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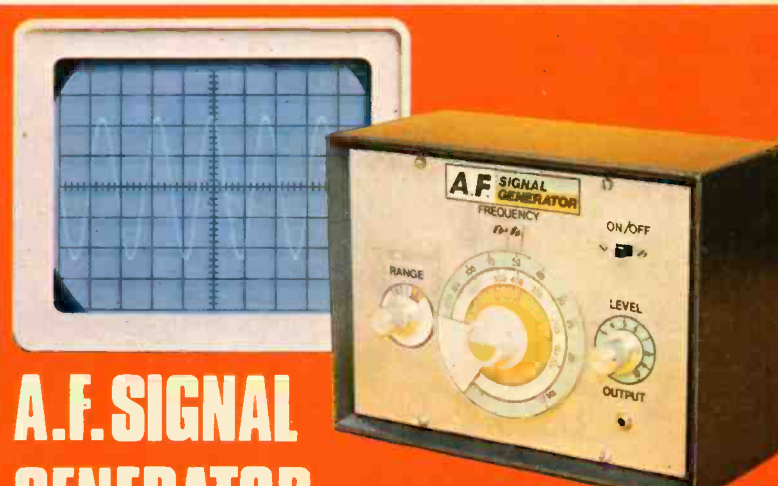

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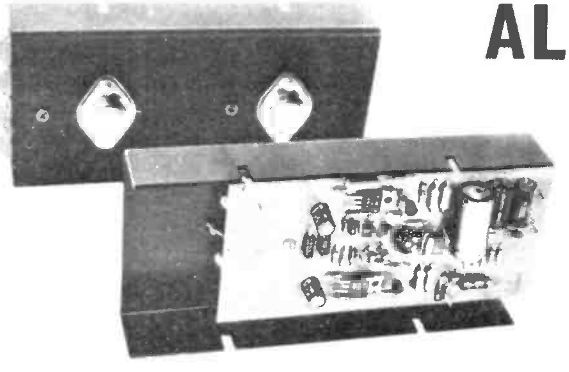

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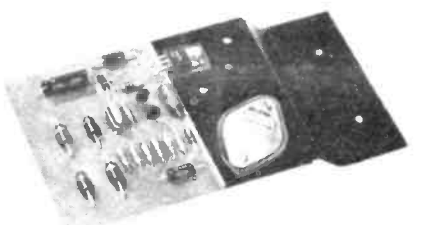

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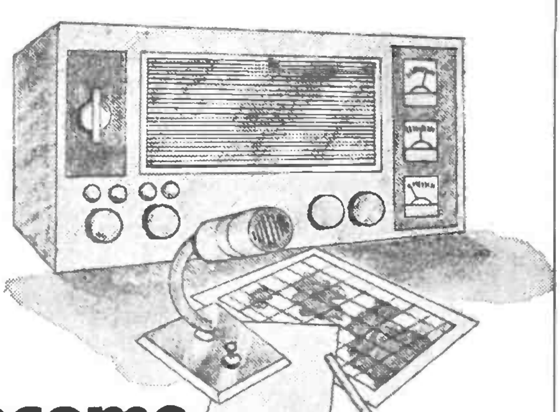

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Projects... Theory... and Popular Features...

One of the most telling impacts electronics has produced on everyday life came about with the arrival of the digital watch. Now, after several years, the analogue versus digital controversy still rages!

An advantage argued on behalf of the analogue timepiece is that the traditional watch or clock face indicates more than merely the immediate time. It enables one very easily to relate the time to the hour (or the hour to the day) as a proportion of time expired or remaining. A useful facility which we all make use of, more or less unconsciously, every time we glance at our watch.

Yet it has to be conceded that there are some applications where digital representation of time is an undoubted advantage: in timing operations, for example, where precise measurement is required without the possibility of ambiguities creeping in due to human error when reading small intervals, such as seconds and submultiples of seconds.

The timing of sporting events is a typical instance where the digital timepiece comes into its own. Modern integrated circuits make possible the construction of a high performance stopwatch like the *Chronostop*.

Apart from the field of sport the *Chronostop* will find useful employment in countless other areas where split second timing is called for.

Microprocessors have emerged from the technical domain and are now being freely discussed in the national press as the harbinger of better times, with more wonderful electronic gadgets for everyone and, of course, an improved standard of living for all. The picture has been clouded a little however with the realisation that the greater employment of microelectronics means, at the end of the day, less jobs for us humans to do.

There are also fears that the microprocessor revolution will see Britain a deprived nation so far as design and manufacture of chips is concerned.

No less a person than the Prime Minister has referred to this fast-changing technology. Mr. Callaghan said last month "The rapid development of microelectronics is one of the most significant opportunities of our time and it presents the nation with a number of challenging issues".

One of these must be, can the UK achieve independence from the US and Japan in this vital field of microelectronics? We have not much time to find out.

Fred Bennett.

Our September issue will be published on Friday, August 18. See page 619 for details.

Readers' Enquiries

We cannot undertake to answer readers' letters requesting modifications, designs or information on commercial equipment or subjects not published by us. All letters requiring a personal reply should be accompanied by a stamped self-addressed envelope.

Telephone enquiries should be limited to those requiring only a brief reply. We cannot undertake to engage in discussions on the telephone, technical or otherwise.

Component Supplies

Readers should note that we do not supply electronic components for building the projects featured in EVERYDAY ELECTRONICS, but these requirements can be met by our advertisers.

Everyday ELECTRONICS

VOL. 7 NO. 12 AUGUST 1978

CONSTRUCTIONAL PROJECTS

GENERAL FEATURES

Back issues of EVERYDAY ELECTRONICS (June 1977 onwards—October to December 1977, January to March 1978 NOT available) are available world-wide at a cost of 60p per copy inclusive of postage and packing. Orders and remittance should be sent to: Post Sales Department, IPC Magazines Ltd., Lavington House, 25 Lavington Street, London SE1 0PF.

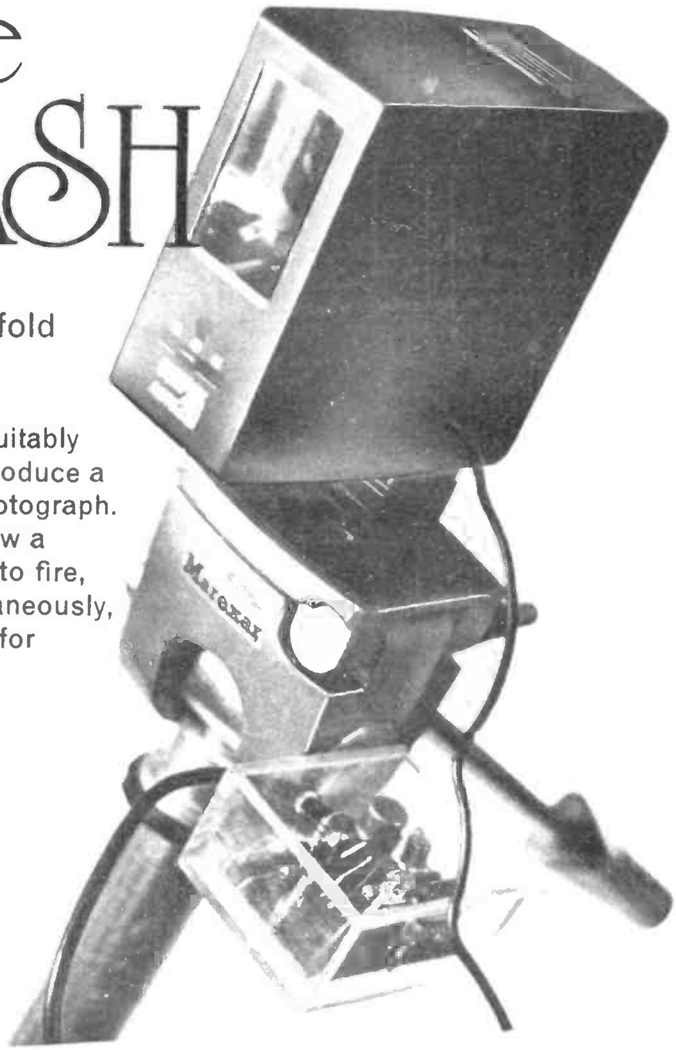
Binders for Volumes 1 to 7 (state which) are available from the above address for £2·85 inclusive of postage and packing.

5 ELECTRONIC MULTIMETERS TO BE WON NEXT MONTH
SEE PAGE 619

Slave FLASH

By R. A. Penfold

Two flashguns suitably positioned will produce a more realistic photograph. This unit will allow a second flashgun to fire, effectively simultaneously, without the need for trailing leads.



WHEN taking photographs by flashlight a common problem is the production of very sharp and unnatural shadows. The usual solution to this is to use two flashguns, the additional one being positioned in such a way that it softens or eliminates the harsh shadows.

It is possible to fire both flashguns direct from the flash contacts of the camera, but this almost inevitably needs long trailing wires which are extremely inconvenient. A much better alternative is to fire one gun using the flash contacts, with the other gun being activated by a photoflash slave unit. This is simply a light activated switch which automatically fires the secondary flashgun the instant it receives a pulse of light from the main flash unit.

The photoflash slave described here incorporates a high gain amplifier which provides very high sensitivity, and the unit triggers very reliably under normal circumstances. An unusual feature of the circuit is that it is powered from the secondary flashgun via its flash lead, and the unit therefore requires no battery of its own.

Although this is by no means unique, circuits of this type do not usually use any amplification and thus have a comparatively low sensitivity.

CIRCUIT DESCRIPTION

The complete circuit diagram of the unit is given in Fig. 1.

A potential of about 175 volts is present across the flash lead, but the available current is very small. A very low current is drawn from the flash lead via R5 and R6, and this charges up C1. The voltage across C1 will rise quite quickly to a level of about 9 volts, and then the voltage across R3 will be sufficient to start to turn on TR2.

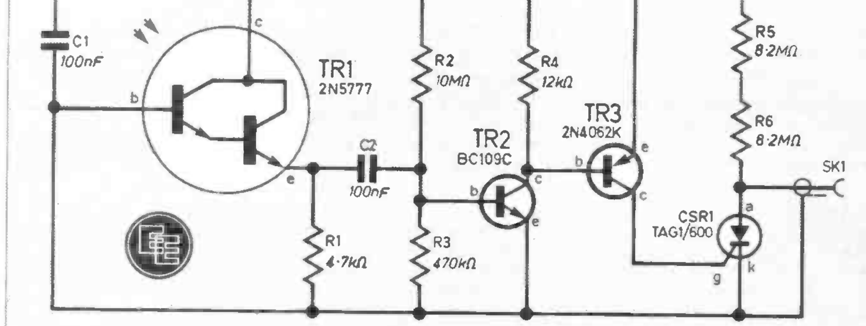
This results in the current from the flash lead being diverted through R4 and the collector/emitter terminals of TR2, and so C1 does not charge up any further. In this way the circuit is provided with the necessary low voltage supply.

PHOTO TRANSISTOR

Transistor TR1 is a photo-Darlington transistor and is used here in the emitter follower mode. The base terminal of this device is connected to the negative supply rail so that it is reversed biased. This is necessary in order to reduce the sensitivity of the cell, as using the cell at maximum sensitivity would result in it having a low collector to emitter resistance under normal lighting conditions.

Bearing in mind the low level of current which can be supplied through R5 and R6, this would represent a virtual short circuit through TR1 and R1, and would prevent any significant supply voltage being developed across C1. The circuit would thus be prevented from operating.

Fig. 1. Complete circuit diagram of the Slave Flash.



COMPONENTS

Resistors
R1 4·7kΩ
R2 10MΩ
R3 470kΩ
R4 12kΩ
R5 8·2MΩ
R6 8·2MΩ
All ⅛W carbon ± 10%

See **Shop Talk** page 595

Capacitors
C1 100nF polyester
C2 100nF polyester

Semiconductors
TR1 2N5777 photo-darlington *npn*
TR2 BC109C silicon *npn*
TR3 2N4062K (see text)
CSR1 TAG1/100 or similar rated 1A 200V thyristor

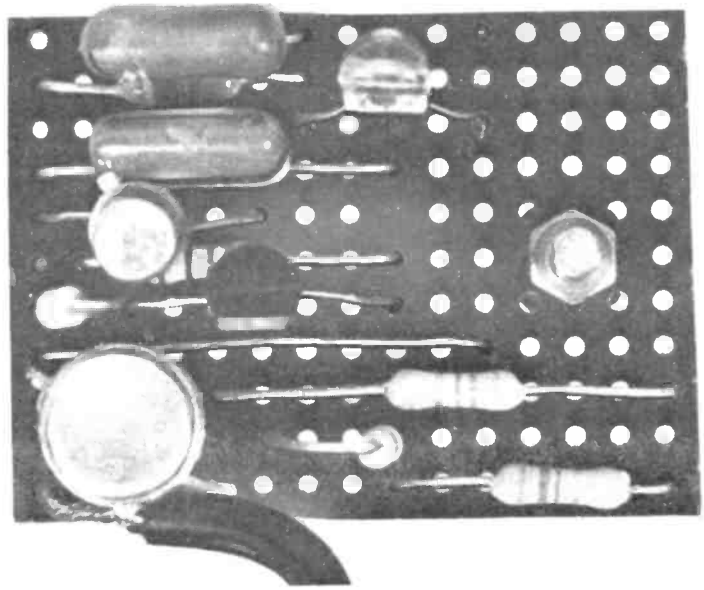
Miscellaneous
SK1 extension lead for flashgun (see text)
Stripboard 0·1 inch matrix 15 strips × 11 holes; small clear plastic case; small rubber grommet; connecting wire.

COMPONENTS approximate cost £4 excluding case

When TR1 receives a pulse of light from the main flashgun its collector to emitter resistance falls slightly and a positive voltage spike is developed across R1. This is fed to the base of TR2 by way of C2, and it causes TR2 to conduct more heavily. This in turn results in TR3 being switched hard on, and a large pulse of current being fed to CSR1 gate as C1 is rapidly discharged through TR3 and the gate circuit of CSR1.

