller electrical angle (345°) and a higher input torque (10 cmg).

Both models are manufactured in servo size 13 and can be supplied with up to 10 ganged cups from Variohm Components, The Barn, Wood Burcote, Towcester, Northants, NN12 7JR.

ELECTRONICS SUMMER SCHOOL FOR SCHOOLTEACHERS

The Department of Electrical Engineering Science at Essex University will be holding its annual Electronics Summer School for schoolteachers during the week of July 7 and, once again, two courses will be run simultaneously. The first course, ESS 8 - Linear Circuit Design, is concerned with the use of transistors and operational amplifiers in linear applications such as amplifiers, filters and power supplies. The second course ESS 9 - Digital Circuit Design, concentrates on the use of the transistor as a switch and develops design using integrated logic circuits; this leads on to combinational and sequential logic concepts.
Further information can be obtained from Bob Mack (quote reference ETI) at the Department of Electrical Engineering Science, University of Essex, Wivenhoe Park, Colchester, Essex, CO4 3SQ.

CHARGE-COUPLED MEMORY

Fairchild have the first CCD memory in large-scale production. The CCD 450, is a 1 Kilobyte serial storage element claimed to be a significant advance in the density of solid-state memory. It is aimed at memory applications in terminal buffers, video display refresh, microprocessor-control data stores, smart terminals, and electronic switching in data-communication networks.

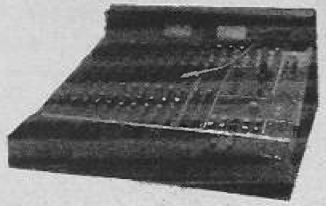
The device utilises a high-performance blend of Fairchild's proven NMOS and CCD technology, and is as easy to use as any MOS memory. The CCD 450 uses isoplanar, buried-channel, ion-implanted barrier structure in the storage registers combined with n-channel silicon-gate MOS structures for on-chip timing, charge detection and level conversion circuitry. The nine bidirectional data lines are TTL-compatible and have three-state output buffers for wired-OR application.

The device is organised as 1,024 words by 9 bits (9,216 bits). It contains nine 1,024-bit low-power CCD registers which are shifted in parallel to provide storage and retrieval of nine-bit words in a byte-serial mode. Each register is accessed by its own bidirectional data line, and all nine registers are serviced by common two-phase data transfer clocks and READ and WRITE control functions. The device operates in four modes: read, write, read/modify/write, and recirculate.

Power dissipation in the read and write modes is 250mW maximum, and only 30mW in standby recirculate mode. Average random byte access time is 200us. The device uses simple two-phase clocking, and is packaged in a standard 18-pin ceramic DIP. Data rate is 50kHz to 3MHz. The device is not expected to be available until the end of the year.

THEATRE MIXERS

A new range of high quality, transportable, stereophonic sound mixing desks, specifically developed for theatre use, have been introduced by Cambridge Electronic Workshop, 8 Perowne Street, Cambridge, CB1 2AY.



Special features on the desk include: continuously variable presence frequency and gain, a bass tip-up filter, separate mic and line inputs and two auxiliary sends with pre/post switching on all ten channels; cue lights; show relay/intercom systems; comprehensive monitoring and PFL; loudspeaker switching; and two sets of tape remotes.

The desks have 30dB internal headroom, distortion less than 0.1% and input noise better than −126dBm. The standard desk has a 24" square base and is 11" high.

COMPONENTS MANUAL

One hundred and ninety seven pounds (and eighty pence) can buy you the 2026 pages of the comprehensive electronic components reference manual recently researched, compiled and edited by the General Electric Company (USA). The 'Component Technology and Standardization Manual' is the result of 20 years' work by a team of 25 engineers and it comes in three volumes. Initially intended as an in-house reference manual, this encyclopaedia has now been made available to the whole electronics industry.

The material was checked and revised by 43 leading electronics companies to eliminate any possibility of a GE (USA) bias.

GE (USA) has appointed London Information as the sole distributor for 'Component Technology and Standardization'. London Information (Rowse Muir) Ltd., Index House, Ascot, Berks, SL5 7EU.

REMOTE BLACKBOARD

A low-cost remote "blackboard", which can transmit writing and sketches along an ordinary telephone line for display on a TV set, has been developed by Open University technologists. This will enable students to look at diagrams, graphs and formulae drawn over the phone by tutors, and because it is a two-way link the students can immediately ask questions and discuss what has been drawn.

