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electronics today international

AUGUST 1975

30p

ELECTRONIC ONE-ARM BANDIT

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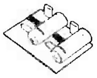
POWER AMPS

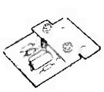
SS103



Compact I.C. amp. 3 watts R.M.S. Single channel (mono) On P.C.B. size 3½"x2". Needs 6-22V supply. **£1.75**

SS103-3

Stereo version of above. (Two I.Cs.) **£3.25**



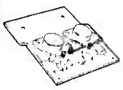
NEW! SS105 Mk. 2

A compact all-purpose power amp. Can be run from 12V car battery. Size 3½"x2". Useful 5w output (mono) into 4Ω using 24V. Excellent value. **£2.25**

SS110 Mk. 2

Similar in size to SS105 but will give 10w output into 4Ω using 24V (mono). Two in stereo give first-class results, suitable for many domestic applications. **£2.75**

SS140



Beautifully designed. Will give up to 40w R.M.S. into 4Ω. Excellent S.N.R. and transient response. Fine for P.A., disco use, etc. Operates from 45V DC. Two in bridge formation will give 80w R.M.S. into 8Ω. **£3.60**

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Active tone control unit to provide Bass and Treble facilities (stereo). **£1.60**

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Pre-amp for stereo ceramic cartridges, radio and tape. **£1.60**

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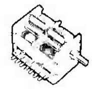
Pre-amp for low-output stereo magnetic cartridges, radio and tape. **£2.25**

BUILD A STEREO F.M. TUNER

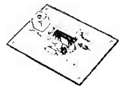
FM Tuners

SS201



Front End assembly. Ganged tuning with well engineered slow-motion geared drive in robust housing. A.F.C. facility. Requires 6-16V. Excellent sensitivity. 88-108mHz. **£6.25**

SS202



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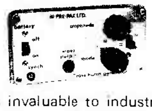

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40P2	PNP	40	40	**30p**

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Type	Polarity	Gain	VCE	Price
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90N2	NPN	40	40	**35p**
90P1	PNP	15	15	**25p**
90P2	PNP	40	40	**35p**

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AUGUST 1975 Vol. 4. No. 8.

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Published by: Modern Magazines (Holdings) Ltd 36, Ebury Street, London SW1W 0LW.

Electronics Today International is published on the second Friday in the month prior to the cover date.

Distributed by: Argus Distribution Ltd.
Printed by: Q.B. Newspapers Limited, Colchester.

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

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BACK NUMBERS: Back numbers of many issues are available for 35p each plus 10p postage.
SUBSCRIPTIONS: Great Britain, £4.25 per year, Overseas, £4.75 per year. (Air Mail £7.50).

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ETI PROJECTS BOOK NUMBER TWO ... SEE PAGE 48

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HIGH-VALUE—PRINTED BOARD PACK. Hundreds of components, transistors, etc.—no two boards the same—no short-leaded transistor computer boards. **£1 75** post paid.

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As above but can have extended cover range down to 20KHz by addition of external capacitors. Order LX63E. Price **11·50** P. & P. 35p.

Both models can be used with any general purpose oscilloscope. Requires 6·3V AC input. Supplied connected for automatic 50Hz sweeping. An external sweep voltage can be used instead. These units are encapsulated for additional reliability, with the exception of the controls (not cased, not calibrated).

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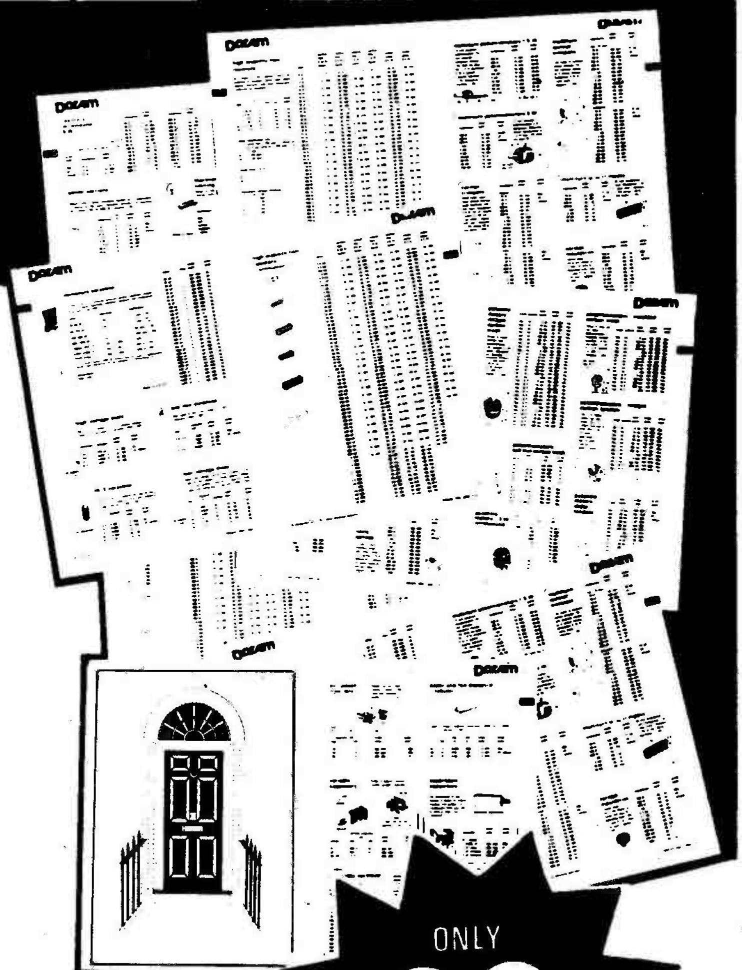

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ETI 8

news digest

NEXT FROM SINCLAIR: PROGRAMMABLE CALCULATOR

It is expected that Sinclair will be announcing another addition to their calculator range at about the time this issue goes on sale. No details are known other than the fact that the price will be 'well under £50', according to a spokesman for Sinclair.

SOLAR POWERED ENGINE

The Research Laboratories of the Delta Group are developing engines that utilise the Shape Memory Effect (SME) phenomenon to convert heat energy directly into mechanical energy. A deformed SME alloy will try to regain its original cold shape on heating, generating large forces which can be harnessed to do useful work.

The engine rotates about a central shaft and the SME elements are alternately heated by hot water and then cooled by cold water, once per revolution of the engine. This mechanical energy extracted maintains the rotation of the engine and provides motive power.

The hot water could be obtained at very little cost by solar heating, making the future of this invention very promising.

CMOS BROCHURE

Motorola have just published a 48-page CMOS brochure, available free to all electronics engineers. The brochure lists the entire Motorola CMOS family, accompanied by a full set of logic diagrams and technical data. There is a section devoted to equivalents of Motorola CMOS devices, including products of other manufacturers.

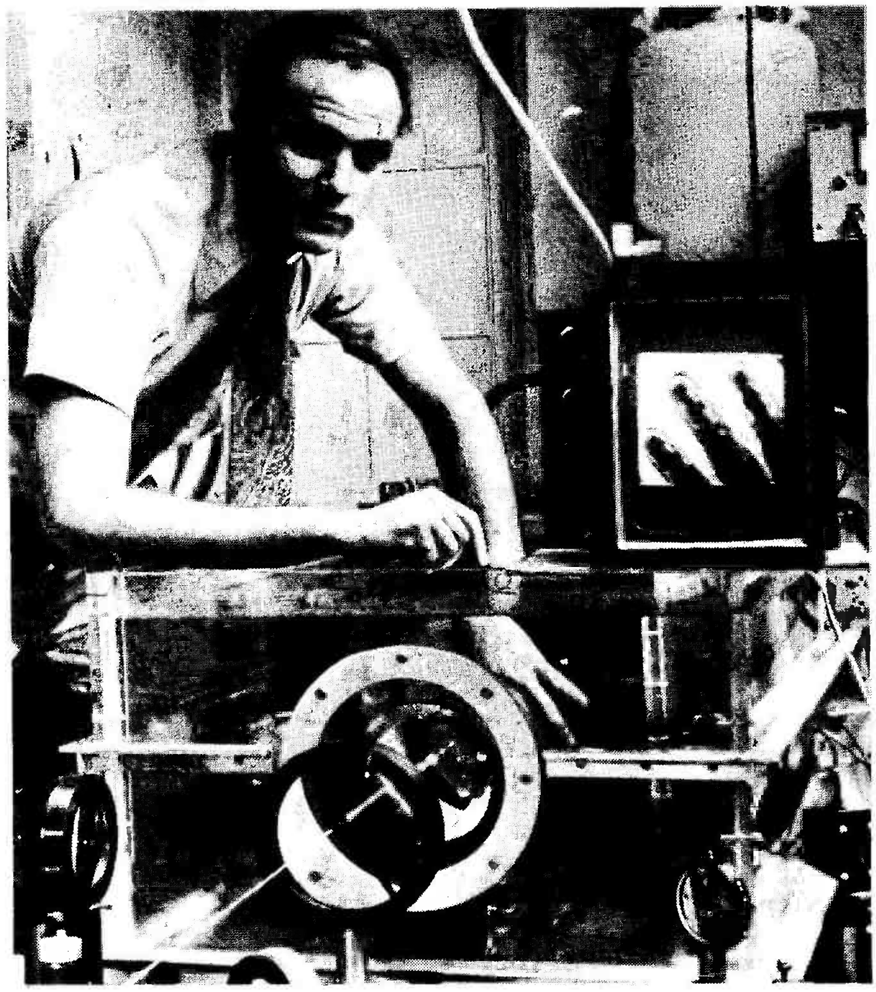
The brochure also includes a CMOS interface guide, design hints and a bibliography of applications notes and technical articles.

NEW CCTV CAMERA

Crow of Reading have a new television camera designed to meet the demand for high resolution pictures in closed-circuit television systems. The new camera the CT100, is British designed and built for systems operating on the 625-line 50-fields-per-second or the 525-line 60-fields-per-second standards. A special version, Model CT100/B, is available for operation from a 24 volt DC supply.

The design of the camera permits choice of pick-up tube; suitable types include vidicon, plumbicon, silicon, infra-red and ultra-violet, with fibre-optic or quartz faceplate.

From Crow of Reading Limited, P.O. Box 36, Reading RG1 2NB.



A new RCA ultrasound system expected to enhance the use of sound waves in detecting malignancies in human tissues is shown being demonstrated in the USA. The TV set on the right shows both the flesh and bones of three fingers of the patient's left hand, immersed in a water tank. Sound waves passing through the fingers strike a very thin pellicle, or membrane, within the tank, causing it to vibrate proportionately to the amplitude of the sound. A laser beam is used in detecting the microscopic pellicle vibrations.

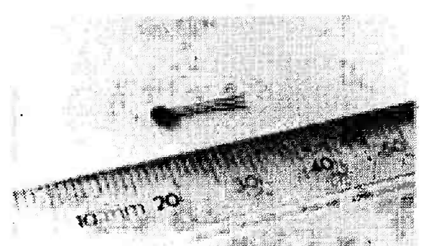
NEW GATED LINEAR AMPLIFIER

Ferranti has introduced a new Gated Linear Amplifier ideally suited to a wide variety of applications, ranging from high quality audio reproduction through to instrumentation, computing and many other allied fields.

Designated the ZN424, it offers a significant improvement over most contemporary op-amps. Open loop gain is approximately 86dB, with distortion of less than 1.5% THD, the noise figure is extremely low.

A data sheet is available from Ferranti which lists the most significant applications for the device, including audio preamplifiers, demodulator, phase sensitive detector, multiplexers, sample and hold circuit and photo cell encoder/decoder circuit.

Ferranti Limited, Gem Mill, Chadderton, Oldham, Lancashire, OL9 8NP.



A range of miniature transistors is being marketed by Micro Electronics Limited in Wembley, Middlesex. This includes NPN-PNP Complementary, high-gain, low-noise, high frequency, switching and high voltage types. The nominal body size is 1.8 x 1.5 x 1.3 mm. These transistors are designed mainly for hearing aids, paging receivers, electronic watches and thick-film hybrid circuits.

Details can be obtained from Micro Electronics Ltd., York House, Empire Way, Wembley, Mddx.

VAT RULINGS

H. M. Customs and Excise and the Electronic Components Board have had meetings subsequent to that reported last month. This has resulted in a much more detailed definition of goods at the standard and higher rates and supercedes that published last month. It will be seen that the list is substantially the same but there are changes, especially with regard to switches and thyristors.

1. Product categories to be charged at 25 per cent VAT
   a. TV cathode ray tubes.
   b. TV tuners including tuners featuring touch button controls and/or remote control units.
   c. TV delay lines.
   d. TV, radio and audio loudspeakers (except loudspeakers suitable only for public address purposes).
   e. TV and radio wound assemblies (deflection coils, colour correction coils, line output transformers, switched mode inductors, wound aerial rods, RF and IF wound assemblies).
   f. All receiving valves for domestic use.
   g. All voltage multipliers for domestic use (triplers etc).
   h. Modules for domestic appliances.
   i. Consumer modules for TV, radio and audio equipment.
   j. Linear integrated circuits suitable for use in TV, radio and audio equipment.
   k. i) Transistors, triacs and thyristors, plastic encapsulated and less than 3 amps rating.
      ii) Power transistors for TV deflection applications.
      iii) All plastic diodes of less than 1 amp rating, excepting 2(f).
      iv) All Zener diodes of power rating less than 3 watts.
      v) Rectifiers of a kind suitable for use in low voltage battery charger equipment having a current rating of less than 5 amps.
   l. Capacitators (excluding those types indicated in 2(m).)
   m. Resistors (excluding those types indicated in 2(n).)
   n. Switches having a rating of less than 5 amps and user controls (variable resistors etc) of less than 2 watts max. dissipation of a kind suitable for use in TV, radio and audio equipment.

2. Product categories to be charged at 8 per cent VAT
   a. Professional assemblies.
   b. Storage systems.
   c. Matrix stacks.
   d. Industrial assemblies (norbit logic elements, etc).
   e. Automobile assemblies (excluding those products used for in-car entertainment equipment - radio, stereo etc).
   f. Microwave products (tube, solid state or passive networks).
   g. Professional deflection assemblies.
   h. All professional tubes.
   i. Infra red devices.
   j. Integrated circuits (excluding items indicated in 1(j).)
   k. Ferrites and wound ferrites (excluding items indicated in 1(e).)
   l. All discrete semiconductors (excluding those items indicated in 1(k).)
   m. Capacitors:-
      i) Paper capacitors of greater than 0.5 microfarad and/or metal cased.
      ii) Sintered Tantalum capacitors of greater than 300 microfarad and/or metal cased.
      iii) Film capacitors meeting IEC specification 68.2 or equivalent (21 day humidity rating) and/or metal cased.
      iv) Electrolytic capacitors meeting IEC specification 103 type I - 85°C or equivalent specification or operating in excess of 200 V.a.c.
      v) Vacuum and pressure gas capacitors.
      vi) Mica capacitors.
   n. Resistors:-
      i) Metal film with a stability better than 1 per cent over 1000 hours.
      ii) Wirewound resistors (except main ballast resistors of a kind suitable for use in TV, radio or audio equipment).
   o. Edge Connectors and connectors for more than 8 ways.
   p. Electro mechanical components - excluding switches having a rating of less than 5 amps and users controls (variable resistors, etc) of less than 2 watts max. dissipation of a kind suitable for use in TV, radio and audio equipment.
   q. Magnets.
   r. Printed circuits for the assemblies described in items 2(a), 2(d) and 2(e).

LOW DEFINITION TV CLUB FORMED

Following a recent meeting at the Nottingham College of Education attended by low definition TV enthusiasts, an Association has been formed. Radio Amateurs are strongly represented and this promises a rapid expansion in the field of LDTV broadcasting in the near future.

The increasing interest in this field, which many have considered long dead, has been encouraged by applying modern components and techniques to the earlier principles.

Further information is available from D. B. Pitt, Esq., 1 Burnwood Drive, Wollaton, Nottingham.

BOWMAR PULLS OUT OF CALCULATOR AND DIGITAL WATCH MARKET

The cut-throat competition in the calculator market has landed the U.S. Bowmar Company in trouble. Bowmar had, until the decision to pull out, the No. 2. position in the U.S., itself the largest calculator market.

The reason for abandoning digital watches is less certain but perhaps they anticipate a similar position in the near future.

On total sales of £30 million, the loss was over £10 million. Bowmar however will continue to make displays.

1978 CALCULATOR SALES

MBA candidates at New York University recently performed a study of the sales of calculators on the domestic market in the U.S.

Their conclusion is that sales will reach 22 million units by 1978, almost double the 1974 figure of 12 million.

They predict that 85 per cent of the total market will be shared by Hewlett Packard Co.. Rockwell International and National Semiconductor Corporation. That is many smaller companies will either cease to exist or find it very difficult to maintain their share of the market.

Even though unit sales will almost double, lower unit prices will mean that sales volume in 1978 will amount to $900 million compared to last year's $658 million.

NEW USE FOR IMAGE MULTIPLIERS

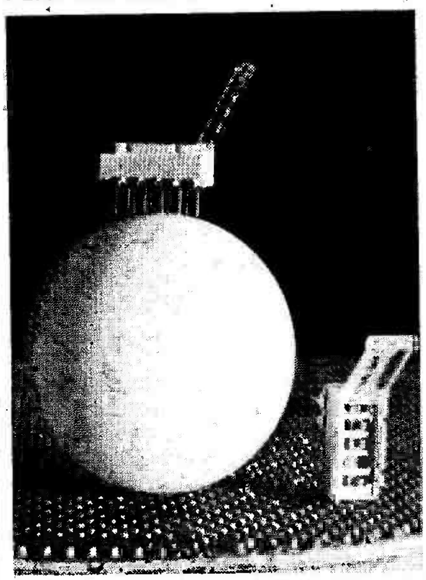
Image multipliers, used by astronomers to study the very faint light of distant stars, are now being used in the USSR for the diagnosis of disease.

Their use follows the discovery that the "super-weak" glow from living cells is an indication of their state of health.

For diagnostic purposes, doctors rely mainly on the faint luminescence of blood cells.

This is increased above the normal level by many infections and inflammation processes, but falls below normal in cases of cancer and some chronic disorders.

FLAT DIL MINI SWITCHES



Siemens has just brought out three types of mini p.c.b. switch containing four, five or eight unipolar on/off switches. The unit has a height of 6.5mm.

BRIGHT 11MM NUMERIC LEDS

New displays, as much as fives times brighter than other HP displays are available from Hewlett Packard. The brightness and height makes them ideal for applications in high ambient light conditions (such as point-of-sale terminals).

Displays 5082-7650, −7660 and −7670 are red, yellow and green common anode, seven segment displays with left-hand decimal point. LED chips are optically magnified to form evenly-lighted segments. Hewlett Packard 5082-7600 Series red, yellow and green high-efficiency numeric displays are £1.75 each in quantities of 100, from Celdis Ltd., 37-39 Loverock Road, Reading, Berks RG3 1ED or GDS Sales Ltd., Michaelmas House, Salt Hill, Bath Road, Slough, Berkshire SL1 3UZ.

NEW 3M CASSETTES

A new range of low-noise, high-output cassettes from 3M is claimed to be 9dB up in high frequency response (over standard cassettes). Scotch New High Energy cassettes feature a completely new gamma ferric oxide tape - not a cobalt tape as previously employed. The uniformity and size of the acicular (needle-like) crystals is very accurately controlled during the manufacturing process to enable a high density coating to be produced for extended high frequency response.

Recommended retail prices excluding VAT are: C.45 - 94p; C.60 - £1.16; C.90 - £1.56.

ELECTRIC VAN USES A.C.

Battery operated cars and buses are being developed in many countries including Britain but an electric van now being tested in Moscow uses an unusual approach.

The battery voltage is converted to AC using thyristors before being controlled and applied to the motors. The design team claim that experiments show improved efficiency, reliability and weight reduction.

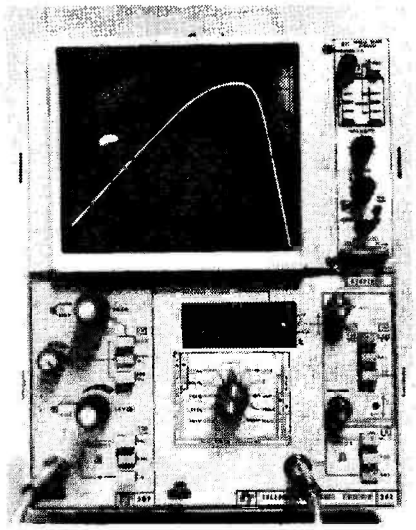
¾-INCH 10-STAGE PHOTOMULTIPLIER

A ¾-inch diameter, 10-stage, head-on photomultiplier tube has been announced by RCA Components. The RCA 4836, is designed primarily for use in helium-neon and ruby laser detection systems. It has high responsivity in the red and near infrared regions of the spectrum. RCA, Sunbury-on-Thames, Middlesex.

PUSH BUTTON TELEPHONE DIALLER AND REPERTORY TELEPHONE STORE IC'S

Details of two newly introduced I.C.'s for telephone applications - the MP 9100 push button telephone dialler and the MP9200 repertory telephone store - have been released by Plessey. The MP9100 is a p-channel low threshold MOS integrated circuit containing the logic required to interface between a standard MF keyboard and a Strowger-type telephone system. Up to 20 digits and 'dial tone waits' can be stored and dialled directly or re-dialled if required. Features include programmable dialling speed, dial pulse mark/space ratio, and interdigit pause.

Plessey Semiconductors, Cheney Manor, Swindon, Wilts.



This audio sweep analyser is capable of providing all essential measurements needed to set up, test and monitor speech, music, data and broadcast channels and systems. It is available from Wandel & Goltermann (UK) Limited, High Street, Acton, London, W.3.

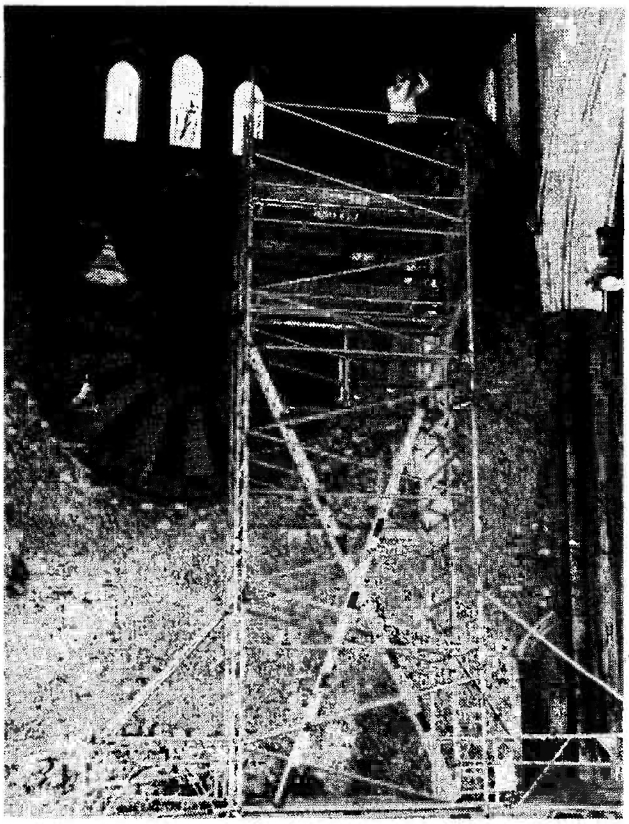
TV IMAGE SENSOR

A self-scanned solid-state image sensor, which can replace conventional TV camera tubes, has been introduced by RCA Electro-Optics. The SID51232 is a high resolution 512 x 320 element silicon imaging device.

The SID51232 eliminates the need for large scanning coils, and there is no image lag.

The new camera 'eye' is the first solid-state image sensor to generate fully standard 525-line video compatible with present TV monitors and accessories. The SID us based upon charge-coupled device (CCD) technology which uses the principle of transferring electrical charges along the surface of silicon wafers. By varying the intensities of light falling upon the wafer surface, proportional changes are produced in the charge collected by the corresponding elements of the CCD. The charge packets are read out by sequentially transferring them to the input of an on-chip video preamplifier.

The SID51232 is supplied in a hermetically-sealed, 24-connection, edge-contacted, ceramic package. The package contains an optical glass window which allows an image to be focused onto the sensor's 12.2mm image diagonal. Physical dimensions of both versions are 30.48mm long x 20.07mm wide x 3.30mm thick. Supply voltage requirements vary from -5 to +20 volts d.c. Operating temperature range is -40°C to +65°C. RCA Electro-Optics, Sunbury-on-Thames, Middlesex.



The surveying team measuring the position of one of the arch braces holding up the roof of the Great Hall at the Castle, Winchester. The survey, which was carried out last week using a DM 500 electronic distance meter, is the first stage in a programme of renovation of the Great Hall. The operator on the scaffolding is holding a retro-reflector which returns an infra-red beam from an instrument on the ground. (Survey & General Instrument Co. Ltd., Fircroft Way, Edenbridge, Kent.)

"ADMIT IT ......YOU'RE WELL OUT OF YOUR DEPTH WITH THIS JOB!!"

GROUND PROXIMITY WARNING SYSTEM

A new Ground Proximity Warning System (GPWS), for commercial airliners, has been announced by Plessey in response to the FAA ruling requiring that all US registered turbine powered aircraft are fitted with such equipment by December Ist. Similar legislation is expected to be introduced in the UK during 1976.

The GPWS gives visual and aural warning of potentially hazardous flight conditions which, if uncorrected, could lead to a crash. The audible warning consists of a synthesized voice giving an imperative warning together with the command "CLIMB" or "PULL UP", according to customer preference; this is accompanied by a continuously flashing captioned light. Both warnings continue until the hazardous situation has passed.

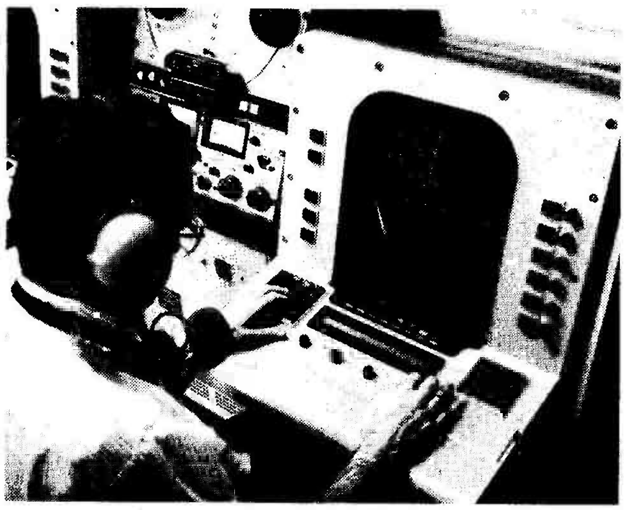
The heart of the system is a microprocessor unit developed by Plessey; this advanced technology mini-computer has more than sufficient capacity to meet the demands and can easily accommodate future developments. Currently, the system devices inputs from the radar/radio altimeter, the air data computer/barometric altimeter, the glideslope/localizer receiver and the landing gear and flap selectors. Discussions have taken place between Plessey Aerospace and a number of airlines in both America and Europe and already an order for the system has been placed by an American local service airline. It is anticipated that deliveries will start in the autumn of this year.

TV GAMES LSI CHIP AVAILABLE SOON

Rumours have been abounding for about a year now that an LSI chip for television games was being developed.

We now have definite news that Logic Leisure, a British Company, have produced a chip which will produce four TV games, with two variations on each, giving eight permutations. There is score and sound facility. Type number is not yet known but the chip is suitable for both 625-line, 50Hz and 525-line, 60Hz.

It is hoped that the chip will be on sale in October and the price tag is going to be in the £10-£12 range (plus VAT). U.K. distributorship is in the hands of Television Sprots Co. Ltd., 6 Half Moon Street, Mayfair, London, WIY 7RA.



A prototype trainer to develop skills in the operation of submarine fire control systems is being developed by Hughes Aircraft Company of California under a contract from the US Navy. Here an engineer reacts to simulated submarine fire control problem on a weapon control console. Submariners will use the device to learn techniques of target locating, weapon pre setting and other functions involved in modern undersea warfare.

Continued on page 67.

MODERN FM RECEIVING TECHNIQUES

In this new series Brian Dance looks at the options facing the enthusiast who wishes to design and build his own FM receiver. The series will be accompanied by a constructional project — the ETI FM Tuner.

DURING the past few years the availability of specially designed linear integrated circuits, ceramic filters and complete front-end units has revolutionised the design of FM receivers. It is now easy for both the receiver design engineer and for the amateur enthusiast to construct receivers of the highest quality.No longer is it necessary to carefully align IF strips and ratio detectors with the knowledge that audio distortion will be the probable penalty if one does not achieve satisfactory adjustment of all the tuned circuits.

This article provides readers with a general review of the techniques developed in the past few years, with particular reference to the needs of the amateur constructor. Many of the devices however are so new that they are not generally available at the time of writing.

Even relative newcomers to electronics should have no difficulty in constructing a receiver using the circuits described. One must take reasonable precautions to keep the length of leads carrying radio frequencies (including IFs) short, but this is less important today than when thermionic valve circuits were used (high circuit impedances rendered stray coupling more probable).

FM receivers will be considered in three main sections: (i) **The front-end** in which the incoming signal frequency (88 to 108MHz) is converted to the normal intermediate frequency of 10.7 MHz; (ii) **The 10.7MHz amplifier** and **demodulator** circuits; and (iii) The **stereo decoder** circuit.

The discussion will be limited to modern, high performance circuits.

THE FRONT-END

The aerial feeds a signal to the 'front-end' of the receiver where it is first amplified by the RF stage before being fed to the mixer. An oscillator signal generated in the front-end is also fed to the mixer. The mixer circuit produces the difference frequency between the input signal and the oscillator frequency. The tuning of the receiver (including the oscillator) ensures that this difference frequency is always kept at 10.7MHz no matter what frequency is being received.

The home constructor can build a front-end unit from discrete components, but inexperienced constructors are not advised to do so. Lead lengths (and hence the positioning of components) can be very critical at frequencies of the order of 100MHz. The stray capacitance and inductance of 1cm of wire are often important in such circuits. Then the front-end has to be aligned, although this is not generally very difficult.

The commercially-built front-end units currently available will be discussed in detail. However, there is no reason why an experienced constructor should not make a front-end unit himself for use with the other circuits to be discussed. A front-end unit using one of the latest ICs can give a very high performance and will be described for the benefit of experienced workers.

TYPES OF FRONT-END

Perhaps the most important decision one has to make when selecting a front-end unit is whether

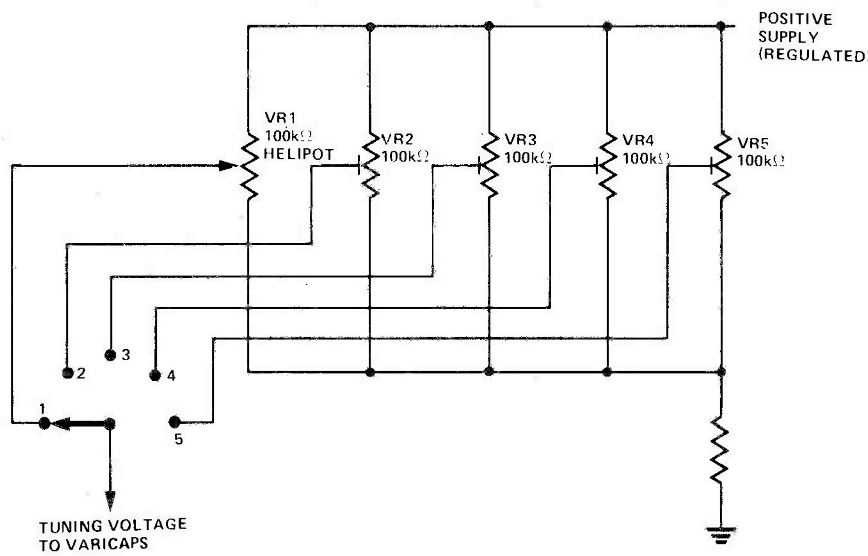


Fig. 1. Simple tuning circuit for a Varicap front-end providing both switched and continuous coverage.

to employ one which is tuned by a ganged variable capacitor or one tuned by 'Varicap' (varactor) diodes. The latter are silicon diodes specially designed for use as variable capacitors, the value of their junction capacitance changing with the voltage applied to them. As the applied voltage is increased, the distance across the semiconductor junction increases and the capacitance becomes smaller.

If a Varicap diode is connected across a tuned circuit, the resonant frequency of the circuit can be changed by altering the voltage applied to the diode. In practice this same tuning voltage is applied to several diodes connected across different tuned circuits so that the resonant frequencies of the latter change simultaneously. This arrangement of Varicap diodes can thus replace a ganged capacitor. As the tuning voltage is increased, the frequency to which the receiver is tuned also increases; the relationship between the tuning voltage and the frequency of the signal being received is non-linear.

A typical Varicap tuning system favoured by the writer is shown in Fig. 1. When S1 is in position 1, the tuning voltage fed to the Varicap diodes in the front-end is obtained from the Beckman 'Helipot VR1 This is a ten-turn helical potentiometer which thus provides a good slow motion action for fine tuning. A Beckman type RB dial or a digital dial is fitted to VR1 Although this dial does not provide an indication in MHz of the frequency being received, it can be accurately reset to any point used previously.

For ordinary domestic reception, it is much more convenient to have switched tuning than continuously variable tuning. Each of the other positions of S1 enables a preset frequency to be received, these preset frequencies being determined by the preset trimmers VR2, VR3, etc. Any reasonable number of switched frequencies can be employed by employing a separate trimmer for each. The writer has used Beckman type 89P 15-turn preset trimmers for this application, since they can be adjusted far more easily than a single turn potentiometer.

The circuit of Fig. 1 thus provides both switched and continuous frequency coverage. If desired, only continuous tuning may be used. In a receiver for use in the home, switched tuning alone is often satisfactory, but in a car radio receiver one also requires continuous tuning unless the car is used in only one locality. Otherwise one would have to adjust the trimmers whenever one moved into a new area.

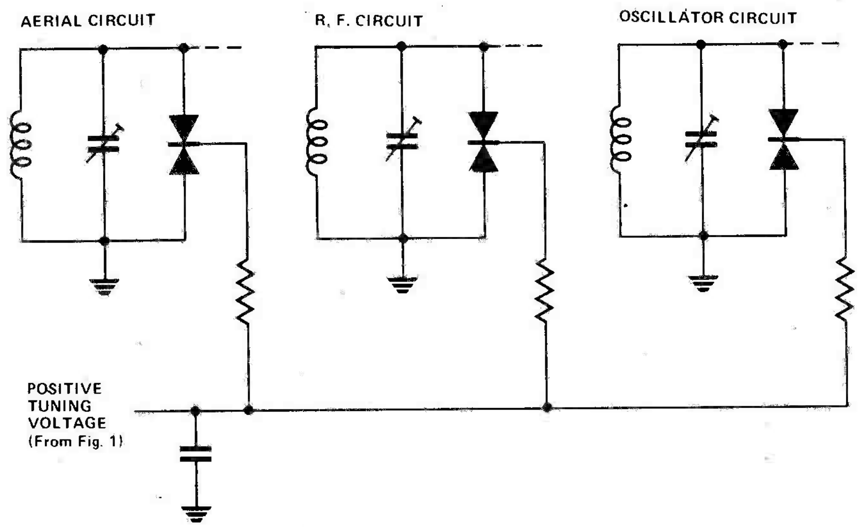


Fig. 2. Basic circuit showing tuning with back-to-back Varicap diodes.

When using Varicap diodes the optimum performance is obtained with 'back-to-back' diodes connected as in Fig. 2. The tuning voltage is applied to the junction of the diodes which are both reverse biased; they therefore present a very high impedance to the tuned circuits.

The use of Varicap tuning in an FM receiver has the advantage that the tuned circuits being controlled can be placed in any position, whereas the use of a ganged capacitor necessitates the circuits being placed close to the capacitor. The latter position may not be the most favourable one from either electronic considerations or from the constructional point of view.

Varicap tuning systems enable the tuning unit to be placed at a point remote from the front-end unit and the individual tuned circuits can be placed in any convenient position. The tuning voltage can easily be obtained from a tapping on a ten-turn helical potentiometer. However, the Varicap tuning voltage must be very well smoothed, since any 50Hz ripple in this voltage will cause a 50Hz frequency variation in the IF signal which will be demodulated to produce hum. The use of Varicap tuning therefore involves the use of a voltage regulator circuit and this adds to the cost. The writer normally uses a TBA 625B (SGS-Ates) integrated circuit voltage regulator when a 12V supply is required or a TBA 625C when a 15V supply is needed. These regulators contain internal circuitry which limits the short circuit current to about 30mA and this should prevent damage to any devices if the constructor accidentally shorts any component.

In FM/AM receivers, a ganged tuning capacitor is normally employed with separate sections in each gang for the AM and FM tuning. Unfortunately variable capacitance diodes with an adequate capacitance swing for AM tuning are quite expensive and it is not normally economical to use Varicaps for AM reception. It is common practice to use a ganged capacitor and scale in such receivers.

To summarise, it is generally preferable to use Varicap tuning in an FM receiver for optimum performance and convenience. However, one may use ganged capacitor tuning — for reasons of economy or because one wishes to have a common tuning control in an FM/AM receiver.

OTHER FACTORS

The performance and price of FM front-ends is also affected by other factors. In general, a VHF front-end employing a MOSFET (Metal Oxide Semiconductor Field Effect Transistor) as an RF amplifier will provide lower cross modulation than front-ends which employ only bipolar transistors. Cross modulation causes problems when one wishes to receive a weak signal close in frequency to a much stronger one.

Some front-ends also employ a MOSFET device as a mixer to reduce cross modulation in this stage and to provide much better isolation between the oscillator and the input. Another approach involves the use of a number of tuned circuits between the RF stage and the mixer to reject unwanted signals before they reach the mixer. Such units are normally tuned by Varicaps, since the use of a ganged

MODERN FM RECEIVER TECHNIQUES

capacitor with enough sections would be inconvenient.

It is desirable that a front-end should provide high rejection of image and other spurious signals, especially if one lives near to an FM station or if one lives in a large city where fire- police and ambulance transmissions are likely to be present.

The noise level of a tuner can also be important, since it affects the minimum signal strength which can be received. It is normally expressed as a 'noise figure' or 'noise factor', a value of 6 dB being typical. The lower the noise figure, the less the amount of noise added to the signal in the front-end. A difference of 2dB to 3dB is only just noticeable.

The input impedance of a front-end unit normally has one of two values. It may be about 75 ohms unbalanced for matching to the co-axial cable used to connect the aerial. Alternatively the input may be balanced with an impedance of about 300 ohms for matching to twin feeder cable. (In a balanced input, neither side is earthed, but in an unbalanced system, the outer braiding of the co-axial cable must be connected to the earthed side of the front-end input.) Although matching is by no means critical, it is advisable to obtain a reasonable match when the signal strength is low, especially if stereo reception is required. At high signal levels 2ft of wire can be used as an aerial, but a better outdoor aerial will reduce noise from passing traffic, etc.