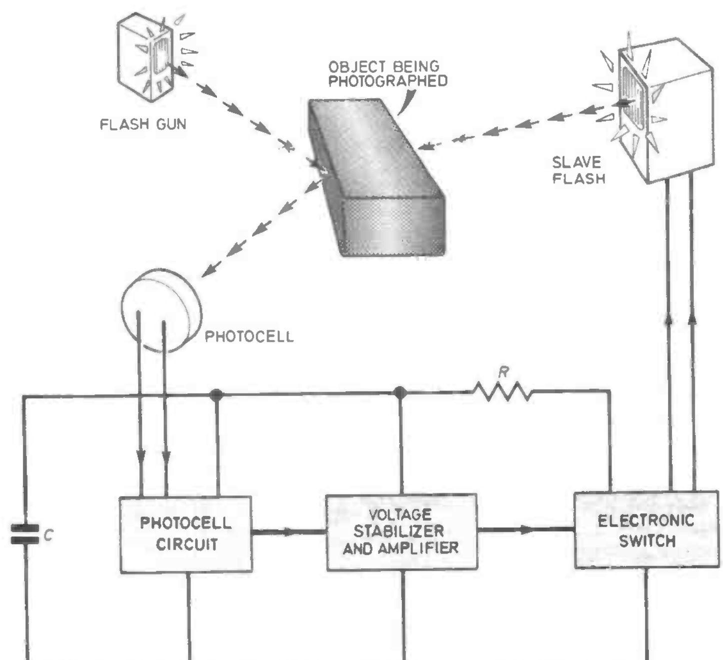
CURRENT PULSE

This pulse of current switches on CSR1 which then completes the circuit across the flash lead and fires the secondary flashgun. Once the flashgun has fired, the current through CSR1 falls to a low level and it switches off. The circuit is then ready to start again from the beginning when the flashgun is recharged for the next firing.



Being purely electronic, the circuit operates extremely quickly and there is very little delay between the pulse of light being received and the secondary flashgun being fired.

The reason for using two resistors in series in the R5 and R6 positions rather than a single resistor of a suitable value is merely that such a resistor is not readily available.



The circuit is powered by the high voltage and low current available from the flashgun. Capacitor *C* charges via the resistor *R* to a level of about 9 volts, this level being set by a voltage regulator. Light falling on the photocell produces a voltage spike which is amplified and passed to an electronic switch.
The current required to trigger the switch is quite high, but is obtained due to the high speed at which *C* discharges. The flashgun is thus fired only very shortly after the main flash.

CONSTRUCTION starts here

All the components are assembled on a 0·1 inch matrix stripboard using the component layout illustrated in Fig. 2. Start by cutting out a panel of the appropriate size so that TR1 is positioned behind this hole.

Note that the curved surface of TR1 is the light sensitive area.

If a metal case is used, the component panel must be mounted with a short spacer being utilised to hold the copper strips on the underside of the panel a little way clear of the case. Even if a plastic case is used it is advisable to use a spacer or a few washers over the mounting bolt between the case and the panel, as otherwise the panel may well fracture when the mounting nut is tightened. A 6BA mounting nut and bolt are suitable.

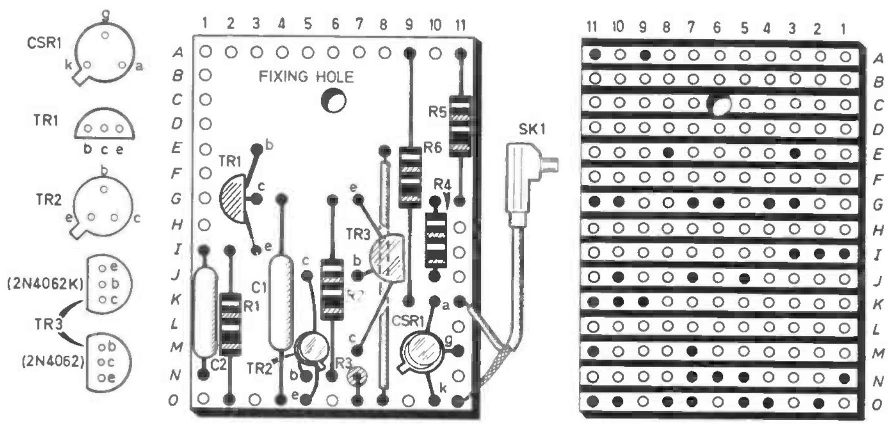


Fig. 2. Stripboard layout and wiring of the socket. Note the leadouts of the 2N4062K transistor. There are two versions, one with the suffix K and one without. Be sure to identify which one you are using. The leadouts of the thyristor also depends on the type used, but are correct for the type specified.

and then drill the single 3·2mm diameter mounting hole. There are no breaks in the copper strips and so the components and link wire can then be soldered into position.

On the prototype a 2N4062K device was used for TR3, but the electrically identical 2N4062 device is also suitable. Note, however, that these two transistors have totally different leadout arrangements, and care should be taken to ensure that the device used is connected correctly.

CASE

Construction is greatly simplified if a clear plastic case is employed with this project as this enables the light from the flashgun to penetrate through to the photocell. If an opaque case is used it will be necessary to drill a hole about 6mm in diameter in the case and then mount the component panel

FLASH LEAD

Sockets to match the plugs fitted to flashguns are not easy to obtain, and are rather expensive. Probably the easiest way of connecting the flashgun to the slave unit is to use a flash extension cable. The unwanted plug is cut off and then the free end of the cable is threaded through a hole about 4mm in diameter which is drilled in the case at any convenient point. The lead is then connected to the component panel before the latter is finally mounted in the case.

The flash lead must be connected with the correct polarity or the unit will fail to work. Normally the outer braiding is the negative lead if a screened cable is used, or the black lead in the case of an ordinary two core cable.

However, this may not always be the case, and it is advisable to check the polarity using a voltmeter if possible. If not, trial and error can be used since the slave unit will not be harmed if the flash lead polarity is incorrect.

USING THE UNIT

When the slave is used indoors it will almost certainly trigger reliably even if it is not positioned to receive a large amount of light from the main flash unit.

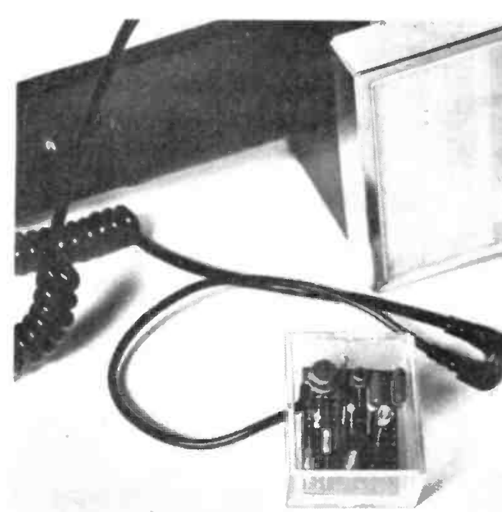
In fact, even at a distance of several metres with something obscuring the slave unit from the flashgun (a low power type) the unit seems to operate reliably from the flashgun (a low power type) the unit seems to operate reliably from reflected light!

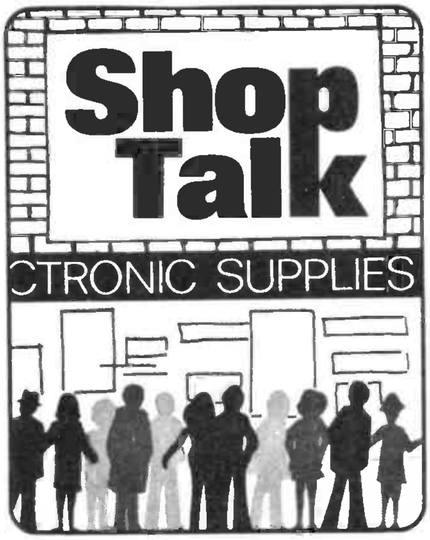
OUTDOOR USE

Out of doors the situation is rather different as in most cases the amount of reflected light will be comparatively small. It will be necessary to aim the photocell at the main flashgun in order to obtain satisfactory operation from a small flashgun at a range of several metres, but this may not be necessary if the main flash unit is a powerful type.

In common with most flash slave units, the unit will not function if it is subjected to a very high level of ambient lighting. If such lighting is present, the unit should be positioned where it is shielded from the light source.

Under uncertain conditions it is always advisable to test the set up once or twice to ensure that it is working reliably prior to making an exposure. ⌑





By Brian Terrell

Soldering Iron

We have recently received news of an inexpensive iron called the Conqueror. This is manufactured and marketed by Light Soldering Developments Limited, Department EE, 97-99 Gloucester Road, Croydon, Surrey. The Conqueror is a thermally balanced soldering iron that can be fitted with a wide range of bit sizes to cater for different uses. The iron is rated at 18 watts with its element enclosed in a stainless steel shaft, with the non-seize push-fitting over this.

A stand suitable for this iron that can hold four spare bits is also available. The spring stand is fitted with a "sponge" for cleaning the bit when in use.

Extras available for the Conqueror are burn proof lead, translucent handle and indicator lamp (to show the iron is on) detachable suspension hook, long life bit and safety collar.

The standard iron can be supplied to operate from 12, 24, 115, 220 and 240 volts and costs £4·68 including VAT postage/packing and comes fitted with a $\frac{1}{8}$th inch bit as standard.

The stand costs £3·50 inclusive and additional bits can be purchased at 54p each excluding VAT and post and packing.

Hand Tools

Next to the soldering iron in the workshop, perhaps the most used hand tool is the side cutter for cropping component leads and cutting wires to length.

A pair of long-nose pliers are found to be in constant use in our workshop for holding components when positioning, bending leads, putting washers onto bolts not directly accessible to the hand. A heftier pair of pliers commonly called electricians pliers will be found particularly useful for such things as tightening the retaining nuts on potentiometers, switches, etc. and with the aid of the long nose pliers for stretching/straightening tinned copper wire for instance, prior to cutting and bending.

With all these hand tools mentioned, the quality of the tool is usually reflected in its cost. Box jointed types are recommended for long, reliable use, with insulated handles for safety and comfort.

Among other tools that should be included in your tool pack are a junior hacksaw for cutting component boards to size, a selection of files for cleaning the edges of the cut board, and for shaping holes in aluminium, Paxolin, Perspex etc and a set of screwdrivers, both standard and Philips types. To complete this list, a set of drills and a wirestripper should be added.

Readers will be interested to know of a catalogue of tools available from OK Machine and Tool (UK) Ltd., EE Sales Department, 40a The Avenue, Southampton, SO1 2SY which contains a vast selection of hand tools both box-jointed and lap-jointed versions. The quality tools are manufactured in the USA and are reasonably priced.

The tools listed in this 14 page illustrated catalogue are various pliers, cutters, strippers, screwdriver, tweezers and soldering irons and prices for each are included.

The catalogue entitled Electronic and Electricians Hand Tools is available free of charge and can be obtained by sending a stamped self addressed envelope to the above address.

Safety Shears

A tool from this firm (not listed in the catalogue) that we asked to receive was a pair of safety shears, type OK SAF 01. These "cutters" can handle wire, hard or soft up to 1mm in diameter. The shears incorporate an adjustable strip located alongside the cutting jaws to hold the wire or lead firmly after it has been cut thus eliminating the hazard of clippings flying into the eyes or falling into a piece of equipment.

The shears are spring loaded and the handles are covered in a bright orange padding for comfortable use and easy identification on the workbench or tool box. We were impressed with this useful tool.

The cost, including VAT postage and packing is £2·58 and is available from the address given above.

This Month's Constructional Projects

Most of the components for the *Audio Frequency Signal Generator* should present no buying problems. Two devices may cause concern, these being the R53 thermistor and a transistor type OC140. The former is now known also as RA53 and can be obtained from Electrovalue Ltd., Doram Electronics and Maplin Electronic Supplies, whose addresses will be found in the advertisement pages.

The OC140 transistor is an obsolete type although it is still stocked by some component suppliers, Watford Electronics, 35 Cardiff Road, Watford, Herts, being one that we have found. The cost is £1·22 including VAT and post/packing.

In the *M. W. Mini* project the tuning capacitor used in the prototype was obtained from a defunct Japanese radio and has a value of 250pF. We have been unable to pin-point a supplier of a solid dielectric type of this value, but Electrovalue Ltd. hold stocks of a 200pF type that should be suitable.

Any value between 200 and 300pF will be suitable, the only limitation being the physical size if the overall size of the prototype is to be maintained.

The photo-Darlington transistor used in the *Slave Flash*, the 2N5777 doesn't appear in many advertisers lists and may prove difficult to locate as was the case in a similar project last year. Arrow Electronics Limited, Leader House, Coptfold Road, Brentwood, Essex, can supply this device at a cost of £1·15p inclusive of VAT and post/packing.

In the past, a suitable socket (plug?) for connecting the unit to the second flash gun has to our knowledge not been available and required buying a flashgun extension lead and removing one connector. Your attention is drawn to a letter published last month from Mr. Mortimer who located a source for the required connector.

The most expensive project this month is strangely the one with the minimum number of components, the *Chronostop*.

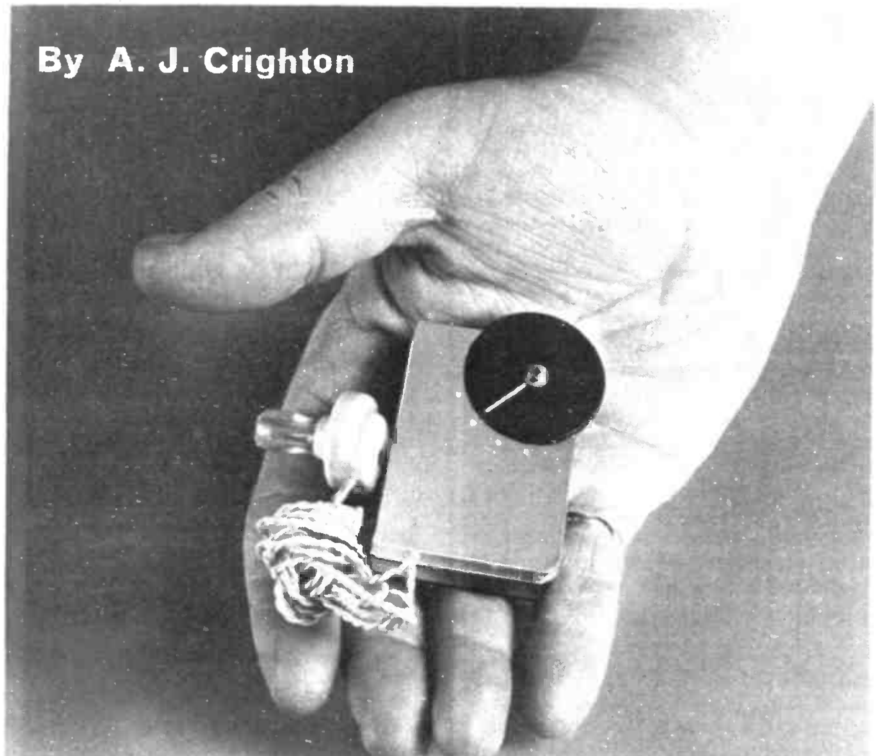
The display devices HP5082-7414 used by the authors of the project were obtained from a calculator "bits and pieces" sale at Henry's Radio in Edgware Road, London. These devices are manufactured by Hewlett-Packard, a major distributor of theirs being Celdis Ltd., (Tel: Reading 582211). They may be able to give a supplier in your area.