The blackboard, and telephone tutorials in general, are being pionerred by the OU to overcome the practical difficulties of bringing some students and tutors together. Some of the university's higher level courses involve students scattered throughout the country, few of whom have a specialist tutor close at hand.

The device makes use of a pen and sketch pad which are wired so that the changing position of the pen is coded into a series of sounds. These can be transmitted and received by ordinary telephone handsets and then a device decodes the sounds into positions on a TV screen.

Inventors, Dr. John Monk and Chris Pinches, of the Technology Faculty, started work on the project as recently as last October, and have already produced an inexpensive prototype which will be used experimentally this year. "The first hundred receivers cost £150-£200, but next year we expect this to be down to £50-£60," said Mr. Pinches. "There has been other work in the field, in this country and aborad, but none has provided a facility anything like as cheaply as this."

PUSH-BUTTON KNOBS

Trampus Electronics, who stocked the special push-button switches for our 4-Channel Amplifier project in the April 1974 issue after a delay (not the fault of Trampus) supplied these with square knobs rather than the round ones suggested.

Readers who ordered these can now obtain a set of 9 of the correct round knobs *Free of Charge* from Trampus if they send a self-addressed envelope with the approximate date of the original order.

ERRATA

Courtesy Light Extender, Feb issue, page 51.
Q1 should be a BC328 in both circuit and Parts List, not BC338 as shown.

MINI-ADS

FOR FURTHER INFORMATION
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Aerial Boosters: £3.20

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HARDWARE

Screws, nuts washers etc.
Sheet aluminium cut to size or in standard packs, plain or punched/drilled to spec.
Printed circuit boards for published designs or individual requirements, one-off or small runs.
Fascia panels, dials, nameplates etc in etched aluminium. 6p for details.

Ramar Constructor Services,
29 Shelbourne Road,
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LEDs

LEDs (with Data clip 1p)	dia. 0.125	0.2	D.I.L. SOCKET
RED	15p	19p	8 pin 12p
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INFRA-RED LEDs with Data: 550µW axial lead, 49p; 1·5 mW TO46, £1·10

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748 DIL 36p

7805 Reg £1·50 Plastic 1·5 Amp

	pence
AC127	15
AC128	15
AF117	20
BC107	10
BC108	10
BC109C	12
BC182L	11
BC184L	11
BC212L	12
BC213L	11
BCY70	15
BCY71	22
BCY72	12
BFY50/51	16
OC71	10
2N706	10
2N2904	16
2N2906	16

2N2926(R)	7
2N2926(G)	12
2N3053	15
2N3055	41
2N3702	12
2N3704	12
TIS43	25
MPF102	40
2N3819	25
2N3823	30

BZY88 zener 2.7 to 33V 9p

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200V,2A:41p
400V,2A:46p

NE555V	60p
ZN414	£1·10
7400	16p
BHA 0002 15 W I.C. AMP	£2·50

IN914	3p
IN4001	5p
IN4002	6p
IN4004	7p
IN4148	4p
OA47	6p
OA81	7p
OA91	5p
OA95	5p
OA200	6p
OA202	7p

Thyristors	50V	100V	400V
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Tested and guaranteed components:
DL704 seven segment LED display 90p, small red LED's 13p each, 5 mixed LED's 60p, 741 op-amp 28p each, or four for £1.50 disc ceramics (our choice) 54p, 30 mixed polyester capacitors 54p, 1/8, 1/4 and 1/2W resistors E12 values 5%, at 1p each, 100 mixed hi-stab resistors £1.10. Please include 15p post etc. For latest lists send SAE (A4), or 10p stamp. **TAMAR ELECTRONICS, P.O. Box 17, Plymouth, PL1 1YJ.**

LED's. Mixed bags Red Green Yellow, .1" .125" .16" .2". 50 - £5 100 - £9 inc VAT & Postage. Larger quantities by negotiation. CWO to **Industrial Electronics Supplies (Stockport) Ltd., 181a Bramhall Lane, Stockport, SK2 6JA.**