The output impedance of a front-end unit is not very important, but it is wise to consider it when matching the succeeding circuit. Note whether your front-end has provision for AGC and/or AFC and how much the frequency of the oscillator drifts with temperature and the power supply voltage.

Do not pay much attention to the recommended power supply voltage when selecting a front-end unit; such units do not normally require more than +12V and this can easily be obtained from the receiver power supply.

TABLE ONE

	TOKO EF-5600U/ EF-5603U	TOKO EC-3302U	LARSHOLT 8319	MULLARD LP1186	TOKO MT-3302UG	TOKO ET-703UA
Type of tuning	VARICAP	VARICAP	VARICAP	VARICAP	GANGED CAPACITOR	GANGED CAPACITOR
Recommended supply (V)	+12	+9	+12	+8	+9	+6
Minimum supply (V)	+9	+6.3		+6	+6.3	
Supply current (mA)	17 (max)	16 (max)	25	6.1	18 (max)	5
Frequency range (MHz)	87 to 109	87 to 109	87.5 to 108.5	87.4 to 104.5 +2 to +12V	87 to 109	87 to 109
for Varicap supply (V)	+3 to +25	+2 to +20	+2.3 to +18	87.4 to 108 +2 to +17V		
Gain (dB)	30 (min)	22 (min)	32	30	25 (min)	16 (min)
Noise figure (dB)	7 (max)	7 (max)	5	6.5	8 (max)	10 (max)
Aerial impedance (Ω)	75	300 (bal.)	75 or 300 (bal.)	75	300 (bal.)	300 (bal.)
Output impedance (Ω)	75	300	Recommended load 150	75	300	1000
Image rejection (dB)	90 (min)	45 (min) (108MHz)	56	40	45 (min) (108MHz)	25 (min)
I.F. rejection (dB)	90 (min)	50 (min) (108MHz)	80	65	50 (min) 98MHz	45 (min)
Spurious rejection (dB)	90 (min) (98±5MHz)	50 (min) (98±5MHz)			50 (min)	30 (min)
Osc. stability with respect to (i) supply voltage		±50kHz (max) for 10% change	50kHz/V	60kHz/V	±150kHz (max) for 10% change	
(ii) Temperature	±100kHz (max) 25°C to 55°C	±150kHz (max) 25°C to 55°C		−10kHz/°C rise	±150kHz (max) 25°C to 55°C	
A.F.C.	Only EF5600U	±120kHz (min) (108MHz)	1.5MHz/V	±200kHz	±120kHz (min)	±200kHz for 0.5V at 108MHz
Output bandwidth (-3dB)	300kHz +120 −60	200kHz (min) (98MHz)	300kHz	200kHz (min)	350kHz	
Gain spread (dB)	6 (max)	4 (max)		1 (max 6)	4 (max)	
R.F. Amplifier	Dual gate MOSFET	Single gate MOSFET	Dual gate MOSFET	MOSFET	Single gate MOSFET	Bipolar
Mixer	Bipolar	Bipolar	Dual gate MOSFET	Bipolar	Bipolar	Bipolar
Total no. of transistors	4	3	3	3	3	2
No. of Varicaps	5 back-to-back	3 single	4 back-to-back	3 single		
No. of 10.7MHz tuned circuits	2	1	2	2	1	1
Capacitor: Angle of rotation					540° ± 6°	540° ± 6°
A.M. tuning (pF)					190.6 76.5 (osc)	323 323
A.M. Trimmers (pF)					12	12

SOME FRONT-ENDS

We will now consider some well-known front-ends. Prices range from just over £3 up to about £8.40 (at present).

Details of a number of front-ends are given in Table 1. The Toko EF-5600U and EF-5603U are high performance units, the difference between them being that the EF-5603U does not have provision for the application of AGC and AFC control voltages. They are neither the cheapest nor the smallest front-end units, but they have an exceptionally good specification. Both of these units have three tuned circuits between the RF stage and the mixer and this enables the high rejection figure of 90db to be obtained against all spurious frequencies. The dimensions of the EF-5600U/5603U are 90x70 x33mm. BB-104 'back-to-back' dual Varicap diodes are used in the five tuned circuits to cancel out the non-linearities in each individual diode.

The emitter of the mixer circuit is connected to a test point (normally left unconnected). The output from the collector circuit of the mixer is fed into two 10.7MHz inductively coupled tuned circuits and then into an emitter follower output stage. This provides a low impedance output. A 0.01μF series capacitor is included in the output circuit enabling direct connection to any succeeding circuit.

THE TOKO EC-3302U

The Toko EC-3302U front-end is another Varicap tuner but smaller and cheaper than the EF-5600U/5603U types. It employs three single Varicap diodes and provides less rejection of spurious signals than the more expensive Toko front-ends. Nevertheless it provides a perfectly adequate performance. As shown in Table 1, the supply voltage can be lower than that required for the EF5600U/5603U.

The EC-3302U output is obtained by means of a coil coupled to the 10.7MHz tuned circuit which is the collector load of the mixer. In many circuits it will therefore be necessary to connect a series capacitor in the output of this front-end to prevent a steady current flowing from the succeeding circuit through the output coupling coil.

The EC-3302U has provision for the application of AFC, but not AGC.

LARSHOLT 8319

The Larsholt 8319 has a slightly better noise figure than the other Varicap tuners shown in Table 1, whilst its capability of rejecting spurious frequencies is intermediate between that of the two Toko types. Four 'back-to-back' BB-104 Varicap diodes are employed and there are two tuned circuits between the RF stage and the mixer.

An unusual feature of the 8319 is the two aerial input impedances. Either a balanced 300 ohm feeder or a 75 ohm unbalanced co-axial cable can be matched by using appropriate tappings on the front-end aerial coil. Dual gate MOSFETs are used in both the RF and mixer stages of this unit. There is provision for the application of AFC to the oscillator stage, but AGC is not used with this tuner.

MULLARD LP1186

The LP1186 is one of a series of Mullard modules, and is 62x31x17mm in size. Although it was originally designed for use with a LP1185 IF amplifier/demodulator module, a somewhat better performance can be obtained by using one of the integrated circuit IF units to be discussed later.

Eight wire connections project from the base of the LP1186 and can be fitted into a standard 'Lektrokit' board which has holes spaced at 0.1in intervals.When connecting wires are soldered to these connections, the solder will hold the module in position. The writer found the LP1186 a very convenient module to use, but at the time of writing it is in short supply. It requires less operating current than the other Varicap tuners covered here.

GANGED CAPACITOR TUNING

The Toko ET-703UA is one of the most economical FM tuners currently available. It employs a two-gang tuning capacitor with a two-gang AM section. The aerial circuit is fixed tuned. A slow motion drive (ratio 3:1) with spring loaded gears is incorporated. Although its specification (see Table 1) is not up to the standard of the more expensive front-ends, the writer has used an ET-703U and found it very satisfactory except when used with a NE563 demolulator circuit. This is because an appreciable oscillator voltage is present at the output of the unit. Whilst this can be reduced by connecting a capacitor (about 82pF) from the output to ground, there is still enough voltage to cause beats with a NE563 oscillator stage. A single transistor is used as mixer and oscillator in the ET-703UA. The output impedance (1k) is rather high. There is provision for the application of AFC but not AGC.

The Toko MT-3302UG front-end is also tuned by a ganged capacitor, but three FM (and two AM) sections are used so that the aerial section can be tuned. This new front-end has many features of the ET-703UA, but the use of a separate oscillator transistor and a MOSFET RF stage have enabled the specification to be considerably improved. As in the earlier ET703UA, there is a facility for applying AFC, but not AGC.

THE SD6000

In the past VHF receivers have always employed discrete semiconductor devices in the front-end unit, since linear ICs which can operate at 100MHz have not been available. This position has been changed, however, by the recent development of the SD6000 device by Signetics in California.

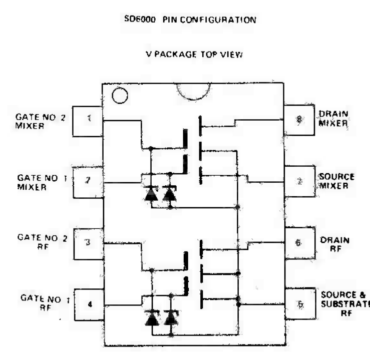


Fig. 3. The internal components of the SD6000.

The SD6000 is encapsulated in a normal eight-pin dual-in-line package. As shown in Fig. 3, it contains an RF dual gate field effect transistor and a similar device used as a mixer. These devices are manufactured by the special Signetics D-MOS (Diffused Metal Oxide Silicon) process which has been used in earlier Signetics discrete devices. It enables precisely controlled channels of less than 1 micron in length to be produced with extremely low parasitic capacitances.

D-MOS devices, like all MOSFET transistors, have very high impedances in their gate connection.

They could easily pick up static voltages which would ruin the devices, but puncturing the insulating layer, if the zener diode connected from each gate to the substrate were omitted. These diodes bypass any static or other voltages which are more positive than +25V or more negative than 0.3V. No special precautions are therefore required in handling the SD6000 or when soldering it into the circuit. If one does not employ an IC socket, it is naturally advisable to use an earthed soldering iron — as with all low power semiconductor devices.

The two D-MOS devices in the SD6000 are positioned in the package in such a way that coupling between them is reduced to a minimum. This not only reduced radiation of the local oscillator signal from the aerial, but also eases stability problems.

The two devices in the SD6000 package each have a maximum permissible drain current of 50mA. The gate leakage and drain currents are each typically 1nA, whilst the feedback capacitance has the very small value of about 0.03pF.

TYPICAL CIRCUIT

A typical high performance front-end circuit using the SK6000 is shown in Fig. 4. It tunes over the normal range of 88 to 108MHz. The SD6000 has also been used in high performance Varicap tuned front-ends.

The noise performance of the SD6000 is really first class, the typical figure being 2,5dB at 100MHz (maximum 3db). The power gain at the same frequency is typically 30dB. The typical variation of the noise figure and gain of the RF stage with the drain current is shown in Fig. 5. The bandwidth is about 300kHz, this being determined almost entirely by the 10.7MHz output transformer.

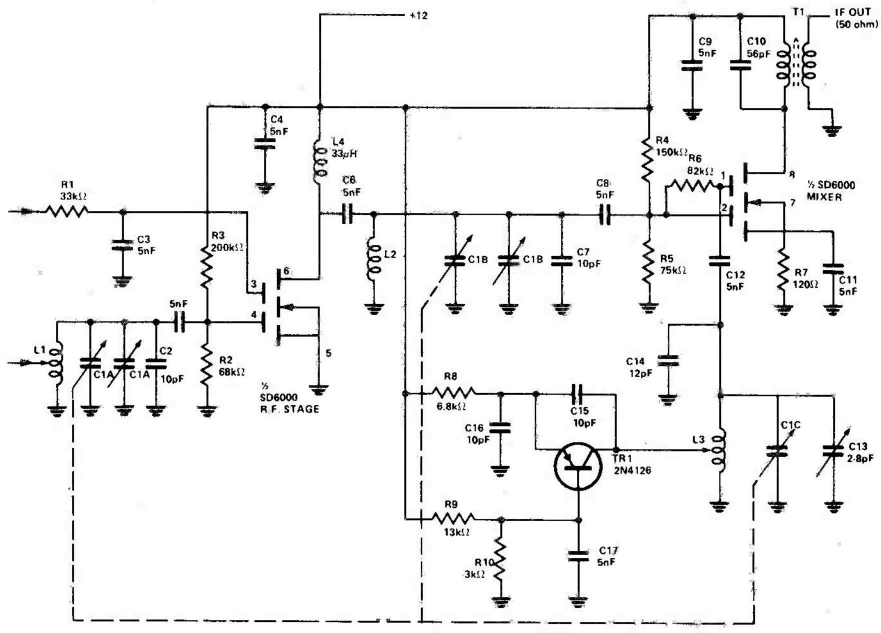


Fig. 4. A typical SD6000 circuit using a three-gang capacitor.

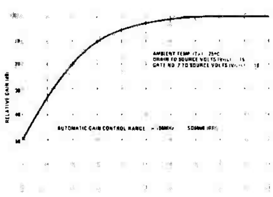


Fig. 6. AGC characteristic of the SD6000 RF stage.

AGC characteristic is shown in Fig. 6, 50dB variation of gain being attainable at 100MHz.

Oscillator voltage from the 2N4126 oscillator stage is fed to gate 2 of the mixer, whilst the signal voltage from the RF stage is applied to gate 1. The use of separate gates of the D-MOS device in this way provides very high isolation between the local oscillator and the aerial circuit and hence minimises spurious radiation. The oscillator stability is of the order of 40kHz per volt change in the supply voltage, whilst a rise in temperature of 10° C may increase the oscillator frequency by about 100kHz.

Details of the coils in Fig. 4 are shown in Table 2. However, newcomers to electronics are advised not to try VHF circuitry.

This article has shown how the incoming signal from the aerial can be amplified at low noise and converted into a 10.7MHz IF signal. Next month we shall consider who this output from the front-end unit can be used to provide the required audio output signal.

The writer is indebted to Mr Russ Hansen of Signetics, California, for providing detailed advance information on the SD6000. Most of the tuners mentioned in this article are available from Ambit International 37 High Street, Brentwood, Essex CM14 4RH.

To be continued next month . . .

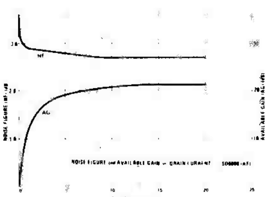


Fig. 5. Noise figure and available gain of the SD6000 RF stage at various values of the drain current.

The incoming signal is tuned by the aerial circuit, after which it passes to gate 1 (pin 4) of the SD6000. AGC is applied to gate 2 (pin 3) of the device. The excellent

TABLE TWO

T1	**10.7MHz transformer**	Cambion type 533-3652-003 J core Primary 30t 26 gauge J core Secondary 2t 26 gauge
L1	**Aerial coil**	4 turns 18 gauge, 3/16 in diam. Air core. Tap 1 turn from the ground sie.
L2	**RF coil**	4 turns 18 gauge on 3/16in diam. air core
L3	**Oscillator coil**	4 turns 18 gauge on 3/16in diam. air core, centre tapped
L4	**Choke**	33µH approx
Tuning capacitor		5 to 20pF, 3 gang

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CA3046	70p	CD4047	£1·65	SL612C	£1·70	SN7454	16p	SN74163	£1·10
CA3048	£2·11	CD4049	81p	SL62DC	£2·60	SN7460	16p	SN74164	£2·01
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CD4006	£1·58	LM702C	75p	SN7402	16p	SN7480	50p	SN74181	£1·95
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CD4009	£1·18	14DIL	40p	SN7405	19p	SN7483	95p	SN74192	£1·15
CD4010	£1·18	LM710	47p	SN7406	45p	SN7484	95p	SN74193	£1·15
CD4011	36p	LM723C	90p	SN7407	45p	SN7485	£1·25	SN74196	£1·60
CD4012	36p	LM741C	40p	SN7408	19p	SN7486	32p	SN74197	£1·58
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CD4022	£1·66	LM7824	£2·50	SN7425	29p	SN74118	£1·00	TAA550	60p
CD4023	36p	MC1303L	£1·50	SN7427	29p	SN74119	£1·92	TAA611C	£2·18
CD4024	£1·24	MC1310P	£2·59	SN7430	16p	SN74121	37p	TAA621	£2·03
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2N2904	22p	40407	35p	BC212A	16p	BFX30	27p	1N3754	15p
2N2905	25p	40408	50p	BC212LA	16p	BFX84	24p	1N4007	10p
2N2906	19p	40409	52p	BC213LA	15p	BFX85	30p	1N4148	7p
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2N3391	28p	AC126	20p	BC259B	17p	ME0412	18p	BA155	12p
2N3392	15p	AC127	20p	BC301	34p	ME4102	11p	BB103B	23p
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2N3704	15p	AC188K	40p	BCY71	22p	MJE370	65p	OA81	18p
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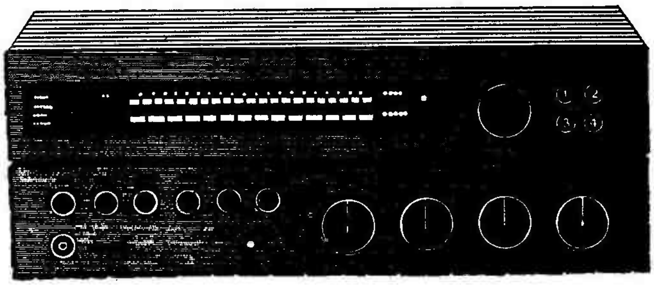

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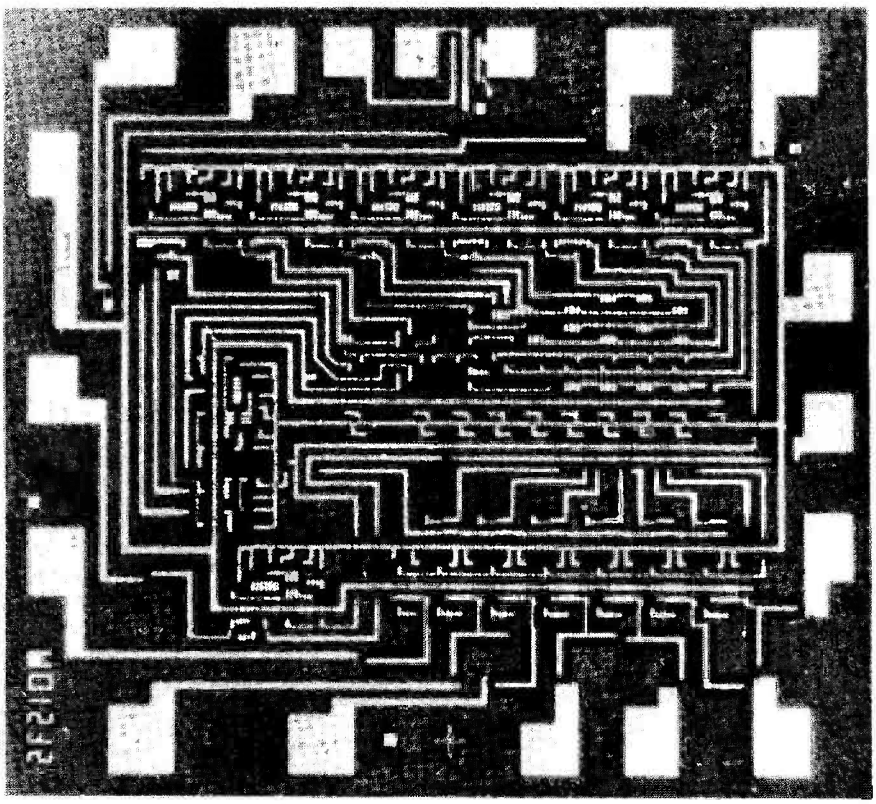
When using a transistor, or IC we know that somewhere inside the package is a small piece of germanium or silicon that performs all the electronic functions. Keith Pitt tells us how it gets there:

HOW SEMICONDUCTORS ARE MADE



MOS digital integrated circuit chip

This short article is intended to show some of the manufacturing stages of silicon devices. (Although they are still being made in quantity, germanium transistors are obsolescent.) The processes described here apply specifically to bipolar devices. MOS integrated circuits, however, are made using the same principles of oxide, masking, diffusion and photolithography.

SEMICONDUCTORS

The electrons which form the chemical bonds holding a metal together are not bound to any particular atom but are shared by all of them. This means that they are free to move around when a voltage is applied and electrons moving under such influence form an electric current. Hence the characteristic low resistance found in metals. In contrast, the electrons in an insulator are firmly bound in fixed positions forming strong chemical bonds that are very difficult to break. As there are no mobile electrons, no current flows. A semiconductor is basically similar. The electrons are not held quite so tightly and the energy of thermal vibration of the crystal lattice at room temperature is sufficient to release a small number of them. As a result it conducts, but not very well. Hence the name: "semiconductor."

The elements of the fourth group of the periodic classification of the elements are carbon, silicon, germanium, tin and lead. The latter two are metals, but the first three all crystallise in the characteristic cubic lattice of diamond. Diamond itself is an insulator, because the energy required to knock an electron out of a bond is extremely high, and is unlikely to be available under normal conditions. At very low temperatures pure germanium and silicon are also in effect insulators, but they both have significant conductivity at room temperature.

When an electron is broken from a bond, it does not actually leave the crystal but "wanders around" inside it. In order to retain electrical neutrality a positive charge ("positive hole" usually simply called a "hole") results at the broken bond. This broken bond can move around when a field is applied, just like an electron, but in the opposite direction because of the sign. In a pure or "intrinsic" semiconductor the numbers of holes and electrons are equal.

This balance can be upset by adding about one part in a hundred million of an impurity atom that has either one more, or one less, electron per atom than silicon. The boron atom has only three bonding electrons compared to silicon's four. As a result its introduction into the lattice brings an excess of holes. Similarly, phosphorus has five and its introduction brings an excess of electrons.

A semiconductor with an excess of electrons (negative charges) is called 'n-type' and one with an excess of holes (positive charges) is called "p-type". (There are still a few holes in n-type and a few electrons in p-type due to the breaking of chemical bonds due to thermal energy and these "minority carriers" are important in the operation of a transistor although this does not concern us here.)

If, within a piece of silicon crystal, there is a change from p-type to n-type, we have a "pn junction". This has rectifying properties. If the bias is one way the resistance is low and, if the other way, it is very high. In essence the production of integrated circuits and transistors is the making of these junctions in a controlled way in a piece of semiconductor crystal.

SILICON PROCESSING

The impurities, boron for p-type and phosphorus for n-type, are introduced into a piece of silicon by a process called "diffusion". If, for example, boron atoms are deposited on the surface, and the whole lot heated to about 1000°C some will "worm their way" or diffuse into the silicon lattice making it p-type. The exact number going in and the distance involved can be calculated and controlled. Conversely, phosphorus atoms in the same way will make it n-type.

If the crystal is already n-type, an excess of boron atoms will turn it into p-type as far as they diffuse in leaving the remainder as it was and giving rise to a pn junction. Conversely we can also turn a p-type crystal to n-type. However, diffusion cannot take place through an oxide layer. We therefore oxidise the surface and selectively diffuse through "windows" etched in the oxide, to define the areas needed for the device.

This method of making silicon devices is known as the "epitaxial planar process". It is "planar" because all the processing is carried out from one side of a thin slice or "plane" of silicon. It is "epitaxial" because the actual device is formed in a thin layer of crystal grown on the surface of the original slice — called an "epitaxial layer".

The actual shape and size of the devices is controlled by a process called "photolithography". The first stage in this is to deposit a light-sensitive material on the surface. Using a photographic plate as a negative, part of the layer is then hardened by exposure to ultra violet light and the remainder is washed away by a developer. This remaining pattern protects the surface from etching when the slice is placed in a chemical etch. A large number of consecutive photolithographic and diffusion stages make up the process. This is shown pictorially below for an npn transistor and the differences between this and an integrated circuit are explained.

MANUFACTURING AN NPN TRANSISTOR

1. Structure required

emitter	n
base	p
collector	n

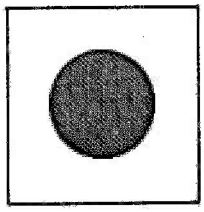
Silicon npn transistor

emitter	p
base	n
collector	p

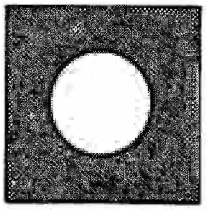
Silicon pnp transistor

2. Preliminary Stages and Photolithography

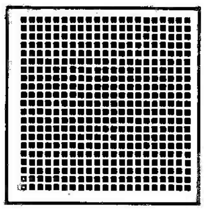
a) Preparation of pattern (a circle is shown for simplicity, but the principle applies to any shape that may be needed.)



Accurate drawing 200 times full size.



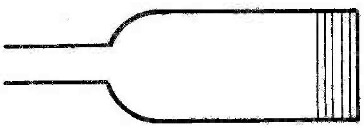
Reversed and reduced to times 20



Life size, right way round image repeated hundreds times giving many devices at once.

b) Preparation of silicon slice

A very low resistivity n-type crystal ("n+"), about two inches in diameter is cut into thin slices, (about 0.004" thick) and an n-type epitaxial layer is grown on one surface. This is known as 'n on n+' and is used for npn transistors; for integrated circuits the base layer is normally p and an n layer is grown on that.



low resisitivity n type (n+) crystal is sawn into slices

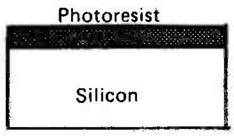
thin (0.004") slice

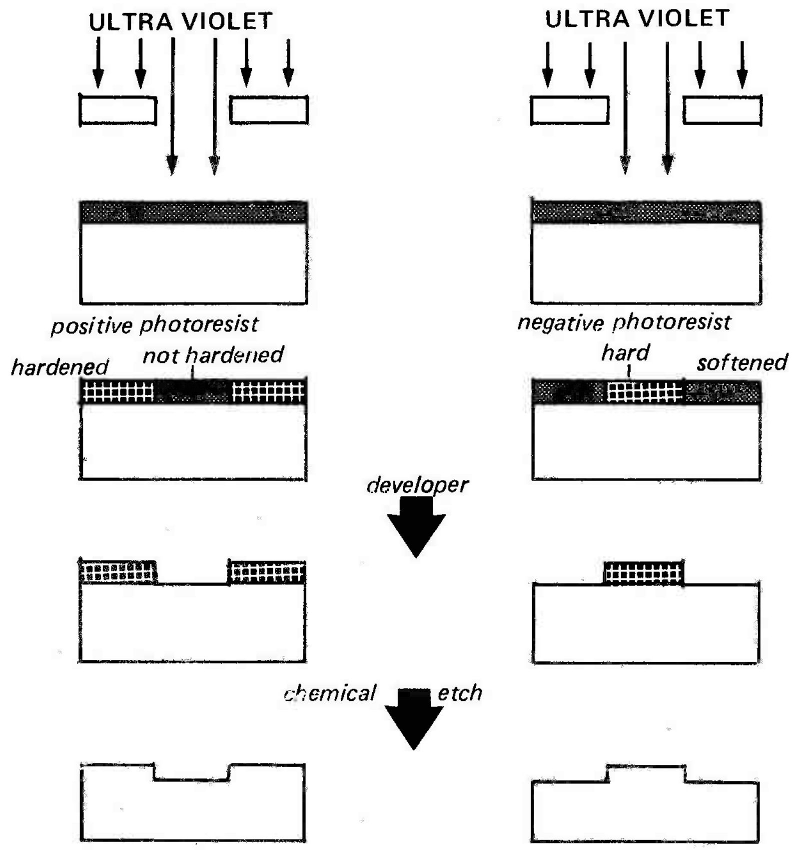
n type epitaxial layer grown on nne surface

continued overleaf

HOW SEMICONDUCTORS ARE MADE

c) Principles of Photolithography

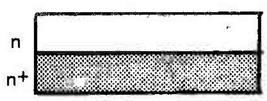




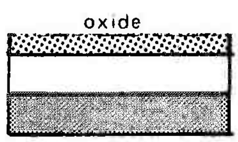
A thin layer of UV sensitive material is deposited on the surface of the slice. (The photoresist may be either positive or negative working and both are used in silicon processing.)

3. Schematic Process for an npn Transistor Using Negative Photoresist.

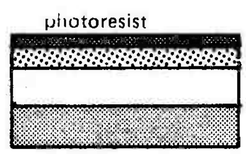
Although the process produces several hundred devices at once, one only is shown for clarity.



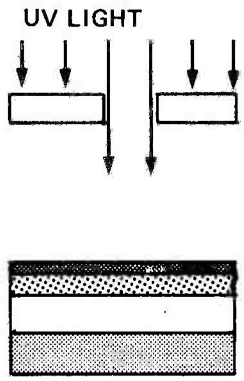
1. Starting slice is n on n+



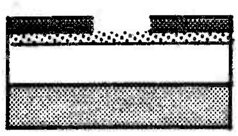
2. Surface oxidised about 1000°C



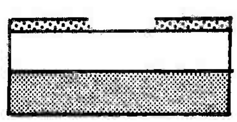
3. Whole slice is coated with photoresist



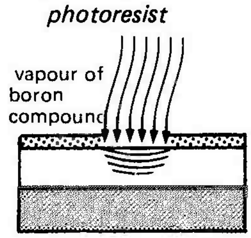
4. Base diffusion pattern exposed to UV



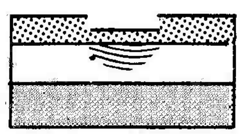
5. Pattern developed exposing oxide



6. Oxide 'window' etched and resist removed leaving clean silicon surface

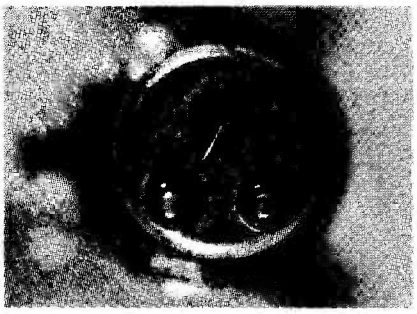


7. Boron diffusion for p-type base at about 1000°C



8. Emitter oxidation

The principles of the following stages are similar, but for clarity the details have been omitted and the sketches have been enlarged. For the emitter diffusion a window is cut in the oxide grown in stage eight. The vapour of a phosphorus compound is deposited during the diffusion stage, again at about 1000°C. This completes the transistor structure. It is now necessary to cut a hole in the oxide layer which was grown over the base in stage eight. This means that both the emitter and base are now exposed and electrical contact is made to them by evaporating a thin layer of aluminium over the whole slice. This metallisation is then etched to form the contact pattern in the final stages of the processing of the silicon slice. The n+ layer is used as the collector contact and the chip is bonded to its package through it.



Close up of a transistor in a metal can with lid removed showing emitter and base connections (Middlesex Polytechnic).

DIFFERENCES FOR ICs

a) No electrical connection is made from the underside and the slice used is usually an n layer grown on p (n on p).

b) Resistors are p type areas diffused into the n type layer. Their value depends on shape and thickness, but they are not good quality components with very negative temperature coefficients and typical tolerances of ± 20%.

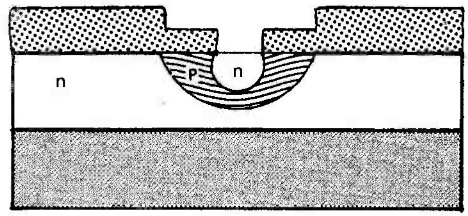
c) Capacitors are voltage dependent devices formed by reverse biasing a diode, ie one plate is a p region in an n layer and that layer itself forms the other plate.

d) The transistor process applied directly into integrated circuits would give devices with all their collectors commoned up. To avoid this a very low resistance p layer, "p+", is diffused as a "ring" round the outside of integrated circuit transistors right through to the under p layer — the "isolation diffusion".

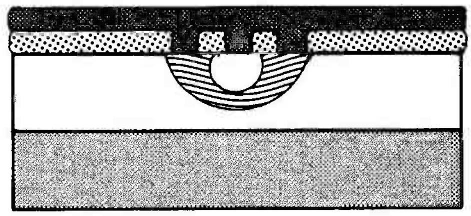
DEVICE FINISHING

The complete slice now contains hundreds of similar devices. At this stage these are probe tested for

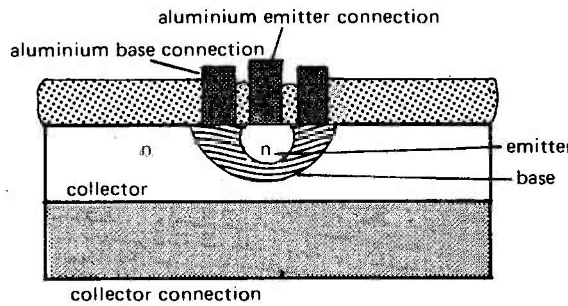
Completed transistor structure



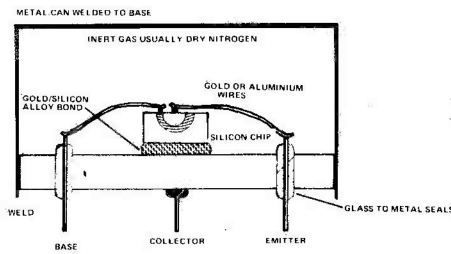
Base contact windows etched in oxide and aluminium film deposited all over slice



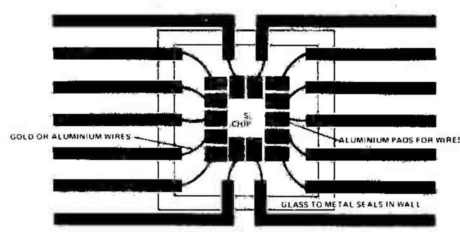
Cross section of completed npn transistor



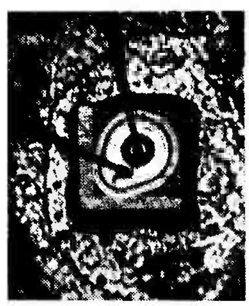
Cross section of metal can transistor

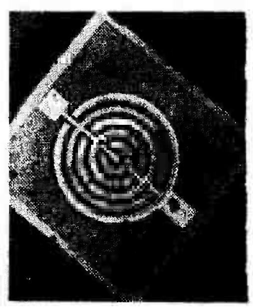


Top view of metal or ceramic integrated circuit flat pack.



(A metal or ceramic top is glazed or soldered on to complete the hermetically sealed package)





Left: Transistor clip showing bonding wires and metalisation (Middlesex Polytechnic).

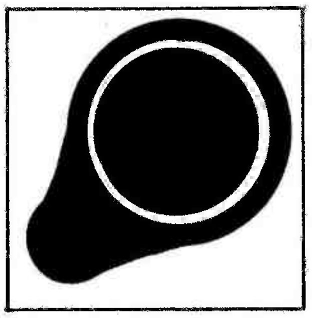
Right: Power transistor clip; the inner pattern is the emitter, the outer pattern is the base (Courtesy of R. Gledhill, Middlesex Polytechnic).

correct electrical function. Failures are marked with an ink blob. Individual devices or "chips" are cut from the slice by scribing it with a diamond stylus. This makes the silicon brittle in the same way as is used for glass cutting. The scribed slice is then broken, releasing the chips for use.

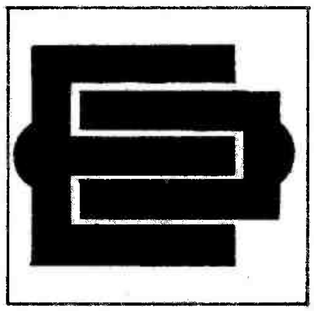
All transistors or integrated circuits are bonded down onto part of a package which may be one of the familiar transistor shapes or the flat pack or dual-in-line of the integrated circuit. The bonding is usually by means of an alloy between the back of the silicon chip and a gold layer on the package. An eutectic alloy of the two metals forms at about 400° C which acts as a thermally and electrically conducting "glue". Gold or aluminium wires are then bonded to the emitter and base for a transistor and to all connections for an IC using either thermocompression or ultrasonic welding. The two sketches show hermetically sealed versions of each, but injection moulded plastic types of both are commonly available and are usually cheaper.

NOTE: All processes described here are idealised and actual production systems differ considerably in detail, but not in principle. ●

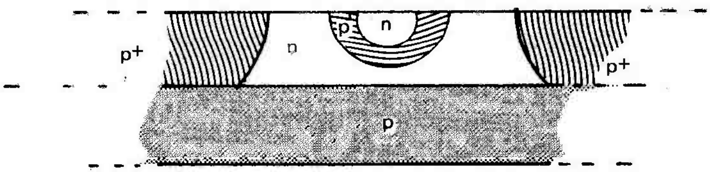
Plan views of the aluminium patterns of two common types of transistor design.



a) Concentric



b) Interdigitated



Isolation diffusion for integrated circuits

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DL747	£2.45	NSN33	£1.65	FND5000	95p

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ET13600. All semiconductors being stocked for this project — current list available — send sae.

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CD4011AE	0.21	CD4041AE	2.02	CD4076BE	1.63
CD4012AE	0.21	CD4042AE	1.37	CD4077BE	0.65
CD4013AE	0.63	CD4043AE	2.02	CD4078BE	0.26
CD4014AE	1.62	CD4044AE	2.02	CD4081BE	0.26
CD4015AE	1.62	CD4045AE	2.29	CD4082BE	0.26
CD4016AE	0.62	CD4046AE	2.02	CD4085BE	1.17
CD4017AE	1.63	CD4047AE	1.37	CD4086BE	1.17
CD4018AE	2.29	CD4048AE	0.78	CD4095BE	1.82
CD4019AE	0.73	CD4049AE	0.62	MC14501	0.32
CD4020AE	1.82	CD4050AE	0.62	MC14502CP	0.65
CD4021AE	1.63	CD4051AE	2.57	MC14508CP	4.20
CD4022AE	1.69	CD4052AE	2.57	MC14510CP	1.26
CD4023AE	0.21	CD4053AE	2.57	MC14511CP	1.95
CD4024AE	1.16	CD4054AE	1.96	MC14518CP	1.87
CD4025AE	0.21	CD4055AE	1.96	MC14520CP	1.87
CD4026AE	1.96	CD4056AE	1.96	MC14528CP	0.87
CD4027AE	0.91	CD4059AD	16.10	MC14553CP	4.07
CD4028AE	1.40	CD4060AE	2.29	MC14566CP	1.21
CD4029AE	1.96	CD4061AD	20.03	MC14585CP	1.45
CD4030AE	0.65	CD4062AT	7.33	MM74C14N	1.16
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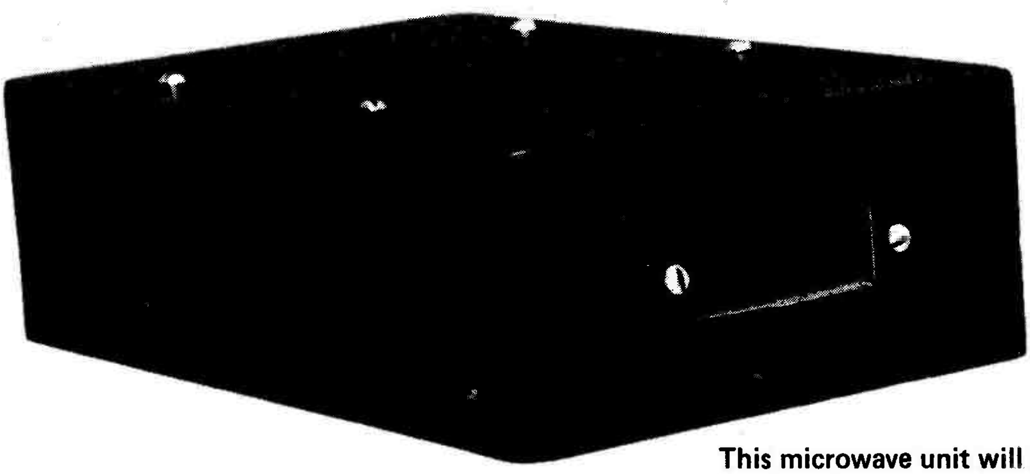
RADAR INTRUDER ALARM



This microwave unit will detect moving objects at ten metres range.