Other similar displays more readily available could be substituted, but wiring and connection details will of course need to be altered.

The heart of the *Chronostop*, the ICM7205, is stocked by A. Marshall Ltd., who regularly advertise in these pages and Watford Electronics, address given above.

A. Marshall (London) Ltd., have moved to new larger premises at Kingsgate House, Kingsgate Place, London NW6. Existing premises are being refitted as a new branch.

By A. J. Crighton



M.W. MINI

DURING recent years, since the introduction of the ZN414 radio i.c. many articles have appeared describing the construction of simple radios. It seems that in many designs using this i.c. the cost can be quite high when compared with the cheaper Japanese radios, making the home constructed version a less viable proposition.

The design here uses three cheap transistors which give comparable results to the i.c., but is cheaper.

CIRCUIT DESCRIPTION

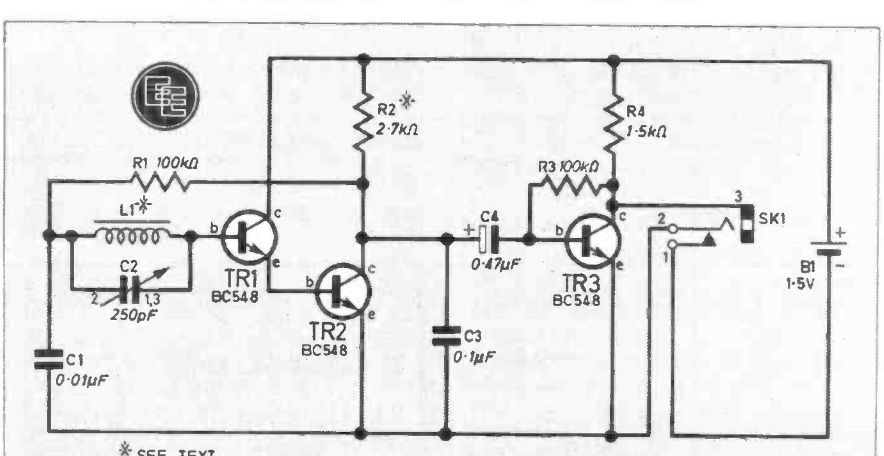
The circuit diagram of the M.W. Mini is shown in Fig. 1.

The tuned circuit, L1/C2 selects the required station, transistor TR1 providing the necessary r.f. amplification. The signal is then passed to TR2, a small proportion of the signal being fed back from the collector to the base of TR1 via the tuned circuit.

A mixture of both r.f. and a.f. is now circulating in this feedback loop, the r.f. reinforcing that coming via the tuned circuit, the a.f. being passed to the audio stage.

Transistor TR3 provides the required audio amplification which is at a sufficient level to drive a crystal earpiece connected to SK1.

Fig. 1. Circuit diagram of the Sub-miniature Radio.



CONSTRUCTION starts here

Most of the components are mounted on a small piece of plain matrix board having 13 by 7 holes as shown in Fig. 2. Connections to the components are made using single-cored wire on the underside. Using this method a smaller layout can be achieved than by using ordinary stripboard.

The aerial coil L1, is home made and consists of 80 close wound turns using 32 s.w.g. wire on a ferrite rod. The jack socket, SK1, serves two purposes; besides being the normal socket for the earpiece, it also turns the power on. To do this a slight modification is necessary to the standard component.

This is shown in Fig. 3, and as can be seen it is just a matter of bending one of the contacts out so a "make" action is achieved rather than the normal "break" action.

The tuning capacitor C2 is one which is seen widely in small portable transistor radios, and may have two sets of gangs. If this is the case, then one set should be ignored. The wiring shown in the diagram is correct for the type used in the prototype.

IN USE

Once you are sure that the wiring is correct and no mistakes have been made the earpiece can be plugged in. As soon as it is pushed in power will be applied

M.W. MINI

COMPONENTS

See Shop Talk page 595

Resistors
R1 100kΩ
R2 2·7kΩ (see text)
R3 100kΩ
R4 1·5kΩ
All ¼W carbon ±10%

Capacitors
C1 0·01 μF ceramic
C2 250pF variable
C3 0·1μF polyester
C4 0·47μF 10V elect.

Semiconductors
TR1, 2, 3 BC548 silicon *npn* (3 off)

Miscellaneous
SK1 3·5mm jack socket
L1 home-made aerial coil (see text)
B1 1·5V D23 battery
Matrix board 0·1 inch 13 × 7 holes; small plastic case 60 × 40 × 15mm; ferrite rod 45 × 9mm; 32 s.w.g. enamelled copper wire; crystal earpice; small flat tuning dial, 25mm diameter to suit C2; connecting wire.

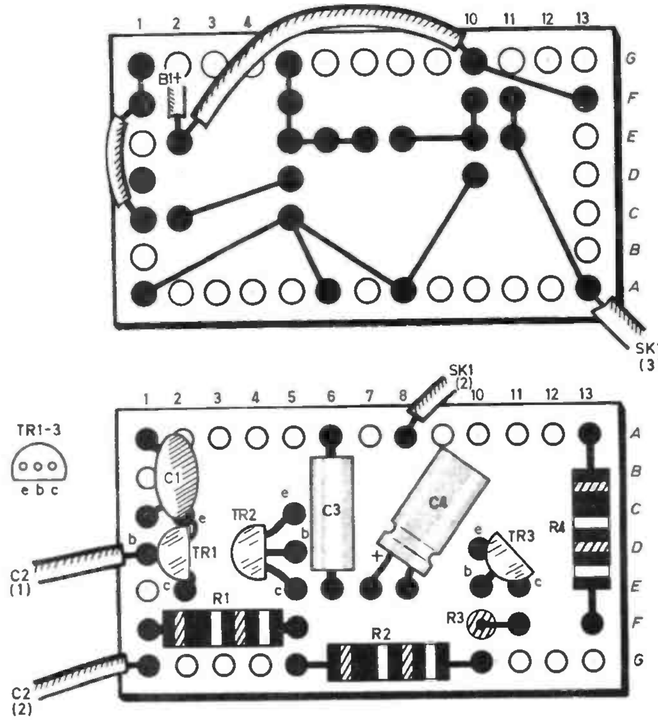
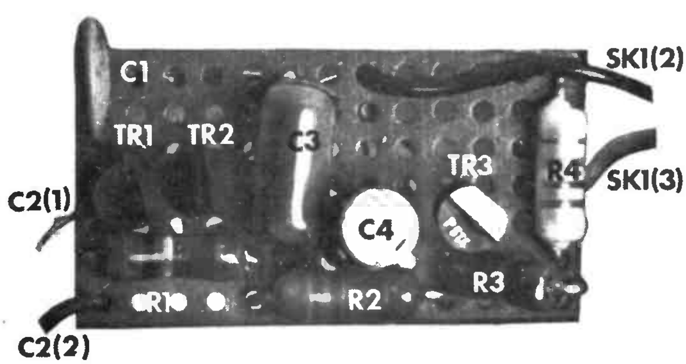


Fig. 2. Wiring details for the matrix board and external components.



The completed circuit board for the radio.

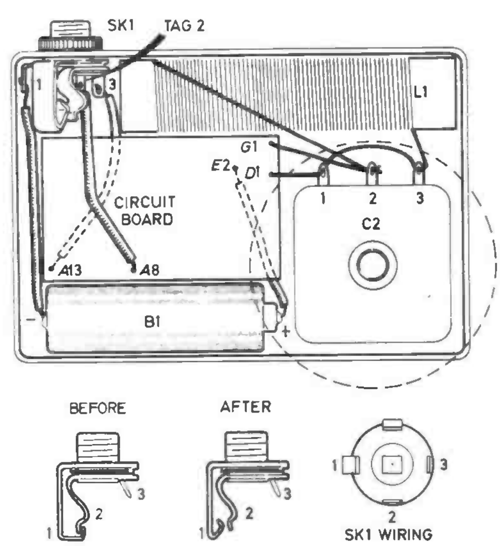


Fig. 3. Modification required to the jack socket and interwiring details.

to the circuit, and some background noise will be heard.

Adjusting the tuning will produce a few stations, the actual number will depend on the type of location. The tuning is quite sharp and some care is needed when tuning. The ferrite rod aerial is directional, and the receiver should be turned around in both planes for maximum signal strength for each station.

If a whistle occurs on some stations as they are tuned in, then some adjustment of R2 will be required. Increasing the value to, say, 3·3kΩ will sove the problem.

COMPONENTS approximate cost £1·50 excluding case

TEACH-IN 78 Part 11

BY GEORGE HYLTON

POWER SUPPLIES AND TRANSDUCERS

WE ARE now nearing the end of the present series, but before we finally end it is appropriate at this time to briefly look at power supplies and how they can be simply constructed.

The second subject, transducers, does in fact cover a wide range of components. Albeit only briefly, it does give the reader an insight into the many other types of components that are in common use today.

POWER SUPPLIES

The many and varied circuits used in electronics require power supplies. A computer, with millions of transistors in its integrated circuits may require a large current at a low voltage. It is important that the voltage be correct. If too low the circuits would not work, if too high they may be damaged.

ZENER DIODE

Some form of stabilised voltage supply is generally used. This protects the computer against fluctuations in the mains voltage. Many voltage stabilisers make use of a device called a Zener diode. In one sense, all silicon junction diodes are Zener diodes.

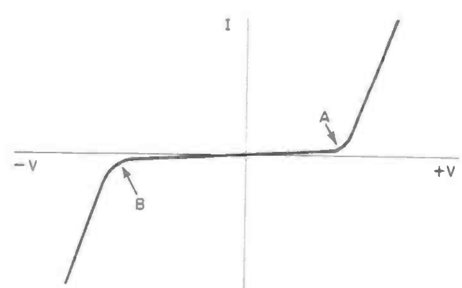


Fig. 11.1. Typical diode voltage/current curve. The bend at A is the forward bias condition. The bend at B is the reverse bias condition.

If you examine how the current they pass varies with voltage for both forward and reverse bias, Fig. 11.1 you find two sharp bends in the curve. Bend *A* is the usual one at round about +0·6V forward bias voltage. That is, it is the *turn on* voltage. Bend *B* comes at a much higher reverse voltage. In ordinary diodes this bend is at anything from about −50V to several hundred volts, or even several thousand.

However, special diodes can be made which break down at lower voltages. The voltage at *B* is called the reverse Zener breakdown voltage and the diodes are known as **Zener diodes**. They can be made with very stable breakdown voltages. Since the current increases sharply once the Zener voltage is exceeded the diode must always be protected by a current limiting series resistance. The power dissipated by a Zener is: voltage times current as usual. So a 10V Zener passing 100mA dissipates $10 \times 0 \cdot 1 = 1W$.

A simple Zener stabiliser, Fig. 11.2a, uses a series resistance *R1* to absorb part of the input voltage. If the input voltage increases, almost the whole of the increase is absorbed by *R1*. The voltage across the Zener is virtually constant, because a tiny increase results in a large current increase in *R1*, which drops more voltage as a result.

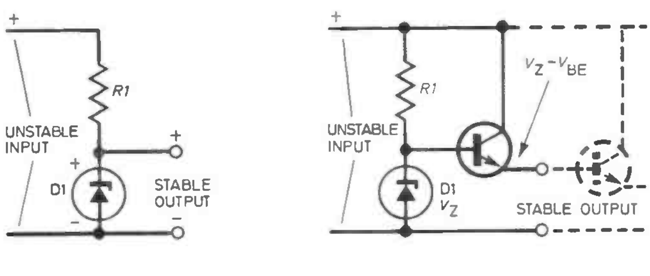


Fig. 11.2. Zener stabilising circuits. In (a) the resistor absorbs part of the input voltage to produce a stable voltage across the diode. The circuit of (b) is to enable the Zener to deliver more current by using an emitter follower.

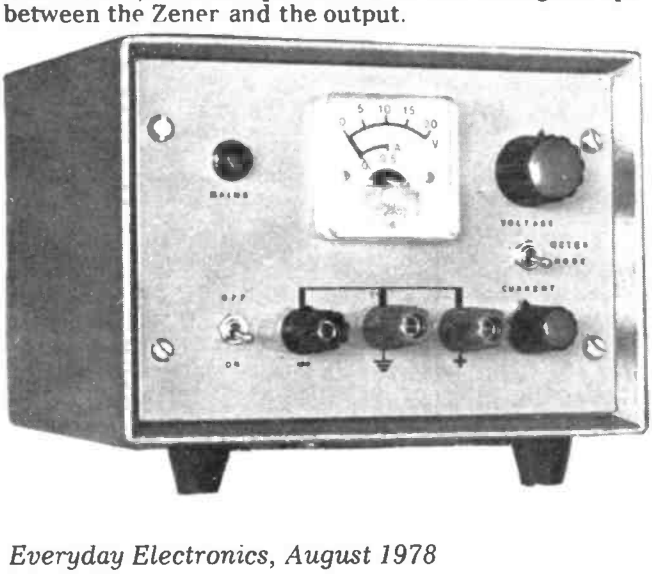
The trouble with this circuit is that both *R1* and the Zener have to handle a lot of power. So circuit designers have dreamed up arrangements which use the steady voltage across the Zener merely as a reference voltage, supplying little current.

EMITTER FOLLOWER

The current needed by the load is supplied by transistors, controlled in some way by the Zener. In the simplest circuit, Fig. 11.2b, the Zener voltage V_Z is applied to the base of a transistor, and the stabilised output taken from the emitter. You may remember this type of circuit, it is called an emitter-follower.

The output is the base voltage, V_Z minus the working base emitter voltage V_{BE}. If you choose V_Z to be about 0·7V above the voltage you need the correct output is obtained. If the transistor has a high current gain not much base current is needed so the Zener need not work very hard.

In any case, a second emitter-follower can be driven by the first shown dotted thereby greatly reducing the current, at the expense of two V_{BE} voltage drops between the Zener and the output.



If this is not stable enough, (the V_{BE} does vary somewhat according to the current through the transistor—the load current), an arrangement is used where the actual load voltage is stabilised. In this, a differential amplifier is used to compare the Zener voltage with a sample of the output voltage, Fig. 11.3.