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BC107/8	9p	ICL8038	290p	7410	15p
BC109C	10p	LM380	100p	7413	30p
BC182/3	10p	LM381	150p	7420	15p
BC184	11p	MC1310	240p	7430	15p
BC212/3	11p	MC1312	220p	7441	75p
BC214	12p	NE560	220p	7447	95p
BD131/2	42p	NE567	250p	7448	90p
BFY50/2	15p	TBA800	100p	7473	36p
TIP41A	65p	TBA 810	125p	7474	34p
TIP42A	70p	TBA820	80p	7475	52p
TIP2955	70p	ZN414	110p	7476	37p
2N2646	35p	1 A Plastic Regs		7489	340p
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2N3055	40p	5, 12, 15, 18, 24V		7493	48p
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40673	70p	SCR CRS1/40	60p	3015F	120p
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0.47µF (1 3/8"x¾")	71p	4.7µF	£1.30	£1.05	85p
0.5µF (1 3/8"x¾")	76p	6.8µF	£1.64	£1.29	£1.09
0.68µF (2"x¾")	80p	10.0µF	£2.00	£1.60	£1.40
1.0µF (2"x¾")	91p	15.0µF	£2.75	£2.15	£1.90
2.0µF (2"x1")	£1.22p	22.0µF	£3.50	£2.90	£2.55

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TRANSISTORS:

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BC147/8/9	10p	BC547	12p	BFY51	20p
BC157/8	12p	BC558A	12p	BFY52	20p
BC182/182L	11p	BF194	12p	OC71	12p
BC183/183L	11p	BF197	13p	2N3055	50p
BC184/184L	12p	AF178	30p	2N3702/4	11p

POPULAR DIODES: All brand new and marked: 1N914 6p; 8 for 45p; 18 for 90p; IN916 8p; 6 for 45p; 14 for 90p, 1S44 5p; 11 for 50p; 24 for £1.00. 1N4148 5p; 6 for 27p; 12 for 48p. LOW PRICE ZENER DIODES 400mW; Tol. ±5% at 6mA. Values available: 3V; 3.6V; 4.7V; 5.1V; 5.6V; 6.2V; 6.8V, 7.5V; 8.2V; 9.1V; 10V; 11V; 12V; 13V; 13.5V; 15V; 16V; 18V; 20V; 22V; 24V; 27V; 30V. All at 7p each; 6 for 39p; 14 for 84p. Special Offer: 100 Zeners for £5.50. RESISTORS: High stability, low noise carbon film 5%; ½W at 40°C; 1/3W at 70° C. E12 series only - from 2.2Ω to 2.2MΩ. All at 1p each; 8p for 10 of any one value; 70p for 100 of any one value. Special Pack: 10 of each value 2.2Ω to 2.2MΩ (730 resistors) £5.00. SILICON PLASTIC RECTIFIERS - 1.5A - Brand new wire ended DO27: 100 P.I.V.—7p (4/26p) 400 P.I.V.—8p (4/30p) BRIDGE RECTIFIERS: 2½A 200V–40p 350V–45p 600V–55p.
SUBMINIATURE VERTICAL PRESETS - 0.1W only: All at 5p each. 50Ω, 100Ω, 220Ω, 470Ω, 680Ω, 1k, 2.2k, 4.7k, 6.8k, 10k, 15k, 22k, 47k, 68k, 100k, 250k, 680k, 1M. 2.5M, 5M.
Please add 10p Post and Packing on all orders below £5.00. All export orders add cost of Sea/Airmail. Please add 8% VAT to orders. Send SAE for lists of additional ex-stock items. Wholesale price lists available to bona fide companies.

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12K, 33K Tin Oxide Resistors per 100 50p

Precision Timers £4.00.

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INDEX TO ADVERTISERS

Ambient Acoustics 55
Ambit 34
Aston University 73
Axial Products 73
B. H. Component Factors 34
B.I.E.T. 75
Bi-Pak 20/21
Bi-Pre-Pak 50
Bywood 9/74
Cambridge Learning Enterprises 56
Chiltmead 32
E.D.A. 22
Electronics Mart 72
Electrovalue 55
Elvins 74
Fibre Optics Suppliers 73
F.U.Q. Components 73
Heathkit 25
Henry's Radio 2
Island Devices 72
Lancashire Mail Order 72
J.C. Jones 73
J.E.T. 29
Maplin 76
Marco Trading 72
Marshalls 55
Minikits 13
Ramar 72
Shortwave Magazine 63
Sinclair 4/5/26/40/41
Sintel 36
Technomatic 72
Trampus 9
Watson 73
Wilmslow Audio 13