IN 1963 J B Gunn reported that he had obtained coherent oscillations by applying an electric field to a crystal of gallium arsenide, and that a power of 0.5 watt at a frequency of 1 GHz could be obtained by this means. Since that time a great deal of research and development effort has been devoted to producing a range of solid-state microwave generators with stable and predictable properties.

The Gunn effect oscillator is the first practicable solid-state microwave source. About five times cheaper than an equivalent klystron source (including power supply), the Gunn oscillator, because of its inherent efficiency, reliability and portability is finding wide use in contactless object detection and observation equipment. Applications include intruder detectors in security systems, aids for the blind, motor car anti-collision systems, contactless actuators and speed and rotation measuring equipments.

Microwaves have many advantages over light, infra-red and ultrasonic waves for such duties. Principal among these is the relatively "unpolluted" section of the spectrum in which they operate: few natural phenomena or electrical machines generate incidental microwaves. Additionally, conventional radio-signal processing techniques may be used to improve the signal-to-noise ratio and the immunity to interference.

One of the latest devices to become available in this field, is the Mullard CL8960 radar module. This device is intended for short range doppler radar applications.

In essence it transmits a beam of very high frequency radiowaves — virtually anything intercepted by the beam will reflect some energy back to the unit. If the intercepted object is moving then the reflected energy will be at a frequency slightly different from the transmitted frequency (the difference depends on the speed and direction of the moving object).

Thus if there *is* a difference between the transmitted and the reflected signal frequencies (i.e. a Doppler shift) then, by definition, a moving object must have caused it.

The CL8960 modules consists of a dual cavity and integral aerial assembly. A self-oscillating Gunn diode is mounted in one cavity and a microwave mixer diode in the other.

Hence the unit is self-contained, needing only a power supply and amplifier for the Doppler audio output.

CONSTRUCTION

We did not attempt to miniaturize the unit as ultra-small physical size is unlikely to be required in intruder detection systems. Our prototype was therefore mounted in a 185 x 120 mm diecast box, the side of which makes

SPECIFICATION

Frequency	10.675 – 10.7 GHz
Power Output with 7.0V dc supply	8 mW typical
Beam Width free space	approx 60°
Range	up to 10 metres
Sensitivity maximum	50 μV at 10 Hz
Internal Filter	30 Hz, five pole low-pass
Output	by relay – either latching or 20 seconds on plus automatic reset.
Input	10-15 volts dc at 150 – 200 mA.

RADAR INTRUDER ALARM

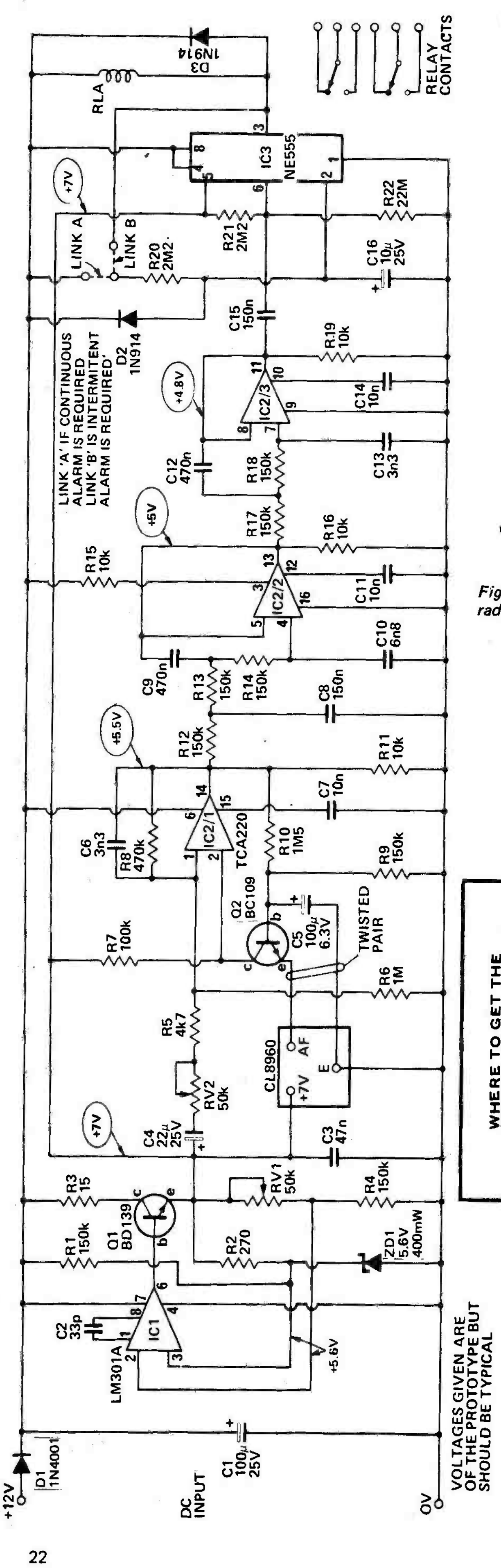


Fig. 1. (left) Circuit diagram of the radar alarm.

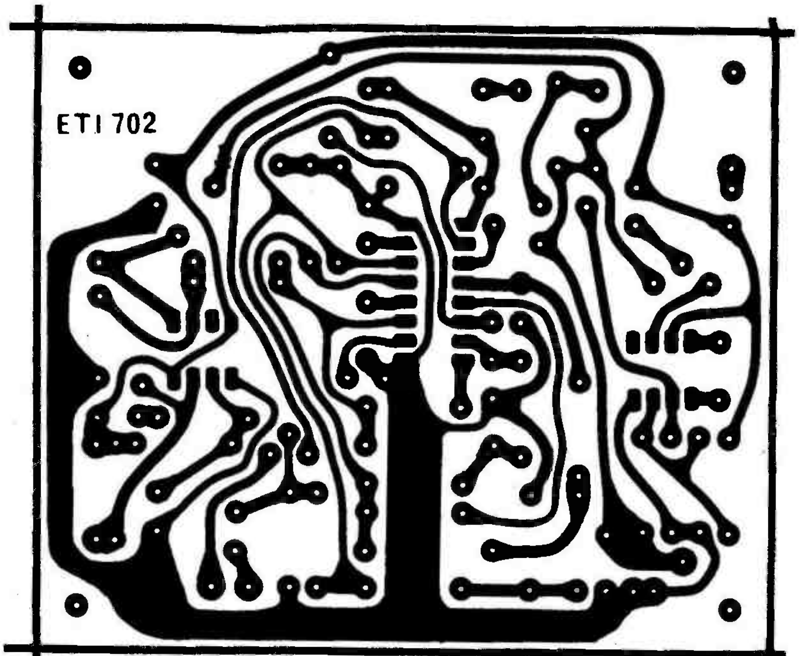


Fig.2. Printed circuit layout.

an ideal rigid support for the radar module.

Assemble the components to the printed circuit board with reference to the circuit diagram and the component overlay. Take particular care with polarization of components and watch for the differing connections of BC109 transistors (see connections at bottom of circuit diagram). The relay may be mounted by simply glueing it to the side of the box.

Do not remove the shorting strap, between the mixer diode and ground, until the module is completely wired into the circuit. The wires from the printed circuit board to the mixer diode should be twisted to minimize pickup — as there is a very low signal level at this point. After these are connected remove the strap by unwinding the end on the mixer diode with the aid of a pair of long-nose pliers and then disconnecting it from the earth terminal.

SETTING UP

The only adjustments required are the setting of the +7 volts supply for the transmitter and setting the sensitivity control.

Initially the transmitter should be left disconnected and a resistor (100 to 1k ohm) inserted from the +7 V line to ground as a simulated load. Switch on and adjust RV1 to obtain exactly 7 volts output. Use some glue or nail polish to secure the potentiometer in this position, switch off, and reconnect the transmitter.

To set the sensitivity it is advisable

WHERE TO GET THE COMPONENTS

THE CL8960 RADAR UNIT
This module is available from SASCO LIMITED
P.O. Box 2000,
Gatwick Road,
Crawley, Sussex.
for £20.00 + 8% VAT + 50p postage.

THE TCA 220 TRIPLE OP-AMP IC
SASCO can supply this to readers buying the radar module for an additional £1.50 + 8% VAT.

The values of resistors and capacitors now follows our new standard. Examples are given below.

Resistors	Capacitors
2R2 is 2.2 Ω	2n2 is 0.0022μF
2k2 is 2.2k	220n is 0.22μF
2M2 is 2.2M	2μ2 is 2.2μF

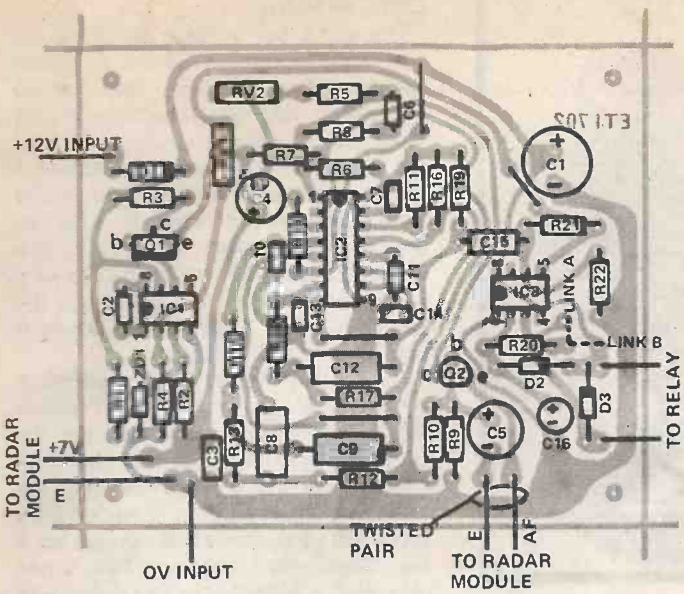


Fig.3. Component overlay.

initially to link the unit for intermittent alarm operation. It may be changed to latching mode later if required. Mount the unit in its normal operating position and adjust the sensitivity such that the desired range is achieved without the unit being over-sensitive. Note that the 10.7 GHz transmitted will pass through timber walls with almost zero attenuation — so movement outside the protected room could set off the alarm if the sensitivity is too high.

This characteristic can be valuable though as it enables the complete alarm to be concealed behind a plastic or wooden screen — or even inside the wall itself if desired.

PARTS LIST – ETI 702

R3	Resistor	15 ohm ½W 5%	
R2	"	270 ohm ¼or½W 5%	
R5	"	4k7	" " "
R11,15, 16,19	"	10k	" " "
R7	"	100k	" " "
R1,4, 9,12	"	150k	" " "
R13,14, 17,18	"	150k	" " "
R8	"	470k	" " "
R6	"	1M	" " "
R10	"	1M5	" " "
R20,21	"	2M2	" " "
R22	"	22M	" " "
RV1, RV2	Potentiometer "	50k Trim. " "	
C2	Capacitor	33pF	ceramic
C6,13	"	0.0033μF	Polyester
C10	"	0.0068μF	"
C7,11, 14	"	0.01μF	"
C3	"	0.047μF	"
C8, 15	"	0.15μF	"
C9,12	"	0.47μF	"
C16	"	10μF 25V	electrolytic
C4	"	22μF 25V	"
C5	"	100μF 6.3V	"
C1	"	100μF 25V	"
Q1	Transistor	BD139 or similar	
Q2	"	BC109 or similar	
IC1	Integrated Circuit	LM301A	
IC2	" "	TCA220	
IC3	" "	NE555	

D1 Diode 1N4001 or similar
D2,3 Diode IN914 or similar

ZD1 Zener Diode 5.6V 400mW
RLA Relay 185 ohm miniature

Radar Unit CL8960 Mullard — see box on page 22.

Die cast box

Four Screw-type Terminals.

HOW IT WORKS ETI 702

The intruder alarm consists of four main sections:

1) The Gunn diode assembly and associated power supply.

2) An amplifier for the output of the mixer diode.

3) A 5-pole, low-pass filter.

4) A detector and relay driver.

The transmitter consists of a Gunn diode in a tuned cavity that requires a supply of 7 volts ±0.1V dc at about 140 mA. No other input is required and the diode automatically oscillates at 10.7 GHz. The regulation of this supply is critical as any variation will frequency modulate the Gunn diode. In security applications a 12 volt battery, together with a separate charger, will most commonly be used and the output of such a system will be anywhere between 11 and 15 volts. Hence we have used a series regulator which has a 5.6 volt zener as the reference element. Integrated circuit IC1 compares the zener voltage to the voltage, as set by RV1 and R4, and controls the series transistor Q1 to keep the relationship of output voltage constant with respect to the zener voltage. Thus RV1 controls the output voltage and is set to obtain 7 volts. A diode D1 is used in series with the input to prevent damage due to reversed polarity.

The mixer diode is in a second tuned cavity next to the transmitter and receives two signal sources. The first of these is 'spill" from the transmitter, constituting a local oscillator signal.

The second signal consists of energy reflected from all objects in the target area. If nothing is moving in the area the reflected signal will be of the same frequency as the transmitted frequency – so the output from the mixer will be the transmitted frequency only.

However a moving object in the area will doppler shift the reflected signal. The difference in frequency will be proportional to the objects velocity, in accordance with the following formula.

f = 71.3 V Hz (V = velocity in metres/ sec perpendicular to module)

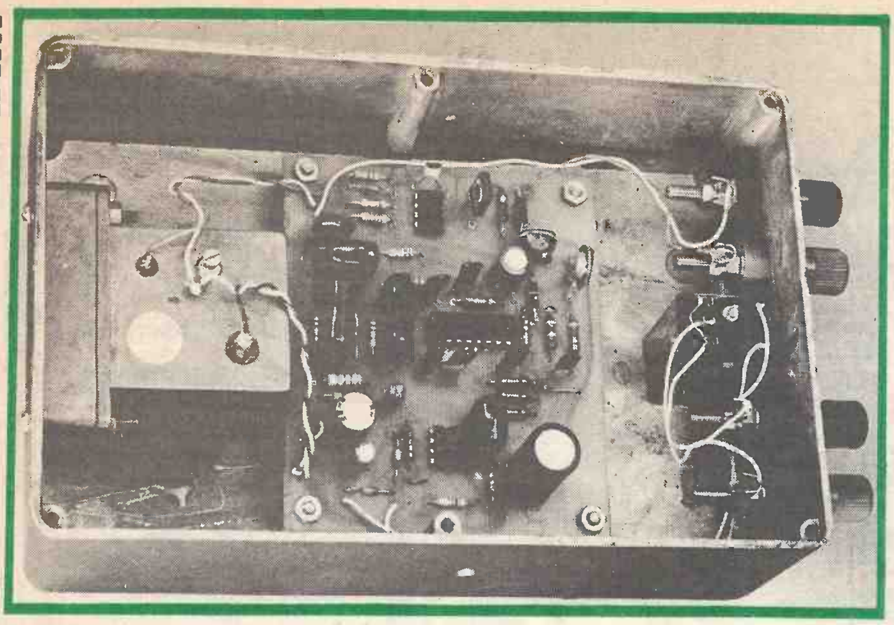
This doppler frequency is amplified by Q2, connected as a common-base amplifier, and again by IC2/1 providing a maximum gain of some 85 to 90 dB.

Approximately 20 dB of gain control is provided by RV2. The collector load of Q2 (R1) provides the 35 micro-amp bias required by the mixer diode and R6, 9 and 10 provide the correct dc conditions for the combination.

The filter consists of two active sections, one three-pole and one two-pole, which together make a five-pole Chebyshev filter. The cutoff frequency is about 30 Hz and the attenuation at 50 Hz is more than 40 dB.

An NE555 timer IC is used as a detector. This IC has two level detectors, one at two-thirds of V_S (input A) and one at one third V_S (input B). However, by connecting the control voltage input (pin 5) to +7 volt these levels will be +7 V and +3.5 V respectively. If input B is less than 3.5 V the output will be high irrespective of input A. If input B is above 3.5 V and input A goes above 7 V, the output will go low until input B again goes below 3.5 V. The voltage at input A is normally held at 6.4 V by R21 and 22 and hence about 600 mV increase is needed to reach the trigger point.

On initial switch on, C16 will be discharged causing the output to be high and the relay unenergized. After about 10 seconds C16 charges to 3.5 volts and this allows input A to assume control of IC3. This initial period is required to prevent false alarms whilst the rest of the electronics stabilizes. If the resistor R22 is connected to the output of the IC (link B) the relay will reset itself after about 25 seconds. If it is retriggered within the next two minutes it will re-latch, however the on time will be less than 25 seconds. If link A is used the initial 10 second delay still occurs, however once activated the alarm will remain on until power is removed.



LIMITATIONS

The alarm has a filter which rejects all frequencies above 30 Hz. A person walking towards the unit at a reasonable rate generates frequencies in excess of 100 Hz. However parts of the body will be moving at different rates and there will be frequencies below 30 Hz as well. It may be possible to approach the unit from a distance at a high and uniform rate without setting off the alarm but the alarm will be triggered the moment one stops or changes pace.

Fluorescent lights, when operating, generate 50 Hz and 100 Hz noise. Whilst this is rejected by the filter the alarm may be triggered by the impulses generated when the lights are switched on, especially if switch-start types are used which flick on and off a few times when starting. This is not normally a problem as the lights will be left either on or off whenever the alarm is armed. ●

ABOUT MICROWAVES

Nature and properties

Microwaves, as the name suggests, are high-frequency, short-wavelength electromagnetic waves. Being of short wavelength, their properties lie somewhere between those of normal radio and visible light waves. They can be focussed and directed by comparatively small structures, but being of high frequency they are more easily deflected and attenuated by solid objects. The high quantum energy involved with microwaves means that some precautions are necessary to avoid personal injury.

The microwave region of the electromagnetic spectrum is arbitrarily defined as lying between 1000 MHz (1 GHz) and the far infrared region beginning at 300 GHz. Over this range of frequencies, similar signal generating and processing techniques may be used. The wavelengths involved range from 30 cm to 1 mm, the location of the microwave region of the spectrum.

In most countries, radiation health regulations specify a safe limit of exposure to microwaves of 10 mW/cm^2, however, under normal circumstances a maximum intensity of 1 mW/cm^2 should be regarded as the limit for continuous exposure. The CL8960 output is only 8 mW. There is therefore no danger in using this device.

Guiding and Directing

The high dielectric and skin losses, together with the small wavelengths, rule out the use of normal discrete components and transmission lines. Coaxial lines, if of low loss, may be employed at the low-frequency end of the region, but at frequencies above about 5 GHz wave-guides are usually employed. Where attenuation is unimportant, short lengths of coaxial line fabricated from copper tube and wire can be used. Careful attention should be paid to matching if stable, efficient performance is expected. Discontinuities, such as sharp bends, are undesirable.

Aerials for use at microwave frequencies may be made of high gain in small sizes, a 5 dB gain antenna is supplied with the CL8960.

Detection

In low-power industrial practice, microwave signal-frequency amplification is seldom employed. Signals may either be detected directly, or converted to some lower frequency by a diode mixer, or Gunn effect mixer-oscillator.

USING THE CL8960

1) The Gunn diode will be damaged if the supply voltage is reversed.

2) The mixer diode will be damaged by forward current in excess of 10 mA.

3) The module is despatched with a shorting strap between the mixer a.f. terminal and −E terminal.

The mixer has a low junction capacitance and may be damaged by transients of very short duration. It is recommended that soldering irons be isolated from the mains and that *the shorting strap should not be removed until all wiring is completed.*

4) A 10 nF capacitor should be connected to, and between, the +7 volt terminal and −E terminal to suppress parasitic oscillations in the supply circuit.

5) Power supplies should have a low source impedance and be capable of supplying up to 250 mA at approximately three volts during the initial voltage rise following switch on.

TABLE 1

Attenuation of 10 GHz microwaves by various materials. Note: true only for thicknesses greater than 1 wavelength (3 cm).

material	attenutation (one way)	notes
heavy rain	0,2 dB/km	not significant in short range radar
dense fog	0,1 dB/km	not significant in short range radar
dry wood	10 to 50 dB/m	very variable, greater when wet
Plexiglas Perspex	15 dB/m	methyl methacrylate type plastic
polyethylene/ polystyrene	<1 dB/m	dry surfaces
expanded polystyrene	<1 dB/m	dry and fresh
glass	up to 50 dB/m	extremely variable
pure water	approx. 5000 dB/m	

Simple Loudness Control

This circuit, intended primarily for the experimenter, enables basic loudness control to be added to simple amplifiers.

THERE YOU ARE, sitting in the lounge room enjoying Beethoven's Fifth. All of a sudden your enjoyment is shattered by your wife — who insists that the music is far too loud, the neighbours five doors up are complaining, and the kids can't get to sleep. So reluctantly you turn the volume down — only to find that the music just doesn't sound the same, the bass has dropped-off badly and even the treble seems to be down.

It is to cater for situations like this, that amplifier manufacturers include 'loudness' controls.

'Loudness' is a subjective evaluation, primarily a function of a sound's intensity, but also strongly influenced by frequency. The keyword is of course 'subjective'. That is the response of the ear is non-linear — both to changes in sound level and also frequency.

This is best understood by reference to the standard curves for the *average* ear. These curves, due to Robinson and Dadson, are now generally accepted as being more accurate than the classical ones generated earlier by Fletcher and Munsen (after whom the effect is called).

In essence, loudness controls compensate for the Fletcher Munsen effect, producing what is generally (but by no means universally) agreed to be a subjectively more pleasing sound at low listening levels.

Loudness circuits do this by progressively boosting bass — and to a lesser extent treble — as volume is reduced.

The objection to loudness controls is that the effect is totally artificial — as one moves further away from an original sound source bass and treble *will* be attenuated more than midrange sounds. So if your penchant is listening to orchestras a hundred metres or so away then loudness controls are not for you!

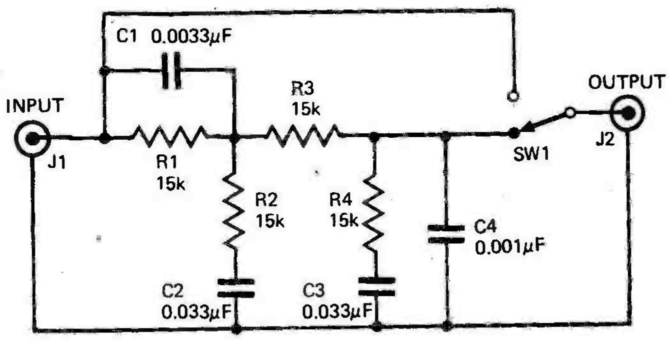


Fig. 1.

Many modern high quality amplifiers have loudness controls built in. In most instances they are manually switched into circuit when required — in a few amplifiers the circuit is switched in at all times.

Nevertheless there are innumerable older or present-day low-priced amplifiers that are not fitted with loudness compensation — and it is for units such as these that this simple project has been designed.

The device shown in Fig. 1 is for a mono amplifier — two are required for stereo amplifiers. It can be very simply assembled on tag strips or matrix board, and, when completed connected between your pre-amplifier and main amplifier. If yours is an integrated unit it should be readily possible to break into the volume control circuit — just connect the unit in series with the slider terminal of the potentiometer. Screened leads may be necessary if long lengths are required.

We would like to emphasize that this is a 'compromise' circuit. Ideally a loudness control must be designed specifically to suit the amplifier for which it is intended. Also the degree of loudness compensation should be related to the volume control setting.

This latter requirement involves replacing the existing volume control by a suitably tapped potentiometer — a device that is not readily available "off the shelf" — so the circuit shown here introduces a fixed amount of compensation that is adequate for moderate listening levels.

This circuit will suit most amplifiers quite well — and in any case can be adjusted by minor variation of component values if required.

Switch SW1 should be a double-pole double-throw type if stereo operation is required. ●

PARTS LIST

R1	15k	5%	½ W
R2	15k	5%	½ W
R3	15k	5%	½ W
R4	15k	5%	½ W
C1	0.0033μF		
C2	0.033μF		
C3	0.033μF		
C4	0.001μF		
SW1	DPDT Toggle Switch		

LINC

Linear Interlaced Network Contest

IF YOUR hobby budget is down at rock bottom, here is a project that will cost from nothing to a maximum of £2, depending upon what you can find at home! For that small outlay you can have hours of fun.

LINC is a game for two players. The name stands for Linear Interlaced Network Contest — and that's what it is. Originally the game was devised (not by this writer) to be played with pencil and paper; — it can tax the brains of anybody from a seven-year-old to a PhD. 'Fun for young and old alike' as the advertisements would say. That this game is not trivial may be judged from the fact that its pencil and paper version gets no less than three pages in Martin Gardner's book 'More Mathematical Puzzles and Diversions'.

This project is an electrical version of the original — no pencil or paper is required.

The game is played by two players we'll call Red and Blue, who sit at adjacent sides of the board (not opposite sides as in chess). The board has 42 blue pegs set out in a regular matrix or network, and the same number of red pegs set out in an identical matrix at right angles to the first, and interlaced with it. Referring to Fig. 1 the circles represent blue pegs and the diamonds represent red pegs. This is the layout of the board shown in Fig. 2.

The idea of the game is for each player to try to form a link between any of the six pegs on his base line and any of the six pegs on the opposite side, before his opponent does so — from his own base line to his opposite side. Thus it will be seen that the player's directions of play are at-right-angles, and as players can play only on pegs of their own colour, they block one another.

To form a link, players take it in turns to join any pair of adjacent pegs of their own colour, by placing a small bridge between them. (Bridges are shaped as shown in Fig. 3.)

As soon as one player has formed a link then his 'Win' light comes on and the game is over. A contest might comprise the best of ten games or first to score ten, and so on.

Each player is provided with 24 bridges marked in his own colour. By placing a bridge between two pegs a player prevents his opponent from following a particular route, and so the links wander in many directions, Figure 2 shows a partially completed game. Often the route of the link is so circuitous that the 'Win' light comes on as quite a surprise.

If we must have rules for the game here they are:

RULES

1) Each player is provided with 24 bridges of his own colour.

2) Decide by the toss of a coin who shall make the first move.

3) Players then take turns to place a bridge on any two adjacent pegs of their own colour, but are NOT allowed to cross any bridge placed by the opponent; indeed the shape of the bridges makes this impossible. Players do NOT have to start by placing a bridge on a base line peg, but may start and play anywhere on the board on pegs of their own colour. Players do NOT have to place every bridge so that it joins on to a bridge already placed on the board, but may put a bridge anywhere on pegs of their own colour. It will be clear then that any peg may have as many as four bridges radiating at right angles from it.

4) The first player to form a link wins, and this will be indicated by his 'Win' light shining.

5) In the unlikely event that all bridges are on the board without either player having formed a link, then play proceeds by moving bridges already placed to new locations.

Variation. The game may be played with a smaller number of bridges — say 18, and making full use of Rule 5.

CONSTRUCTION

First of all let it be said that the board may be of any reasonable size, and the network of pegs may include more pegs than in the prototype. The thing can be built to taste.

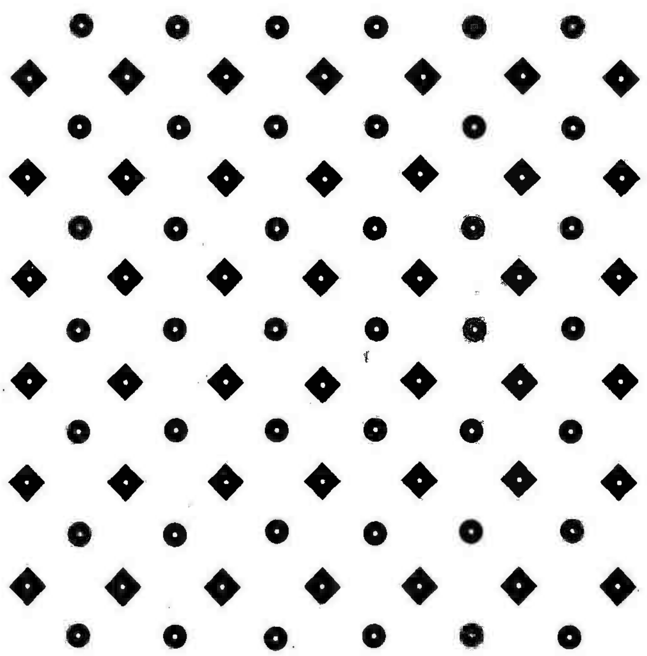


Fig. 1. Layout of interlaced networks of pegs.

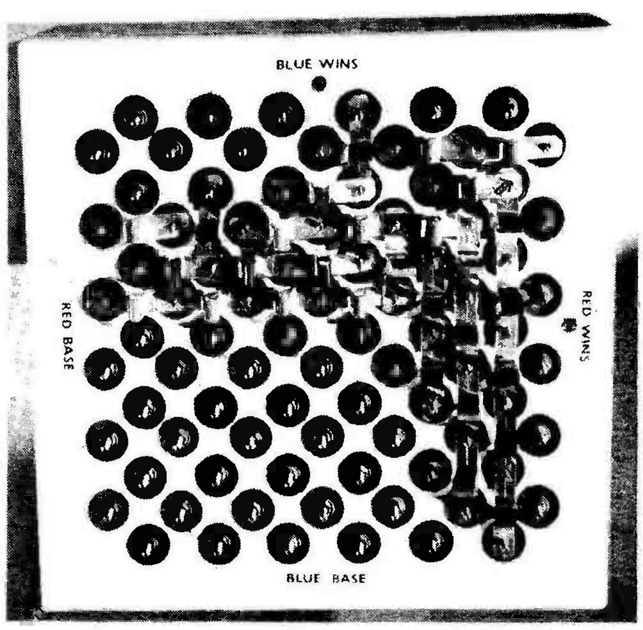
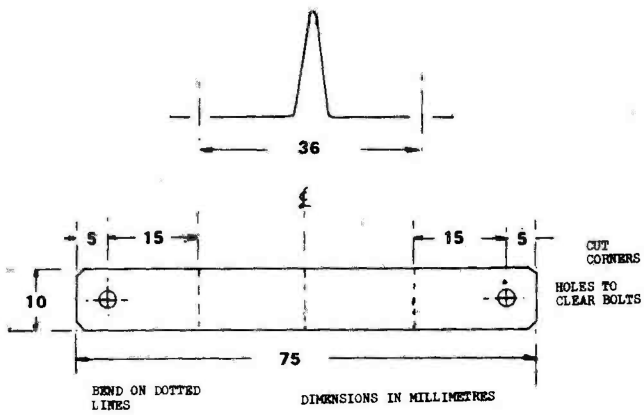


Fig. 2. A partially completed game.



Dimensions of bridges, for use on a board with a 32mm pitch matrix.

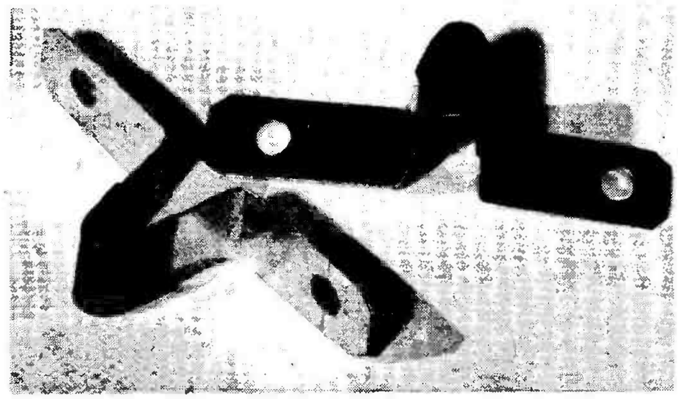


Fig. 3. The bridges — shaped to prevent one crossing another.

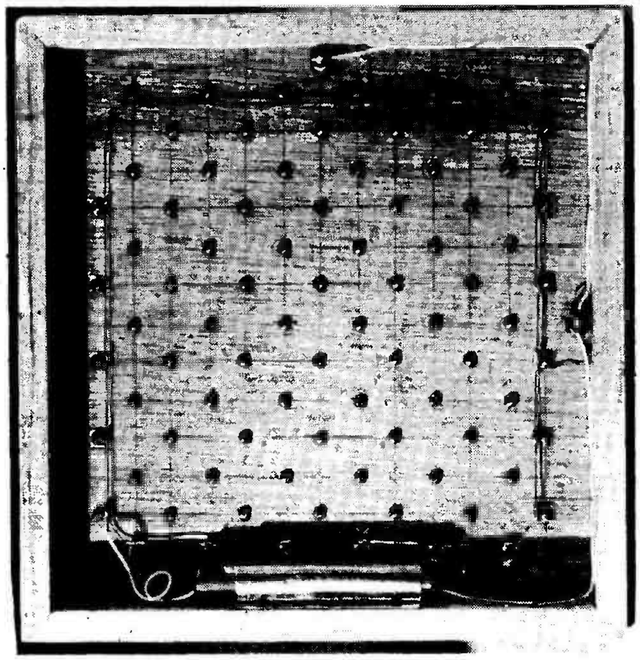


Fig. 4. Underside view of board.

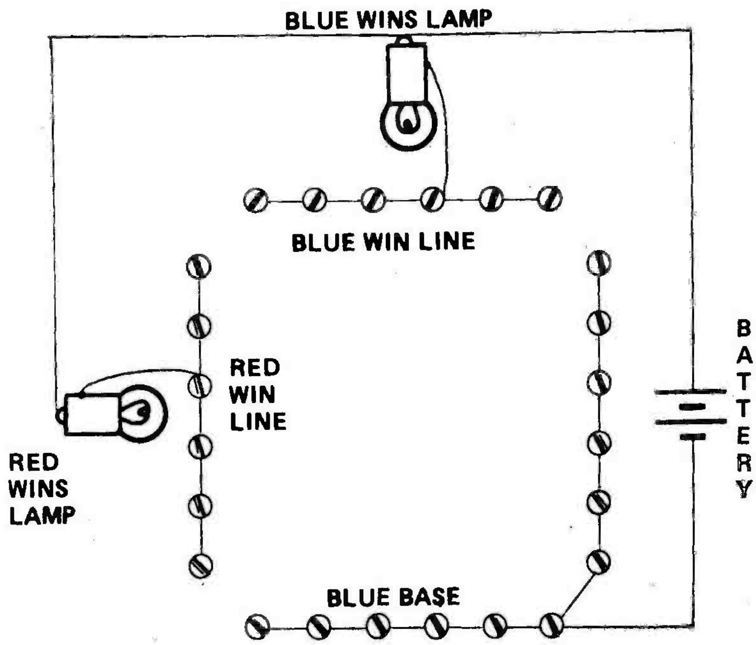


Fig. 5. Wiring diagram — simplicity itself!

The prototype was built on a piece of three-ply 256 mm square, supported on a frame of suitable timber. The pegs of each network were set out on 32 mm centres.

Pegs in the original version were ½" x 1/8" steel nuts and bolts, but smooth-sided pegs are easier to use.

The pegs were colour marked by fitting coloured plastic discs on each bolt below the nut. The plastic came from old desk diaries, and was reasonably thick, so it lay flat.

The underside of the board is shown in Fig. 4, where it is made clear that only the base line and win line pegs have any wiring. When the bridges form a link between a base line and a win line, then a circuit is closed and the appropriate lamp indicates the winner. The wiring is shown in Fig. 5, clearly no switch is required. The battery — two HP7 cells in series — is held under a clip made from aluminium, and leads soldered to it. The win lamps were lens-end bulbs held in clips fashioned from brass, with leads soldered on.

Bridges were made from 0.015" brass shim stock. These are adjusted so that they must be squeezed a little to place them on the pegs. In this way they make adequate contact.

PARTS LIST

Three ply about 256 mm square
Timber for support framework
Nuts and bolts — 84 ½" x 1/8" or similar
Shim brass enou... ...idges.
Battery — two 1.5V cells
Bulbs — two lens end torch bulbs
Hook up wire, coloured plastic, paint.

The hole spacing of the bridge exceeds the spacing of the pegs. If the bridges get loose then they must be spread out to restore their grip on the pegs. Note that the holes in the bridges must be an easy clearance over the pegs. It is best to mark them all out on a sheet of shim brass — including the bending lines, drill them, and then cut them apart.

Bridges can be colour coded with coloured plastic tape or, by dipping them into tins of enamel and letting them dry with the V hanging down.

If your budget is so low that shim brass is 'out' — don't despair — try tinplate, tin cans etc!

That's all there is to it. Good lincing.

VIDEOPHONE -experimental link

Prototype system links fifty-five subscribers through five exchanges.

IN RECENT YEARS experiments have been conducted in several countries with picture telephony, a new medium of communication which makes it possible for the parties at either end of a telephone connection to see each other and show documents or objects. Development in the Netherlands started as early as 1968 at the Philips Research Laboratories, and culminated early in 1972 with the opening of a simple local network incorporating 20 sets.

After studying the first results, the Netherlands PTT decided to set up an experimental network for joint use with Philips over a period of two years. This is expected to give sufficient opportunity for evaluating the technical, ergonomical and operational aspects. There are other points of interest such as possible changes in the communication pattern of the subscribers and more specifically the extent to which picture telephony can obviate the need to travel.

NETWORK CONFIGURATION

The experimental network finds its subscribers exclusively among those who have to be in frequent touch with each other on account of their functions. As such it interconnects various offices and laboratories at Waalre (Philips Research Laboratories, 20 subscribers), Eindhoven *(Philips' Gloeilampenfabrieken,* 10 subscribers), Hilversum *(Philips' Telecommunicatie Industrie,* 11 subscribers), The Hague (PTT Directorate General, four subscribers, and *Philips Telecommunicatie Nederlands,* one subscriber), and Leidschendam (PTT Laboratories, nine subscribers). Thus the total number of subscribers at present is 55.

Existing equipment and facilities are used wherever possible for transmission and switching. From an operational point of view, however, the experimental network is entirely separate from the public telephone network.

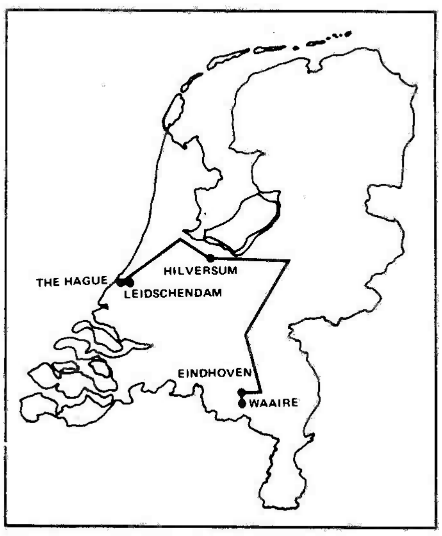
The PTT provides the transmission paths via radio relays and cables; Philips Telecommunicatie Industrie supplies the equipment, such as the picture telephones, the exchanges and the repeaters. Because few subscribers are involved, the exchanges can be small; four of them are of conventional design, while the fifth (at Waalre) is an experimental computer-controlled type. Each conventional exchange is equipped with a switching matrix composed of reed relays for switching the video signal. A special modulator -demodulator developed by the PTT Laboratories permits two picture telephone conversations to be conducted simultaneously on a radio relay. For the local sections of the network transmission takes place over the conductors of existing telephone cables. The network, including the exchanges, employs a total of some 300 repeaters.