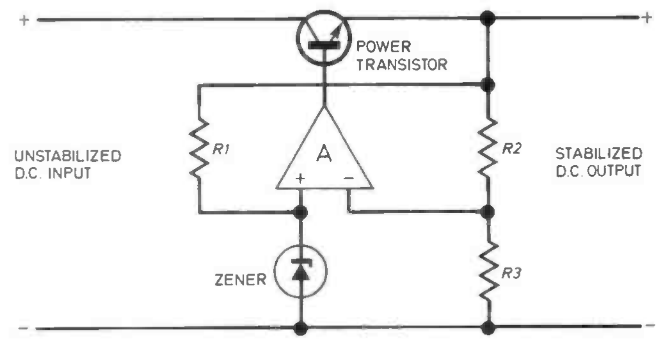


Fig. 11.3. A voltage stabiliser circuit. A sample of the output voltage is compared by the op amp and used to control the output.

FEEDBACK

If there is any difference it is amplified and then used to control the series transistor in such a way that the difference is reduced. Yet another example of negative feedback. With this arrangement the output voltage can be higher than the Zener voltage. If *R2* is twice the value of *R3* for example, the output voltage is three times the Zener voltage. The output voltage can be made variable by substituting a potentiometer for *R2* and *R3*.

This is useful for setting the voltage to a precise value. Zeners have tolerances like other components.

Stabilised voltage supplies often have special safety precautions against overload or short circuit. Usually these take the form of sensing the output current and turning the output off, or limiting it to a safe value if the load tries to draw too much current. Current sensing is done by monitoring the voltage drop across a small resistance in series with the load.

Nowadays it is possible to buy integrated circuits which contain the differential amplifier and protection circuits. The user adds the series transistor, Zener, various potentiometers to set up the voltage and protection, and capacitors.

MAINS POWER SUPPLIES

So far we have not said how the unstabilised d.c. supply is obtained. In mains powered equipment the high mains voltage, 240V, 50Hz in the UK, is converted to a suitable low voltage by a step-down transformer. The use of a transformer has two great advantages.

First, the low voltage secondary can be well insulated from the high voltage primary. Dangerous high voltages are kept to the primary.

A neatly built example of an amateur power supply.

Second, the voltage transformation is made with very little power loss. A perfect transformer would have no loss, so 240V, 1A input could be transformed to 1V, 240A output (remember watts=volts×amps?), giving the same power out as went in.

Real transformers waste some power in the resistance of the windings and some by driving useless currents round and round in the magnetic core.

These unwanted currents are known as eddy currents. To reduce them the iron cores, known as "stacks", are formed using thin metal parts, called laminations. The majority of small mains transformers used in electronics are only about 50 per cent efficient, that is, about half of the available power is lost.

Really big transformers as used in power stations have to be much more efficient, to avoid overheating. Even 1 per cent of the output is a lot of power lost!

RECTIFICATION

Transformers deliver a.c. and this must be rectified to turn it into d.c. Nowadays silicon diodes are the usual form of rectifier, though you may also come across selenium rectifiers, and in old valve equipment, valve rectifiers. The simplest rectifier arrangement is the half-wave rectifier circuit, Fig. 11.4.

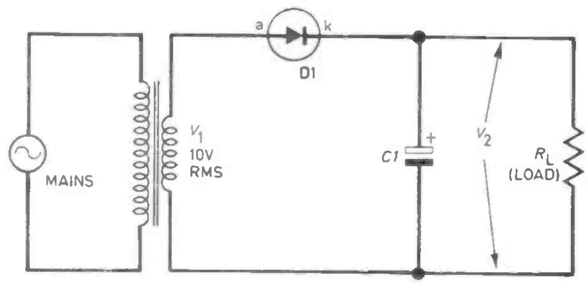


Fig. 11.4. A simple power supply using half wave rectification. R_L is the output load resistor.

HALF-WAVE

Half-wave rectification allows current to flow during only one half cycle of each complete wave of the a.c. input. Without *C1*, the load receives a "pulsating d.c." voltage. This is all right for some jobs, such as charging batteries or driving model cars, but it is no use for, say, a computer because the d.c. supply is off for half the time and varies in voltage for the other half.

Adding *C1* is a great help, because this capacitance charges when D1 conducts and discharges the rest of the time. If large enough, the large pulsations are **smoothed** out and only a small sawtooth **ripple** remains. If there is no load, *C1* becomes charged to very nearly the peak of the applied a.c. voltage, e.g. to 14V if the voltage is 10V r.m.s. Transformer voltages are quoted in r.m.s. values.

When a load is connected the voltage falls. The extent of the fall depends on how big *C1* is and how much load current is taken. For any power supply there is a maximum safe output current.

A measure of the fall in output voltage is produced by doing the calculation:

$$\frac{\text{No load voltage} - \text{full load voltage}}{\text{No load voltage}}$$

This is often called the **regulation** and expressed as a percentage. Thus if the voltage falls from 100V to 80V the regulation is:

$$\frac{100-80}{100} = \frac{20}{100} = 20\%$$

As more load current is drawn the ripple increases, because the reservoir capacitance *C1* is drained of more of its charge during the non-conducting intervals of D1. If a voltage stabiliser is connected between *C1* and the load it is important that, even at the troughs of the ripple, there should be enough voltage to allow the stabiliser to work properly. The stabiliser then removes the ripple as well as keeping the output voltage constant.

Half wave rectifier circuits are seldom used with mains transformers. The reason is that the d.c. load current flows through the transformer secondary.

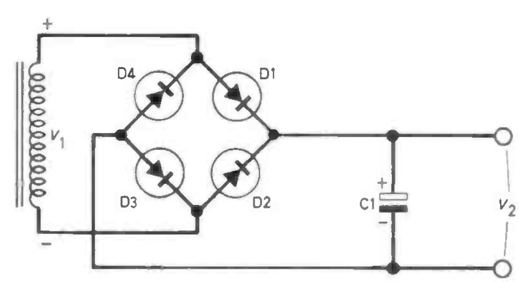


Fig. 11.5. A full wave rectifier circuit. Diodes D1 and D3 conduct on the positive half cycles, while D2 and D4 conduct on the opposite half cycles.

This is bad because it increases the magnetisation of the iron core. Iron can only take a certain magnetisation.

If you try to magnetise it more and more strongly a point is reached at which it becomes "full up". This is called core saturation and has the effect of reducing the inductance of the windings drastically. Consequently the impedance of the primary falls and a large and possible damaging current flows through it from the mains.

FULL-WAVE

To avoid this, full-wave rectification is used. With this circuit the d.c. during one half cycle is followed by an opposite polarity d.c. during the next. That is, the core receives only an alternating magnetic field. To steer the output current of the transformer secondary in the required directions four diodes are needed, Fig. 11.5.

If you think of a diode symbol as an arrowhead, current flows in the direction in which it points.

During the half cycle shown, D1 and D3 conduct, charging *C1* as shown. On the next half cycle, D2 and D4 conduct, again charging *C1* as shown. Whatever direction the current takes in the transformer winding *C1* is charged the same way. Whichever pair of diodes is non-conducting is reverse biased at the time.

An alternative circuit, the push-pull rectifier consists of two half-wave rectifier circuits back to back, Fig. 11.6. Diode D1 conducts on the half cycle shown. Current flows back into the winding via the centre-tap and diode D2 conducts in the next half cycle. The effect of the d.c. in one half winding is cancelled by the d.c. in the other, flowing in the opposite direction.

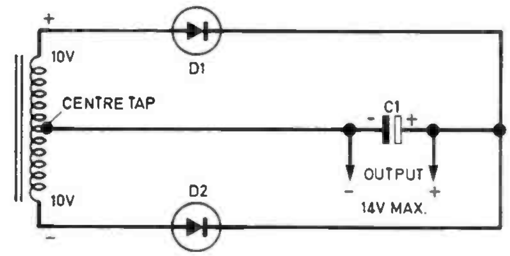


Fig. 11.6. A push-pull rectifier circuit. Although saving on the number of diodes used, the transformer does require a centre-tap.

CURVES

With full wave rectification *C1* is charged twice every cycle, lowest curves in Fig. 11.7, so the ripple is reduced. The four diode full wave rectifier of Fig. 11.5 is often called a bridge rectifier.

Referring back to the half wave circuit, think about the voltage across D1 at the peak of the non-conducting half cycle. Suppose there is no load, so *C1* is fully charged. The anode is at a voltage of −14V. The cathode is at something near +14V (the voltage stored in *C1*). These voltages are "series-aiding" and add to place 28V across D1.

That is, D1 has to be able to withstand a reverse bias of twice the peak value of the applied voltage. It is vital that D1 has a reverse Zener breakdown voltage of more than this. Otherwise current will flow backwards, spoiling the rectification and subjecting D1 to large internal heating which will destroy it. Diode manufacturers quote a peak inverse voltage (p.i.v.) which must never be exceeded.

The 1N4001, for example, has a p.i.v. rating of 50V. High reverse voltages occur in all rectifier circuits where the diodes feed a reservoir capacitor.

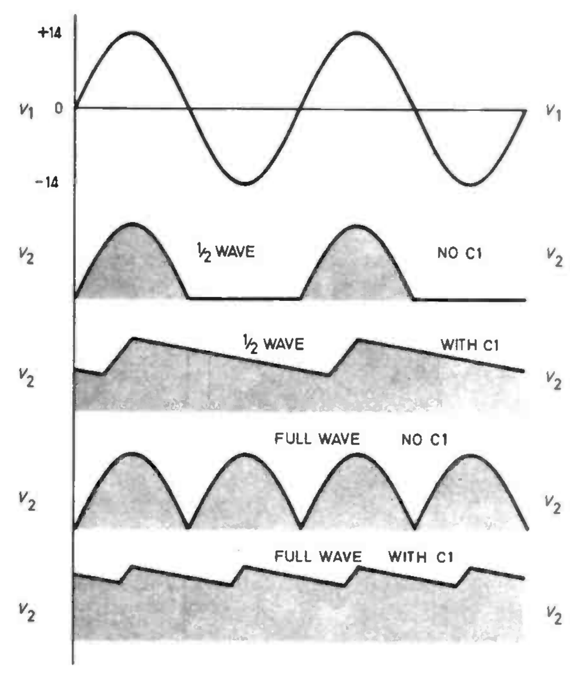


Fig. 11.7. Typical graphs showing the various outputs obtained from the previous three figures. In all cases the input is the same and is shown by the top graph.

TRANSDUCERS

LIQUID TRANSMITTER

A little over 100 years ago Alexander Graham Bell, a Scot who emigrated to North America, invented the telephone. One of his major problems in making it work was to convert sound efficiently into electrical energy and back again.

One of Bell's attempts at making a microphone, a device which converts sound waves into corresponding electrical currents or voltages, was his "liquid transmitter".

This used a wire partially immersed in a conducting liquid. Fig. 11.8 The opposite end was attached to the centre of a diaphragm. When someone spoke into the diaphragm it vibrated, moving the wire up and down in sympathy, this altered the amount of wire in contact with the liquid.

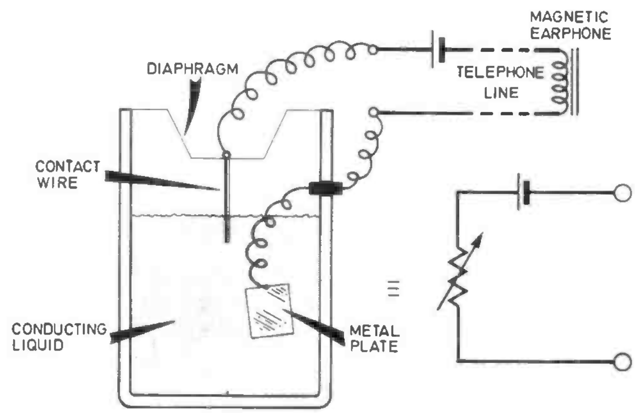


Fig. 11.8. Bell's liquid transmitter. When sound waves strike the diaphragm the contact wire is caused to move. The equivalent electrical circuit is shown alongside.

When a current was passed through the wire the audio variations modulated the current flow between the wire, a fixed metal plate immersed in the liquid and the outside circuit.

The arrangement is really just a resistance which varies in sympathy with the movements of the diaphragm and hence in sympathy with the sound. Its associated circuit diagram is a resistance in series with the battery which supplies the current.

Bell's liquid transmitter was not very successful. It was replaced by a device still in use today in most British telephones. This is the carbon microphone. Fig. 11.9.

Here the diaphragm presses down on a container full of carbon granules, hard shiny grains of carbon. Increasing pressure improves the contacts between the granules and reduces resistance. Decreasing pressure has the opposite effect.

So, when sound vibrates the diaphragm, the resistance of the carbon microphone varies in sympathy.

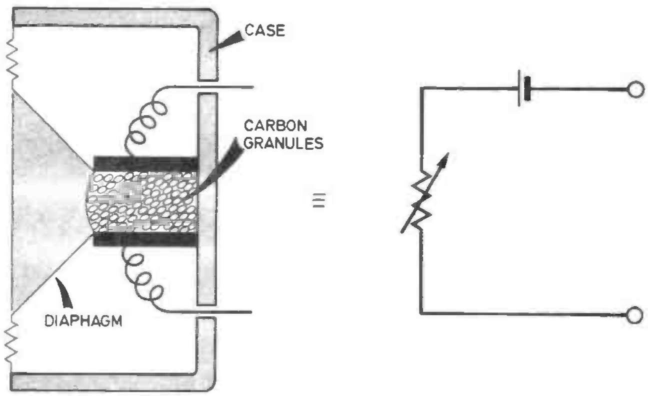


Fig.11.9. The carbon microphone. As the equivalent circuit shows, the principle is the same as the previous figure, but this system is more reliable.

Devices like these, which convert one physical quantity into another are called **transducers.**

The most familiar are the microphone, loudspeaker, gramophone pickup, and telephone earpiece but there are many others.

A great many transducers are designed to detect movement of some kind. If an a.c. generator generates one complete cycle of voltage when its shaft is turned once, then it produces an output frequency which is a direct indication of the frequency of rotation of the shaft.

Slow movement is often measured by making whatever is moving change a resistance. For example, it is possible to buy potentiometers which have no end stops like the ones you have been using, but allow the shaft to be turned round and round the same way.

These 360° pots can be used to indicate the angle through which a shaft has been turned. Straight pots of the slider type can be used to indicate straight-line movements.

STRAIN GAUGES

An important class of movement detectors are strain gauges. These detect the very small movements which occur when a structure of some kind, for example a bridge moves under a load, or expands and contracts with temperature changes.