BANDWIDTH

In picture telephony it is of great economic interest that the bandwidth on trunk circuits, and hence the number of telephone channels occupied, shall be restricted to the lowest possible figure. A bandwidth of about 1 MHz proves to be adequate, permitting a moving picture of a person's head and shoulders to be transmitted with adequate resolution. Such a picture telephone signal can be transmitted by present-day telephone cables over a length of 1.5 to 2 km without any intermediate repeaters being needed.

In order to reduce the bandwidth from the 5 MHz television standard to about 1 MHz, the number of lines used in picture scanning has been reduced from 625 to 325. The number of picture spots per line has been reduced proportionally. This has resulted in a bandwidth of 1.3 MHz, which is roughly one quarter of the television standard. By way of illustration, this may be compared to a television news broadcast where the head and shoulders of the announcer occupy about one quarter of the picture area with the same resolution.

Future compatibility with the existing television standard being a desirable feature, the design objective has now been set at 313 picture lines, which is the closest possible approximation to half the 625 lines of the television standard.



Videophone trial network.

SIGNAL STRUCTURE AND TRANSMISSION SYSTEM

The picture telephone system uses an advanced digital synchronizing technique and, in conjunction with sound, is transmitted on the "sound in sync." principle. During frame flyback a digital code word is transmitted which accurately defines the end of the past frame period and the start of a new one. During part of the line

	picture telephone	broadcast television
– number of picture lines	325 *	625
– picture frequency	25 Hz	25 Hz
– line interlacing	1:2	1:2
– bandwidth	approx. 1.3 MHz	approx. 5 MHz
– aspect ratio (picture width-to-height ratio)	4:3	4:3

* For full compatibility of the two systems, a change to 313 lines for picture telephony would be preferred.

Discussions among designers, developers and production specialists dealing with a new product can be held by picture telephone.

Diagrams and sketches made on a blackboard can be displayed and commented upon.

flyback a series of short pulses ensures that an HF oscillator in the receiver remains in synchronism with a similar oscillator in the transmitter. The remaining part of the line flyback time is used on a sound in sync. basis to transmit the delta-modulated sound signal, which is also in a digital form. The visual information is transmitted in the conventional way by an analogue signal. Transmission of the combined picture, sound and sync. signals take place on one pair of conductors for each direction. Thus a 4-wire connection is available for the sound signal, which means that crosstalk will not occur in the transmission path. Since, moreover, the sound information is transmitted digitally, i.e. without any loss variations, the loudspeaking telephone section with the associated speed switches is highly stable, so that the speaker at the other end can easily be interrupted.

Although digital signalling would have been quite feasible too, a separate pair of conductors is used in the experimental network for purely practical reasons. The 6-wire circuit thus obtained makes it possible, if desired, to switch the entire network to the conventional mode of picture telephone transmission with analogue synchronization and separate transmission of the sound and signalling information.

The 20 subscribers at Waalre are using the picture telephones which have been in use there for some years. For all the other subscribers Philips' Telecommunicatie Industrie has developed a picture telephone solely for use in the experimental networks, and not intended for future marketing. The picture telephone is composed of three discrete units:

– a picture set with camera, picture tube and loudspeakers;
– a control set with keys for selecting any desired picture telephone subscribers and for the control of sound and the local picture, the control set also contains the microphone;
– a terminal box accommodating the power supply and other ancillary equipment.

The picture set is placed about one metre in front of the subscriber's seat. The control box can be placed within easy reach.

The camera has an automatic lighting control system, which adapts the camera to any changes in lighting conditions. The use of a Plumbicon type camera tube permits electronic zoom and height control. Special electronic circuits ensure good gradation and contour crispness.

The picture tube has dimensions of about 190 x 140 mm. This means that the pictures are large enough to be viewed by two persons in full comfort. A polarizing filter has been fitted in front of the tube to prevent reflections, resulting in good contrast without troublesome flicker even under conditions of strong incident light.

DISPLAYING DOCUMENTS OR OBJECTS

A fold-out mirror fitted on top of the camera makes it possible to show pictures of texts, drawings or objects placed on the table. Normal typewriter text cannot be reproduced legibly on account of the system's limited resolution, but larger letters (not more than 25 to a line) can be easily read.

Widely spaced handwritten text, drawings, graphs and diagrams can be displayed and discussed, and so can small equipment units or components.

The camera may also be trained on blackboards or planning-boards to transmit the information shown on them, provided the size is adequate.

PICTURE TELEPHONE CONFERENCES

For conferences to be held by picture telephone, participants at either end of the connection are seated in pairs in front of picture sets. The picture to be transmitted at any given moment is selected either automatically by speech detection or manually by the chairman. Thus the screens at the other end of the line will always show a picture of the present speaker and his neighbour.

Connections between the conference are established via the normal picture telephone circuits: to this end the equipment need only be supplemented with a conference control unit and a few picture telephone sets. The connection existing between the two groups taking part in the conference can be interrupted for consulting a third party connected to the network. This is a feature distinguishing picture telephone conferences from "conference television" or a similar form of meeting conducted by line television, where the parties at either end assemble in special studios interconnected by fixed circuits employing the 5 MHz transmission standard. ●

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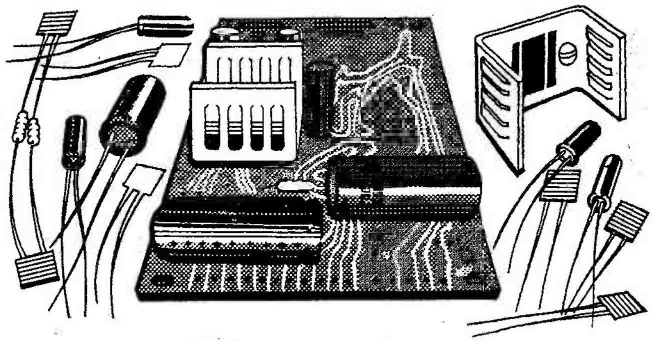

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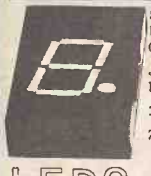

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2N706&8 11p
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Build our straightforward F.M. tuner which incorporates the latest circuit techniques and is intended as a companion to our series 'FM Receiver Techniques'. The tuner head is preassembled and a PLL, Varicap tuning etc are also used: tuning is by present push-buttons.

ETI/DORAM £500 DESIGN COMPETITION

We have arranged with Doram for an unusual competition. Using the components listed in their catalogue, design your own project and you could win some fabulous prizes.

PHOTO TIMER

An excellent circuit with good repeatability using I.C.'s. The timing range can be varied from 1 second to 16 minutes and an unusual feature is incorporated — a series of LED's which give an indication of progress through the timing cycle.

THE PHOTOPHONE

Light beam telephones are not an unknown gimmick and laser beam communication links are now being researched. However, as long ago as 1880, Bell developed a practical design for communications using light. Details next month.

What to look for in September's

ETI

ON SALE AUGUST 8th

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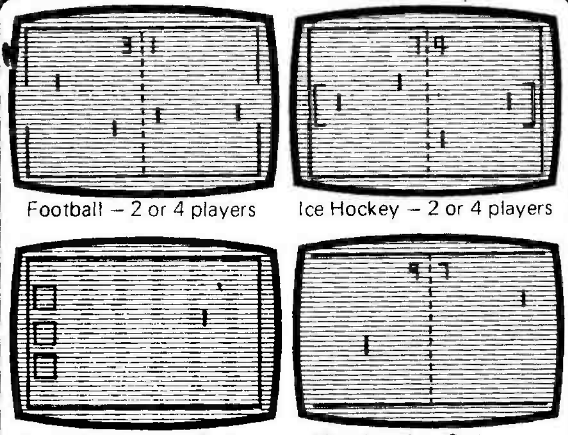
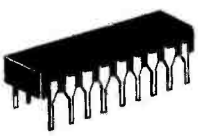
The features mentioned here are, at the time of this issue going to press, in an advanced state of preparation. However, circumstances, including highly topical developments may affect the final contents.



Football – 2 or 4 players
Ice Hockey – 2 or 4 players
Snare the Square – 1 player
Tennis – 1 or 2 players

There is only one way to manufacture video games - one LSI chip



FEATURES:

Digital score read out on screen.
Simulated audio tones.
Bats reflect at five different angles determined by the player.
Automatic ball serve and speed change.
All bats can move in any direction.
Compatable with all world wide receivers.
Fully interlaced picture.

For the first time, **one single LSI chip** is available which provides seven video games. Tennis, football and ice hockey for two or four players and a single player, snare the square.

Each of the seven games is, in it's own right, more sophisticated than any other game of it's kind. The device runs for weeks on a standard nine volt battery and requires only a few external discreet components to provide a working game. A product of space age technology, this NEW LSI CHIP represents a break-through in the video games industry.

Designed for the consumer market, it permits the manufacture of elaborate low cost home games.

Logic Leisure are World Distributors for this device and are seeking a limited number of International Video Game Manufacturers for exclusive agencies.

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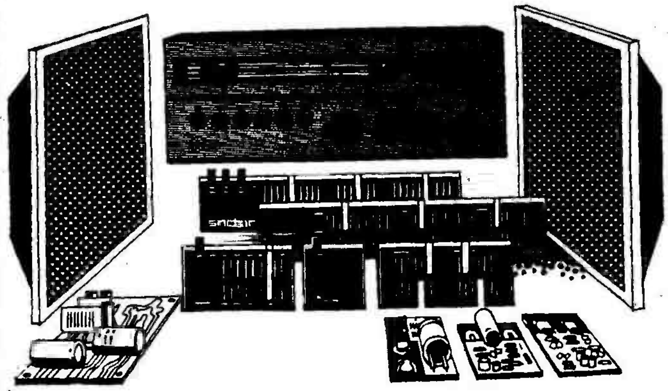
Sinclair hi-fi



The watts...

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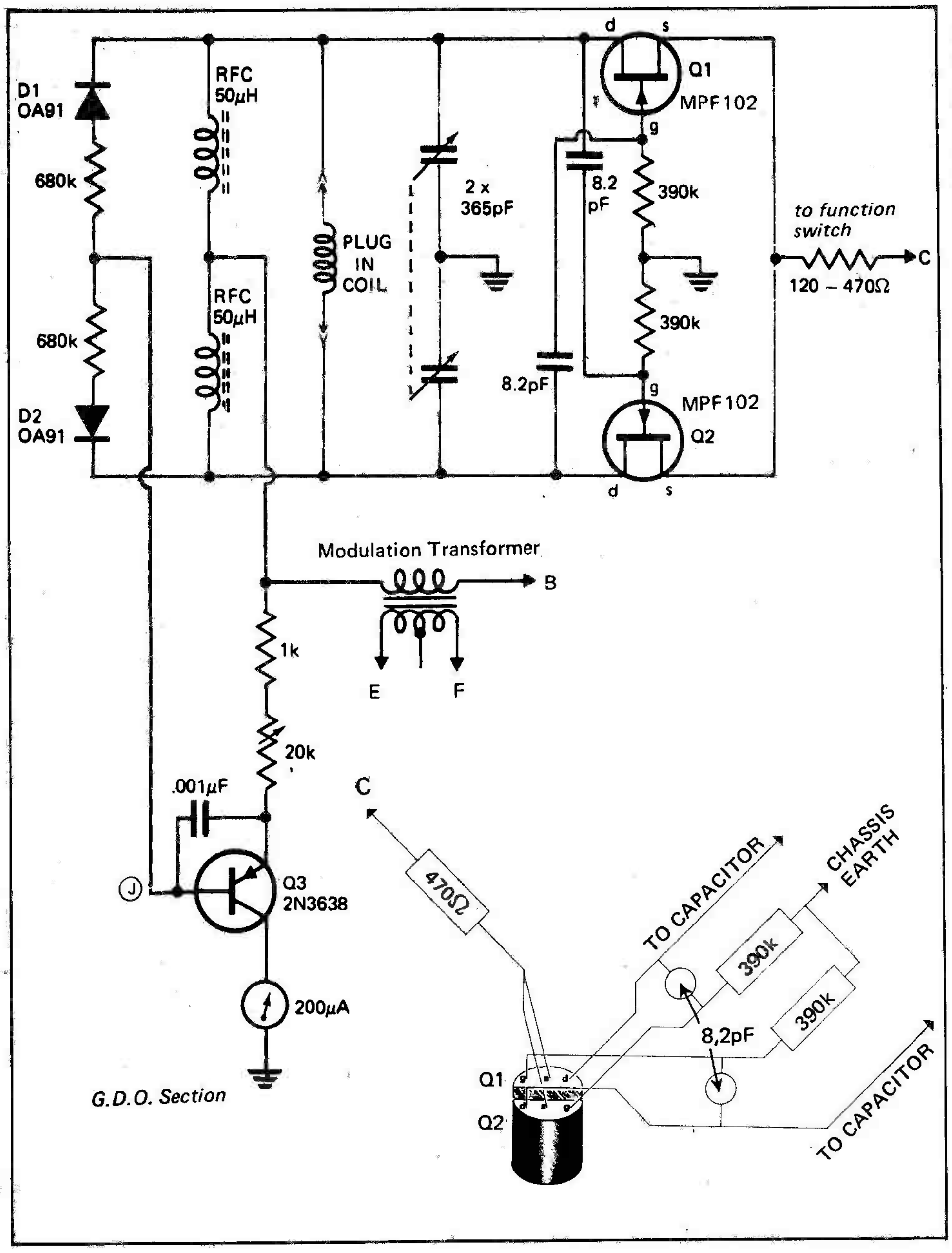
VERSATILE GDO



G.D.O. Section

GRID DIP OSCILLATORS are commercially available, but most are either expensive (£30 upwards) or have various performance failings – in particular frequency variations with different potentiometer settings and a very large amplitude variation across the dial.

This unit does not suffer from either problem.

It is unique in that if it is switched to 'Diode', the oscillator is switched off – if it is now brought near an oscillating tuned circuit the unit will not only indicate oscillation but in the 'Dip' position the unit will oscillate at exactly the same frequency as the external oscillating tuned circuit. (This facility has hitherto only been possible with valve GDO's.)

Another most useful facility is that the frequency of prototype tuned circuits can be speedily checked by connecting the coil to a spare plug, plugging it into the GDO unit and then measuring the frequency on a digital frequency meter.

MODULATOR

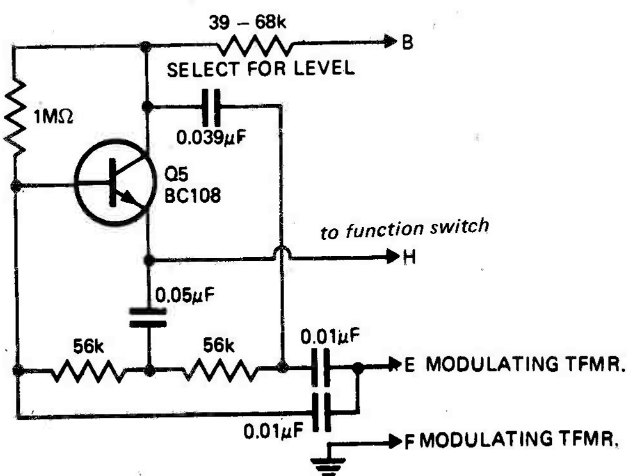
The low-level modulator provides AM and very slight FM. The AM level is about 5%, quite adequate for most applications. If the dc resistance of the primary winding across EF is too low (less than 50Ω), the circuit may not oscillate. The circuit is switched on by connecting "H" to ground via the function switch.

The alternative high-level modulator modulates over 100%. Connect EF across the low impedance side of the transformer.

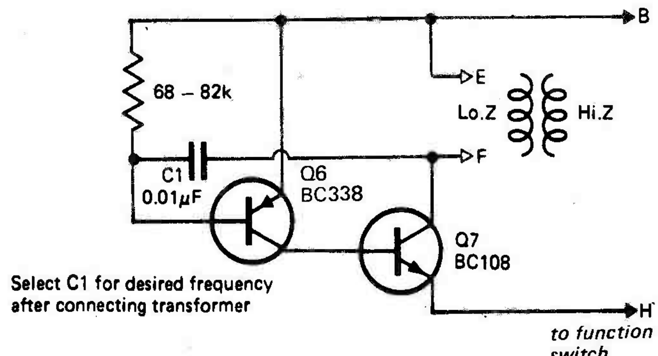
CRYSTAL CHECKER

Useful range of this section is 2-20 MHz. When (if) the crystal oscillates, diodes D5 and D6 rectify the waveform and apply a turnoff bias to the base of Q3.

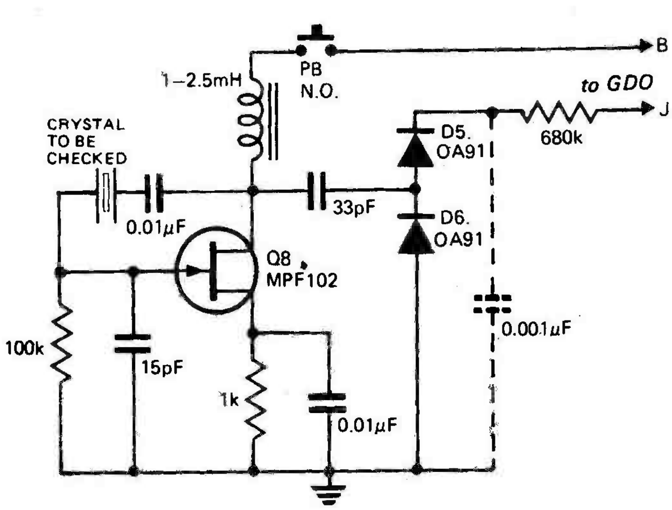
To use this facility the GDO section is switched to "DIP" and the coil is removed, (although this is not



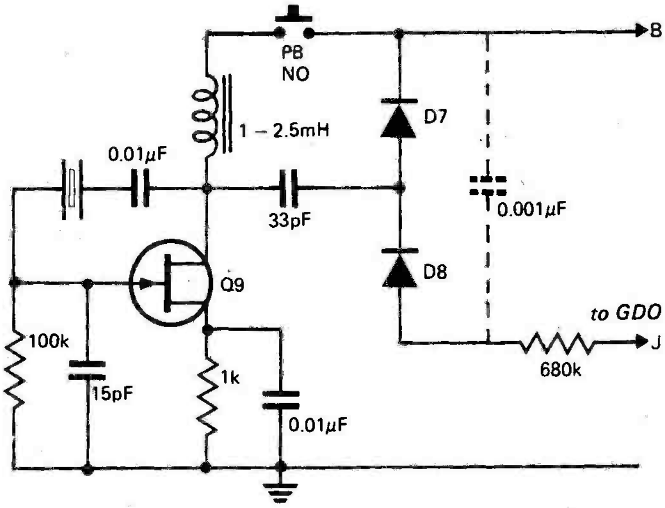
Low-level modulator (~5%)



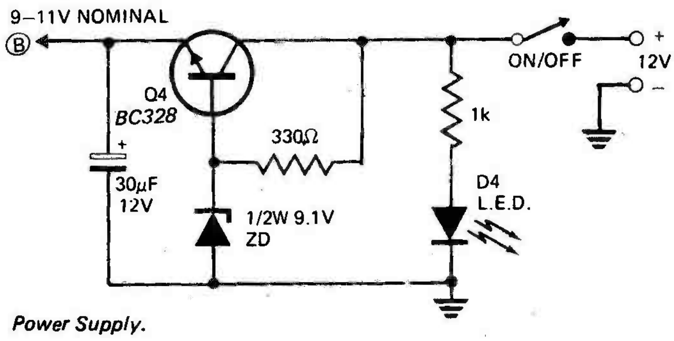
High-level modulator (~ 100%)



Crystal checker.



Alternative connection for diodes in crystal checker for forward meter reading with GDO in 'diode' position. Capacitor shown in dotted lines, may not be needed.



Power Supply.

essential). Unplugging the coil causes the circuit to oscillate at VHF and a bias is generated turning on Q3. If the pushbutton on the xtal checker is depressed, the circuit will oscillate at the xtal's fundamental frequency and diodes D5 and D6 will generate a voltage opposing that generated by D_1 and D_2 and the needle will dip.

If it is desired that the reading be made in the forward direction, the alternative connection for the diodes can be made and the GDO function switch set to the "DIODE" position.

Note however that with this device crystals will be oscillating in their fundamental mode, and sometimes a crystal that will not operate in any other circuit will still operate in this circuit.

POWER SUPPLY

The power supply regulates the voltage supplied to the oscillator. This ensures long term stability.

CONSTRUCTION NOTES

The meter section should be left as is and not converted to npn as many may be tempted to do.

The more sensitive the meter the better but an ordinary 0-200μA edge type uncalibrated meter is suitable. An 0-1 mA is satisfactory up to about 40 MHz. Use thick wire or brazing rod from capacitors to coil socket.

The modulation transformer is from the junk box. It should be a miniature type – one side centre tapped – both sides should have fairly high dc resistance. Some work better than others. If more than one is available try them.

Two versions of the basic circuit have been built, one – as shown – using 0-365 pF and another version using 0-15 pF dual gang capacitors.

If the device will not oscillate reliably, increase the 8.2 pF capacitors to 12 pF or so, and the rf chokes to about 100μH (for use below 15 MHz).

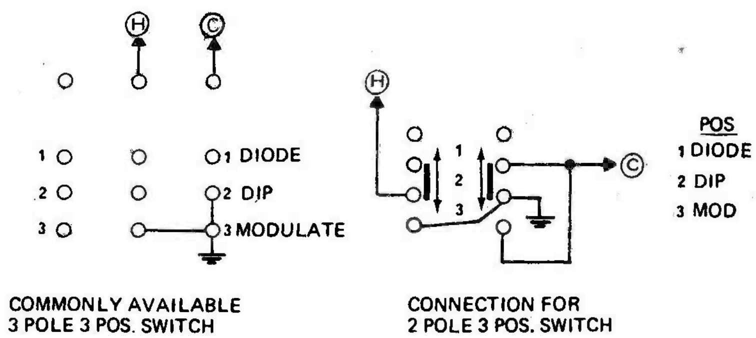
If the oscillator does not start instantly, pull the coil out. The unit should now be oscillating at VHF. If not, double check connections and check the earth on capacitors.

The two FETs, 8.2 pF capacitors and two 390 k resistors are assembled as shown, and mounted directly on the capacitors. Keep leads from capacitors to coil very short.

Note that even if the unit is assembled in a metal box, with only the coil protuding, it can cause severe TVI at distances up to 100 metres (on the fundamental frequency).

Harmonic content is low but nevertheless there is some, the strongest appearing at 3 f. FM deviation is very slight but can be useful on harmonics due to the multiplier effect. ●

WIRING UP THE FUNCTION SWITCH



Two different function switches are shown. The one on the left is a three-pole, three-way device, that on the right is a two-pole, three-way device.

The Library Pen
-A DATA CAPTURE SYSTEM FOR LIBRARIES

by Terry Mendoza

Issuing terminal — the librarian simply runs the 'pen' over the borrower's card and then over the books.

EVERY major library has the formidable task of keeping track of the whereabouts of their stock of books. In addition to those on the library shelves, and those actually on loan, some will be at the binders and others on extended loan to branch libraries or schools. A complex amount of cross-checking is necessary when, for instance, a person wishes to reserve a book which is already on loan.

Plessey have developed a flexible computerized system, adaptable to any sized library which takes all the hard work out of this gargantuan and continuous stock-taking operation.

The system may even be applied to groups of libraries which feed data by handline to a central data capture unit and, ultimately to a computer.

Self-adhesive bar-coded labels or 'badges' affixed to the books, and on each borrower's loan-ticket, are the basis of the whole system. The number of each label consists of nine BCD (binary coded decimal) 4-bit figures, the digital coding relying on thin or thick strokes for registering 0 to 1. Above the coding the number is printed in figures. To the left of the BCD number code is the start code sequence of two thick strokes, one thin and one thick stroke.

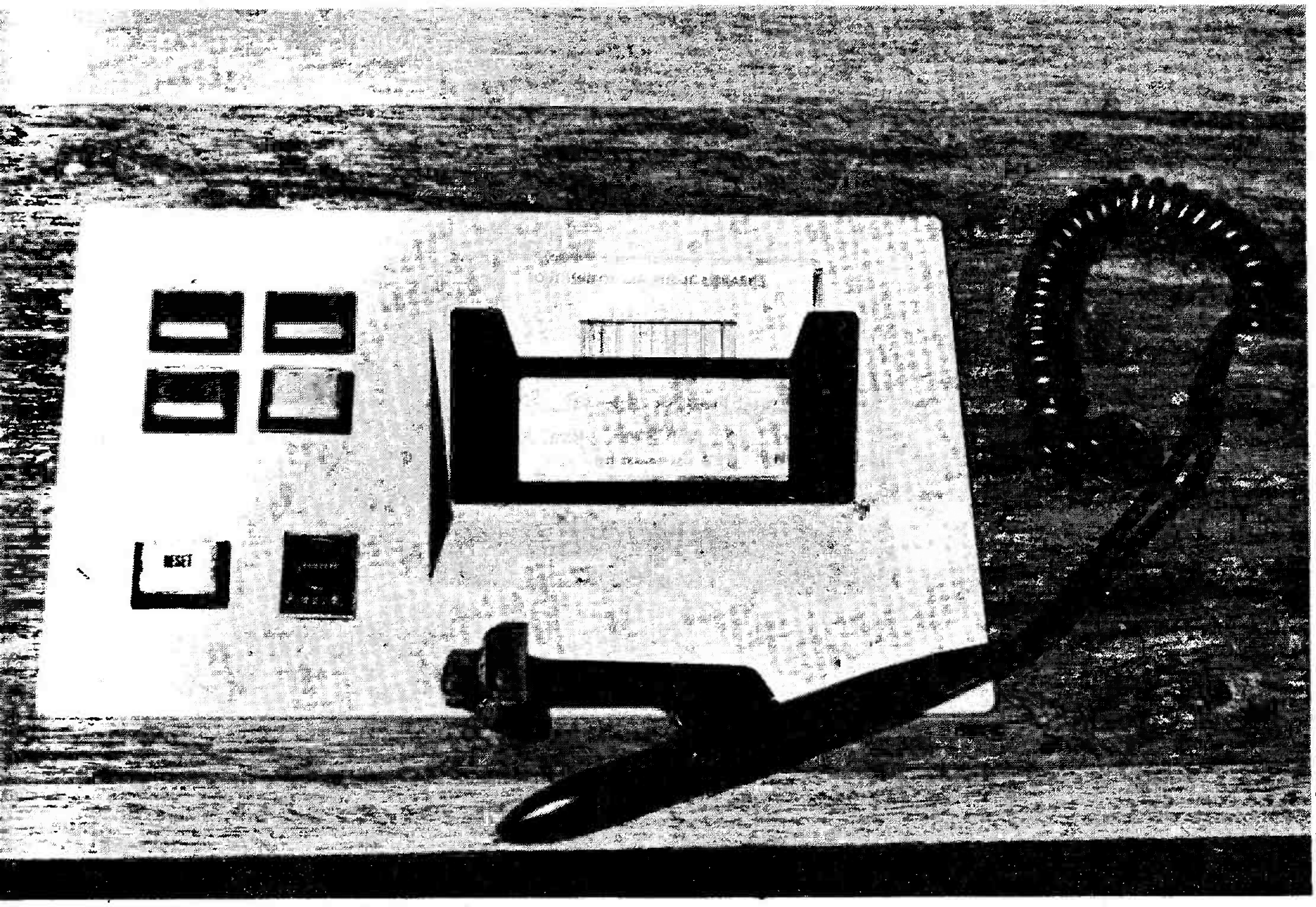
To the right of the numeral code is a 'check' code related to the number and ending with a thick terminating bar and an 'end' code. The start/end codes allow the reading to be carried out in either direction with the special 'library pen' and hence is equally suited to left or right-handed individuals.

Attached to the pen is a self-inking date stamp and after the code has been 'read', the date can be stamped as normal. The pen 'nib' is linked by a fibre-optic pathway to the issue and discharge terminals at the librarians' counter. These terminals are connected to a cassette tape storage unit which is part of a Data Capture Unit. A 2000 entry 'Trapping Store' and a Composite Terminal with a small manual keyboard complete the basic system.

THE SYSTEM IN USE

In use a borrower takes his chosen books to the issue terminal where the librarian's first action is to run the pen over his membership card, registering a nine digit number in BCD form. If the numeral and the check code do not tally, the librarian is informed by a flashing 'error' light that she has to repeat the 'read card' operation.

The coding of the 'read card' is as follows: The first digit differentiates the various classifications of borrowers from the material borrowed! Hence '1' may indicate an adult, '2' a junior, '3' a student, whereas '0' may be a book and '9' a disc. The second digit indicates the period allowed before overdue notices are automatically sent by the computer i.e. '0' is allocated to visitors and four weeks elapse before overdue notices



The recording pen and associated unit.

are sent out, '1' is allocated to normal borrowers who are 'chased' after six weeks and so on to '9' which indicates an indefinite loan period, as when material is transferred from one library to another.

The next six digits indicate the borrower's number, allowing 999,999 possible borrowers. (One beauty of a computerized system like this is that the library can be informed of any borrowers who have not taken out books for over a year. This gives the library a true idea of how many people are using the library facilities. Many other statistics may be made readily available, from 'which days are most popular with borrowers' to 'which type of reading matter is favoured'.

Having registered the details of the borrower, the librarian now runs the pen over the 'badges' on the books. The first digit here identifies the number as relating to a *book* and not a disc or borrower; the next six digits identify the book title, the eighth the type of book, fiction or non-fiction and the last digit can be either used in conjunction with the previous one to detail the subsection in which the book is catalogued within the library or the number of copies of the title owned by the library.

9303466 11

A coded label (shown here full size) is attached to each book and also the borrowers' cards.

All information goes into the data capture unit and at the end of each day is fed from the cassette tape onto the central computer memory.

Now if a borrower wishes to reserve a book, say by telephone, the reference code of the book is keyed into the trapping store using the keyboard of the composite terminal. An LED display on the composite terminal visually indicates the number that is going to be keyed into the trapping store when the 'enter' key is depressed so that the librarian can double-check the number before entering it.

If the required book is out on loan, the librarian receives visible and audible 'trap' indication as it is being returned that it has been reserved, and the number is automatically erased from the trap store. If the book has been taken from the shelf by a borrower the 'issue' librarian will be warned that the book has already been reserved, but the book number in this instance will not be removed from the trap store. Borrowers' numbers may also be keyed into the store so that once a card has been reported lost it cannot be utilised by another person. Every so often the contents of the trapping store are transferred onto magnetic tape and may be printed out so that the progress of a reserved book in the system may be checked.

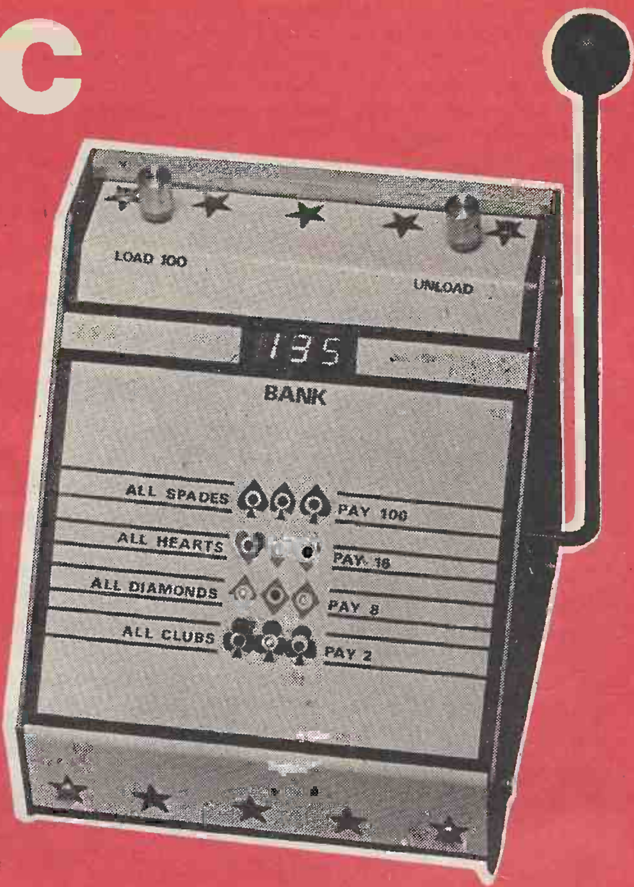
Another regularly used print-out is the 'error' sheet which tabulates 'impossible' book or borrower numbers, which might occur with a defaced label.

At the front end of the data capture unit is a high-speed multiplier which can accept ten lines of data, not only from the 'pen terminals' in the vicinity, but also by landline from other libraries in the area. The multiplexer labels each signal with a source code (main or branch library etc) and the function being performed — renew, reserve, issue or discharge.

Although it is not a feature of this system, the day cannot be far away when it will be possible for a borrower to type the subject of his interest on an alpha-numeric keyboard and select his choice of books from the instantaneous computer print-out which will also indicate which books are already on loan. ●

ELECTRONIC ONE-ARM BANDIT

eti project



Play for hours — without it costing you a penny!

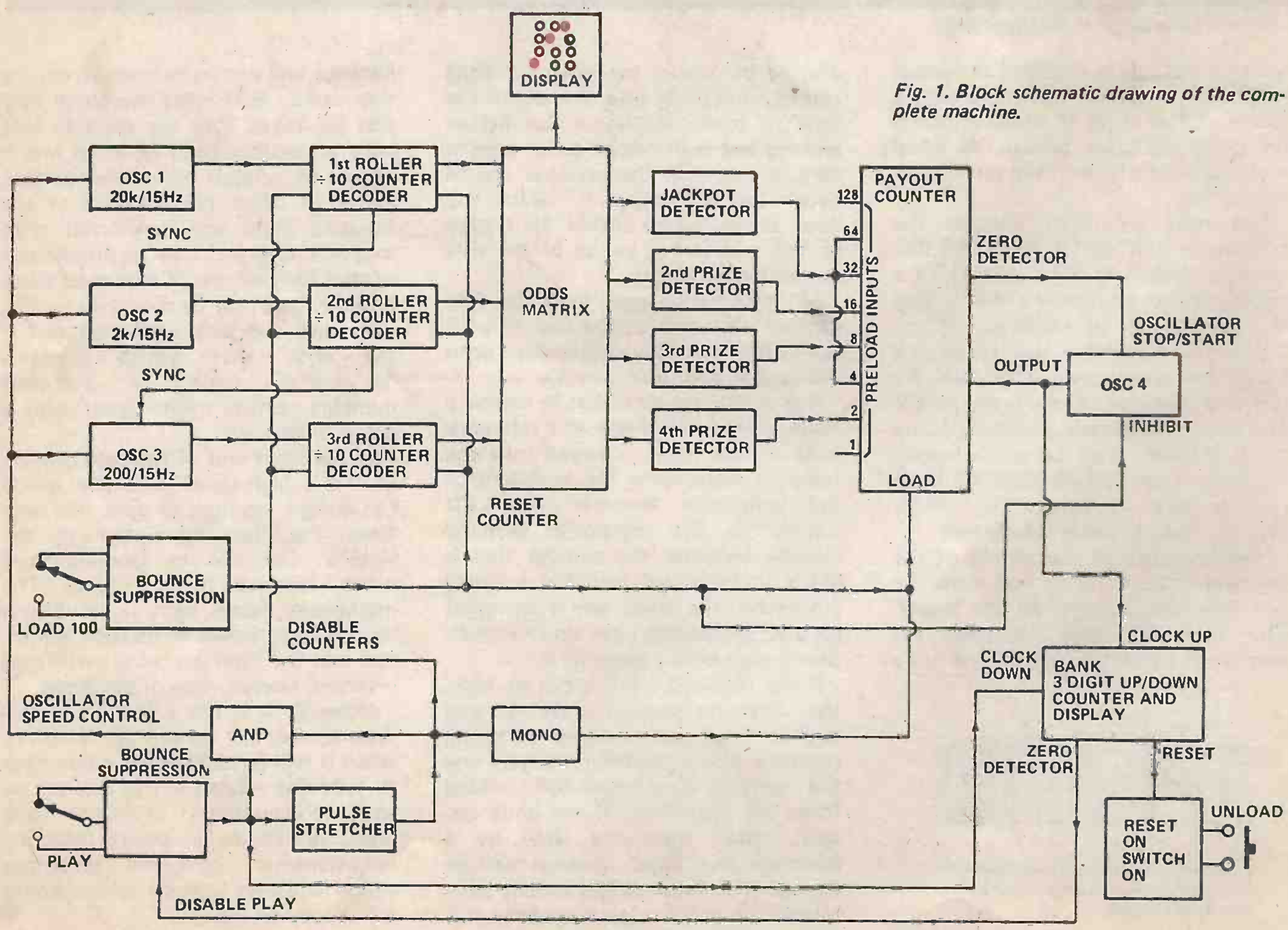


Fig. 1. Block schematic drawing of the complete machine.

OVER THE PAST YEARS we and other magazines have published many electronic games and puzzles ranging from very simple to very complex. We have published mainly simple ones since many complex games like noughts and crosses are expensive and have limited appeal since once the routine has been found the machine can always be beaten.

Here however is a rather more complex game — but one that cannot be beaten in the conventional sense.

The one-arm bandit described here works similarly to a conventional mechanical machines with which most people are familiar. It requires no skill and can be enjoyed by all types of people.

So that the machine does not contravene gaming laws no coin slot or tray is used, instead we use a three-digit display to show the status of the game. Every time the handle is pulled one unit is subtracted from the display or "bank" and if a winning combination is obtained then the appropriate number is added to the bank. To start the game 100 is added to the bank by pressing the load button (which would be a key switch if money was involved). The game finishes when you like by pressing the unload button or when the bank reaches zero.

PRINCIPLE OF OPERATION

Each wheel of the conventional one-arm bandit has been replaced by a decade counter which has ten separate outputs which represent positions on the wheels. These three counters are allowed to be clocked rapidly for a random period (time the handle is pulled for) and then stopped. The final state of the counters determine if a prize has been won.

With three decade counters the total possible combinations is 1000. Therefore if we use 10 different "symbols" on each wheel the chances of a prize would be 100/1 (10 possible wins each at 1000/1). Therefore like a normal machine we weight the rollers by having less than 10 "symbols" and having some symbols repreated more than once on each roller. The table below gives the number of times each symbol is on each roller and a breakdown of the odds of each prize.

Detectors are used for each winning combination and these set the appropriate value (2, 8, 16 or 100) into the payout counter. At this time, oscillator 4 starts up and clocks this counter down to zero.

The output of oscillator 4 also adds the appropriate number into the bank, which is a three digit up down counter. When the play lever is initiated one unit is subtracted from the bank. When the bank reaches zero, further play is inhibited.

Initially on switch-on the bank is reset to zero and it can be reset at any time by pressing the unload button. To commence play the load button must be pressed. This resets the rollers to zero which represents a jackpot, loads this into the payout counter and is then clocked into the bank.

Obviously this machine would not last long in a club with a payout of

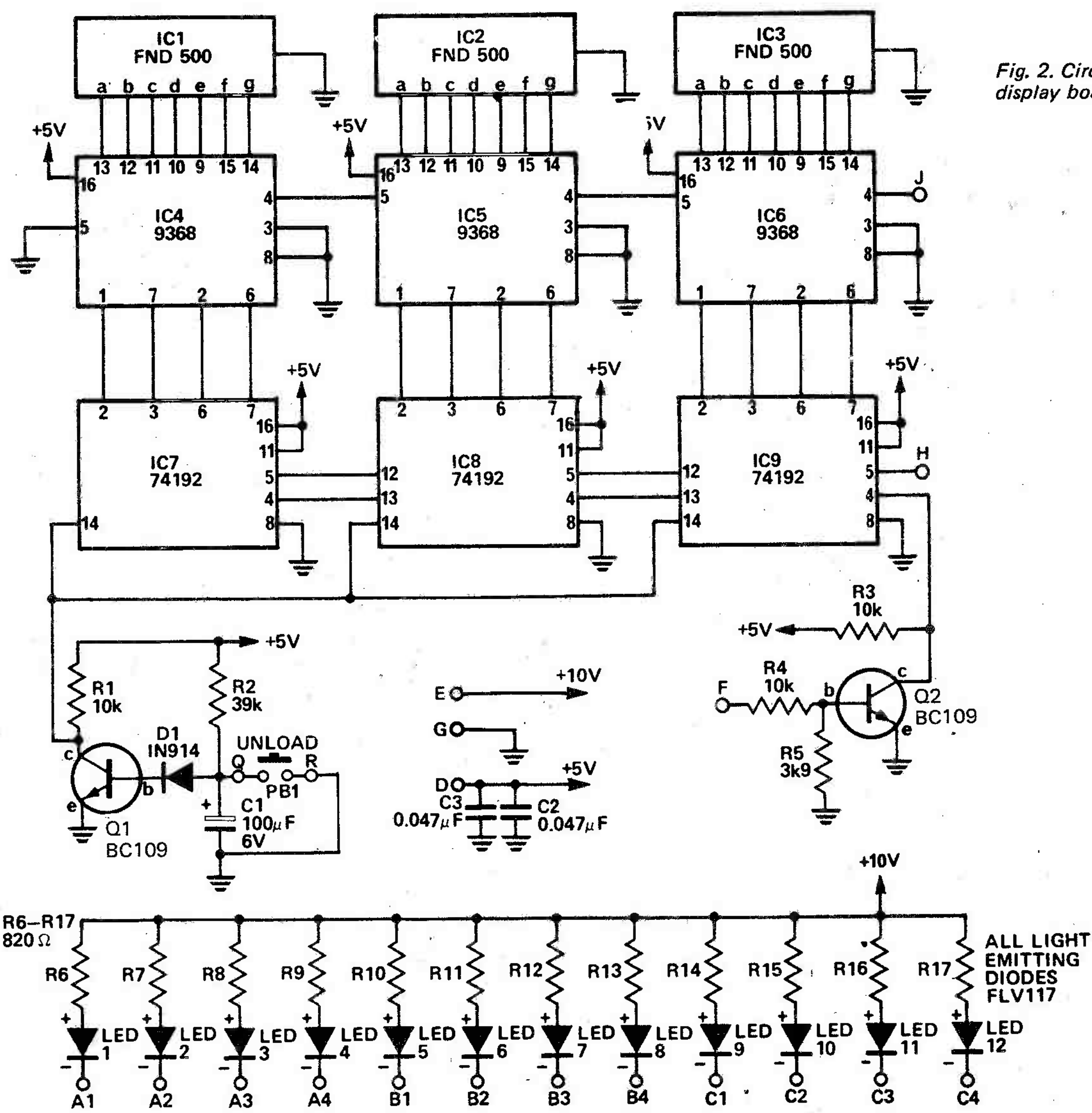


Fig. 2. Circuit diagram of the display board.

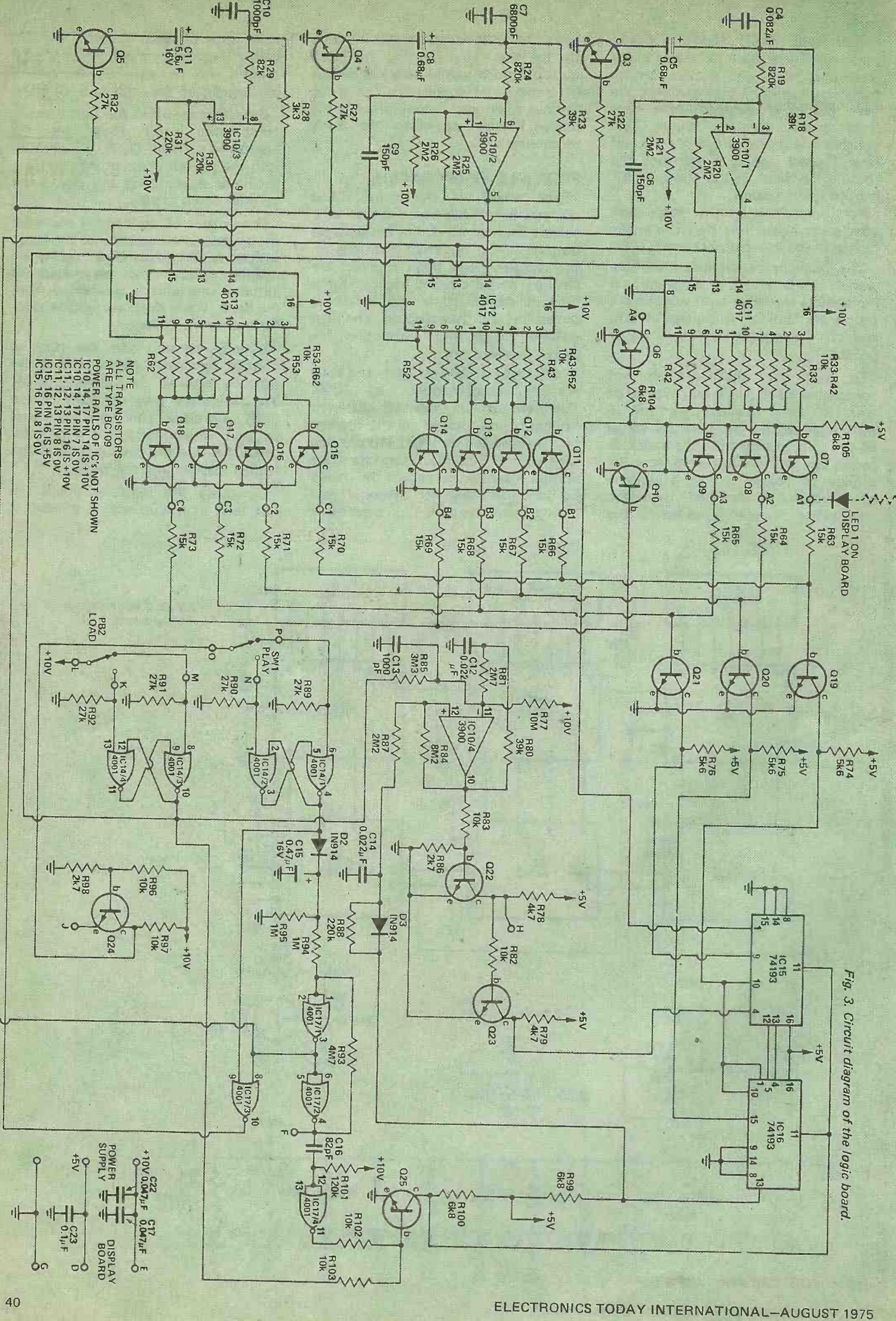


Fig. 3. Circuit diagram of the logic board.

PRIZE	1st ROLLER	2nd ROLLER	3rd ROLLER	WINS 1000 Plays	ODDS	VALUE OF PRIZE	TOTAL VALUE IN 1000 Plays
Jackpot	1	1	1	1	1000/1	100	100
2nd	2	2	4	16	62.5/1	16	256
3rd	2	3	5	30	33/1	8	240
4th	5	4	10*	200	5/1	2	400
TOTAL				247	4/1		996

* 4th prize is not decoded on the 3rd roller. However if 4th prize is on both the 1st and second roller it is automatically lit up on the 3rd. This is similar to 10 10 – on a normal machine.

Fig. 4. This table shows the number of times each symbol is on each 'roller' – and a breakdown of the odds of each 'prize'.

99.6%. If required the payout can be changed either by changing the value of the prize or changing the weighting of the rollers. Reducing the jackpot to 64 (which is easy) reduces the payout to 96%.

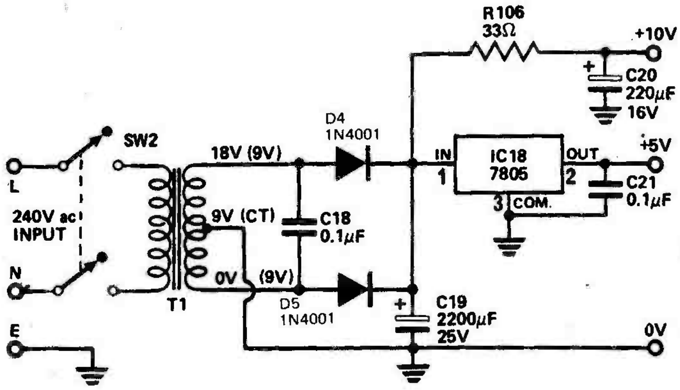


Fig. 5. Circuit diagram of the power supply

PARTS LIST – ETI 529

R106	Resistor	33 ohm	1W 5%
R6-R7	"	820 ohm	¼W 5%
R86,98	"	2k7	" "
R28	"	3k3	" "
R5	"	3k9	" "
R78,79	"	4k7	" "
R74,75,76	"	5k6	" "
R99, 100,	"	6k8	" "
R104,105	"	6k8	" "
R1,3,4	"	10k	" "
R33-R62	"	10k	" "
R82,83,96	"	10k	" "
R97,102,103	"	10k	" "
R63-R73	"	15k	" "
R22,27,32	"	27k	" "
R89,90,91,92	"	27k	" "
R2,18	"	39k	" "
R23,80	"	39k	" "
R29	"	82k	" "
R101	"	120k	" "
R30,31,88	"	220k	" "
R19,24	"	820k	" "
R94,95	"	1 M	" "
R20,21,25	"	2M2	" "
R26,87	"	2M2	" "
R81	"	2M7	" "
R85	"	3M3	" "
R93	"	4M7	" "
R84	"	8M2	" "
R77	"	10M	" "
C16	Capacitor	82pF	Ceramic
C6,9	"	150pF	"
C10,13	"	0.001µF	Polyester
C15	"	0.47µF 16V	electro-
C7	"	0.0068µF	"
C12,14	"	0.022µF	"
C2,3,17, 22	"	0.047µF	Ceramic
C4	"	0.082µF	Polyester
C18,21, 23	"	0.1µF	Ceramic
C5,8	"	0.68µF 16V	"
C11	"	5.6µF 16V	"
C1	"	100µF 6V	"
C20	"	220µF 16V	"
C19	"	2200µF 25V	"

Q1-Q25 Transistor BC109, BC549 or similar

IC1,2,3 (DISPLAY)	Integrated Circuit		FND 500
IC4,5,6	"	"	9368
IC7,8,9	"	"	74192
IC10	"	"	3900
IC11,12,13 (CMOS)	"	"	4017
IC15,16	"	"	74193
IC14,17 (CMOS)	"	"	4001
IC18	"	"	7805

D1,2,3 Diode IN914 or similar
D4,5 " 1N4001 or similar
LED1 — LED12 TIL209 or similar

PB1 Push Button normally open
PB2 Push Button 1 pole change over

SW1 Switch see text.
SW2 " 2 pole 240V toggle

T1 Transformer 240V/9V-0-9V @ 1A

PC Boards ETI 529A, 529B
Metal Box (150 x 150 x 150mm sloping front)
8 way tag strip
3 core flex and plug
front panel escutcheon
handle
nut & bolts
12mm threaded insulated spacers

WHERE TO GET THE COMPONENTS

DISPLAYS

The three FND 500 displays are available from:
Micro Marketing Ltd.,
396 Bath Road,
Slough,
Berks.
for £6.83 inclusive. Micro Marketing also supply the 9368 drivers for an additional £4.86.

CASE

Special arrangements have been made with Arbour Electronics Ltd., of Unit 13, East Hanning-Industrial Estate, nr. Chelmsford Essex, CM3 5BC. Arbour can supply the case shown on our front cover, including the arm, but with no holes drilled so you can build up the machine according to your own taste.

The price is £4.80 including VAT and P & P.

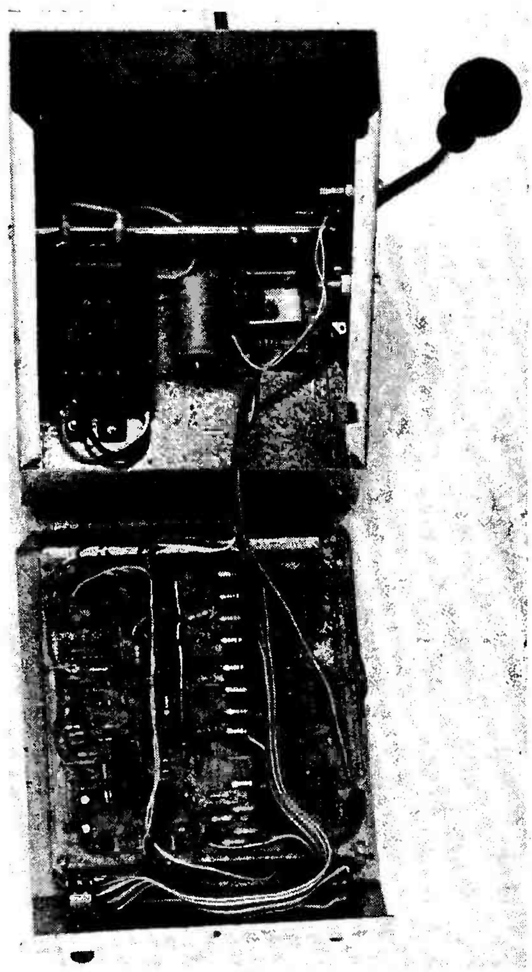


Fig. 6. Internal view of one-arm bandit showing location of major components. Note rubber band arm-return spring.

Continued next month . . .

CONSTRUCTIONAL METHODS

Project Building Guide

ELECTRONIC PROJECTS may be constructed in several different ways. The simplest by far is by using a printed circuit board. Boards, etched and drilled for specific projects are readily available from companies whp advertise in this magazine. Alternatively, pc boards (as they are usually called) can be made at home.

Other methods of construction include matrix board, Veroboard and tag strips. The pros and cons of each method are described in this article.

VEROBOARD

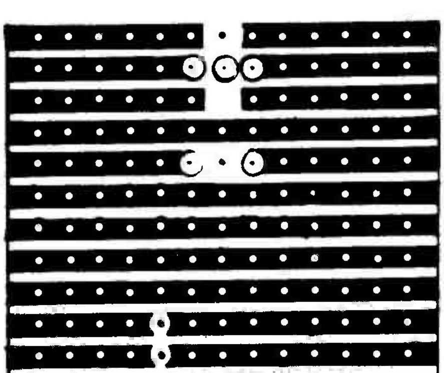
Veroboard is a commercial product specifically made for rapidly assembling prototype equipment, or for building one-off projects etc.

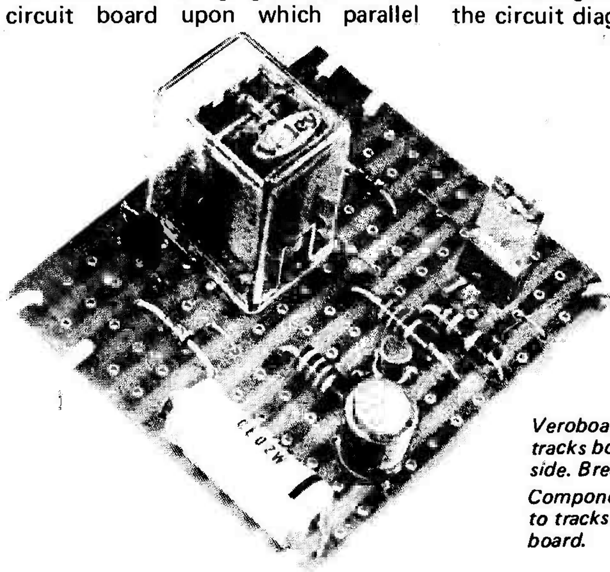
It consists of a high-grade laminated circuit board upon which parallel copper strips are bonded. The board is pierced by a matrix of holes, for inserting component. These holes may be at 0.1, 0.15 or 0.2 inch spacing. For miniature electronic work, incorporating integrated circuits, the 0.1 inch pitch is most commonly used, whilst for general electronics, the 0.15 inch pitch is very popular.

USING THE BOARD

To assemble a circuit using Veroboard, the components are inserted into the board such that they are interconnected by the copper strips in the desired pattern. Where a break in the copper strip is required a sharp drill or a 'spot face cutter', specifically made for this purpose, is used.

The components for a simple circuit may be placed on Veroboard in the same configuration that they have in the circuit diagram. This makes circuit





Veroboard – board has copper tracks bonded to non-component side. Breaks are cut where necessary. Component leaos are solderea to tracks on copper side of board.

checking much easier and any faults are subsequently easier to find.

Most connections may be made directly to the copper strip but, where strong connections are required, or where many wires are to be terminated at the one point, Veroboard pins may be inserted to make secure terminals.

MATRIX BOARD

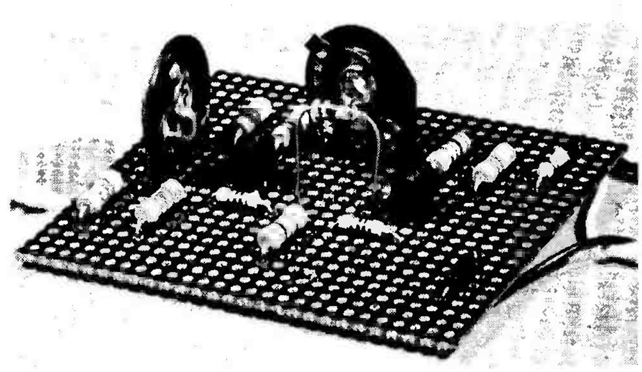
Whilst Veroboard is very suitable for one-off equipment that is to be used permanently, it's rather difficult to strip and use again.

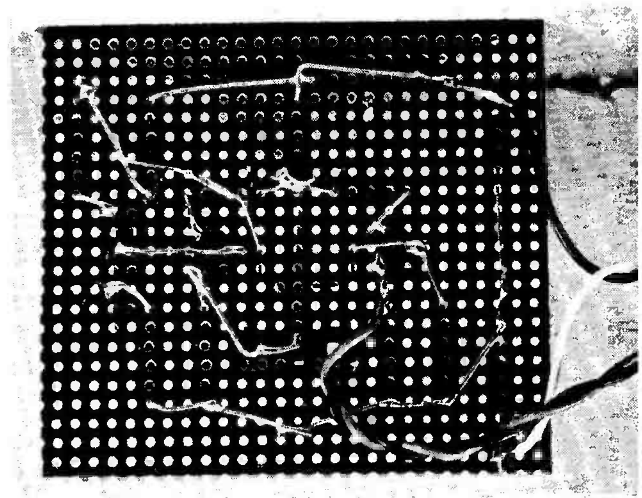
Matrix board, is more suitable for re-use in mocking up first prototypes but may also be used for equipment of a more permanent nature.

Matrix board is perforated with holes, in the same way as Veroboard, but does not have the copper strips. To use it one inserts the components through an appropriate set of holes and makes connections by routing the component leads at the rear of the board or, by using tinned copper wire to link the components. This sounds pretty messy, but it is surprising how quickly circuits can be built up and – how neatly they can be made.

Where component leads or the tinned hook-up wire cross they should be insulated by a small piece of insulating 'spaghetti'. This does not need to be done as often as one would think and quite complex circuits may be assembled neatly, compactly and speedily.

Matrix board is available in 0.25 inch or 0.1 inch spacings. The latter is preferable for miniature electronic work. Turret pins and eyelets are also available at low cost if required. Thus the matrix board system is ideal for assembling experiments as well as of one-off special equipment.





MATRIX BOARD – Components are inserted through holes and leads soldered on non-component side. Novices find matrix board easy to use as components and wiring can be positioned exactly as on the circuit diagram.

PRINTED CIRCUITS

Printed circuit boards simplify electronic circuit building enormously – to the extent that some enthusiasts feel that it is degrading the hobby to that of 'painting by numbers' – but of course you can always make your own circuits, as explained here.

The boards are made of a phenolic resin or glass fibre laminated with a thin copper sheet bonded (generally) to one side.

Intercomponent wiring is formed by etching away the unwanted copper – so that only the required tracks remain. Holes are then drilled for the components which are mounted on the non-component side and their leads soldered directly to the copper tracks.

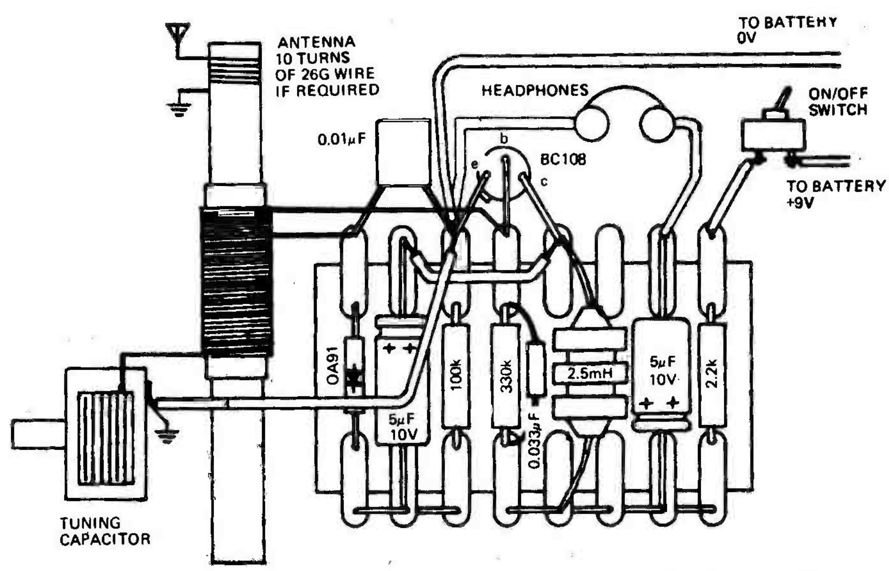
Most component and kit set suppliers stock printed circuit boards already drilled and etched for most popular projects. They also stock printed circuit board material for those who like to make their own boards.

There are very many different ways of etching printed circuit boards. The method described here is virtually identical to that used by our own projects laboratory at ETI. We use this method as in our experience it is the simplest, least messy way of making professional looking boards.

Although printed-circuit boards can be prepared for etching by painting the design on the board with bituminous or other etch-resistant paint or ink, one of the so called photo-resist methods is preferable by far.

Two methods are used – **negative resist** and **positive resist.**

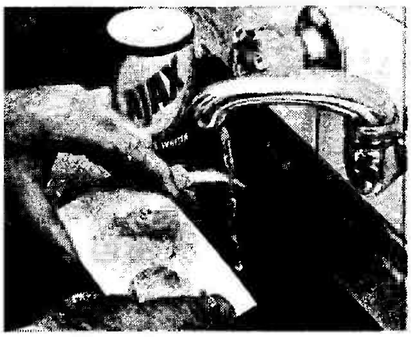
The negative resist method is very effective, it is commonly used commercially but requires a photographic negative of the printed-circuit layout, whereas the positive resist process does not. Hence, using positive resist, a step which may



Tag Strips – construction is quick, cheap and simple. However the method is only really suitable for small scale projects as inter-tag wiring will otherwise be extensive and tedious. The method also wastes space. (Circuit shown is of a single transistor reflex receiver).

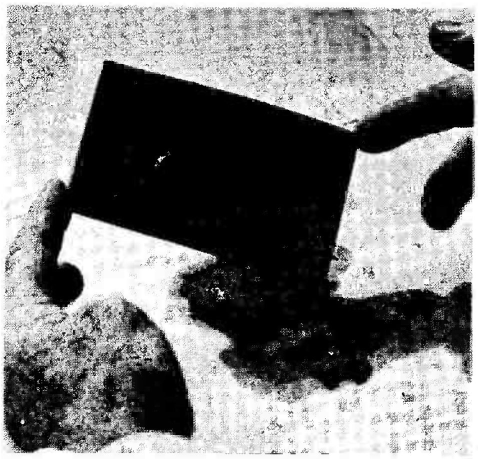
CONSTRUCTIONAL METHODS

The artwork is prepared (full size) on a piece of transparent film using opaque PC board tape and pads. An original master is shown here together with an etched but untrimmed or drilled board.



The laminate should be thoroughly cleaned with paper towel and abrasive cleanser powder until the surface is uniformly bright, and wets uniformly.

The prepared laminate is coated with a thin film of 'resist' and allowed to dry.



Excess resist should be drained off and the board dried in a dark and dust free place.

The artwork is placed on top of the copper side of the board and sandwiched between a piece of foam and a sheet of glass. The board should then be exposed to light with a high ultra violet content for a time as detailed in the text.

After exposure the resist is developed (see text) the board allowed to dry and then etched in ammonium persulphate or ferric chloride solution. The board here is seen when partly etched.

be difficult for some experimenters is eliminated.

HOW IT WORKS

The copper surface of the board is coated with resist and then exposed to light through a piece of translucent film upon which the desired circuit pattern has been layed out with opaque artwork tape and/or ink. When subsequently developed the resist that has been exposed washes away leaving an etch-resistant pattern of the required circuit. The exposed copper may be etched away with ferric chloride or ammonium persulphate.

THE ARTWORK

Materials are available from suppliers for making the so-called 'artwork'. This is the required pattern laid-out full size, with opaque tape onto nylon film. Tapes of various widths are available together with stick-on transistor and IC pads. Such materials, although relatively expensive, greatly facilitate making artwork.

Mecanorma, of 49–51 Central Street, London EC1, can supply these (also resist patterns).

1. LAMINATE PREPARATION

(a) Allow an 8 mm border beyond the finished board perimeter to simplify handling.

(b) Scrub laminate thoroughly with a powdered abrasive cleaner using a new Scotchbrite pad or clean paper towelling and water. (Do not use sponge type kitchen pads or steel wool, due to their susceptibility to grease retention.)

(c) Hold scrubbed laminate under running water and check that the copper surface 'wets' evenly all over. If a break appears, rescrub and retest.

(d) Dry with a clean piece of paper towelling, being particularly careful not to touch the prepared surface of the laminate with the fingers. (Skin oils will contaminate the surface and nullify the preparation.) Then brush the surface with a 'soft', clean brush to remove lint, dust etc.

2. COATING THE LAMINATE

(a) Pour a small pool of resist in the centre of the prepared laminate and thinly smooth over the surface with a ½" to 1" paint brush. (Use a new brush and keep for use with CCPR 12 Resist only. Wash brush in methylated spirits, then in soap and water). A "streaky" appearance when wet usually settles evenly during the drying process.

(b) Place coated laminate in a preheated oven at 80 to 90°C (176 to 194°F) for 10 minutes. This will dry the resist sufficiently for exposure.
It is recommended that ovens using exposed or infra red elements not be used as the red light may prevent the photo-sensitivity from functioning. Where these and gas ovens are employed, bring the oven up to temperature and switch off, then place the prepared laminate in the upper section of the oven for 15 to 20 minutes.

Kodak Ltd., can supply photo-sensitive resists: Resists Dept, Swallowdale Lane, Hemel Hempstead, Herts. Electrovalue (28 St. Judes Road, Englefield Green, Egham, Surrey) supply "Positiv–20" which will cover about 10 boards for under £1 (N.B. This uses caustic soda for developing.)

EXPOSING

Now place the artwork in intimate contact with the prepared board by sandwiching the board and artwork between a sheet of polythene foam and a piece of thoroughly clean glass.

The sandwich must now be exposed to light. This can be done in several ways – two of which are described below.

(a) Direct sunlight may be used – the exposure time should be four to five minutes.

(b) Using 2 x 20 watt blue/violet fluorescent tubes (with an output of around 3900 angstroms) mounted on a twin batten unit, at a distance of 25 mm, a master made on single matte film, typically requires an exposure time of four minutes. The time will vary depending on the film used (clear, single matte or double matte) and the distance between the tubes and the work. Clear film typically halves the exposure.

When an ultra violet light is available, this is ideal.

DEVELOPING

(a) Mix the developer according to the instructions. Place the solution in a glass or plastic tray. (Do not use aluminium containers as this solution is alkaline and will be contaminated by the aluminium).

(b) Immerse the exposed laminate in the developer and rock gently, avoiding splash. Another very satisfactory method is to lightly brush over the surface, while fully immersed, with a clean paint brush.
The exposed areas should dissolve completely within two minutes. This developer should be treated with care. Always wash hands and other exposed skin areas as soon as possible.

(c) Rinse the developed laminate under running water and dry off with a soft cloth, then allow to stand in free air to stabilise for approximately 30 minutes.

(d) Where a very hard finish is needed, post baking at 100°C (212°F) for five to 10 minutes is recommended. Allow laminate to fully cool before etching.

ETCHING

Two suitable etchants are:

(a) **Ferric Chloride:** Yellow lump (hydrated). Mix 1 kilogram with each litre of water. To speed dissolving, heat the water to between 75 and 85°C (167° – 185°F).
Ferric Chloride: Anhydrous. Mix 500 grams with each litre of cold water. Important, add the powder to the water slowly stirring continuously, as this process generates extreme heat.
An ideal etching method for one or two small boards is to use a plastic paint roller tray and plastic handled nylon bristle hand broom. Place the board on the draining board, and the *cold* ferric chloride in the reservoir, then sweep the ferric chloride up and brush over the surface of the resist. This should be done at approximately one stroke per second. This should give an etch time of four minutes with a fresh solution of etchant. Ferric chloride is available from Electrovalue or some chemists.

(b) **Ammonium Persulphate:** Dissolve 200 grams in half litre of water. This solution should be heated to 40°C (100°F) but not above 50°C (125°F) for etching. Form a "basket" of plastic tubing and use a continuous "dunking" action until fully etched. Constant agitation is essential and a fresh solution should etch in five to seven minutes. This is a particularly clean etchant, but does not etch as much area as the same volume of ferric chloride. Note that this particular etchant is extremely slow when used cold.

Warning: Avoid spillages. If spilt or splashed, wash from affected areas immediately otherwise damage will occur.

When etching is completed, wash off in running water, then strip the resist off with methylated spirits or lacquer thinners. However if required this resist may be left on the finished board as it does not greatly impede soldering.

The resist is not a flux, therefore an electrical grade cored solder should be used in final assembly.

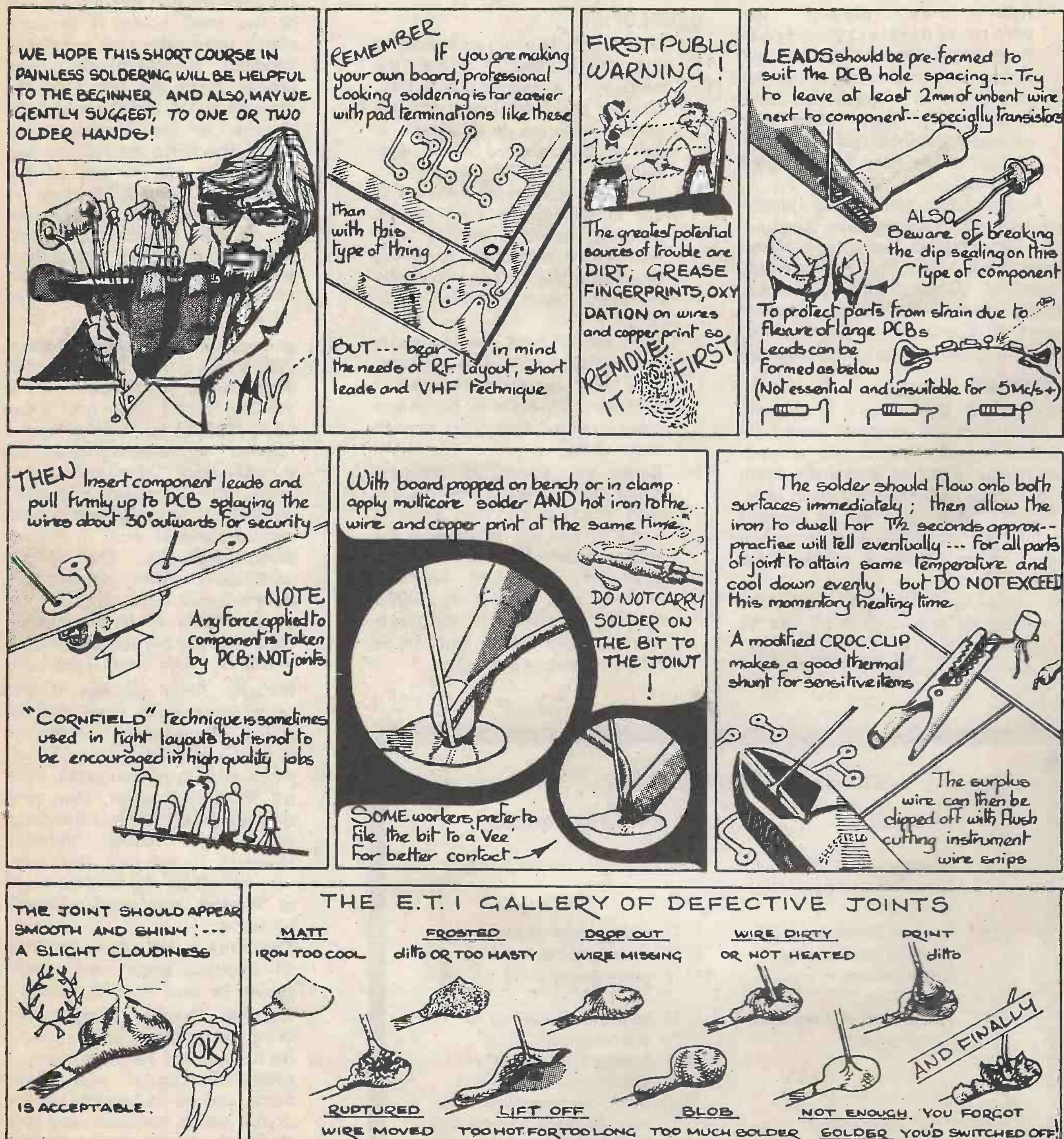
Warning: Exercise caution when using all chemicals, do not smoke, do not use the resist, thinners or methylated spirits near naked flame, and on no account use any utensil which has been used with chemicals for food or drinking purposes. Good housekeeping is essential for good results – keep all utensils clean and dust free. ●

SOLVING PC BOARD PROBLEMS

	PROBLEM	PROBABLE CAUSE
(a)	Resist will not "take" in spots (breaking surface tension).	Laminate not cleaned properly.
(b)	Resist will not wash off exposed areas during development.	(1) resist under-exposed (11) developer too weak (111) oven temperature too high
(c)	Resist washes away during development.	(1) board baked at too low a temperature (11) baking time too short (111) developer too strong (1V) board overexposed or has been exposed to ultra-violet light prior to development.

ETI Soldering Guide

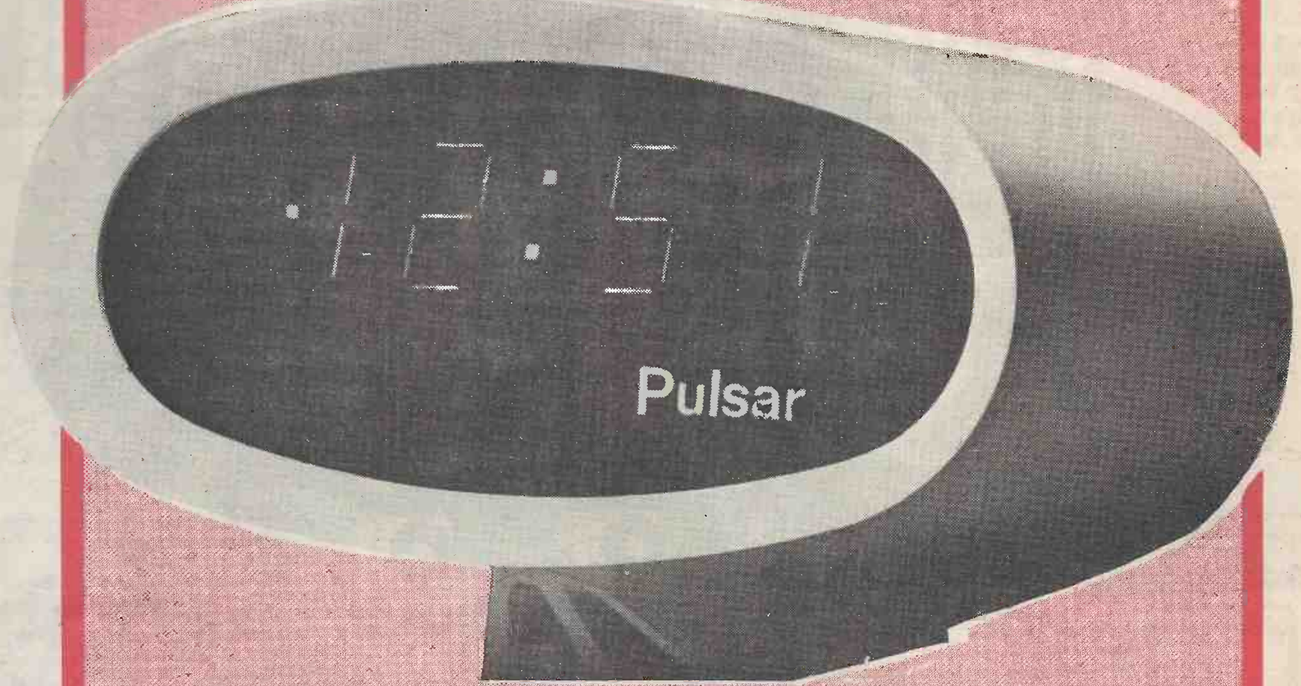
Last month as part of our Project Building Guide we described how to solder. Here W.R. Pullen illustrates the main points.



EXCLUSIVE TO ETI READERS

Pulsar: £13.95

Digital Alarm Clock



When we first came across this inexpensive, superbly designed digital clock we knew that ETI readers would share our enthusiasm. So we have arranged a special consignment carrying ETI's own brand name: Pulsar. Not only that, but the price of only £13.95 (including postage and 8% VAT) is far less than you will pay for this clock elsewhere.