One common type of resistance strain gauge is a piece of paper or plastic with a metal resistance "track" printed on it. The gauge is glued firmly to the structure so that it expands and contracts with it. This stretches or compresses the track, changing the resistance by a small amount.

To detect the change, the resistance is usually made part of a balanced bridge circuit, Fig. 11.10. Any strain unbalances the circuit, giving a tiny output voltage which is amplified so that it can be easily observed or recorded.

It is common practice to make one arm of the bridge from another gauge which is near the first one but not strained.

In this way changes in resistance due to temperature can be compensated.

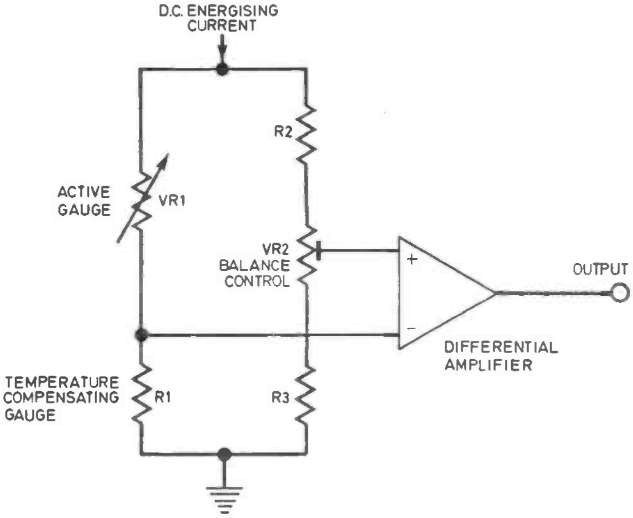


Fig. 11.10. Resistance strain gauge in the form of a balanced bridge circuit. Strain on VR1 causes it to change resistance and upset the balance.

NON–CONTACTING TRANSDUCERS

It is often inconvenient to connect wires to a moving object. A good example is a rotating shaft where the wires would get twisted. To measure its movement without connections needs some sort of non-contacting transducer system.

There are many ways of solving this kind of problem. If a magnet is fixed to the shaft, so that it passes close to a fixed coil once every revolution, a voltage will be induced in the coil at every pass. But fixing a magnet, which is necessarily made of heavy material, may unbalance the shaft, causing vibration.

An alternative, shown in Fig. 11.11 is to attach a thin piece of lightweight reflective material to the shaft. A light beam reflected off the shaft at this point undergoes an increase in reflected brightness when the reflective material passes. This can then be detected by a **photodetector.**

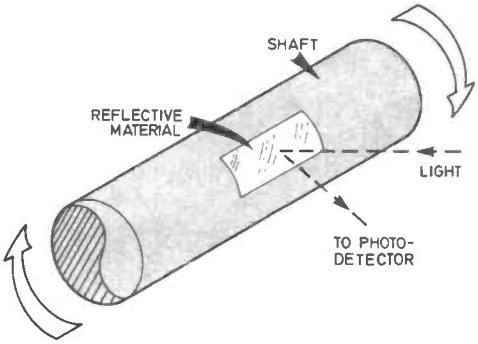
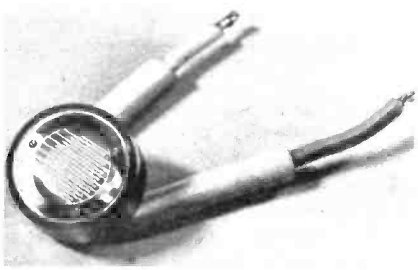


Fig. 11.11. A photo-electric system for detecting rotation. A reflective patch on the shaft directs light to a photodetector once every revolution.

PHOTODETECTORS

There are many kinds of photodetector. You are certain to come across some of these in the future.

One of the simplest is the photo resistor, commonly called a light dependent resistor, l.d.r. An l.d.r. usually consists of a resistive track of cadmium sulphide or cadmium selenide on a flat surface, glass or plastic, with a transparent cover. Light beams can be considered as streams of fast particles, photons.



A light dependent resistor.

When a photon hits the l.d.r. material it may knock an electron out of an atom. This temporarily freed electron can now act as a current carrier, the effect being to reduce the resistance.

Photoresistors are robust and relatively cheap and are sensitive to the light from filament lamps, which is really mostly invisible infra-red radiation. They are also rather slow to respond to light, making them unsuitable for some purposes.

PHOTOCELLS

Photovoltaic cells are used in photographers' exposure meters. As their name suggests, they generate a voltage when light falls on them, that is the energy of the light is converted into electrical energy.

The traditional p.v. cell is made of a thin layer of specially sensitised selenium and is slow to respond. However the silicon photovoltaic cell is now often used for the kind of job we are talking about.

It is a miniature version of the solar cells used to convert the sun's energy into electrical energy. These cells respond quickly and are made with large active areas, which can be useful if the light is unfocussed. They respond well to filament lamp light.

PHOTOTRANSISTORS

The most popular silicon photo-detectors, however, are the phototransistor. and the reverse-biased photodiode.

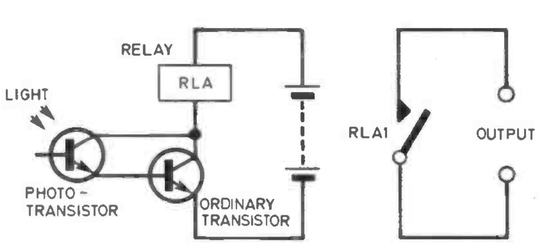


Fig. 11.12. The photo Darlington photodetector is a light sensitive transistor coupled to an amplifying transistor.

The silicon phototransistor is just a silicon transistor in a housing which lets the light in. In most applications the base is left unconnected.

Light falling on the active area releases electrons and therefore creates holes in equal numbers. These *electron-hole* pairs act as input current carriers. The transistor amplifies the current, giving a large output.

A phototransistor is often combined with an ordinary transistor in one package. Fig. 11.12. This combination, the **photo-Darlington** has a very high sensitivity. It can be used to operate a relay as shown.

Silicon phototransistors respond in a few tens of microseconds. If this is not fast enough then a reverse-biased photodiode is a possible alternative.

PHOTODIODES

A photodiode is normally reverse-biased by a d.c. voltage, this holds it in the non-conducting state until light strikes it.

The resulting free electrons are then attracted to the positive terminal and the holes to the negative. The reverse bias voltage acts as an accelerating voltage and the response time can be short—less than a microsecond, though it depends to a very large extent on how the diode is used in the circuit.

A high value load resistance—slows down the response considerably—to a millisecond. Fig. 11.13.

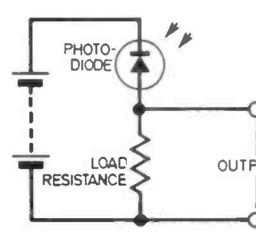


Fig. 11.13. A basic circuit using a photodiode. Here the output is taken from across the load resistance.

A completely different kind of photocell is related to the radio valve. Instead of having a heated cathode, emitting electrons, as in an ordinary valve, there is a photocathode, Fig. 11.14. This is an unheated metal plate coated with a substance from which electrons can be knocked out by light.

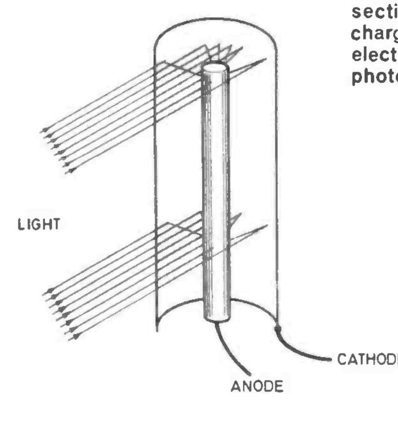
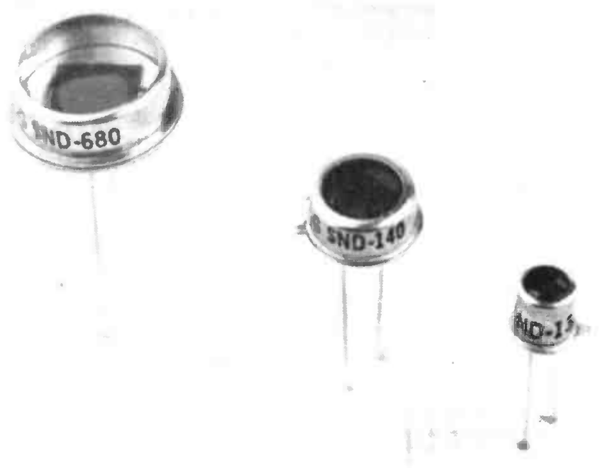


Fig. 11.14. A photo-detecting valve diode. The curved part is the photocathode, and the anode the round section. The positively charged anode collects electrons emitted from the photocathode.



Examples of typical photodiodes.

These electrons, emitted into the vacuum, are collected by the positively charged anode. In simple vacuum photocells the photocathode is usually curved into half a cylinder. The anode is a single stiff wire, which stops the minimum amount of light.

The sensitivity of these vacuum photocells is low. One early method of improving it was to let a certain amount of gas into the device. Accelerated electrons colliding with the gas molecules knock off more electrons which in turn are accelerated, and so on. If the process is allowed to continue the photocell is destroyed. Therefore the anode voltage must be set carefully so that a useful amount of this **ionisation multiplication** is obtained but without risk to the cell.

You may come across these simple photocells in old film equipment, where they were used to convert variations in light from the optical sound tracks into audio frequency currents and voltages.

The valve-type photocell is still very much alive in the specialised fields of nuclear physics and image tubes, but in developed forms.

In nuclear physics, the presence of a nuclear particle can be revealed by allowing the particle to pass through a substance called a *scintillator*, which responds by emitting a tiny flash of light. Counting the flashes tells you something about the *number* of particles. Measuring the intensity of the flashes tells you about the *energy*.

Photodetectors for this work must be very sensitive (since the flashes may be feeble) very fast, and must give an output strictly proportional to the intensity of the light.

PHOTOCOUPLERS

We have been talking about converting light into electrical signals. Frequently the opposite is required; electrical signals to light.

Filament lamps can be used but they require a lot of power and are slow. Gas-discharge lamps, such as neon tubes are faster but require high voltages.

Light emitting diodes are very fast, use low voltage and low power. They are not linear, that is, the light emitted is not strictly proportional to the electrical input.

A simple light modulator Fig. 11.15 uses a transistor to drive current through the l.e.d.

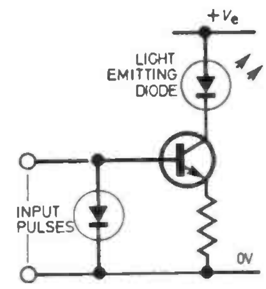


Fig. 11.15. An l.e.d. can be turned on and off very quickly by pulses of current to produce modulated light.

Modulated light can be easily detected at a short distance by a photodiode or phototransistor, and turned back into electrical signals. The usefulness of doing this apparently pointless exercise is twofold.

First, there need be no electrical connection between the l.e.d. and the photodectector. It can be air, or transparent plastic, or some other good insulator. This enables one side of the arrangement to be set at a very different voltage from the other, if necessary thousands of volts apart.

The other useful property is that the output device need not be earthed.

Combinations of l.e.d. and photodetector, in neat packages with black outsides to prevent external light interfering, are known as **photocouplers.** They can be used for example to isolate the controls of a mains operated device from the mains voltage.

BALANCED CIRCUITS

The electrical balance principle mentioned in connection with strain gauges is often used with other kinds of transducers. It has the great advantage of enabling the wanted signals to be separated from unwanted ones.

In the case of the strain gauge bridge there may be 1 volt d.c. across the circuit. But the variations due to strain may be only a few microvolts. The standing d.c. must be removed, otherwise it would mask the small wanted signal and also make large amplification of it impossible. The 1 volt would just overload a high-gain amplifier.

Inductive balanced circuits, Fig. 11.16. are frequently used when small movements have to be measured.

Suppose L1 is free to move but L2 and L3 are fixed and equal. The voltages induced in L2 and L3 by the field of L1 drives currents, i_1 and i_2 in opposite directions through *R*. They tend to cancel.

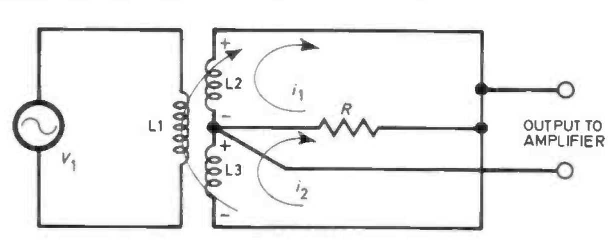


Fig. 11.16. A balanced inductive circuit. If L1 is free to move with respect to L2 and L3 it can be placed in a "null" position. Any movement of L1 now unbalances the circuit, the change being detected and amplified.

There is some position of L1 at which they cancel exactly, and no output voltage appears. This is the "null" or "balanced" position. If the output is applied to a high gain amplifier, a tiny movement of L1 produces a detectable output. Movement in one direction produces an output voltage in phase with V_1.

Movement in the other direction produces an anti-phase output.

METERS

Although they are not usually regarded as transducers, pointer meters have the typical transducer property of turning one thing into another; current into movement.

In **moving iron** meters the current energises an electromagnet which attracts a small piece of iron which is attached to the pointer. The method works with both a.c. and d.c. but has various disadvantages.

In practice it is used mainly for cheap insensitive meters for indicating battery charging currents or testing batteries. The usual meters for electrical measurements are of the **moving-coil** variety. These work rather like electric motors.

A pivoted coil is placed in a specially shaped magnetic field. Current in the coil produces its own magnetic field. The interaction between the two causes the coil to turn round against the force of a hairspring until it finds a balanced position. The pointer is attached to the coil and turns with it.

A good moving-coil meter is sensitive, accurate, and linear—that is the pointer movement is exactly proportional to the current. Moving-coil meters respond only to d.c. For a.c. they are fitted with rectifiers, usually a full wave bridge rectifier arrangement.

The equivalent circuit of a moving-coil meter is a resistance in series with an inductance. For d.c. purposes the inductance is unimportant and the meter is just a low resistance. To convert such a meter into a voltmeter a series resistance is added. In the circuit of Fig. 11.17 this is resistor R_m.

For example, if the meter requires 1mA for full-scale deflection (f.s.d.), and it is to be converted to read 10V f.s.d. the total resistance must be 10 kilohms. If the meter coil itself is 100 ohms the required extra resistance is 9900 ohms.