Pulsar is of course fully built, tested and guaranteed – and is completely electronic. The display is Planar Gas Discharge giving very bright 0.7in high characters – so bright in fact that there is a control on the back panel for reducing it!

There is a full alarm facility: using a small switch on the back displays the alarm time for setting. There is also a 'snooze' facility. You want five minutes more sleep? Just tip Pulsar forward, the 'bleeper' alarms cuts off but will start again after five minutes.

The photograph shows ETI's Pulsar as close to full size as possible. The colon dividing the hours and minutes flashes once a second while on the left the small square indicates p.m.

Available only to U.K. and Eire readers at £13.95. Demand is expected to be enormous, there is no limit, but please allow 28 days for delivery.

TO: PULSAR OFFER,
ELECTRONICS TODAY INTERNATIONAL, 36 Ebury Street, London SW1W 0LW.

Please find enclosed my cheque/P.O. (payable to Electronics Today International) for £13.95 for a Pulsar Alarm Clock.

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. . . .

Readers not wishing to cut their copy may order on their own notepaper.

TWO GREAT publications from ETI

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No1

NOW AVAILABLE ONLY FROM ETI

No2

ETI Projects Books contain reprints of popular constructional projects from past issues. The first was in November 1974, the second has just been published. (We apologise to readers who had to wait for Project Book 2. This was delayed for a few weeks due to a printing dispute).

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SPARKRITE MK 2

CAPACITIVE DISCHARGE ELECTRONIC IGNITION KIT

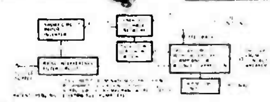
Sparkrite MK2 is a high performance, high quality, capacitive discharge, electronic ignition system.
Because of the superb design of the Sparkrite circuit it completely eliminates problems of the contact breaker. There is no misfire because contact breaker bounce is eliminated electronically by a pulse suppression circuit which prevents the unit firing if the points bounce open at high R.P.M. Contact breaker burn is eliminated by reducing the current to about 1/50th of the norm. It will perform equally well with new, old, or even badly pitted points and is not dependent upon the dwell time of the contact breakers for recharging the system. Sparkrite incorporates a short circuit protected inverter which eliminates the problems of SCR lock on and therefore eliminates the possibility of blowing the transistors or the SCR. (Many capacitive discharge ignitions are not completely foolproof in this respect.)

Sparkrite can therefore give you:–
up to 20% better fuel consumption, instant all weather starting, cleaner plugs – they last up to 5 times longer without attention, faster acceleration, higher top speeds, longer coil and battery life, efficient fuel burning and less air pollution, smoother running, continual peak performance.

NOTE – FUEL CONSUMPTION
The fitting of a Sparkrite MK2 should reduce fuel consumption although the amount of the reduction will vary. A fair estimate of the savings which could be expected, based on reports by our customers and upon our own experience, are as follows:–
4 cylinder vehicle 10% improvement
6 cylinder vehicle 15% improvement
8 cylinder vehicle 20% improvement
It is worth remembering that while fuel saving is important there are many other advantages to be gained from fitting a Sparkrite ignition system.

THE KIT COMPRISES EVERYTHING NEEDED
Ready drilled pressed steel case coated in matt black epoxy resin, ready drilled base and heatsink, top quality 5 year guaranteed transformer and components, cables, coil connectors, printed circuit board, nuts, bolts, silicon grease, full instructions to make the kit negative or positive earth, and 10 page installation instructions.
WE SAY IT IS THE BEST SYSTEM AT ANY PRICE

OPTIONAL EXTRAS
Electronic R.P.M. limitation.
This can be included in the unit to prevent over revving, an advantage to most companies, hire firms, high performance drivers etc.
Electronic/conventional ignition switch.
Gives instant changeover from "Sparkrite" ignition to conventional ignition for performance comparisons, static timing etc., and will also switch the ignition off completely as a security device. Includes: switch, connectors, mounting bracket and instructions. Cables excluded.



PRICES
D.I.Y. assembly kit £10.93 incl. V.A.T. post and packing
Ready built unit £13.86 incl. V.A.T. post and packing
(Both to fit all vehicles with coil/distributor ignition up to 8 cylinders.)
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R.P.M. limiting control £2.42 incl. V.A.T. post and packing
(Fitted in case on ready built unit, dashboard mounting on kit.)
We can supply units for any petrol-engined vehicle (boat, motorcycle, etc.) with coil/contact breaker ignition. Details on request.
CALL IN AND SEE US FOR A DEMONSTRATION.

ELECTRONICS DESIGN ASSOCIATES of WALSALL

Aluminium boxes

These project boxes are manufactured from 18 gauge aluminium and come complete with lids and screws.
The prices shown include V.A.T. (at 8%) but 18p should be added to the total order value for postage and packing.

Order number	Length (inches)	Width (inches)	Height (inches)	Price (inc. V.A.T.)
7	5¼	2¼	1½	47p
8	4	4	1½	48p
9	4	2¼	1½	46p
10	5¼	4	1½	49p
11	4	2½	2	46p
12	3	2	1	38p
13	6	4	2	58p
14	7	5	2½	75p
15	8	6	3	93p
16	10	7	3	£1.14

Boxes can be made to any size but the minimum order for special sizes is 500. General trade enquiries welcome.

Fluorescent light kit

You can build this reverse polarity protected 12 volt, 8 watt, fluorescent light. You will receive all of the necessary parts:- white enamelled ready drilled metalwork, ready drilled heatsink, printed circuit board, high quality components and transformer, end caps and cable, the fluorescent tube, nuts bolts and washers etc., and simple assembly instructions and operating instructions.
When complete the light has a wide variety of uses such as workshop and workbench illumination, garage lighting, emergency lighting, lighting for camping caravaning or boating, as an inspection lamp and many more.
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UNDERSTANDING COLOUR TV

Driving the shadowmask tube

by Caleb Bradley BSc.

THE 'SHADOWMASK' colour cathode ray tube was first demonstrated by Radio Corporation of America in 1950. It has been the display device for virtually all domestic colour receivers throughout the twenty five year history of colour television and has been improved throughout this time to reach its present standard of colour fidelity.

To produce a realistic colour picture, the red, green and blue 'brightness copies', which are transmitted in encoded form in the PAL television signal and recovered as separate vision signals by the receiver decoder, must be reproduced in lights of these colours and additively combined in the viewer's eye. The shadowmask tube uniquely achieves this by reproducing all three pictures *at once* on a single screen. Each picture is fragmented into dots and the three sets of primary coloured dots are intermixed evenly over the screen area. At normal viewing distance the individual dots are not seen and their lights merge together to produce the picture containing a full range of colours.

ELECTRON GUNS

Electrically the shadowmask tube is like three monochrome cathode ray tubes combined in one glass envelope. The neck of the tube contains three electron guns, each resembling the single gun of a monochrome tube — see Fig. 38. The parts of each gun are as follows:

Heater This is a spiral of high resistance tungsten wire which is run at red heat by an ac supply of, typically, 6.3 Vrms, 0.3 A per gun. The wire is coated with alumina to insulate it from the cathode.

Cathode This is a small disc of nickel alloy which is supported by a ceramic disc. The end of the cylinder is coated, as in a valve, with oxides of barium, strontium and calcium to encourage electron emission when heated.

Control Grid Unlike the wire mesh grid of a valve suggested by the schematic diagram this is a closed-end metal cylinder with a small hole to pass the electron beam. The intensity of the beam current of each tube is controlled by the difference in potential between its grid and cathode, and in this way the quantities of primary coloured lights at the screen are controlled. The grid voltage with respect to the cathode varies within the range 0 V to −150 V at cut-off.

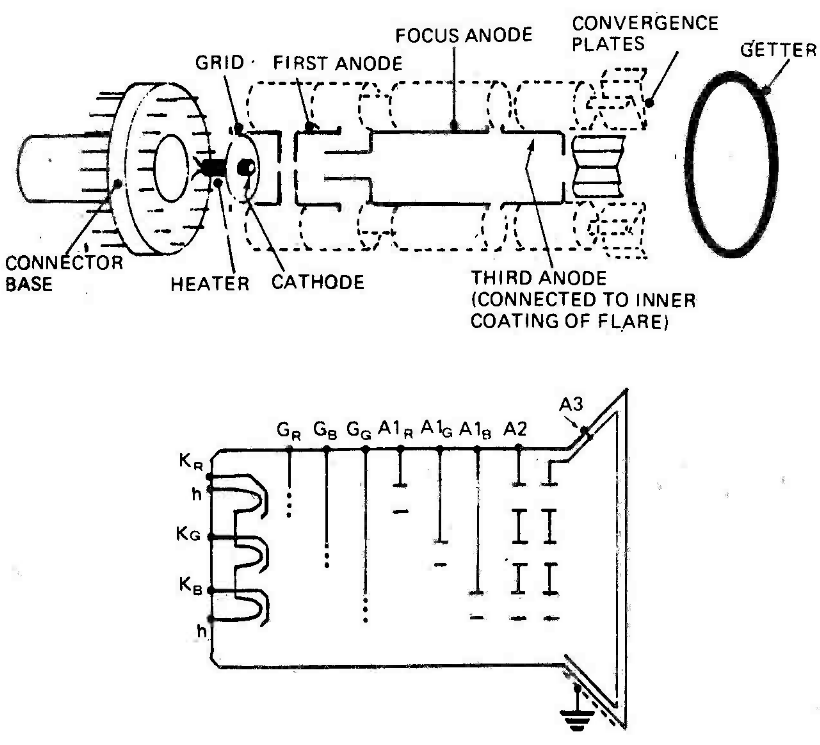

Fig. 38a) Triple electron gun assembly of the shadowmask colour tube, showing one gun in detail (remaining two are shown dotted). b) Schematic diagram for the tube.

PRIMARY OR COLOUR-DIFFERENCE DRIVE

The grid-to-cathode voltage for the red gun must be the original red camera signal E_R, likewise E_G for the green gun and E_B for the blue gun. In practice there are two ways of connecting the decoder to the tube to achieve this — see Fig. 39. Both methods are used in commercial receivers.

The receiver decoder always initially demodulates the signals U and V from the PAL subcarrier. In the primary drive system these two signals are fed to a matrix of summing resistors together with the luminance signal Y. By appropriate summing proportions the three primary colour signals are obtained and fed to the tube cathodes via drive amplifiers to give the necessary voltage swings. The tube grids are strapped together to a fixed voltage which can be varied by the brightness control. Thus the three beam currents are controlled by E_R, E_G and E_B.

The alternative colour-difference drive method applies signals to both the grids and cathodes of the guns which themselves perform most of the matrixing. Luminance is applied directly to all three cathodes. U and V are simply fed to the blue and red grids via drive amplifiers of weighted gains to convert them to $(E_B - E_Y)$ and $(E_R - E_Y)$ respectively; $(E_G - E_Y)$ is obtained from U and V by a simple matrix (in effect just two summing resistors) and is similarly fed to the green grid.

Remembering that it is the relative grid-to-cathode voltages which control the beam currents it is clear that for, say, the red gun, −R on the cathode

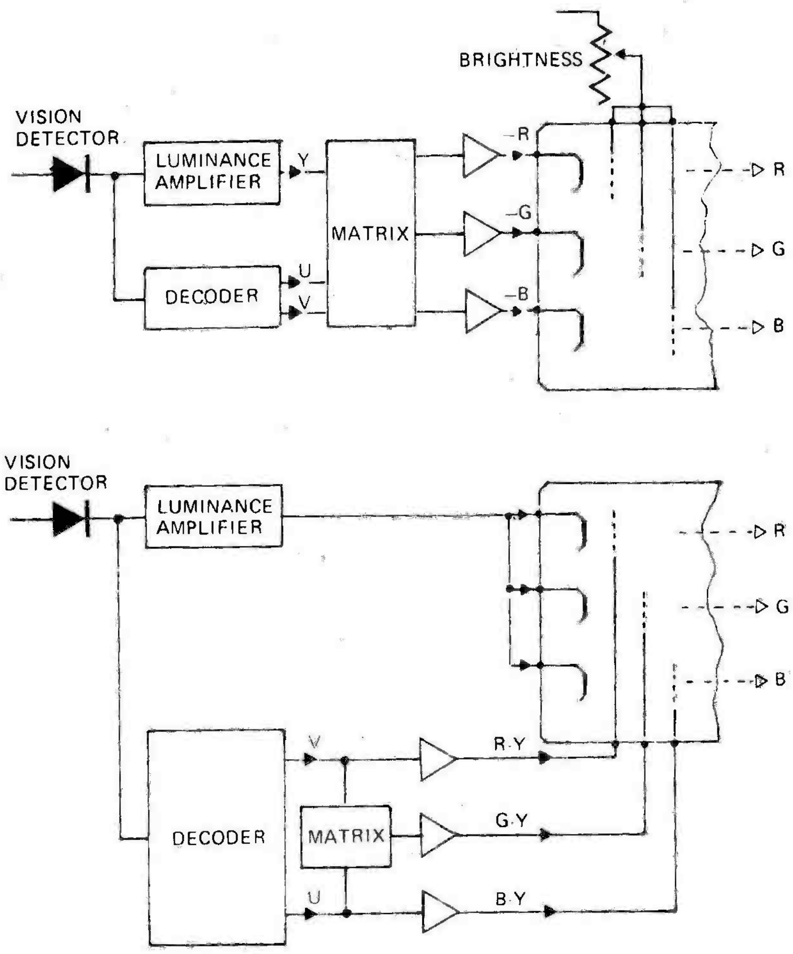

Fig. 39a) Primary colour drive. b) Colour-difference drive.

with the grid fixed gives exactly the same beam modulation as does R-Y on the grid with Y on the cathode. The decoder we described in Part 5 (Fig. 34) was one intended for colour-difference drive.

The pros and cons of the two methods are various. Colour-difference drive has the advantage that most matrixing is eliminated. Only the luminance amplifier needs to have a wide frequency response since the three colour-difference signals have small bandwidth. Brightness control is not simple to apply though and involves clamping the luminance signal to a variable voltage. Primary colour drive involves only three identical drive amplifiers and many aspects of receiver design are simpler. Primary colour drive to the grids is also possible but cathode drive, as used in nearly all monochrome receivers, has the advantage of greater tube gain.

To continue our dissection of the electron guns:–

First Anode This is held positive with respect to the cathode by 200 to 500 V and attracts the electron beam from the cathode through the grid. The three 'A1' voltages can be adjusted in the receiver to allow the efficiencies of the three guns to be matched; these controls are often called 'background' controls since they are intended to balance the guns near cutoff to ensure neutral dark grey tones. Switches are usually provided for removing individual A1 supplies. This ability to disable individual guns is necessary for the vital adjustments of purity and convergence, to be described.

Focus Anode All three focus anodes are linked inside the tube and are operated at about 4500 V.

Third Anode This is formed by a conductive coating on the inside of the tube flare with a special connector moulded into the glass. It is operated at the very high potential of 22 to 25 kV.

The effects of the three anodes at progressively higher potential are:

a) To accelerate the electron beam to a very high velocity towards the screen phosphors which it strikes at about 320 000 000 km/hr! A monochrome tube can provide adequate brilliance with rather less electron energy (a typical third anode voltage is 16 kV) but, as will be seen, the shadowmask colour screen is less efficient than a simple monochrome phosphor.

b) The potential differences between A1 and A2 and between A2 and A3 (using alternative nomenclature for the anodes) represent electrostatic lenses which focus the electron beams on to a small spot on the screen. The second anode is called the focus anode because the spot size is optimised by adjusting its voltage.

Convergence Plates These serve to concentrate magnetic fields applied from outside the tube on to individual electron beams to adjust the relative positions of the three images on the screen.

Getter Ring During manufacture its barium filling is evaporated on to the tube glass. This 'gets' or absorbs any gas molecules left in the tube after evacuation and sealing; these molecules tend to escape from inner surfaces during use.

Shadowmask This is a steel plate perforated with thousands of tiny holes which is mounted in the path of the electron beams just before the screen phosphors deposited on the inside faceplate. Its function is to ensure that through each hole each electron gun can 'see', because of its position, only a dot of the correct primary colour phosphor – see Fig. 40. Thus more than 2/3rds of the electrons emitted by each gun are merely absorbed by the shadowmask while the remainder pass through to a particular set of phosphor dots. Hence the inefficiency of light production compared with a monochrome tube which has a continuous phosphor and of course no shadowmask.

Enormous precision is needed in the positioning of the phosphor dots relative to the shadowmask. First the

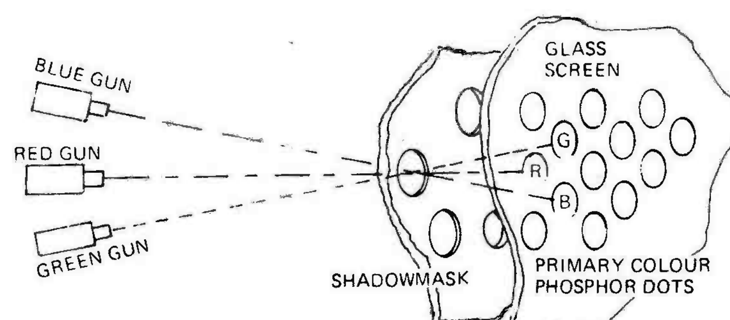

Fig. 40. Principle of shadowmask. The beam from each gun can only reach the phosphor dots of one colour.

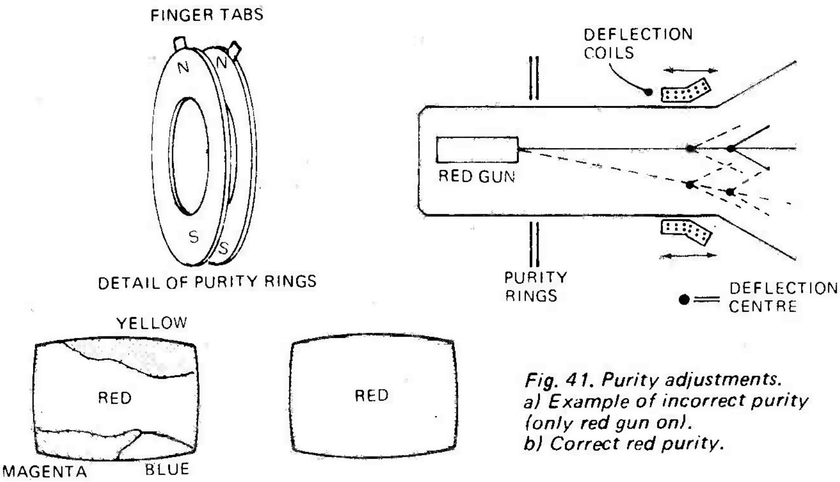

Fig. 41. Purity adjustments.
a) Example of incorrect purity (only red gun on).
b) Correct red purity.

shadowmask is fixed in place. Then a slurry of photosensitive material and the phosphor of one primary colour is run onto the screen through the shadowmask. A small ultraviolet light is then shone on the shadowmask from the position the relevant electron gun will occupy. The dots of light cast on the slurry cause the phosphor to be fixed in place at these points; the rest is washed away. The process is repeated for the other two phosphor colours with the light in different positions to yield a three-colour screen as in Fig. 40.

PURITY

The three electron beams are magnetically deflected in unison by a set of horizontal and vertical deflection coils mounted on the tube neck. These are fed with sawtooth waveform currents at the correct scanning frequencies to cause the beams to scan the standard television raster.

Although the beams are actually bent along a curve as they pass through the field of the deflection coils there is an abstract 'deflection centre' from which all deflected beams from a particular gun seem to originate. This deflection centre must lie exactly where the corresponding ultraviolet source was placed during manufacture of the tube, otherwise the shadowmask cannot allocate the three beams to the three types of phosphor properly. Because of the manufacturing tolerances involved it is necessary to provide adjustments to the deflection centres, known as purity adjustments since they ensure the raster scanned by each gun is a pure primary colour.

The adjustments available are shown in Fig. 41. Immediately after the focus anode the electron beams pass through a steady magnetic field across their path produced by two rotatable ring magnets — the 'purity rings'. The strength of this field can be adjusted by relative adjustment of the rings toward assisting or counteracting each other, and its direction can be varied by rotating the rings together. The effect of the field is to bend the paths of the three beams slightly (only the red gun is shown in Fig. 41). The purity rings resemble the picture shift magnets fitted to monochrome tubes but have the different purpose of shifting the effective beam deflection centres up or down, right or left inside the deflection coils. The normal procedure is to switch on one gun alone (usually red) and adjust the purity rings for a pure red raster. However the best obtainable may resemble Fig. 41a). Here purity is only correct near the centre of the screen i.e. zero deflection current. The cure is to shift the deflection centres fore or aft. The deflection coils are held in a sliding mount to allow this adjustment. After achieving red purity (Fig. 41b), only slight trimming is needed to obtain equal purity from the blue and green guns.

MAGNETIC EFFECTS

Since electrons are readily deflected by magnetic fields it is important that only wanted magnetic fields are allowed to exist inside the shadowmask tube if good purity is to be obtained. A magnetic shield of iron or steel sheet is fitted around the outside of the tube flare to minimise the effect of stray alternating fields in the receiver e.g. from the line output and possibly mains or audio transformers.

The earth's magnetic field, although weak, can permanently magnetise the steel shadowmask and cause purity errors. The tube may be exposed to other magnetic fields during its life, e.g. from vacuum cleaner motors, under-floor electric heating or from railway equipment if ever transported by train! These possibilities are dealt with by arranging for the shadowmask to be automatically demagnetised every time the receiver is switched on. This is done by applying a strong ac field (500 ampere-turns copes with all likely magnetisation) for a fraction of a second, decaying progressively to a negligible value (0.3 ampere-turns causes no visible effect on registration). A similar process is used for bulk erasing magnetic tapes; it is loosely called *degaussing*. The degaussing coil is fixed around the tube shield in such a way that the shield acts as a pole piece for the alternating field to help direct it on to the shadowmask. A typical degaussing circuit makes use of a ptc (positive temperature coefficient) thermistor and a vdr (voltage dependent resistor) — see Fig. 42.

At switch on, the thermistor is cold, (low resistance) so heavy ac current flows through P, vdr and the coil L. Power dissipated in P causes its temperature and resistance to rise so less voltage appears across vdr and L. Since the resistance of vdr increases with decreasing voltage, the current in L rapidly diminishes and diverts to R which keeps P hot during viewing.

In the early days of colour a portable mains-powered degaussing coil was standard equipment for servicemen but automatic degaussing circuits as in Fig. 42 now make this unnecessary except for extreme cases.

To be continued . . .

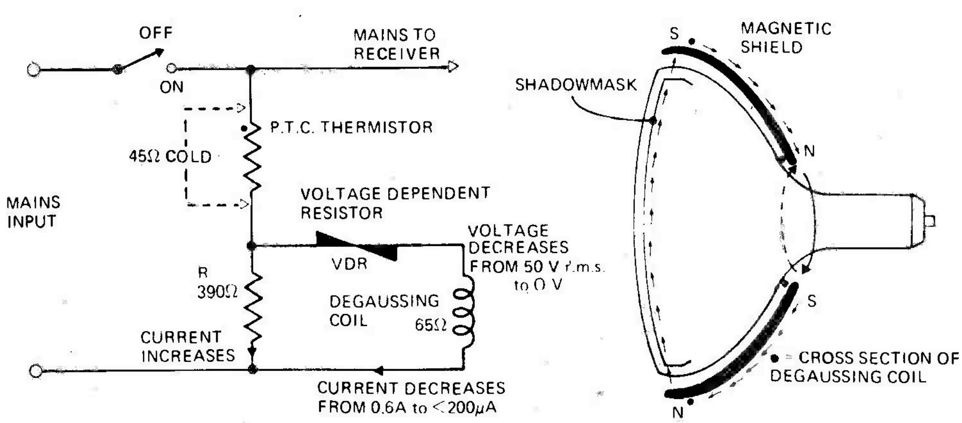

Fig. 42a) Automatic degaussing circuit. b) Cross section of tube showing instantaneous flux during degaussing.

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ELECTRONICS —it's easy! PART 18

Generating signal waveforms.

THROUGHOUT electronic systems, repetitive waveforms of specific shape are commonly processed in order to achieve the desired function. Typically used are — sine waves, square waves, triangular and sawtooth waveforms as well as many types of pulse train.

For instance one may need a sinewave signal generator to determine the response at various frequencies of an audio amplifier. This is done by feeding a sinewave into the input (as shown in Fig. 1) whilst monitoring the amplitude and wave shape of the output. By such means it is possible to establish an amplifier's gain and distortion over its working frequency range. A suitable signal source for this task, would need adjustable frequency range over the audio band (10Hz—20 kHz), adjustable amplitude, and above all an adequately pure sinusoidal wave shape. Any distortion in the test sine-wave would of course affect measurements.

Similarly radio and television receivers are tested by injecting known sine-wave frequencies, only here, the frequencies used are much higher.

In the construction of a radio transmitter, or a multiplexed signal system, a basic carrier is required upon which the modulation is impressed. This technique was described in Part 5 of this series. Here however, the requirement is for fixed frequencies; there may not be the same need for waveform purity as in the testing of a superior audio amplifier.

An excellent example of the need for signal generation is in electronic musical instruments such as the electronic organ or music synthesizer. Both types of instruments require numerous waveforms to be generated over a wide range of frequencies. These waveforms are then mixed and modified in amplitude and time to create an enormously wide variety of sounds. Virtually any sound can be created — from surf breaking on the rocks to conventional musical instruments.

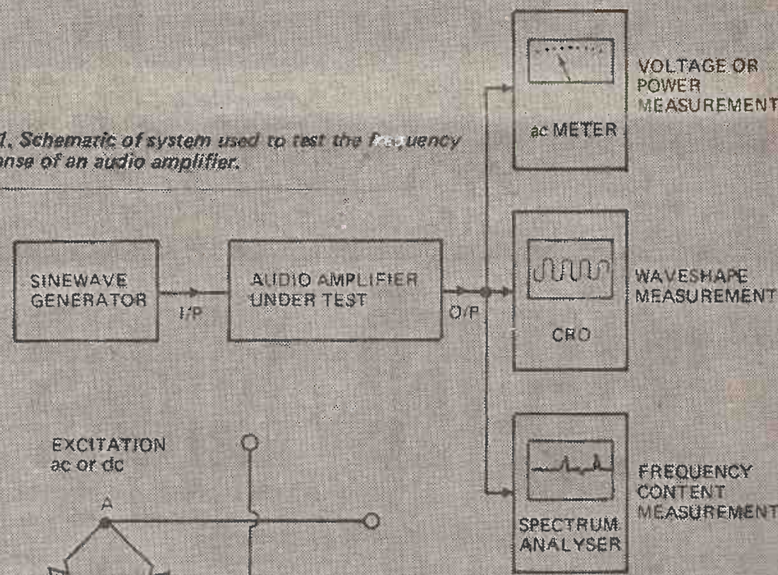


Fig. 1. Schematic of system used to test the frequency response of an audio amplifier.

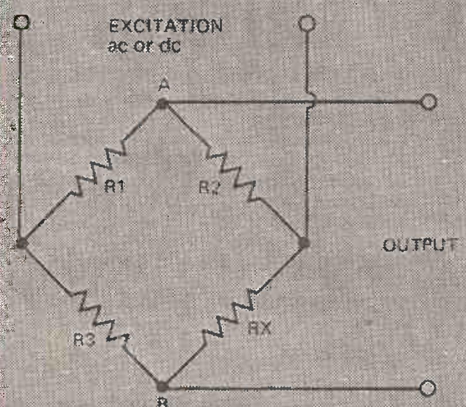


Fig. 2. The Wheatstone bridge is commonly used in instrumentation for measurements with various types of sensor. The bridge is usually excited by an ac source so that the output may be more readily amplified.

In instrumentation a measuring bridge similar to that shown in Fig. 2, is often used. This particular configuration, known as a Wheatstone bridge works as follows.

If, when an excitation voltage is applied to the bridge, R1 equals R2 and R3 equals RX there will be equal voltages at points A and B, and hence, there will be no output.

Resistor RX is usually a sensor, such as an LDR, thermistor etc which changes its resistance proportionately to the quantity (light, temperature pressure etc) being measured. As RX changes in value the bridge will become unbalanced and an output will

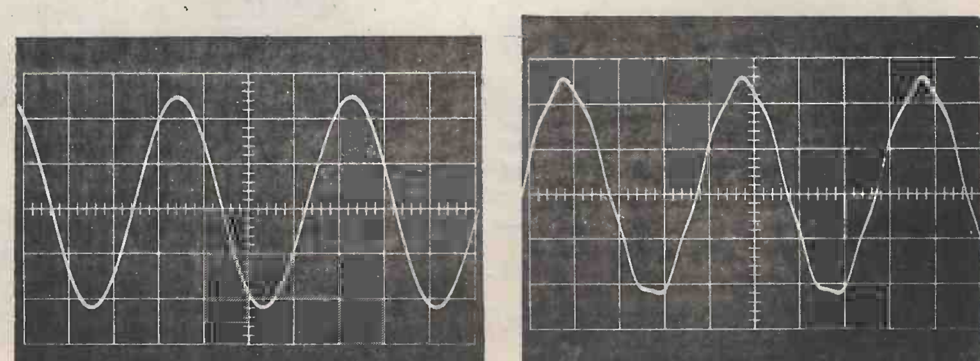


Fig. 3. Various waveforms as photographed on an oscilloscope screen.
(a) Sinewave
(b) Sinewave with harmonic distortion
(c) Square wave
(d) Square wave with ringing.
(e) Sawtooth or ramp.
(f) Triangular
(g) White noise

be obtained, which is proportional to the change in light level etc.

The excitation used is most often ac because then the output will also be an ac voltage. An ac voltage is more easily amplified and more easily extracted from noise than a dc voltage.

Some instrument applications require a steady sine-wave to excite resonance in a mechanical component, this, in turn, is used to maintain the signal at a constant value. Many accurate clocks work on this principle.

The pacemaker, used to strobe the failing human heart into regular pumping action, puts out a steady train of stimulating pulses. In this application the design demands are for long-life, utmost reliability and, in the case of implanted units, small size.

The time-base generator as used in the cathode-ray-oscilloscope, or in the television camera and monitor, provides a signal that steadily increases in amplitude in order progressively to deflect the electron-beam of a cathode-ray tube across the imaging surface. Once the end of the trace is reached it may retrace back again at the same rate or fly back at a much higher speed to start again. The generation of sawtooth and triangular signals that fulfil timing operations — the sweep action of a flat-bed plotting table is another example — is an often met need.

Digital calculators and computers (really one and the same thing in many cases), require a steady source of timing pulses — a square or rectangular wave train — that pulses the digital — computational circuits along pulse by pulse. This is called the system clock. In many systems, clock rates may be as high as several million pulses per second.

In some applications a short burst of waveform only is required — not a continuous train. In this case the unit must generate the signal needed and then stop, waiting for the next demand. Ultrasonic and radar distance measuring devices are examples of this need: a single pulse is fed to the transducer or antenna, the time taken to go the target, bounce off and return, is then measured against a time base. The cycle is then repeated for the next measurement.

Although noise is usually regarded as having only nuisance value in electronic systems, the occasional need arises where noise must be generated. The obvious way to test the performance of a system under noisy conditions is to feed it with signal and noise mixed together. By adjusting the signal-to-noise ratio the performance of the system on noisy signals may be measured.

One last example is the provision of tremulant (amplitude modulation) in electric guitars. This is simply the amplitude modulation of the artist's created musical sounds with a constant low-frequency signal. Once the string vibration has been transduced into an electrical equivalent signal form this is modulated by the low frequency signal.

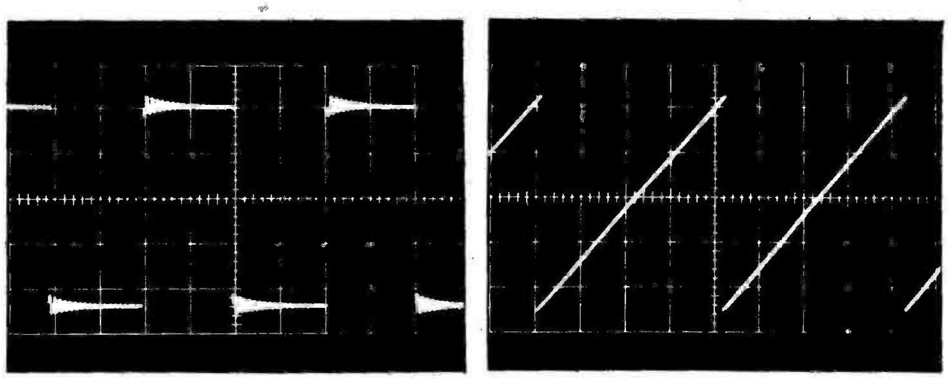
These are but a few of the vast number of applications. The range of performance specifications vary so widely that we must employ many different generating methods to cover all needs. What is good for audio frequency is of no value at UHF frequencies. It is, therefore, necessary to study many alternatives if a really useful knowledge of electronic systems is to be gained.

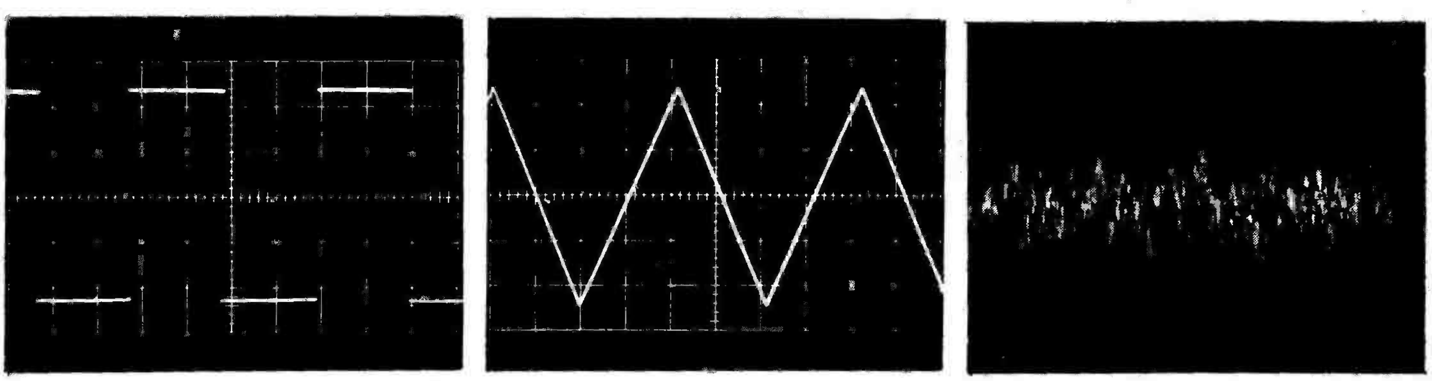
SIGNAL TYPES

In Part 4 we saw how all wave forms are composed of numerous sine-waves of different frequency and amplitude. In theory we need only generate sine-waves and mix them together as needed to obtain any desired waveform. In practice, however, this is rarely the way that wave shapes are created. There are many much simpler ways. For example, consider the generation of a low frequency square wave. All we need is a mechanical switch that repetitively opens and closes a dc circuit. To provide a ramp we need only use the voltage building up across a capacitor as it is fed from a dc source.

This is not to say that the Fourier-analysis method is of no value. Indeed, by recognising that waveforms *can* be built up from sine-waves we can improve wave shape by following design procedures that observe this rule. A perfectly-adequate, pure sine-wave can be generated by filtering the higher harmonics out of a square wave signal; a much used technique.

A variety of wave forms is shown in Fig. 3. They are photographs taken of signal generator outputs applied singly and in various combinations to the vertical "Y" amplifier input of a cathode ray oscilloscope. The CRO trace is swept across the screen by its own in-built time-base generator. With practice it is possible visually to assess





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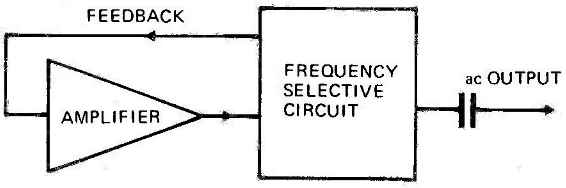

Fig. 4. Basic block diagram of a feedback oscillator.

the quality of a wave shape to within a few per cent by studying its geometric shape. A mask, cut out in the shape of the required function, if placed over the CRO graticule, is a useful aid in wave-form distortion studies. Serious work, however, requires the use of expensive frequency analysers which record the amplitude (and possibly phase) of the frequencies present. A pure sine-wave will have no energy at any other than the frequency desired. Thus, in practice, distortion shows up as energy at other higher frequencies.

The square wave should be perfectly sharp and square-cornered — deviations from perfection show up as an obviously rounded rise and fall or as decaying ringing oscillations at the step transitions. Signal analysers are again ideal for studying the imperfections but are not always available due to their high cost.

Most general-purpose signal generators will provide both sine and square waves — this is because the square wave is easily derived from a sine-wave by amplification and clipping of both half cycles. More expensive generators will provide ramps, and triangular waveforms as well, and perhaps single shot pulses of any waveform type, the pulses being manually initiated or triggered by an external signal.

More expensive, instrumentation signal-generators generally fall into two groups; precision sine-wave (and other shapes) generators with two outputs that can be varied in phase with respect to each other, at the other extreme is the pulse generator which provides digital forms of signal.

For practical reasons, generators cover a specific range of frequencies. There are low frequency generators that provide signals of various waveforms with repetition rates of cycles per hours to several kilohertz. (What is low is highly subjective — the earth scientist regards periods of hundreds of years as definite ac signals; the electronic engineer would treat these as pure dc, ac signals being to him those from one cycle per second upward. The optical engineer works with frequencies of terahertz! It is all a matter of relativity.

The audio range is covered with generators providing from around 10 Hz to 20-100 kHz, there being little need for higher or lower frequencies in audio studies.

Radio frequency, (RF) generators provide frequencies needed in radio work, for example, 500 kHz to 1.5MHz for the broadcast bands. Yet higher are systems for testing and driving radar networks (in the GHz range).

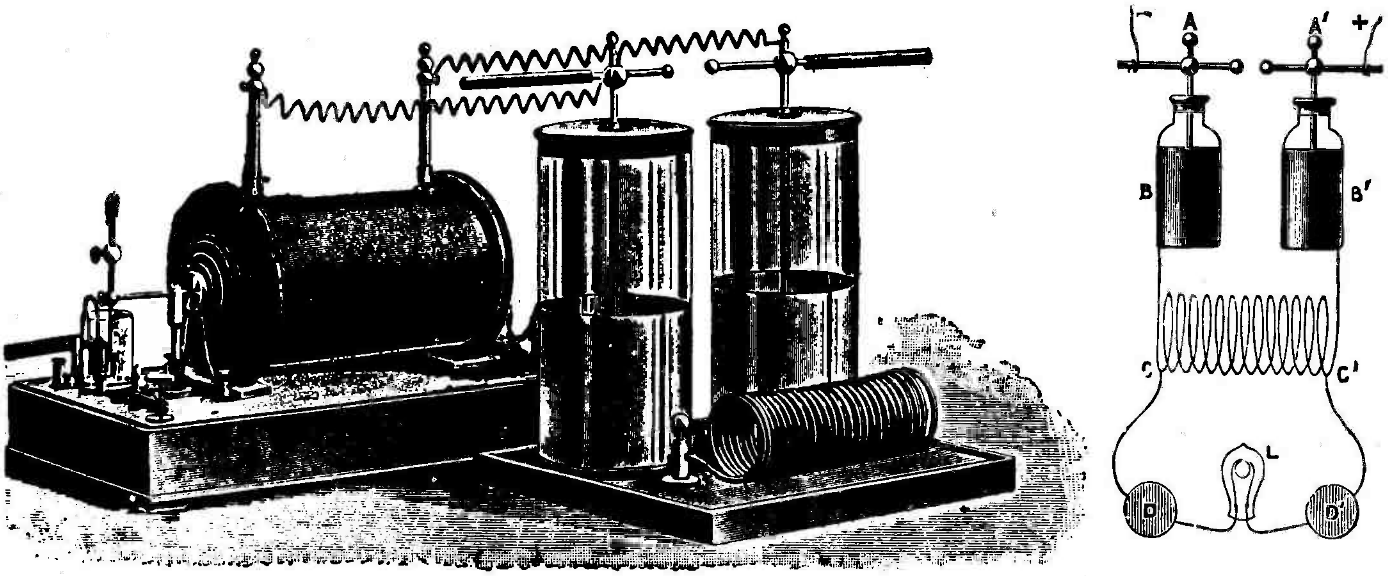

Fig. 5. High frequency generation using a spark discharge from a tuned LC network. The D'Arsonval high frequency apparatus employed two Leyden jars where the outer coatings were joined by a helix, and the inner coatings fed by an induction coil.

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The Kit includes: MK50204, 28-pin skt., CA3081 segment driver and P.C.B. £14.00 + VAT.
(For H.MM.SS.s use MHI-D7x7/6, for M.SS.s use a four-digit MHI display).

MHI-5378 (DIGITAL CAR CLOCK KIT)

Uses the new National MM5378 Auto-Clock chip. The Chip has full car/boat clock facilities with a voltage range of 9-20v with no-loss-of-time down to 5v. Timing source is a 2.097152 MHz Quartz Crystal which is driven and divided by the chip. Facilities include: (i) display on/off switching with ignition leaving the clock running at all times (draws about 5mA). (ii) display brightness control. MM5738 kit skt CA3081, 2MHz Xtal and Trimmers, P.C.B. £15.10 + VAT. (Interfaces with MHI four-digit displays kits).

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MHI-D707	4 or 6-digit display kit, 0.3" digits supplied with PCB.	4dig.£6.60+VAT 6dig.£9.50+VAT
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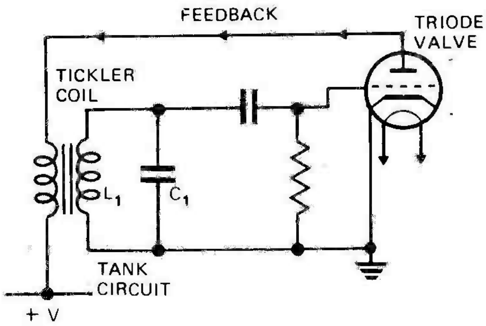


Fig. 6. Schematic of Armstrong's oscillator – the first practical unit to apply positive feedback to the thermonic valve. Developed in 1914.

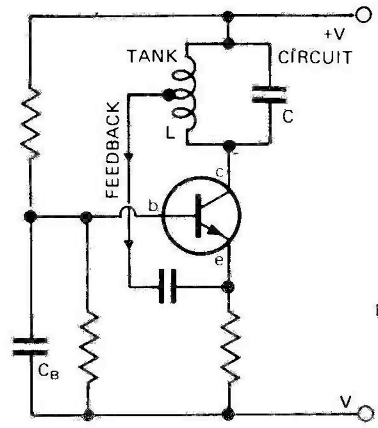


Fig. 7. The circuit of one of the basic forms of feedback oscillator. This type (feedback from tap on tank coil) is known as a Hartley oscillator.

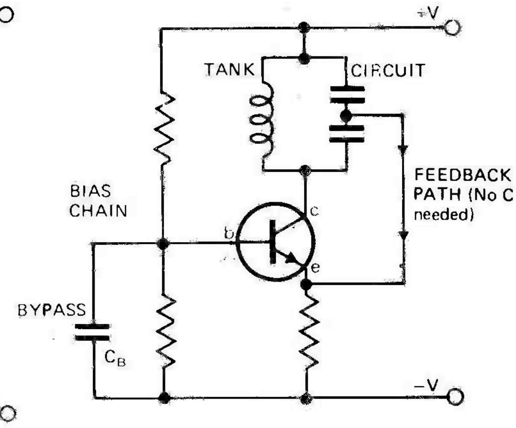


Fig. 8. An alternative arrangement of feedback taps the capacitor rather than the coil. This circuit is called a Colpitts oscillator.

Noise generators provide basically white noise (white noise is defined as having constant power at all frequencies) within the range of interest. There is no sense in building the generator to provide megahertz frequencies when the unit is intended for 1 Hz system testing. By appropriate filtering noise generators may also provide 'pink noise' (noise which falls off uniformly as the frequency rises) or one of many forms of 'grey noise' (non-ideal white noise where the power at various frequencies follows no set law).

Some generators can provide bursts of signal waveform at preset intervals between them. These are useful in radar and sonic distance gauging, in telegraphy and in electronic-music synthesizers.

You might by now feel that the variety of needs implies an overwhelming number of techniques to comprehend. Fortunately the techniques used are far fewer than the possible applications, and many techniques are common to a number of frequency ranges.

BASICS OF GENERATION

Open loop – The desired waveform may be created by using an appropriately shaped mechanical device. A time-varying waveform can be produced by rotating the mechanical part at the speed required. For example, the experiment described in Part 5 used a rotating blade to alter the light level on a light-dependent resistor. The photo-optical method of generation is economic where very low-frequency waveforms of great complexity are needed. One commercial unit uses a circular transparent disk that can be masked as needed. One unusual application of such a device was to simulate the electro-cardiogram signal of a snake. This allowed the data processing equipment, used in research on snakes, to be tested without a live snake, (snakes vary their heart rate randomly from minutes to hours between beats).

Rotary mechanical generators generally produce signals in 'open-loop' – no use is made of the signal produced to modify itself. Tone wheels for electronic organs and strobing lines on turntables also operate this way. In general, however, most signal generators used in electronics make use of feedback, or closed-loop systems.

Closed-loop – on several previous occasions we have seen how negative feedback (that is, the sign of the feedback voltage is opposite to the signal input) helps to stabilise circuits. Examples are, the use of an emitter resistor to improve thermal stability in the basic ac transistor – amplifier stage, and in the operational amplifier networks where a desired gain is obtained from a much higher gain amplifier; the advantage of negative feedback being greater precision and stability.

The converse also applies: positive feedback leads to enhanced instability. By arranging for the output of the active device to feed back into its input with like sign (similar phase) any small change in input leads to rapid build up of output – up to an amplitude governed by the circuit. If the circuit can then be so arranged

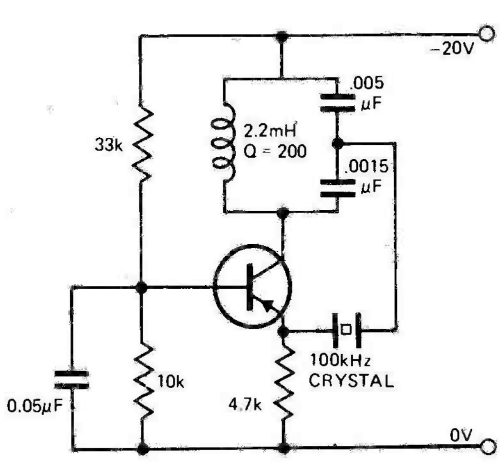


Fig. 9. Oscillator using feedback via a crystal in series-mode.

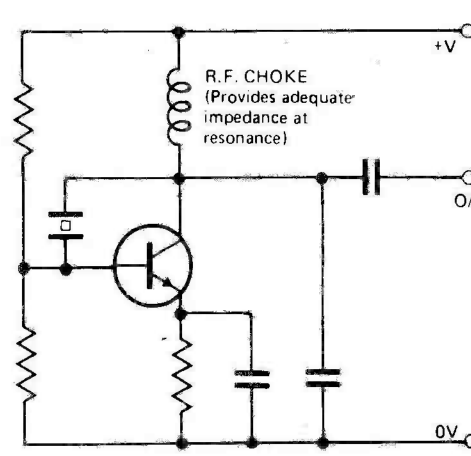


Fig. 10. The Pierce oscillator uses the quartz crystal in its parallel mode of vibration.

that once this limit is reached the source of energy is disconnected the output will fall to zero again. In the meantime the source becomes energised again and the device output again rises. The process repeats providing a steady cyclic signal of wave form decided by the mechanism used. Some oscillators, as such generators are called, produce square-waves, some sinusoids, others ramps.

In general, feedback oscillators can be shown as a system, with a block diagram as in Fig. 4. An amplifier feeds a wave-shaping circuit that controls the time-behaviour of the all-important positive feedback. This diagram should also help to explain why high-gain circuits often oscillate, for any in-phase feedback will turn what is intended to be a stable circuit into an oscillator – the higher the open-loop gain the less in-phase signal needed to cause oscillation.

The natural frequency of oscillation of a feedback system depends upon component values and can be estimated with reasonable accuracy in most designs. There are three basic criteria that must be satisfied if a feedback circuit is to oscillate. Firstly, the phase shift through the amplifier and forming circuit must be zero, or close to zero at the frequency of oscillation required. Any shift toward 180^{o} provides increasingly greater stabilising action. Secondly, the voltage gain of the amplifier and forming circuit must be greater than unity at the frequency needed. Thirdly, the voltage gain must drop to unity once oscillation has begun. If it did not do this, the amplitude would keep on building up with time.

These rules will become more evident as we now look at several design alternatives.

BEFORE ELECTRONICS

Before thermionic valves were invented the generation of high-frequency signals was particularly difficult. One way was to use the oscillatory discharging action of a magnetic-induction coil coupled to Leyden jars. The two formed a tuned circuit which, when the jars were fully charged from the dc source, discharged across a spark gap. A typical layout is shown in Fig. 5 along with contemporary equipment used in medical-electricity treatment around 1900. These produced a train of bursts of decaying oscillation.

Also commonly known at the beginning of this century were the Faradic coil generators. These were based on the electric-bell principle. A magnetic coil was fed with current. As the magnetism built up it pulled in a small armature that opened a contact thus disconnecting the coil. This then allowed the armature to return closing the contact again. The system, therefore, oscillates at a characteristic frequency. High voltage pulses were produced from this chopped primary current by induction in a secondary winding having a large number of turns.

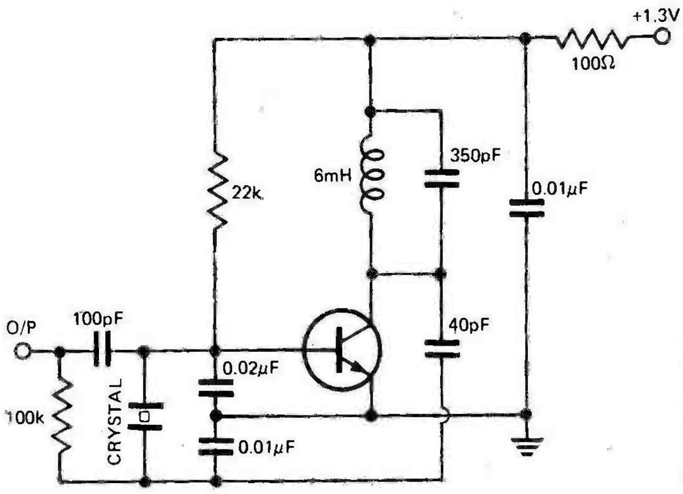


Fig. 11. This very stable oscillator, with a temperature coefficient of one part in 10^8, is used for calibration purposes.

These two devices were commonly known when the first triode active element was invented in 1907. They probably led to the creation of the first useful thermionic valve oscillator built by Armstrong in 1914.

ARMSTRONG OSCILLATOR

Armstrong's arrangement is shown in diagramatic form in Fig. 6. The resonant circuit L_1 C_1, if initially charged, will oscillate at its natural frequency, decaying to zero in a few cycles as the energy is dissipated in resistive losses in the coil. When combined with an amplifier, the valve senses the periodic changes in the tuned circuit and feeds a signal back (via the tickler coil), into the tuned circuit, which reinforces the resonance, making up for the losses. Provided the phase is correct the oscillation builds up to a level limited only by non-linearity of the amplifier stage. It is like pushing a child on a swing. In this case the resonant circuit provides the frequency control for it will not resonate at any but its natural frequency. Away from resonance the system responds too weakly and oscillation dies away.

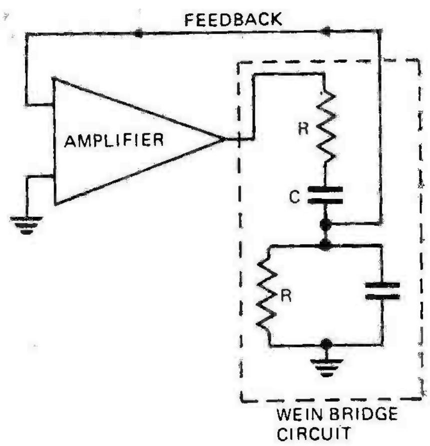


Fig. 12. The Wien bridge network (in the dotted box) provides feedback which is a maximum at one particular frequency. If an amplifier, having sufficient gain, has positive feedback via such a network it will oscillate.

HARTLEY OSCILLATOR

If the inductor of the resonant circuit (called the tank) is tapped, the signal produced at that point can be used to provide the correct amount of positive feedback as shown in Fig. 7. In this case the base of the transistor is effectively earthed through the low impedance of C_b. Thus variations in the tank circuit provide positive feedback to the active element. (Feeding the signal to the base is negative feedback, to the emitter is positive feedback.)

COLPITTS OSCILLATOR

The same effect can be obtained by splitting the capacitor instead of the inductor of the tank circuit. Figure 8 shows the so called Colpitt's arrangement. The output may be taken from the collector, the emitter or from the tank inductor by transformer action.

In each of the above resonant-circuit forms of oscillator the amplifier acts to inject a pulse of current, rather than a smooth change, into the tank circuit. When the amplifier operates this way it is called Class C mode of amplification. The tank circuit provides the quality of waveform. Think of the swing again. This oscillates sinusoidally yet is pulsed to keep it going. In Class -C operation the

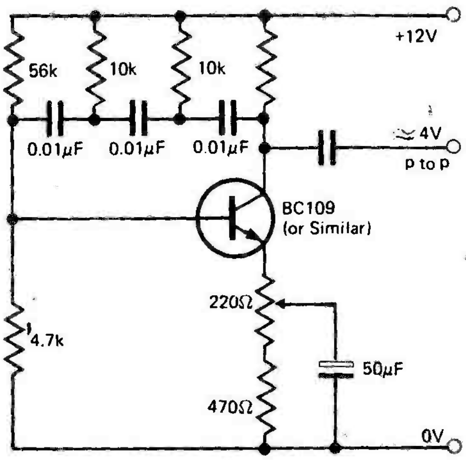


Fig. 13. Inexpensive sine wave generator uses a ladder network to phase shift the output signal 180° at the required frequency of operation.

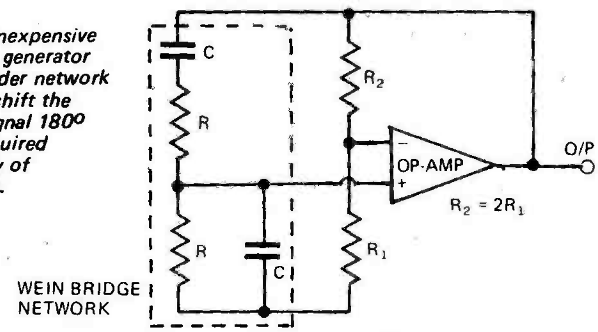


Fig. 14. Wien bridge oscillator using standard, linear op-amp IC (LM301, µA741 etc). The frequency of oscillation fo = 1/2πCR. Thus if f_0 = 1000 Hz suitable values for R and C would be 160 k and 0.1 microfarads respectively.

active element does not need to respond in the linear region of its characteristic curves. The practical advantage is that it can handle considerably greater power levels in this mode. The actual signal in the active element is, however, a highly distorted version of the output.

QUARTZ CRYSTAL OSCILLATOR

In some designs the frequency generated must be extremely stable. The degree of stability is related to the quality of the resonant circuit in the resonant-type of oscillator. Normal LC tank circuits will achieve quality factors (Q, that is the ratio of reactance of the coil to its resistance) of about 100 but not better because in passive electrical tuned circuits the Q is limited by resistive losses in the inductance.

Mechanical tuned circuits, especially those based on the resonance of quartz crystals, have Q's of 10^5 — they will resonate with about 1000 times greater stability than LC tank circuits.

Quartz is particularly useful for it also possesses sizeable piezo-electric effect. Voltages applied to deposited contact areas will cause the thin slice of quartz to change dimensions. Upon removal of the voltage the crystal resumes its shape generating a voltage whilst doing so. Thus we have an electro-mechanical transducer which is compatible with the electric circuit and which can be used as the equivalent of a superior electrical tank circuit.

A series mode quartz-crystal oscillator is shown in Fig. 9. The crystal "tank" couples the Colpitt's connection back to the active element. The collector tank circuit, which can vary a little due to its low Q, will become synchronised to the natural frequency of the quartz crystal.

Quartz crystal oscillators are useful for frequencies well above audio — in the region of 100 kHz to 100 MHz — but find little application at low frequencies due to the natural limitation of quartz resonance within practical crystals. Where precision low frequencies are needed a quartz oscillator output is divided down to obtain reduced cycle periods. The quartz crystal can also be used in its parallel mode of resonance (decided by the way it is cut and connected). The Pierce crystal oscillator, shown in Fig. 10, uses the parallel mode.

Quartz crystal clocks and watches operate on this principle. A highly stable signal frequency is counted giving time from the known period of the waveform. A highly stable circuit is given in Fig. 11. The tank circuit is tuned to nominally 100 kHz and maintains its value to within one part in 100,000,000 per degree Celsius change or per 10% change in supply voltage.

PHASE SHIFT OSCILLATORS — WIEN BRIDGE

Another method of obtaining sinusoidal oscillation is to provide the feedback by a network that only provides zero phase shift at one very specific frequency. The stability of frequency then depends upon the network configuration and the stability of the component values.

The Wien-Bridge oscillator is the most commonly encountered phase-shift arrangement. Referring to Fig. 12 it can be shown mathematically that the right-hand network (taken from a Wien bridge arrangement) feeds back a signal which is sharply maximized for one particular frequency and which has zero phase shift. Provided the amplifier has adequate gain the system will oscillate.

The main advantage of phase-shift circuits is that, for low frequencies in

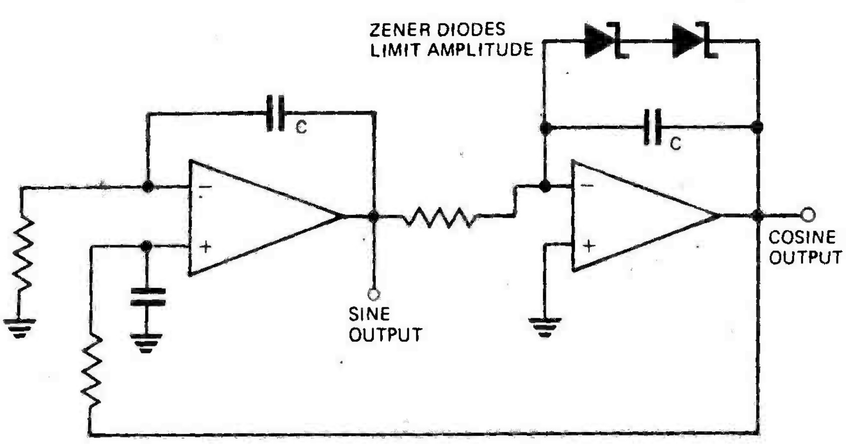


Fig. 15. Generation of sine and cosine waves by implementation of a second-order, differential equation by means of two IC stages. Both stages are essential even if only one output is required.

the audio region, large and expensive inductors are avoided.

LADDER NETWORK PHASE-SHIFT OSCILLATOR

The appropriate phase shift can be obtained if the output of the amplifier is fed back to the input by a chain of RC filter stages. A typical circuit, set to generate 800 Hz, is given in Fig. 13 Note that it is a conventional ac amplifier stage (refer to part 10) with the ladder network added between the collector and the base to provide the selective positive feedback.

USING IC's

Although many designs of oscillator are based on a single transistor amplifier it should be clear that any amplifier can be wired up with feedback to provide oscillation. Thus, the now inexpensive integrated-circuit operational amplifier is capable of providing better performance with lower output impedance than designs built with discrete components.

Application notes include numerous designs — we show one, that of a Wien bridge oscillator in Fig. 14. For this the bridge circuit, added to the op-amp, is balanced at $f_o = 1/2\pi CR$. The greater the gain the closer the system holds to this value — hence the improvement obtained by using an op-amp opposed to a single transistor (gains 100 000 and 100 respectively).

In our earlier discussion of operational amplifiers (part 8) it was stated that capacitance feedback around a single stage provides an integration action. The solution of a second-order differential equation (those that describe the behaviour of the spring-mass system, L-C resonant circuit and pendulum movement) is a sinusoidal signal. If there is no effective damping the system resonates continuously. We can therefore, using two op-amp integrators, set up such an equation and set it going to produce sinewave and cosinewave signals. Figure 15 shows how this is done. The Zener diodes clamp the output to a set maximum value; without them the output would increase to uncertain limits.

In the next part we will continue with other classes of oscillators — those that produce non-sinusoidal waveforms, those that provide a signal frequency that is electronically adjustable, those that provide digital signals and those that must be used to generate signals at very high frequencies where techniques of amplification are quite different to those based on transistors.

FURTHER READING

Most books on transistor circuit design explain the principle and theory of oscillators. Few devote much space to the subject however the following will be found helpful.

"Electronics for the Physicist" — C. F. G. Delaney, Penguin, 1969.

"Transistor Manual" — General Electric, 1969.

"Electronic Instrumentation Fundamentals" — A. P. Malvino, McGraw-Hill, 1967.

Books and articles on electronic music hardware cover many circuit ideas.

"Electronics in Music" — F. C. Judd, Neville Spearman, 1972.

For operational amplifier designs consult manufacturers' application notes and books on the subject such as —

"Operational Amplifiers — G. B. Clayton, Butterworths, 1971.

"Modern Operational Circuit Design" — J. I. Smith, Wiley, 1971.

"Operational Amplifiers — Design and Application" — J. G. Graeme and G. E. Tobey, McGraw-Hill, 1971. ●

ELECTRONICS — IN PRACTICE

THE BEST WAY to become familiar with oscillators is to build a few basic circuits such as those given here. Figure 16 shows the circuit for another form of phase-shift oscillator that uses a twin-T (a form of frequency selective bridge) feedback arrangement. Its frequency output is stable to within a few parts in 10 000 for 10% supply variations. To obtain best temperature stability (0.2% change for a temperature change of — 20°C to 80°C) use stable capacitors such as polycarbonate types.

The advantage of this circuit is that it will operate at low freqüencies. If $C_1 = C_2 = C_4/2$ and $R_3 = R_4 = 2R_5$ then the resonant frequency will be at $f_o = 0.159/R_3C_1$. (f_o in hertz, R_3 in ohms, and C_1 in farads). With the values shown the circuit operates at 60 Hz.

BIRD SOUND GENERATOR

As an example of synthetic sound generation the circuit given in Fig. 17 produces a chirping sound similar to that of a bird. The adjustable resistor alters the tone of the chirp.

If a light dependent resistor (ORP12 for instance) is inserted in series with the adjustable base-bias resistor, the chirp will only occur when the ambient light level is high — the bird goes to sleep at night. An amusing trick is to mount the entire circuit inside a small box — when the lid is opened the bird chirps.

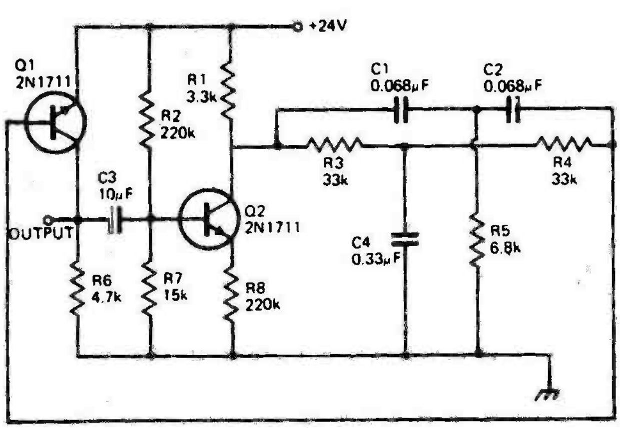


Fig. 16. Phase shift oscillator based on a twin-T, frequency selective network.

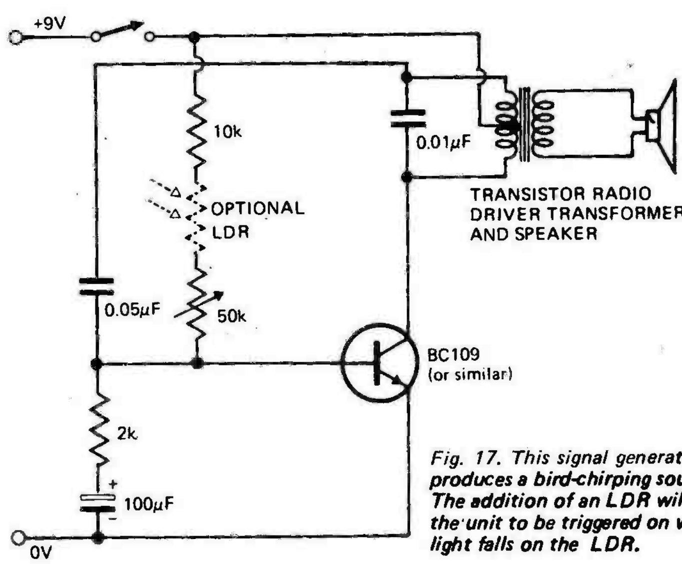


Fig. 17. This signal generator produces a bird-chirping sound. The addition of an LDR will allow the unit to be triggered on when light falls on the LDR.

Electronics Tomorrow

by John Miller-Kirkpatrick

RECENTLY one type of application has been mentioned several times to me and as a result I have put several hours thought into it. The application in question is for digital stopwatches for timing of races and/or for timing action-reaction differences. Having done quite a bit of research into the the matter I have come up with the various alternatives required and answers to some of them. Most stopwatch applications require timings down to a tenth of a second especially where the stop/start mechanism is manually operated as human reaction times start to juggle the figures any faster than this. Those applications requiring timings faster than a hundredth of a second, such as car rally speed checks, use some form of mechanical or electo-mechanical switching such as rubber pressure switches, photo-switches, etc. Eventually these switching systems themselves become inaccurate when accuracy to less than 0.0001 seconds is needed.

At the other end of the scale many events take a matter of minutes to complete and thus a readout showing hours is unnecessary; certainly applications requiring readout of more than one hour are very rare. Those applications which do require more than minutes readout do not usually require accuracy of more than a tenth of a second. Thus if we use a six digit readout we can satisfy most requirements with readouts of H.MM.SS.s or M.SS.sss. The latter obviously has to be quartz crystal controlled but the former could be timed from a reasonably stable RC or LC network.

The basic functions required of a stopwatch chip are therefore quartz-crystal or CR timing source, readout of either a tenth or a hundredth of a second, and stop/start/reset/split/freeze, etc., facilities. What I usually say now is that all of these features are now available in one chip from Nastek Ltd and that the price of the chip is an amazing £5.50. Unfortunately not true — the chips that have been produced so far are limited in one way or another, viz — *Intersil chip* — I can't remember its number but we featured it several months ago. It has readouts down to 1/100 seconds, Rally and Split features, Quartz input, Direct drive to low-current LEDs. The chip has been available for well over a year and sales in the private sector of the market have probably never got off the ground. The first price that I heard of for this chip was £67 (Dear Ed. please print sixty-seven pounds in case anybody thinks it's a printing error), there has been a drastic price reduction I hear to the current price of about £44 per chip — well done Intersil, I wish you large profits.

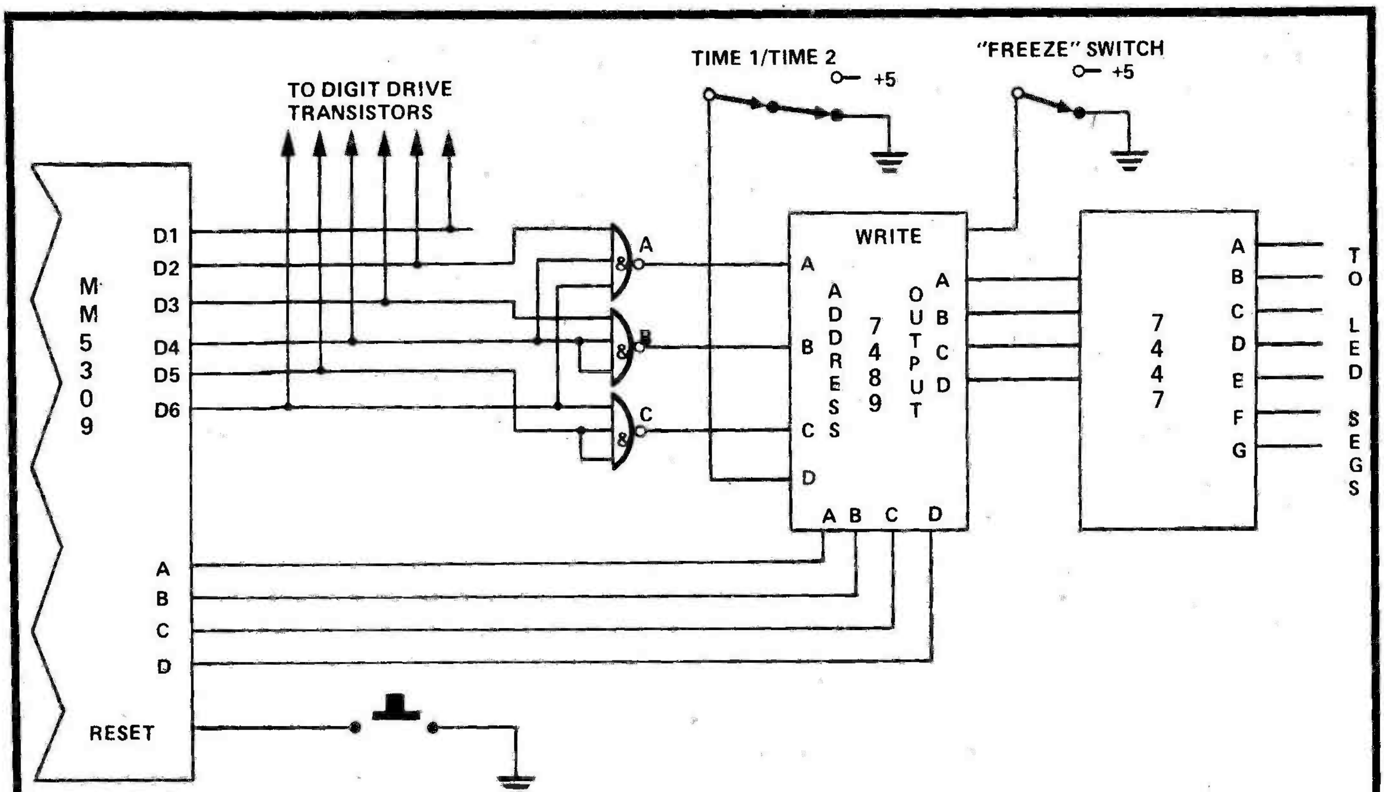
Texas TMS3952, the long rumoured and eventually produced clock chip from Texas Instruments. The story behind this is another TI farce with delivery dates always being 'next month' but nobody having any form of spec available. It seems to be TI policy to sell the idea, get the orders and then think about designing the product (TIFAX?). The TMS3952 has alternative readouts of HH.MM.SS or MM.SS.ss, 300kHz quartz or CR input and is available (?) with BCD output in place of the standard seven segment outputs. TI have issued, withdrawn, issued, withdrawn, reissued, etc this chip until I do not know the current situation. Bywood had about 20 of the chips and these were possibly the only ones ever to come into the country, certainly TI have never made a noise about it and most TI distributors have never heard of it.

Siliconix — a similar story to that of the Intersil chip except that Siliconix have not released a price on the chip because they prefer to sell a complete unit. The Accusplit III has a MM.SS.ss readout (Sperry), quartz crystal, Split and Lap timing all built into a rugged if heavy case. I have played with one of these units and it seems to offer very good value for money at about £75 plus VAT for the complete unit.

National Semiconductor's answer to the problem is the MM5309. This is a modification of the MM5311 a proven clock chip and one of the first available in the UK. The MM5309 has HH.MM.SS readout and a timing source of 50Hz, stop/start is done by inhibiting the 50Hz input via a CMOS or TTL gate, reset sets the clock to all zeros (right back to the 50Hz counters). As with the MM5311, outputs are available in seven segment and inverted BCD. Price £5.18 — if it will do what you want its a great chip.

Emihus EDC 6051/EDC 6052 HEEC2. This plethora of numbers defines one chip originally designed for European Electronic Counting Ltd as the HEEC2, it was then released by Emihus (or is it just *hus?*) as the 6051 (alarm works) or the 6052 (alarm circuit not working). This chip if you can get it will do virtually whatever you want it to. It has eight digit output, quartz input (just the countdown — no onboard oscillator), can count in HH.MM.SS.ss or can be converted to count wholly in decades, BCD output, STOP/START/RESET, etc. By switching into decade mode and putting 5kHz into the 50Hz input you get 1/1000 sec output, if you input 500kHz you can get 0.00001 sec output. If the crystal input is used you get 0.01 seconds accuracy otherwise the eight digit output does nothing which is why you have to use a multiple of 50Hz. Price about

The Accusplit III.



Latching BCD outputs without de-multiplexing.

£8.50 if you can get them, EEC have run out and delivery from Emihus is extended to say the least, a shame because this really is a versatile chip.

Mostek's answer is the MK50204 which we detailed in this column a couple of months ago. Basically a calculator chip which will act as a HH.MM.SS.s stopwatch or as a calculator. Input is a nominal 140kHz CR network, but presumably a crystal could be used. Bywood are doing a kit using this chip but without all of the calculator keyboard inputs, just three of the 20 possible keys give you reset (clear), count-up (+), or count-down (–). Pressing + alternately gives you stop/start in count-up mode and similarly – in count-down mode. As this chip will count down a time can be preset and counted down to zero or to –0.1 and the – lamp used to switch the end of the count.

So thats what is available in the way of 'stopwatch' chips, the best buy is either the Accusplit III or one of the BCD output chips and a bit of TTL (or CMOS). Which bit of TTL or CMOS? well how about the 7489 (74C89) 64 bit RAM. By using one of these memories to store the BCD outputs one can 'freeze' the time on the display whilst the clock is still counting. We will use the MM5309 as an example mainly because of the inverted BCD outputs, if using any other chip you would have to invert the BCD before or after the memory as the memory itself inverts the data. Let us assume that we want to freeze a 6-digit time; the way we do this is to store the multiplexed data for each digit in the memory and then retrieve it at the next occurence of that digit drive. As the 7489 requires BCD addressing and the clock chip has 1 of 6 addressing we have to convert the 1 of 6 into BCD form.

There is an easy way to do this if the clock chip has active-low outputs (5 at '1' and 1 at '0') and guess what? – the MM5309 has active-low digit drives; for other chips invert with a 7400 or 7404 first. If you connect up a 7410 three input NAND as shown the A gate will go high if any of digits 2, 4 or 6 is low (on), similarly B gate will go high if digits 3 or 4 are on and C gate will go high if 5 or 6 is on, all gates will be low if digit 1 is on. If you remember the digit drives 0–5 instead of 1–6 then we have 'A' during 1, 3 and 5, 'B' during 2 and 3, 'C' during 4 and 5, in other words A, B and C give a BCD readout of 0–5 corresponding to the digit drive which is active.

This BCD address is applied to the ABC of the 7489 memory address inputs and the MM5309 inverted BCD data is applied to the ABCD data inputs. If 'Write' is enabled then the memory outputs will always give the inverse of the memory inputs i.e. the true BCD for that digit, this is then decoded by a 7447 and fed in parallel to six LEDs. When the 'Write' is disabled the outputs will give the inverse of the last data written for each digit thus effectively freezing the display, the clock can be counting from that point or can be reset to zero at the same time as the freeze.

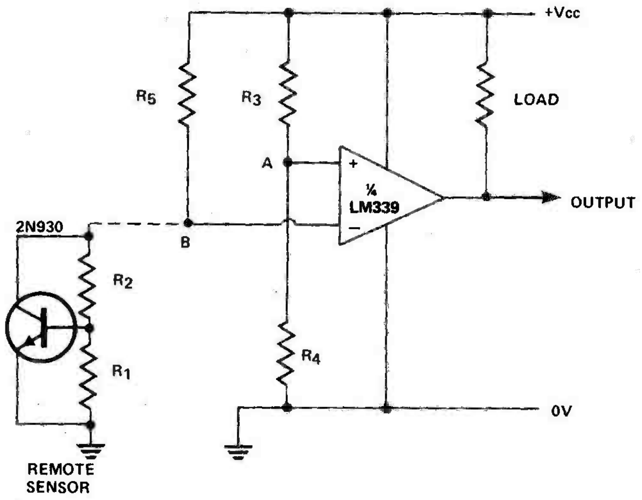
We did not mention the required status of the D input of the address of the memory, if this is at logical '0' memory words 0–7 will be used if it is at logical '1' then words 8–15 will be used. By switching this input between the two states two different times can be frozen affecting the counting of the clock. Similarly if only four digits are used for each reading then only address lines A and B need be converted from the digit drives leaving address lines C and D to define 1 of 4 freeze times. An example of the use of this might be to time 1st, 2nd, 3rd and 4th runners in a race assuming that all started at the same time. Total cost for four 4 digit times about £25, there's no other stopwatch that will give that function for that price. Perhaps your local sports club or the sports master at school would like you to build one – there's no harm in asking!

REFERENCES

Intersil – contact Celdis Ltd, Loverock Road, Reading.
Texas Instruments, Manton Lane, Bedford.
Siliconix, 30a High Street, Thatcham, Newbury, Berks, RG13 4JG. (Mr. Vincent).
National Semiconductors (UK) Ltd. The Precinct, Broxbourne, Herts.
Emihus, Clive House, Queens Road, Weybridge.
Mostek, 240 Upper St, London N.1.

tech-tips

REMOTE TEMPERATURE SENSOR



The circuit shows a temperature sensing device which can be used to indicate at a remote point when the temperature passes through a certain value or to give an alarm when this occurs.