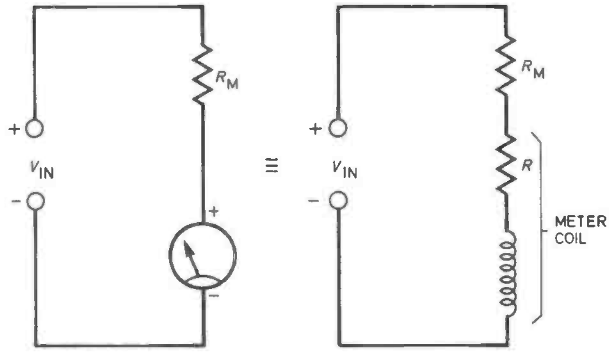
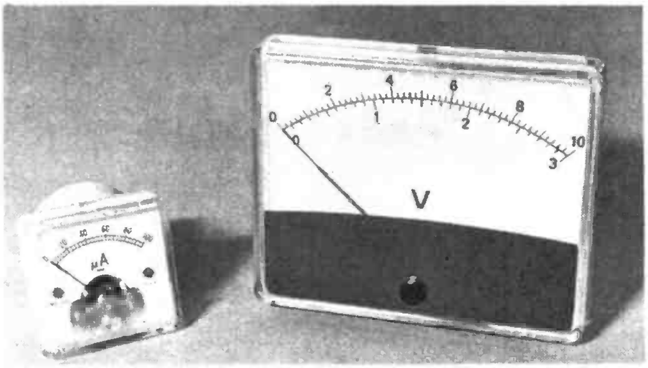


Fig. 11.17. A moving coil voltmeter and its equivalent circuit. The total resistance is $R_m + R +$ the coil resistance.



Examples of modern moving-coil meters.

Several of these **multiplier resistances** can be provided, and the appropriate one selected to suit the voltage to be measured. Meters with arrangements for measuring a wide range of volts and ohms are known as VOMs (volt-ohmmeters). A more general term is multimeter.

For electronics work a multimeter should have a small f.s.d. current. That is it should be a sensitive meter, 1mA or less. The sensitivity is often quoted in a curious unit "ohms per volt". A 1mA f.s.d. meter is 1kΩ/V and a 100μA meter 10kΩ/V

QUESTIONS

11.1. A photo-Darlington is a kind of:
- a. photovoltaic cell
- b. phototransistor
- c. photodiode

11.2. A photocoupler contains:
- a. two l.e.d.s
- b. one l.e.d. and one photodetector
- c. two photodetectors

11.3. The "turn on voltage" for a silicon diode is:
- a. + 0·6V
- b. − 50V
- c. − 0·6V

11.4. A moving coil voltmeter of 50kΩ/V is set to its 100V range. Its resistance is:
- a. 500Ω
- b. 50kΩ
- c. 5MΩ

11.5. A photodiode is normally:
- a. reversed-biased by a d.c. voltage
- b. forward-biased by a d.c. voltage
- c. reversed-biased by an a.c. voltage

ANSWERS *(To part ten)*

10.1. ABBCCBCC (b)

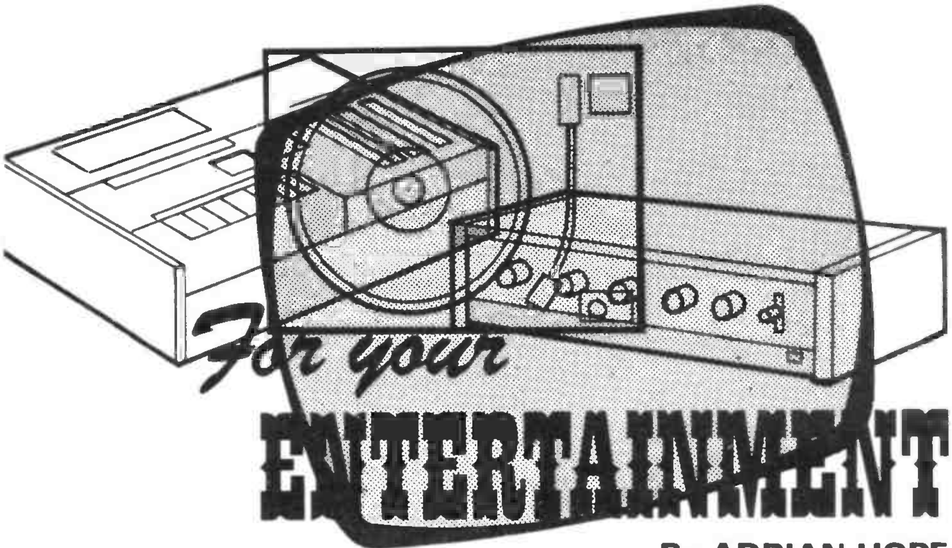
10.2. 255 (a)

10.3. a NOR gate (b)

10.4. 23 (a)

10.5. A NOR gate (a). The bar over the letter C means "not", the plus sign means "or".

Next month sees the final part of the present series and deals with one subject which many people find hard to grasp— **MATHS!**



For your ENTERTAINMENT

By ADRIAN HOPE

Time Out

As a follow-on from our previous pieces on mains supply frequency variations I found, surely, the most curious situation of all in Japan.

It's well known that in Europe the mains supply is at 50Hz, or 50 cycles per second, whereas in the USA it is 60Hz. Japan is usually thought of as being a 60Hz, 100 volt mains country. In fact this is only true for the Osaka area of the country. In Tokyo the situation is different. Although the voltage is still 100V the frequency is 50Hz!

What this means is that a clock, tape recorder or gramophone that is dependent for its speed on the mains frequency won't work properly in both Osaka and Tokyo. A clock bought in Tokyo will run fast in Osaka and a tape recorder bought in Osaka will run slow in Tokyo.

This could also cause real problems for television transmission (where frame rate is related to mains frequency) so the stations have their own generators making them independent of local mains supply.

Speed Control

As previously mentioned there is a current hi fi fad for incredibly precise speed control on gramophone turntables. This is achieved by locking the turntable speed to the oscillation of a crystal. The result is speed control far, far in excess of that available in the cutting room when the master tape is transferred to master disc lacquer using a cutting lathe turntable locked to mains frequency. Remember that mains frequency can legally vary by one per cent up or down.

At long last, one cutting room has come up with an answer to the problem of mains variations. It's so simple that it is astonishing that no one ever thought of it before.

The Strawberry Mastering Room, recently opened in London, is designed and equipped solely to cut master disc lacquers from master-tapes, whether recorded at the Strawberry Studios at Stockport and Dorking or at other studios hiring the Strawberry cutting facilities. The Strawberry studio in Stockport is, by the way, most famous for the 10cc recordings made there.

The Mastering Room in London has a standard Neumann cutting lathe which, like other cutting lathes, is locked to mains frequency rather than a crystal. Thus, its speed will vary with mains frequency fluctuations. But the master tape will normally be exactly accurate in speed because the tape deck on which it was recorded and on which it will be replayed is crystal-controlled.

What normally causes the problems of speed discrepancy is that the tape speed remains steady while the lathe speed varies with the mains. What the Strawberry designers have done is override the crystal control of the replay tape deck in the cutting room and so make it dependent on mains frequency.

Normally this would be a retrogressive step, any mains frequency fluctuation altering the pitch of the tape playback by a corresponding amount. But because **both** the cutting lathe **and** the replay tape deck are locked to mains frequency they will both vary in speed by exactly the same amount.

So the master lacquer will be cut at exactly the correct pitch. If, for instance, the mains frequency is up by one per cent, the master tape will be running one per cent fast **and** the master lacquer will be running one per cent fast. Thus all records pressed from the master lacquer and sold in the shops will be one hundred per cent accurate in cutting speed and thus musical pitch.

Buzz-off

A surprising number of modern electronic and technological innovations really are what the advertisers say—spin-off from the space projects.

First, and most popularly known, we had non-stick frying pans, thanks to the plastics developed to coat space capsules for re-entry. But surely most significant of all, has been the overall impetus given to miniaturisation, not only in pure electronics but in allied fields such as magnetic, battery and solar power technology.

It costs so much to blast anything into space that the rocket payload must be kept as light as possible. So there has been a massive incentive to make everything as small as possible. It is arguable that pocket calculators, digital wristwatches and microprocessors would not yet exist if it had not been for the space race.

Less desirable spin-offs from space have been the buzzword and the buzzphrase. "We have lift off" started a whole new vocabulary and computer workers now communicate with each other in a language quite incomprehensible to other mortals.

Sense of Humour

I am reassured to find that they do have a sense of humour about it. A delightful document, apparently out of Honeywell, tells the uninitiated how to coin their own buzzphrases and buzzwords. This technical writing kit is based on the Simplified Integrated Modular Prose (SIMP) writing system, it explains. There are four SIMP tables, *A, B, C,* and *D,* each with ten phrase segments.

As the instructions explain anyone who can count up to ten can use them to generate up to forty thousand incomprehensible but intelligent-sounding buzzphrases, simply by juggling one segment from each table into a complete phrase.

The buzzword generator works in the same way. Three columns of word parts can be joined together in any order. Take any three digit word, 765, for instance, and you end up with "optical, logic" and "programming". Put them together and you have "optical logic programming" or OLP for short.

The sad thing is that it's rather too close to the truth to be funny. I'll bet that any one of us could go round talking about OLP for years and never be challenged; if we were challenged we could bluff our way clear with a few well chosen meaningless buzzphrases. In fact, a useful moral can be had out of this. If you don't understand what someone is talking about, don't be afraid to say so. The chances are that they don't understand either and are only parroting something they heard from someone who didn't understand either.

TELEVISION GAMES

By N. HUNTER

part 1

HOW THE CHARACTERS ARE GENERATED ON YOUR TV SCREEN

EARLY in 1969 inventor Ralph Henry Baer of Sanders Associates Inc. registered a patent that includes the following extract:

"*...standard television receivers can be utilized as active rather than passive instruments. This is accomplished by certain embodiments having participants manipulate the controls of a control unit connected to the television receiver to cause a symbol, such as a rectangle, bar, 'dot' or a pair of dots to be displayed upon the TV screen by means of which the participants can play a variety of games...*"

This historic patent entitled "Television Games and Training, Apparatus and Method" introduced the TV game, a sophisticated toy that has sold over 30,000,000 worldwide, and marked the beginning of a new era in consumer electronics.

TV games filtered into this country from the USA in the early seventies and first made their appearance in pubs and amusement arcades, and the immediate popularity of these simple games ("simple" by today's standards) prompted several UK manufacturers to take up the challenge, and so the British TV games industry was born.

The first games available on the UK domestic market used dozens of expensive TTL i.c.s and, unfortunately, whilst the public were prepared to fork out 5p for a game in their local they weren't willing, or able, to spend £50 or more to obtain a system of their own.

Nevertheless, these early games enable us to study a subject that since the introduction of the TV games chip has been shrouded in complex technology.

In this first article it is hoped to impart to the reader an understanding of the principles of TV character generation, the basis of all TV games, by analysing the oldest and most well-known TV game—tennis. Later on we shall examine a method of updating earlier versions of TV games by adding extra circuitry, and in doing so provide an insight into the inner workings of the more complicated games available.

But before we can even begin to understand TV games a basic knowledge of TV picture structure is essential.

TV FUNDAMENTALS

The transmitted v.h.f./u.h.f. signal is demodulated inside the television receiver to derive the video signal (Fig. 1) which carries all the information necessary for the TV set to reproduce the original picture.

Line sync pulses are extracted from the composite video signal to trigger the receiver line timebase oscillator, whilst the luminance information is used to modulate the brightness of the picture. Every time the line timebase is triggered, the small spot produced by the picture tube electron gun assembly is deflected across the face of the screen, in approximately 44μs, to describe a horizontal white line of varying brightness.

After 312½ lines of video information there occurs a set of broader pulses known as the field pulses whose function is to trigger the field timebase oscillator which in turn deflects the spot to the bottom of the screen in approximately 25ms.

The combined effect of the line and field timebases is to produce an illuminated grid of 312½ lines, but this is only half the picture (literally) because every other field is arranged to trigger half a line later, thereby interlacing two sets of 312½ lines to compose the whole frame of 625 lines (raster) in 50ms. See Fig. 2.

GENERATING A RECTANGLE

If the luminance information remained at black level for the duration of the whole frame then the screen would be blank, but if on every line at the same point, relative to the line sync pulse, a white level pulse was inserted then a white vertical line would be displayed on the screen. See Fig. 3.

Similarly if only a few lines per field were completely at white level then a horizontal white band would be displayed, and a combination of both would produce a cross.

The waveforms of Fig. 3 are easily reproduced by the readily understandable arrangement of monostables shown in Fig. 4.

Monostable MS1 is clocked by the negative transition of every line sync pulse so that its output (Q1) goes to logic 1 (approx. +4V for TTL) for $t1\mu s$ and triggers MS2 when it returns to logic 0.

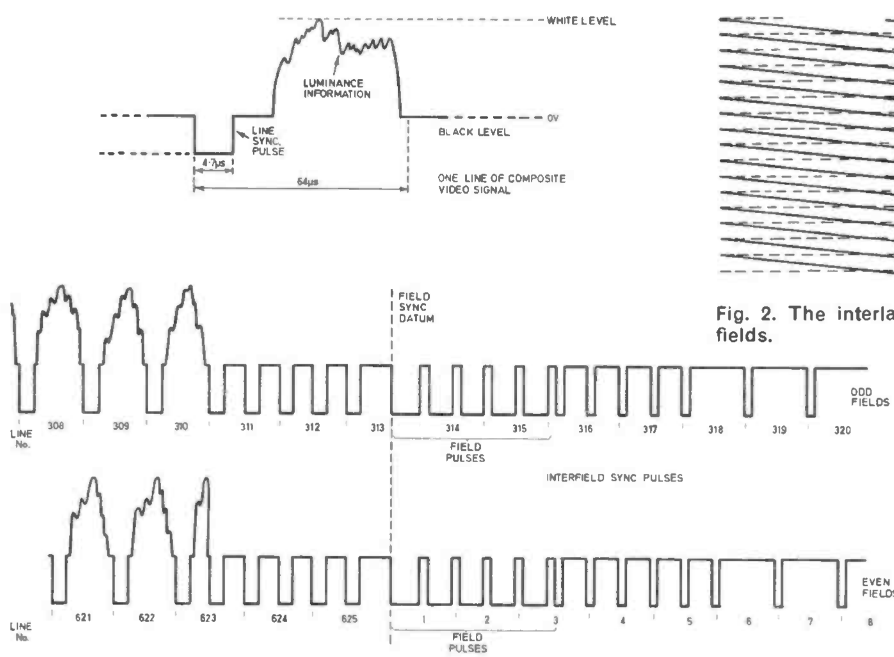
The output of MS2 (Q2) when combined with line and field syncs is then u.h.f. modulated and displayed as a vertical line on a TV screen: it should be obvious that the horizontal position of this line is proportional to the period of MS1, that is the longer the period of MS1 then the further to the right of the screen will the line appear. The same is true for the monostables MS3 and MS4 except this time increasing the period of MS3 will shift the horizontal line produced downwards.

By logically "OR"ing the outputs of MS2 and MS4 and re-combining with line and field syncs, the displayed result would be a cross. Now if we were to logically "AND" Q2 and Q4 then the only output pulses would be those where Q2 and Q4 are simultaneously at logical 1 (i.e. at the point of intersection of the two axis of the cross) and the displayed rectangle would look remarkably like a TV games manufacturer's concept of a tennis racquet.

MOVING THE RECTANGLE

The next step is to arrange for the "bat" to move around the screen by varying the periods of MS1 and MS3 with ganged variable resistors of the joy-stick type, or just up and down by varying $t3$ with a single potentiometer.

A disadvantage of the monostable circuit is that of nonlinearity, that is, constant rotation of the potentiometer does not produce a corresponding change in period over its entire range. This manifests itself as a gradual speeding up of the bat as it moves



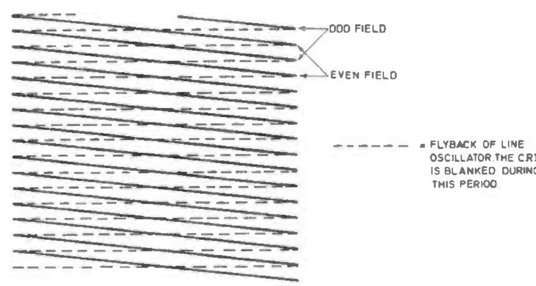


Fig. 2. The interlacing of alternate (odd and even) fields.

Fig. 1. The video signal, which is derived from the broadcast signal by conventional demodulation techniques within the television receiver.

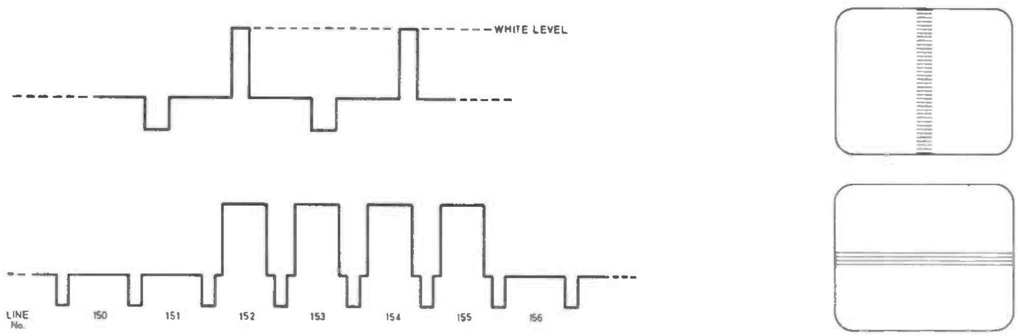


Fig. 3. TV waveforms of simple displays.

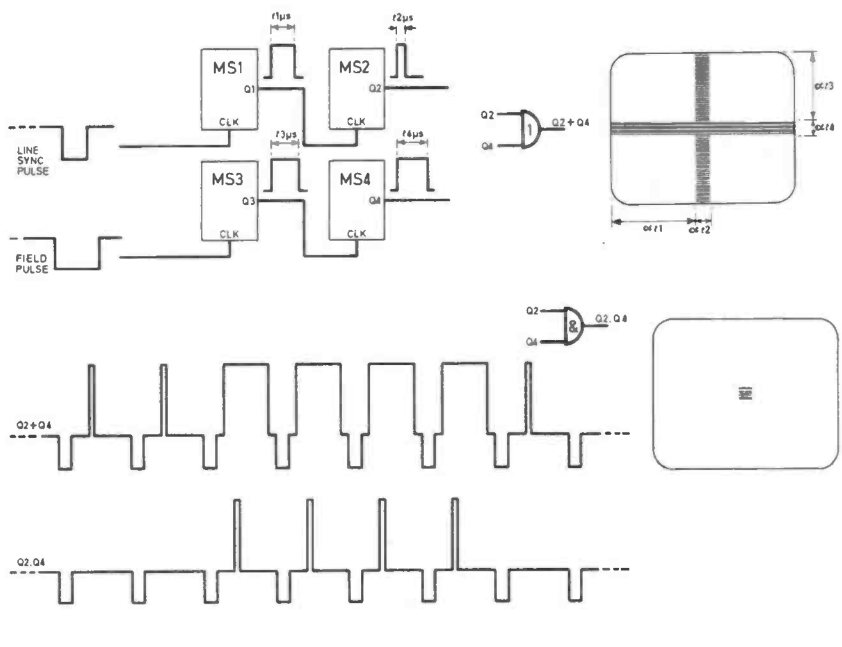


Fig. 4. Monstable circuitry needed to generate a "bat"

Fig. 6 illustrates the displayed graphics of a typical tennis game. It is interesting to note that early games systems provided an overlay mask with the sidelines and a net marked on, but in modern games these are electronically generated in a similar way to the bat, as is the ball. The position of the net and sidelines is preadjusted by trimmer potentiometers.

MOVING THE BALL

For a moment let's look at the voltage output of a potentiometer used to move a character horizontally across the screen. As the rotation of the potentiometer increases so does its wiper voltage and Fig. 7 shows the low frequency (relative to line rate) ramp produced, whose period is the time taken to move the characters from one side of the screen to the other. Moving the character back to its original position causes the ramp to slope in the opposite direction.

The main difference between the ball and the bat circuitry is

across the screen when the potentiometer is rotated at a constant speed.

This problem can be overcome by using the method favoured by the authors of early constructional articles, that is, the analogue comparator (Fig. 5) instead of the monostable.

A d.c. voltage applied across the control potentiometer provides a varying voltage on the wiper according to the potentiometer's position, and a line sync triggered ramp generator produces a gradually increasing reference voltage in a 44μs period.

Applying both to the inputs of a high gain operational amplifier causes the op-amp to change state when the reference voltage just exceeds the wiper voltage; therefore the larger the wiper voltage the longer the op-amp takes to change its output condition, thereby producing an output pulse of period linearly proportional to the position of the potentiometer.

The need for the second monostable can be overcome by differentiating the op-amp output voltage, but, because the trailing edge does not produce a clean transition on screen from black to white this only works for short duration pulses.

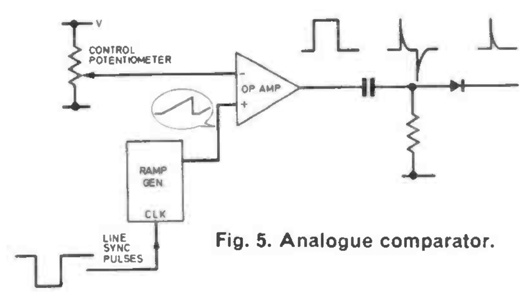


Fig. 5. Analogue comparator.

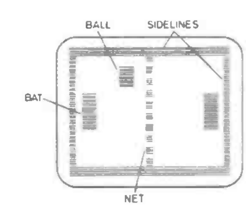
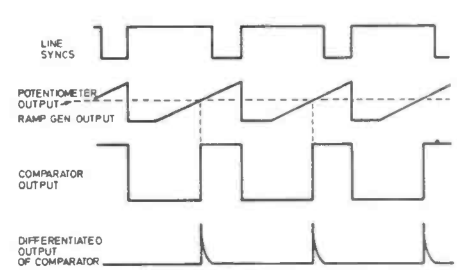


Fig. 6. Tennis graphics.



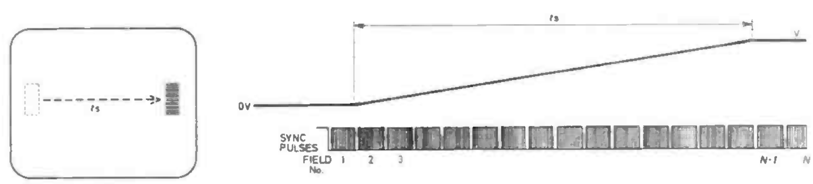


Fig. 7. Waveform from control potentiometer in moving character across the screen.

that the position of the ball is controlled not by a potentiometer but by two ramp generators (horizontal and vertical) such that a combination of the two makes the ball travel diagonally.

Logically ANDing the outputs of ball and bat circuitry indicates "contact", and this is used to change the slope of the ball's horizontal ramp generator, and hence the direction of movement of the ball itself.

Similarly ANDing the ball and sideline circuitry can deflect the ball away from the sidelines by changing the slope of the ball's vertical ramp generator. Fig. 8 shows the state of the ramp generators in a typical situation.

All that is left to say about the tennis game is scoring. This is achieved simply by ANDing the outputs of the ball and the left and right hand sidelines, any contact must indicate that a player has missed the ball so that his opponent gains a point.

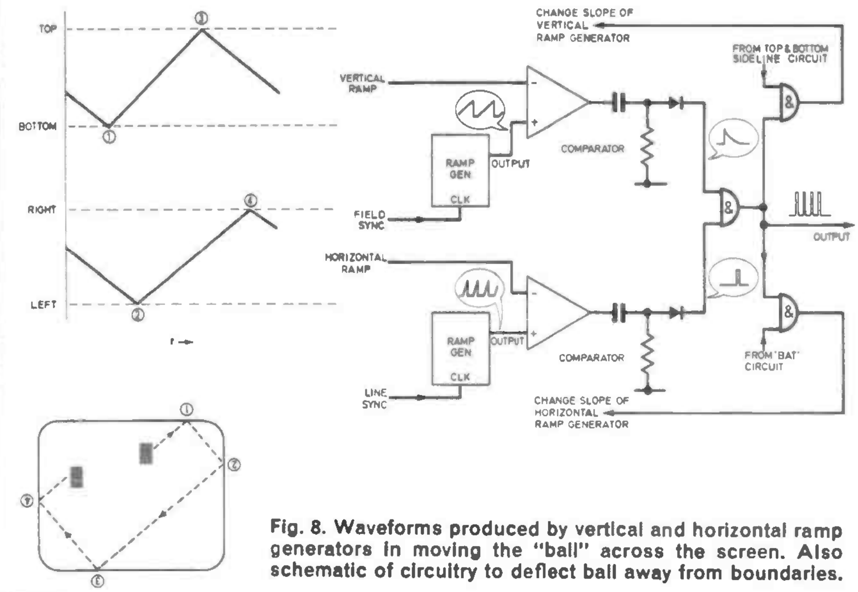


Fig. 8. Waveforms produced by vertical and horizontal ramp generators in moving the "ball" across the screen. Also schematic of circuitry to deflect ball away from boundaries.

MORE COMPLEX SYSTEMS

Realising that most people become quickly bored with the simple tennis game, designers came up with soccer, squash and then a slight departure from the norm, rifle games—the latter using a "rifle" with a photocell that registers "hits".

Although technical publications abounded with constructional articles and pub-goers were presented with an alternative to darts, TV games never caught on in this country, presumably because of the large outlay required.

The revolution came in 1976 when the Scottish plant of General Instruments Microelectronics Ltd. produced the world's first TV games system on a chip, the AY-3-8500. This i.c. device provides six selectable games: tennis, soccer, squash, practice and two rifle games. The introduction of this l.s.i. chip dramatically reduced the price of a games system bringing it within reach of most people's pockets, and so far G.I. have worldwide sales exceeding 15,000,000.

DETAILED-CHARACTER GENERATION

All the games mentioned so far have one thing in common, that is, the players and ball are represented on screen as rectangles, as this is by far and large the easiest shape to generate. The motorcycle stunt game featured in the May edition of EVERYDAY ELECTRONICS is an example of how the simple rectangle has been superseded by by a more complicated character—in this case a representation of a motor-bike.

In next month's article we shall explain in more detail the circuit techniques used to produce these characters and demonstrate a way of updating and enhancing the graphics of earlier systems.

To be continued

JACK PLUG & FAMILY... BY DOUG BAKER

I YIELD to no one in my desire to be with it, provided I am convinced that the latest invention is better than the article it replaced. I went overboard for microgroove records when they came out and also for stereo and I could never understand why they took so long to catch on generally, but now my friends tell me it's all "old hat" and quadraphonics is the thing.

On this however I am prepared to make a stand. I point out that I am hampered by only having two ears. They then look at me disbelievingly, as much to say they think it unlikely that anyone who is weird enough to reject the latest gimmickry can possibly only have one pair of earholes!

The more patient ones explain that in a real concert hall the sound is reflected off the back wall, hence the need for four speakers. My reply to this is that it is also reflected off the floor and the ceiling and taken to its logical conclusion, every inch of my room, walls, floor and ceilings would be covered in speakers! I wonder if this idea of quadraphonics was thought up by the loudspeaker manufacturers?

Coming more on to my home ground, while still talking of new trends, I phoned a colleague of mine the other day for some transistors. "Oh nobody uses them now, microprocessors is the name of the game to-day". I told him that I am very sorry, but I do not believe it.

And now microprocessors

"Microprocessors," I told him, "is a very specialised section of electronics dealing with computers; the majority of constructors get their enjoyment from experimenting with discrete components and this is why this magazine is so popular".

Flotsam and Jetsam

In the course of business we often buy quantities of miscellaneous goods in the hope, that among all the flotsam and jetsam of some abandoned electronic project, we shall find enough standard items to sell and recover our outlay.

In most cases we are left with a great many articles that are just not quite standard: old sockets, transformers with odd ratios, meters with odd scales and we then have the amusing task of trying to work out how to alter them to make them saleable. I am sure many of you have a lot of fun buying surplus items, and use a great deal of ingenuity trying to make them useable. If you do not, then you should try it. Apart from the enjoyment it could also prove to be profitable.

Having forgotten about such vexing objects as microprocessors, I was just beginning to cheer up and take a more optimistic view of things generally when I suddenly picked up a little book entitled "A Guide to the Language of Microcomputers". Curiosity forced me to open it and I wish now I had not. Let me tell you some of the words they use: Glitch, Floppy Disk, Baud Rate, Algol, Axia, Fortran, Tristrates, Lifo, Byte, Usart, Ram and Rom. Oh! dear, will our hobby really come eventually to this? If it does, as the immortal Sam Goldwyn used to say "Include me out"!