The sensing unit itself contains a 2N930 transistor. The base-emitter voltage of this device appears across R1 and (as the base current is far less than the collector current) the voltage at the upper end of R2 will be the emitter-base voltage multiplied by (R2 + R1)/R1. The base-emitter voltage changes with a temperature coefficient of −2.2mV/°C and this change is multiplied by the same factor before being applied to the LM339 circuit.

The potential at point A is set by the resistors R3 and R4. As the temperature of the sensor transistor rises, the voltage at point B falls. At the time this voltage falls below that at point A, the output of the LM339 voltage comparator will go 'high'. If, however, the input connections to the LM339 are reversed, the output will go 'low' when the temperature of the sensor falls below the preset point.

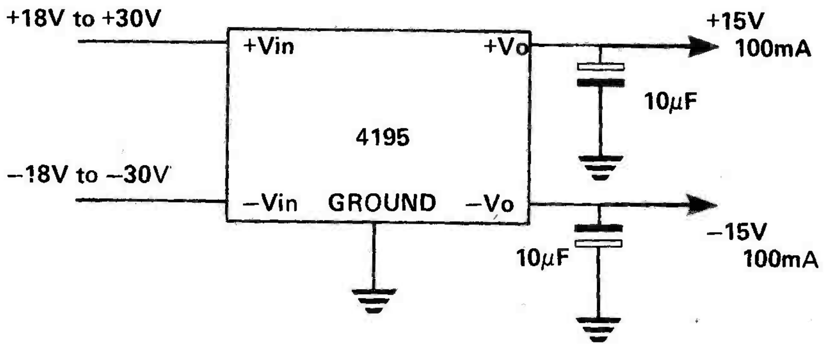
The LM339 contains four separate voltage comparators in one package; only one of these comparators is used in the circuit shown. The other three comparators could be used with another three temperature sensing transistors so that an indication is given when the temperature passes through three other preset values.

The value of R5 should be chosen so that the current passing through the remote sensor unit is about 10µA. If the temperature range over which operation is required is narrow, the ratio R2/R1 may be large so that the system is very sensitive to small temperature variations. A potentiometer may be substituted for R3 and R4 so that the temperature at which the comparator switches is variable. The voltage at point B is highly linear over a very wide temperature range (about -65°C to +150°C) and therefore the potentiometer which replaces R3 and R4 can be given a linear calibration.

A feedback resistor may be connected from the output to the non-inverting input to provide a small amount of hysteresis (so that the temperature at which the output changes when the temperature is rising is different from that when it is falling); one then has the basis of a thermostat.

The output current has a maximum value of about 15mA.

SIMPLE BALANCED REGULATOR



When experimenting with operational amplifiers and other circuits, one often requires balanced positive and negative power supplies of about ±15V. One can, of course, employ two separate stabiliser circuits employing an integrated circuit voltage regulator.

A simpler solution is shown in which the new Raytheon 4195 ±15V dual-tracking voltage regulator is employed. Only two capacitors are required in addition to the regulator device, so it is convenient to employ one of these regulators on each printed circuit board.

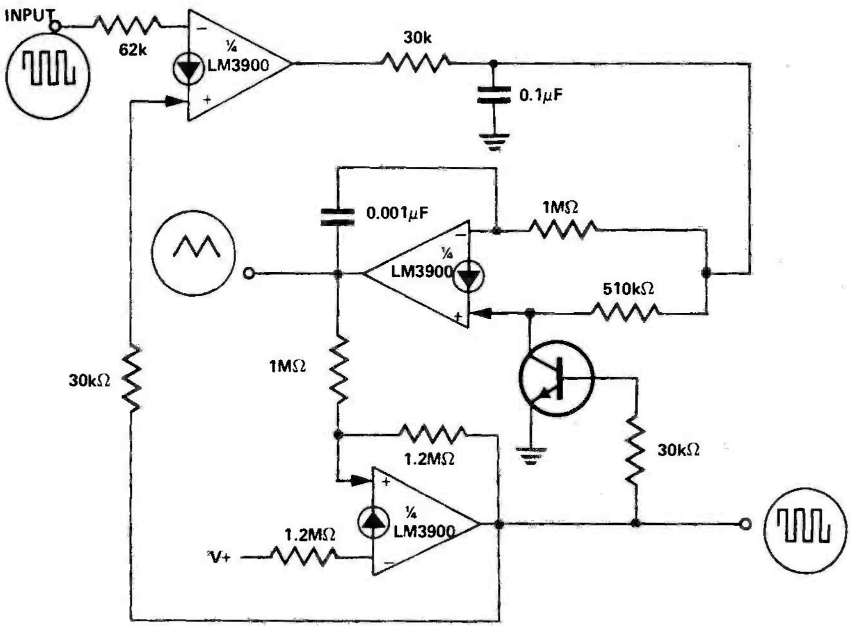
The circuit can supply up to 100mA from each output and is fully protected against short circuits. In addition, the device switches itself off if the temperature of the chip exceeds +175°C, so there is no danger of thermal damage. The short circuit is typically 220mA.

As the load current varies from 1 to 100mA, the output voltages stay constant to 5mV in a typical case. If the input voltage varies between the limits shown, the typical output voltage is 2mV. The temperature coefficient of the output voltage is about 0.005% per °C. The ripple rejection is about 75dB and the output noise voltage 60µV r.m.s.

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

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

ECONOMICAL PHASE LOCKED LOOP



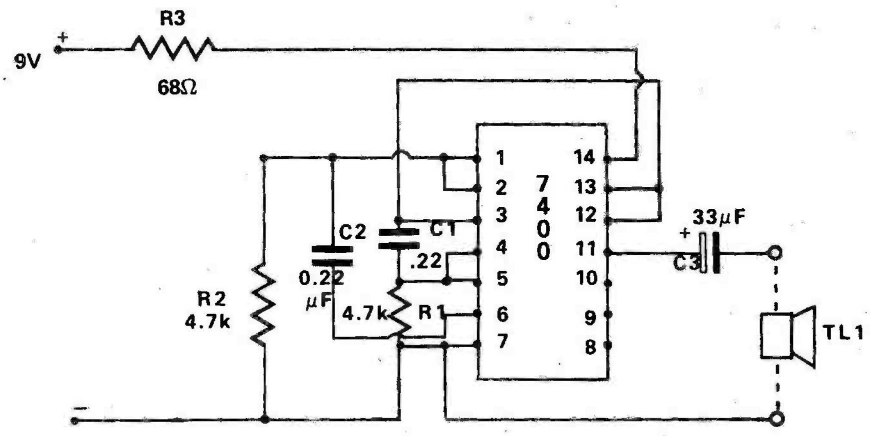
Integrated circuits which have been specially designed as complete phase locked loops are available, but many of them tend to be rather expensive devices. The circuit shows how the economical LM3900N integrated circuit can be used to build a phase locked loop which has a centre frequency of about 3kHz.

The LM3900N contains four current differencing amplifiers in a single 14 pin dual-in-line package. Only three of these amplifiers are used in the circuit shown, so the fourth amplifier is available for other purposes. The price of the LM3900N is about 69p, so it is one of the cheapest linear devices available. The special circuit symbol shown is used for the amplifiers in this device, since they are not a conventional type of operational amplifier.

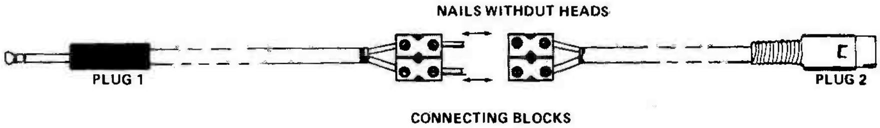
If desired, the locking range of this phase locked loop may be increased by employing the fourth amplifier in the LM3900N in the input circuit to increased the signal amplitude.

UNUSUAL MULTIVIBRATOR

This device uses 3 gates of the 7400 TTL IC. Gates 1 & 2 together with associated components form a simple astable multivibrator. The output is fed directly to gate 3 which acts as the output stage. If the output is taken to a transducer as shown above, its impedance should normally be 85 ohms or higher. But depending on the characteristics of the IC used, even 8 ohm earpieces can be driven. The prototype circuit was used as a tone generator for use in editing tapes and for separating recorded items on tape.



UNIVERSAL AUDIO LEADS



There are so many different types of connectors on the market (DIN, jack, phono, etc.) that it would be very expensive to have a separate connecting wire for all the combinations one could possibly use. Crocodile clips can be used, but only for temporary joins, and they are liable to short-circuit. The same problem occurs with bare wires.

One solution to the problem is as follows. Each of the plugs or sockets which are likely to be used is joined by a short length of cable to a two-section connecting block. The opposite connections of the block are converted into a sort of plug by means of two nails with their heads cut off. Then, whenever it is necessary to make a connection between two plugs or sockets, the screws of one side are loosened, the nails removed, and the jutting out nails of the other plug are inserted into the connector, which is then screwed up.

The result is a strong join which can easily be dismantled and the plugs used again, but which also can be used for long periods with no danger of breakage or short-circuit.

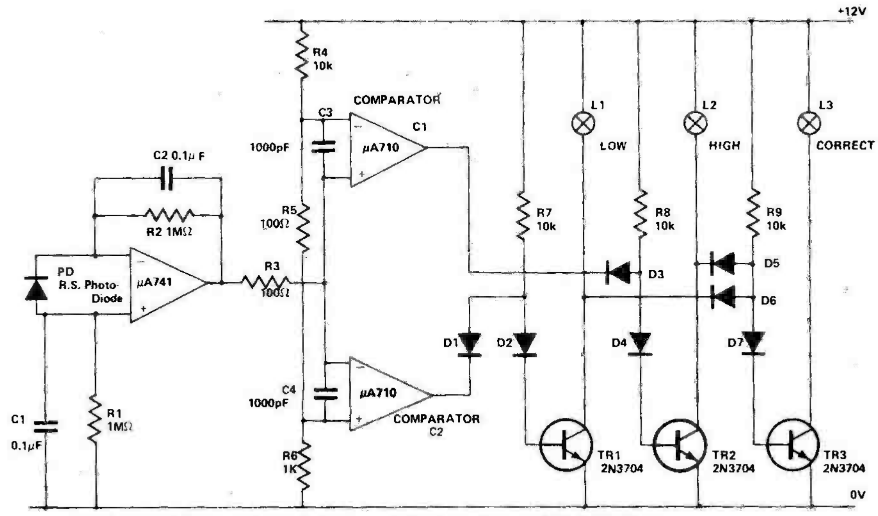
tech-tips

LIGHT LEVEL INDICATOR

When conducting optical experiments, or calibrating photocells, it may be necessary to set a known light level each time before the experiment is performed. The following circuit provides a simple means of setting a light level to a particular value.

A silicon planar photodiode, strategically placed in the optical system, generates a photocurrent proportional to the incident illumination which is fed to the input of an op-amp connected as a current amplifier. The output is thus the equivalent photocurrent developed across a 2Mohm resistor.

Two comparators are used to compare the output voltage with a fixed reference set by a potential divider chain. Comparator 2 is set at nominally 1 volt and Comparator 1 at 1.1 volts.



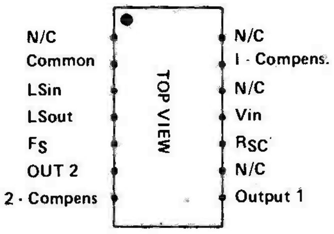
SUPPLIES FOR AMPS 741 ±12 TO ±15V 710 +12V, −6V SIGNAL DIODES 1N4148 OR SIMILAR

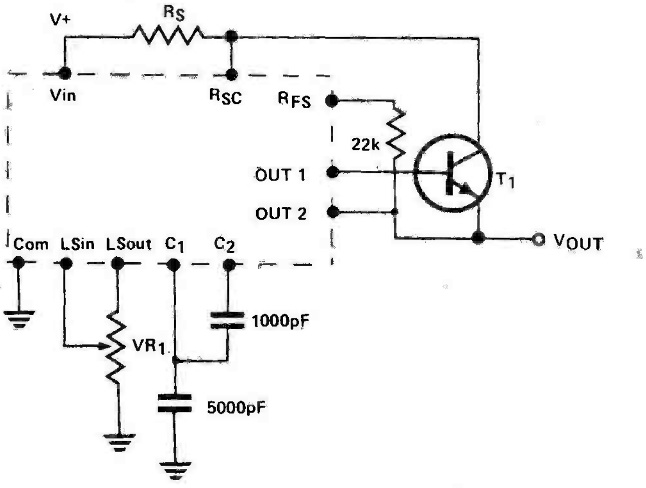
The amplifier output is fed via R3 to the inverting input of comparator 2. When the output is below 1 volt, the output of comparator 2 is positive which enables the current in R7 to turn on TR1, lighting lamp 1 indicating 'Too Low". When the output of the amplifier is above 1.1 volts the output of comparator C1 will be positive, enabling current in R8 to turn on TR2 and lighting lamp L2 indicating "Too High". If the amplifier output is between the thresholds, both comparator outputs will be low, both lamps will be off, and the current in R9 will be enabled to TR3 and L3 will light giving the green indication "Correct".

Changing the values of R1 and R2 alters the basic sensitivity of the system, C1 and C2 provide decoupling of noise pick up for remote detection or small content of AC lighting and R3, C3, and C4 minimise instability in the comparators as they pass through their linear region.

Values in the diagram shown give an acceptance band of 10%. Reducing the value of R4 to 50 ohms reduces the pass band to 5%. For closer bands, higher gain comparators may be used (eg.μA734, or LM311), but light levels closer than this are rarely necessary.

IC STABILISED POWER SUPPLY





This circuit uses the TVR 2001 IC to stabilise voltages from 8 to 38V at a maximum current of 5A. The TVR 2001 consists of a zener-amplifier combination, incorporating foldback and short circuit protection.

In the circuit shown, the short circuit resistor was 2.5 ohm and R_{fb} as shown. With an output voltage of 9V this would give a maximum current, before foldback, of 210mA. The short circuit current on foldback is 50mA. The output voltage is selected by the setting of VR_1, a 10K linear wire-wound type. The output transistor (T_1) can be virtually any NPN power transistor. Capacitors C_1, C_2, are used for frequency compensation purposes. If desired, TWO fixed resistors may be used in place of VR_1, to obtain a single output voltage. The voltage differential of this particular device is typically 2.5V.

With the set of components illustrated the maximum current obtainable would be around 700mA. The output transistor would, of course, need efficient heat sinking.

Continued from page 9

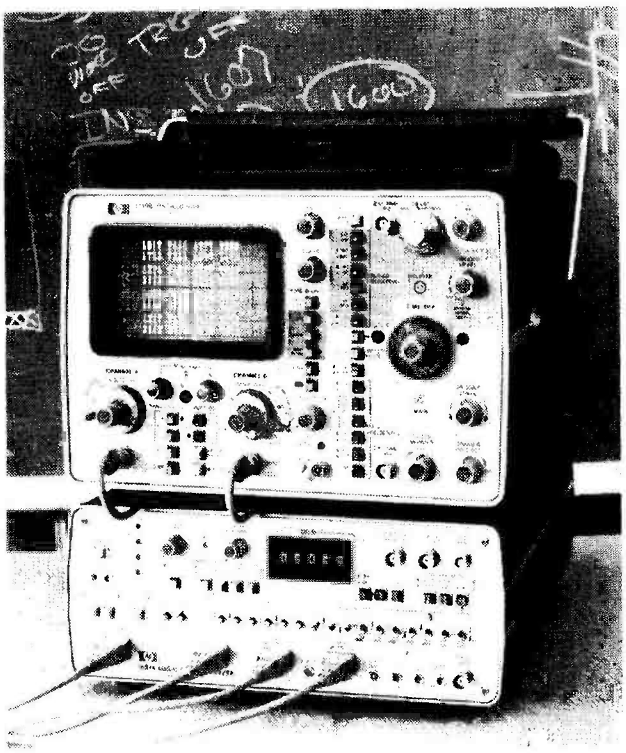
SOLAR ENERGY TRIALS IN AUSTRALIA

Field trials are currently being undertaken by a number of Australian organisations using solar cells from Lucas (Australia).

The use of Solar energy for powering telecommunication equipment in remote areas is being studied by the Australian Post Office which considers that the dramatic price reductions of silicone solar cells over the past few years and the low power consumption of modern equipment makes their use feasible.

Current schemes under investigation include forestry radio repeater stations, railway signalling and natural gas pipeline monitoring.

LOGIC STATE ANALYSERS



The HP1607A in use with an HP Scope.

Two new Logic State Analysers from Hewlett-Packard can present a sequential flow of data in the form of words formatted in 1's and 0's. The Model 1600A can show a 16-channel sequence on its own CRT. The 1607A will produce a 16-channel word format display on any modern laboratory oscilloscope. When the two units are used together a 32 channel sequence can be shown.

The 1600A also introduces a new technique, that of "mapping" of logic operations which takes advantage of the ease with which humans can detect patterns and pattern changes. Both Analysers are capable of working at clock rates up to 20MHz, which makes them compatible with most modern computers and they can trigger on preset data words. Hewlett-Packard, Winnersh, Wokingham, Berks.

SILICON–LASER SUPER SWITCH

Bell Laboratories have developed a semiconductor switch that operates in 10 picoseconds, that is, 10 to 100 times faster than any conventional junction semiconductor.

The new switch uses laser beams to start and stop an electrical signal and may be the first time optical pulses have been used to switch electrical signals.

The switch is capable of switching up to 100 volts with the application of only a few microjoules and potentially may be capable of working as fast as one picosecond.

FERRANTI RADAR FOR MARITIME HARRIER

Ferranti, Scotland, have announced that following the approval of the Maritime Harrier programme they will be engaged in the development and manufacture of the associated radar.

The radar, to be named BLUE FOX, is a derivative of the Seaspray radar for the Lynx helicopter but will incorporate major changes from that equipment because of its different role. BLUE FOX will possess air-to-air intercept and air-to-surface modes.

70-WATT P-N-P DARLINGTON TRANSISTORS

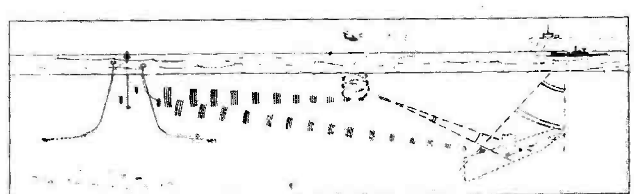
Three 100W silicon p-n-p Darlington transistors, designated RCA8350, RCA8350A and RCA8350B, have been announced by RCA Solid State - Europe.

The new devices are rated for -40, -60, and -80V V_{CBO}, with 10A collector current and 100W device dissipation. They are specified for a minimum gain of 1000 at 5A. The RCA8350, RCA8350A, and RCA8350B are complementary to the JEDEC n-p-n types 2N6383, 2N6384, and 2N6385, respectively.
RCA, Sunbury-on-Thames, Middlesex.

JAPANESE BUY BRITISH UNDERWATER TRACKING RANGE

EMI has received a contract from the Japanese Defence Agency to supply a portable acoustic tracking system (PATS). The system is moored at sea, enabling underwater vehicles and targets to be tracked and their performance analysed.

The underwater range comprises three separate sea-borne hydrophone units positioned in the form of a triangle with sides about 200 metres in length. Each hydrophone is suspended from a floatation unit on the surface which in turn is secured to a moored buoy.



The hydrophone units are connected to a battery powered UHF radio transmitter mounted on one of the buoys. Signals received by the hydrophone are telemetered to a Master Control Station, which can be based either on board ship or on shore dependent upon where the PATS is laid. The mooring buoys are semi-permanent, but the rest of the system is portable.

Symbols printed on the plot denote the tracks and present positions of the underwater vehicles. Depth of each vehicle is displayed on a digital display adjacent to the plotting table. All data is recorded and a teleprinter provides a print-out of the co-ordinates in three dimensions for the vehicles being tracked.

news digest

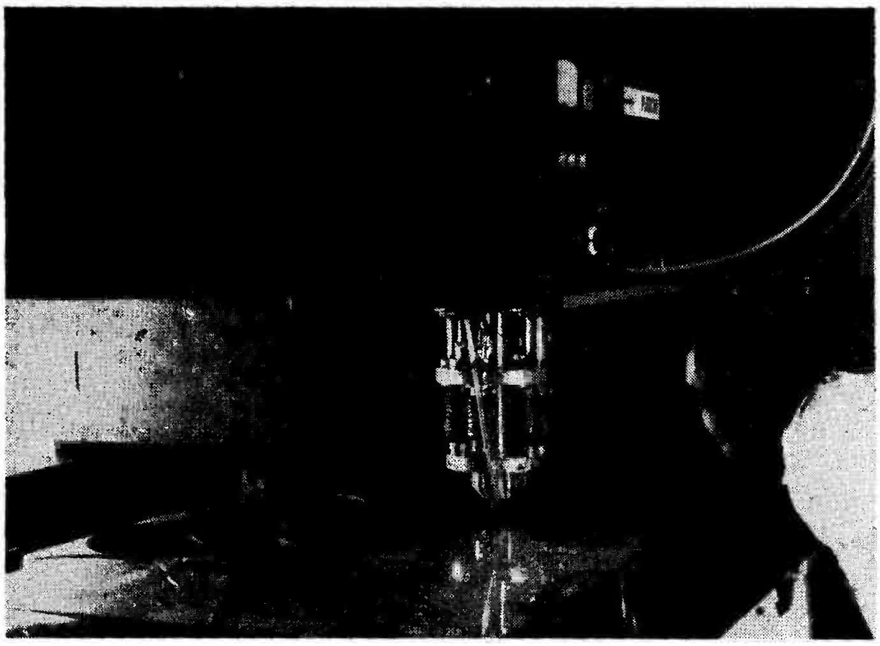
DESIGN COUNCIL AWARDS

The 1975 Design Council Engineering Products and Components Awards have been announced. Apart from JCB, MiniTunnels International, Colt International, Dowty Rotol, awards went to Vickers (for a Scanning Interferometer and Microdensitometer), to Dewhurst & Partner (for vandal-resistant illuminated pushbuttons and indicators), to Oxley Developments (for the Snap-lox connector), to Ferranti (for their Carbon Dioxide multi-fold Laser), and to Penny & Giles (for their conductive plastic studio fader).

The Ferranti Laser, the MF400, has reduced the previously cumbersome workshop laser to a compact unit 1½m long by 0.5m square, whilst incorporating the same standards of ruggedness and reliability of previous high power cutting lasers.

length to under fifteen feet by folding the laser's discharge tube in half. During 1970 Ferranti began work on the multi-fold technique, whereby the laser's discharge tube is made as twenty-four short tubes arranged in zig-zag formation around a cylindrical sub-structure. The laser light is diverted from one section of the discharge tube to another by mirrors. This is the technology behind the Ferranti MF400 workshop laser.

The combination of the aluminium alloy sub-structure and leaf-spring supports allows the laser to be subjected to normal forces and vibration without disturbing its internal alignment. The complete assembly weighs only 55 kg (120lb) and is therefore light enough to be mounted on x-y control equipment for mobile operation.



The Ferranti MH.400 multi-fold laser cutting stainless steel at the Crumlin, Gwent, works of Laser Cutting Limited.

By using a high-power laser, one is able to undertake a large number of cutting jobs involving a wide range of materials; such jobs as the shape-cutting of fine guage metals, plastics, ceramics (and other materials requiring a fine and smooth cut) are handled. When cutting the laser exerts no mechanical force on the workpiece, thus overcoming deformation problems. There are no cutting edges to wear out.

There is a direct relationship between the length of a gas laser and its output power: the more power required, the longer the laser. In 1967 a typical 500W carbon dioxide laser was the length of a London bus - 9 metres long. By 1969 Ferranti had reduced the

To increase a carbon dioxide laser's output power Nitrogen is added to the CO_2. Then by introducing Helium into the mixture a further increase of output power is achieved. To prevent wastage of these gases, the power supply of the MF400 incorporates a patented gas recirculation facility.

The P & G fader uses conductive plastic to give a low reactance (hence flat frequency response), stepless control with a smooth "feel". The faders now have a reputation in the pop music world ... 'Blood, Sweat and Tears' (the US pop group) came to London to buy these components. The basic price starts at £18.

CONSTANT CURRENT LED'S

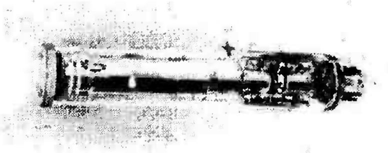
A disadvantage of conventional LED's as indicators in conjunction with a series resistor is that the luminous intensity changes with variations in supply voltage; this is usually noticeable as "flicker" which is undesirable. Now Litronix have introduced a range of constant current (and therefore constant brightness) Light Emitting Diodes.

The smallest device available, the RLC210, is 0.2" high (excluding leads) and light output remains constant for supply voltages between 4.5 and 11 volts. The larger RLC201 is 0.34" high and is operable between 4.5 and 16 volts; a restricted voltage range, but higher light output version of the RL 201 is also available and designated the RL200.

If any of the above devices are required to operate from higher voltage unstabilised power supplies, this can be accomplished by connecting a suitable zener diode in series with the L.E.D. *Jermyn, Sevenoaks, Kent.*

SILICON TARGET VIDICON

A two-thirds inch diameter silicon target vidicon with magnetic focus and deflection has been introduced by RCA Electro-Optics. The silicon target vidicon, RCA4833, has a broad spectral response (380-1100 nanometers) including a substantial sensitivity in the near-infrared region. Thus use of available light can be made both day and night.



The silicon target structure is highly resistant to image burn-in and, with minimal 'comet-tail' effects, has excellent discharge capabilities. The tube can be exposed to direct sunlight without target damage. RCA Electro-Optics, Sunbury-on-Thames, Mddx.

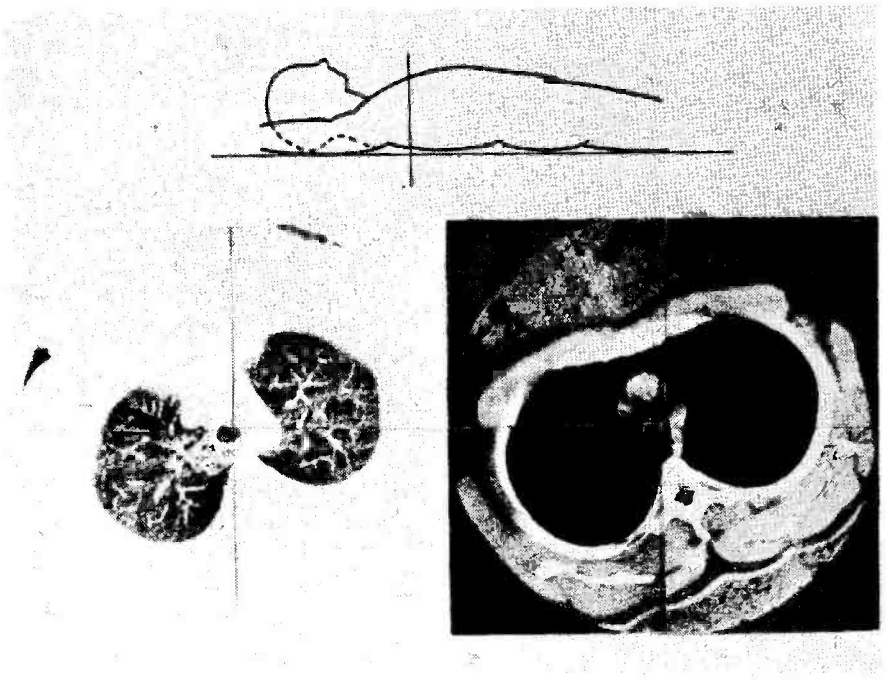
ZENER WALLCHART

A new chart lists the large range of zener diodes by Motorola. Zeners in plastic, glass and metal cases with a choice of case outlines covering power requirements from 400mW to 50W and voltages from 2.4 to 200V are covered. The range includes Pro-electron (BZY, BZX) and Jedec (1N) registered devices in addition to Motorola's own in-house types.

HISTORIC PICTURES FROM EMI'S NEW MEDICAL DIAGNOSIS SYSTEM

Details of the human body which it has previously been impossible or extremely difficult to detect using conventional X-ray techniques are revealed in an historic series of pictures just released. They were produced by a revolutionary medical diagnosis system for examining the whole body, originated in EMI's Central Research Laboratories, Hayes, Middlesex.

Specifically designed to apply a fundamentally new X-ray technique invented in the Laboratories to the examination of the body, the system produces highly accurate and detailed pictures of complete cross-sections through the patient. Each section is approximately 1cm thick and is scanned in only 20 seconds.



Produced by the 'whole-body' scanner system developed by EMI's Central Research Laboratories, this pair of pictures through the upper chest demonstrates the advantage of the variable "window-level" facility. The information taken during a single scan is used to give a picture (right) of the top of the heart surrounded by the lungs.

Using the same data, the doctor can produce a picture (left) of the soft lung tissue in the same body cross-section.

The section is viewed looking up the body from feet to head. The spongey layer around the section is a padded band used to help position the patient in the machine.

Commenting on these pictures, EMI's research director, Mr. W. E. Ingham, said, "This new method of examination is destined to bring about a complete transformation in the use of X-rays in medical diagnosis. It is as though a doctor can hinge open the patient's body at any point he chooses and study bones, organs and tissue formations in that cross-section of the body. Without any exploratory surgery he can examine the kidneys, spleen or lungs, for example, in relation to the surrounding tissue."

The pictures released by EMI were taken during recently-completed research trials on the new system, which is shortly to be installed at hospitals in the UK and USA for full-scale clinical trials.

The 'whole-body' examination system uses the computerised axial tomography X-ray technique pioneered in EMI's research laboratories and first introduced in 1972 in the EMI Scanner, a system for diagnosing brain conditions. In three years, the EMI Scanner has achieved a remarkable success, radically changing the approach to brain disease diagnosis and winning to date over £27 million of orders from hospitals around the world.

As well as giving doctors 100 times more diagnostic information on tissue than can a conventional X-ray, the technique has made other major contributions to health care. It has eliminated factors which previously made many brain examinations painful and even hazardous to the patient and extremely costly in terms of hospital facilities and skilled medical staff.

MICROWAVE CHIP KIT

To meet increasing demand from designers of microstrip (strip-line) circuitry, Vitramon Limited have announced their first microwave chip capacitor kit.

The kit is priced at £20.00 and contains 90 pieces VY73 sized chip capacitors of 18 different values from 1pF to 30pF. From Vitramon Limited, Wooburn Green, Bucks.

VHF RECEIVERS

Eddystone Radio, a division of Marconi have two new professional vhf receivers. The 1990R/1 covers the band 25 to 235MHz; the 1990R/2 gives coverage to 500MHz.

The two receivers provide reception facilities for AM, FM, CW and pulse transmissions.

The receivers use single-conversion with an IF of 21.4MHz. They utilize a MOSFET RF amplifier and diode quad balance mixer for good two-signal performance. Front-end selectivity is provided by three tuned circuits ahead of the mixer on each range, but these can be by-passed for wideband applications.

The receivers are supplied with either a switched ten-channel crystal facility or an integral synchronizer unit which allows continuous tuning with locking facilities every 100Hz. The receivers can also be operated with externally derived oscillator signals. Automatic frequency control can be used when required.

Low-level pre-filter and post-filter IF outputs are available at low-impedance for connection to ancillary equipment. Two separate audio amplifiers are used, one of which provides line output and is equipped with a pre-set level control.

Other features include a dual frequency crystal calibrator and a panel meter which can be switched to read carrier level or 600 ohm line level as well as serving as a centre-zero tuning indicator for FM. Accessories include a cabinet for bench mounting, a plinth loudspeaker, special aerial systems and a matching panoramic display unit.

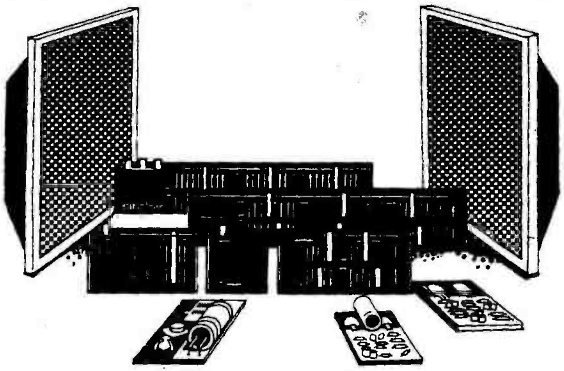
Eddystone Radio, Marconi House, Chelmsford, CM1 1PL.

ERRATA

Electronic Ignition, May issue, p. 26.

The SCR is a 15A, 500V types as shown in the parts list. The 2N5574 is a Triac and should not have been mentioned here.

Sinclair Project 80



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7425	30p	74151	72p
7427	37p	74153	85p
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AF125	30p	BFX29	30p	2N930	18p
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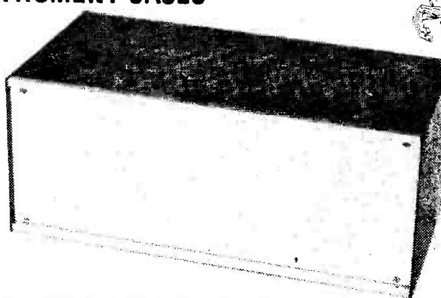

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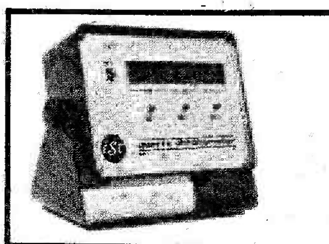

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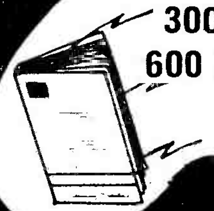

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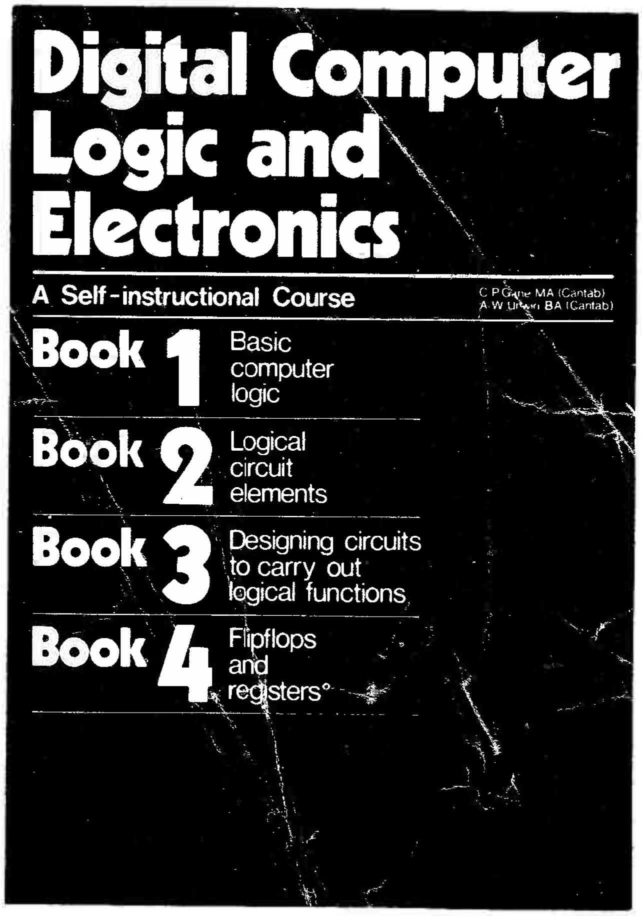

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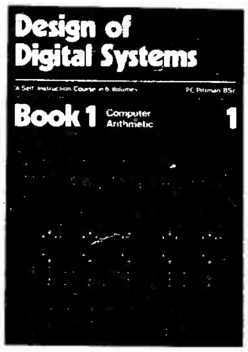

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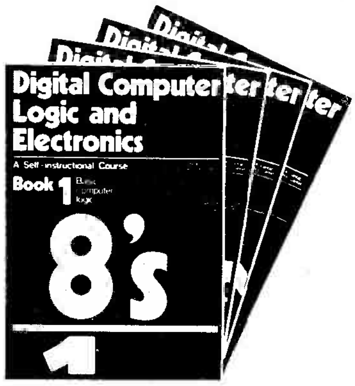

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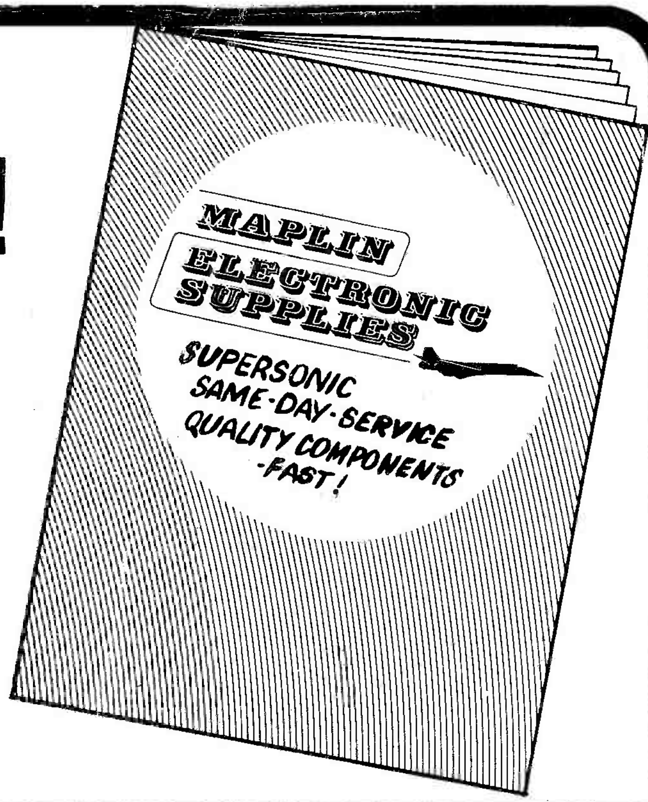

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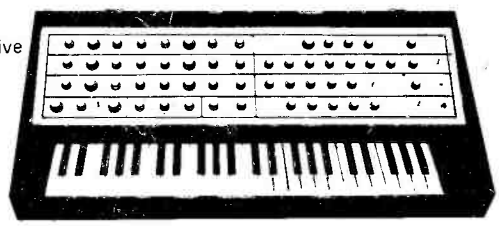

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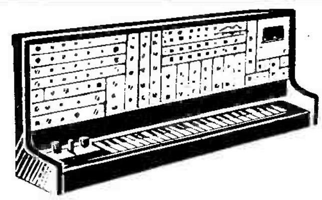

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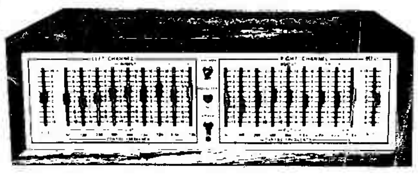

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