CROSSWORD No 6

BY D.P. NEWTON

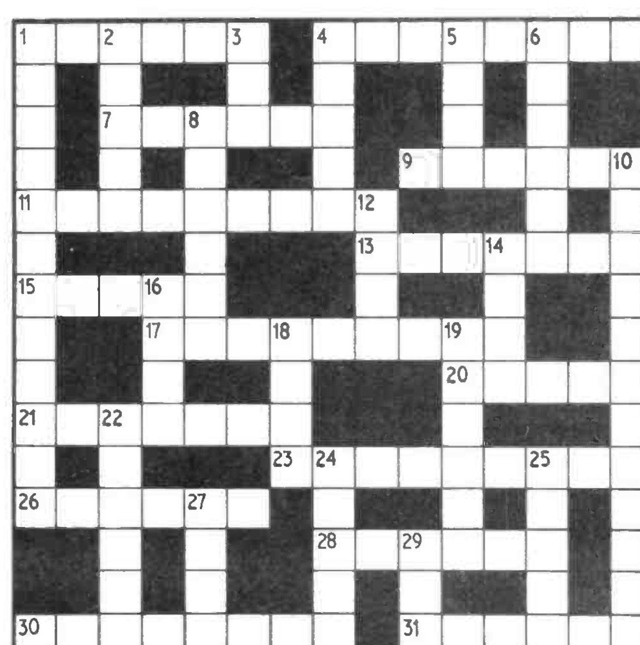
ACROSS

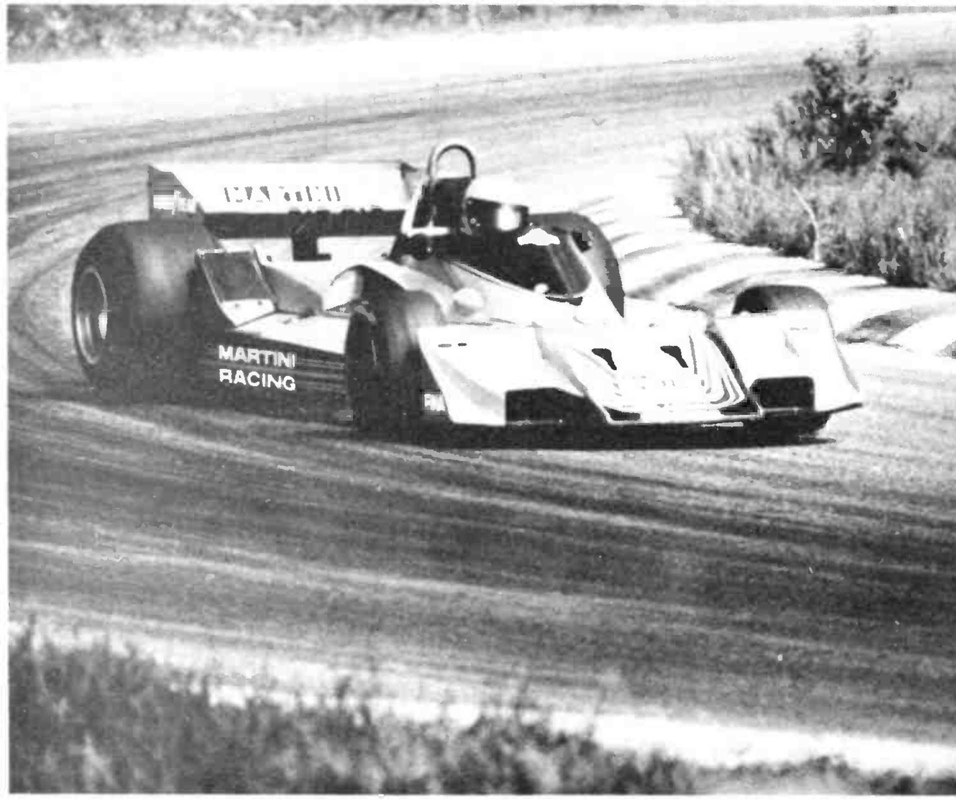
1 A mechanical seal.
4 Stripped down to this basic form.
7 Re-amplify to obtain again.
9 Arachnida used as a spanner.
11 A supplier of positively charged nuclei, in general. (3,6)
13 Capacitor from the pottery kiln?
15 Royal dog.
17 Appliances providing personal sound.
20 Re-organise itself to begin with for message understood. (Anag.)
21 To do this is akin to suppression.
23 A type of fuse resistant to quick blowing.
26 Brown, brown and black.
28 Almost a step up from a triode to give a set of four.
30 Some leads may be this at a distance.
31 In the past.

DOWN

1 The breakdown of insulating property in rarefied media may lead to this unwelcome habit on application of a large voltage. (3,8)
2 Acoustical instrument used as a warning.
3 Leafy refreshment.
4 Pertinent to sound.
5 A route for feedback purposes.
6 A capacity for ganging up on a bicycle.
8 She is renowned.
10 The secondary property of some cells.
12 A wave, on reflection.
14 In addition.
16 A mechanical device for modifying speed.
18 An example of Italian inclinations in architecture.
19 You don't have to have a head for this means of rubbing out.
22 To be this, a variable device is fixed previously.
24 Toned to a musical pitch for a past memo. (Anag.)
25 Means of communication, we hear.
27 Leyden is a place, in part, of idyllic surroundings.
29 Small label.

Solution on page 626





CHRONOSTOP

SPLIT SECOND TIMING

By R. W. Coles & B. Cullen

CHRONOSTOP is a very functional, high technology project which displays time intervals of up to one hour, and measures to a precision of one hundredth of a second using a six digit display. Ideal for sporting events such as swimming, athletics and motor racing, the circuit features SPLIT and TAYLOR lap timing modes in addition to normal START/STOP operation.

But Chronostop is not limited to sports timing; with the versatility available in this low cost design the benefits of accurate timing can now be extended into many other areas such as the photographic darkroom or the chemistry and physics laboratories. The authors

Left. Show-jumping at Hickstead. Fritz Ligges on Genius in the 1977 European Championship.

Top. John Watson driving a Brabham-Alfa BT45 in the Swedish Grand Prix 1977.

Right. Men's breastroke final at the 1976 Olympic games.

have even found it useful on the electronics work bench for calculating the value of large electrolytic capacitors from their time constants, checking the operation of simple 555 timers and a host of other timing jobs which used to be neglected. Good timekeeping can now be enjoyed by anyone, because while nobody in their right mind would consider the construction of a traditional clockwork stopwatch on the kitchen table, even a comparative beginner in electronics can tackle the construction of Chronostop, thanks to the marvels of modern electronics and the availability of Large Scale Integrated Circuits (LSI)!

INTEGRATED CIRCUIT

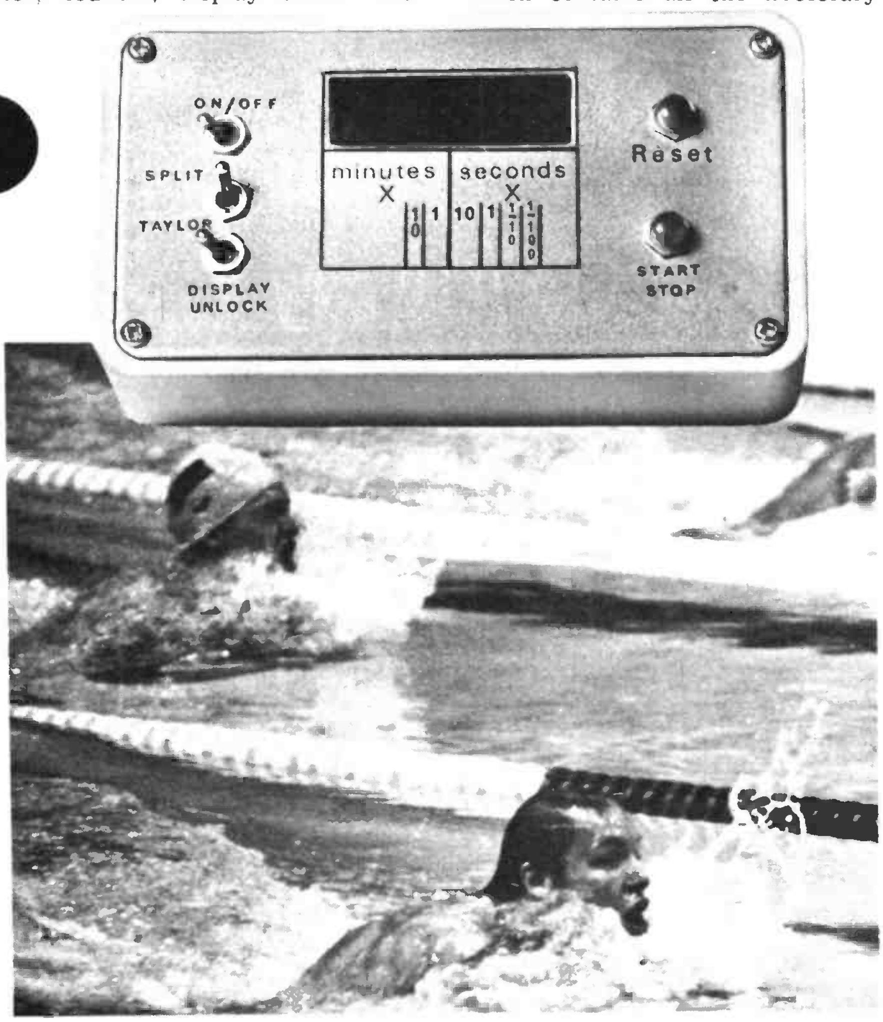
The design is based on a 24 pin stopwatch chip made by Intersil and coded ICM 7205. The chip uses CMOS technology to ensure the lowest possible power drain, and contains *all* the necessary oscillator, counter, display driver and control logic circuitry needed for a full-function stopwatch. All that's needed in addition to the ICM 7205 is a crystal, six seven-segment l.e.d. display digits, some simple switches and a few capacitors. Power is provided by a 4·5 volt torch battery which gives a very long active life, and all circuitry, including the display, is mounted on a single piece of 0·1 inch matrix Veroboard approximately 63mm square.

CIRCUIT ACTION

The overall circuit diagram for Chronostop is shown in Fig. 1, and as you can see, there isn't a lot to it. The ICM 7205 contains all the "clever-bits", and to get a feel for the circuit operation it is better to study Fig. 2 where the chip boundary has been ignored to produce an overall block diagram for the system.

Inside the 24 pin plastic package of the ICM 7205 there is a tiny chip of silicon about 2·5mm square which contains all the necessary active components to form a complete stopwatch circuit. In the centre of the silicon chip are the many hundreds of MOS transistors which make up the binary divider circuits and the control logic, and around the periphery are other transistors, much larger in area, which act as high current display drivers.

P



OSCILLATOR

The chip also contains an oscillator circuit and this is accurately tuned to a frequency of 3·2768 megahertz with the aid of an external quartz crystal XL1 which acts in a similar way to a high-Q *LC* tuned circuit. Because low cost crystals have a finite accuracy limitation, Chronostop includes an extra trimming capacitor C1 which allows fine adjustment of the oscillator frequency for maximum accuracy.

The 3·2768 megahertz frequency is divided down within the chip by a chain of 15 binary (÷2) flip-flops to produce a frequency of 100 hertz to drive the display counters.

The display counters themselves also use binary flip-flops, but in this case they are connected up in groups of three or four for each digit, with special resetting logic provided for each group to produce the correct decimal counts of 0 to 5 or 0 to 9. The output of each digit counter is still in binary form, or more correctly, binary—coded—decimal (BCD), and this has to be converted into a quite different code which will switch on the appropriate segments of the display.

MULTIPLEXING

Code conversions of this kind are easily handled by the ICM 7205 using a technique known as "table-look-up". For each of the ten possible four-bit digit counts (0 to 9), there is a seven-bit entry in an on-chip read-only-memory table, and the outputs from this table form the on/off drive signals to control the seven l.e.d. segments for each digit. There is no need for a separate look-up-table for each of the six digits in the display because the chip uses a technique known as "multiplexing" to drive it.

In a multiplexed display scheme only one digit is actually *on* at any one time, the appropriate digit being selected by means of the "digit drive" lines which are activated in sequence at a rate of about 1 kilohertz. The high multiplexing frequency makes the strobing effect invisible to the human eye, and the ICM 7205 contains circuitry to gate the correct digit count to the look-up-table and from there to the seven "segment drivers" in step with the digit drive signals. This approach not only saves internal circuitry but also eliminates the many interconnections between the logic and the displays which would be necessary if digits were individually driven.

The display itself is made up of two, four digit, dual-in-line l.e.d. units X1 and X2 made by Hewlett Packard. Each unit is wired internally for multiplexed operation, and each segment of each digit is made up of a semiconductor light emitting diode junction which produces monochromatic red light when energised. Only two digits of the left hand display package are needed, hence the unconnected drive pins, 1 and 10 on X2. The current limiting resistors normally needed in l.e.d. drive circuits are not needed in the Chronostop circuit because the driver circuits in the ICM 7205 are self limiting.

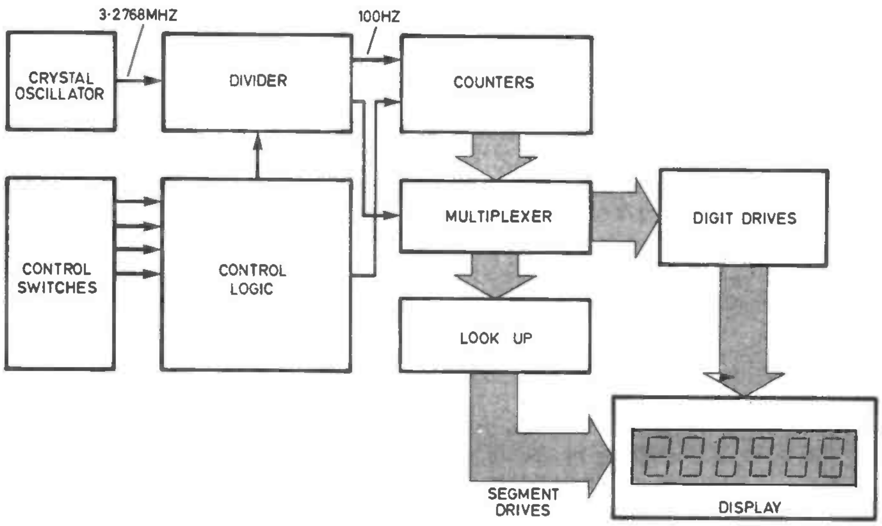
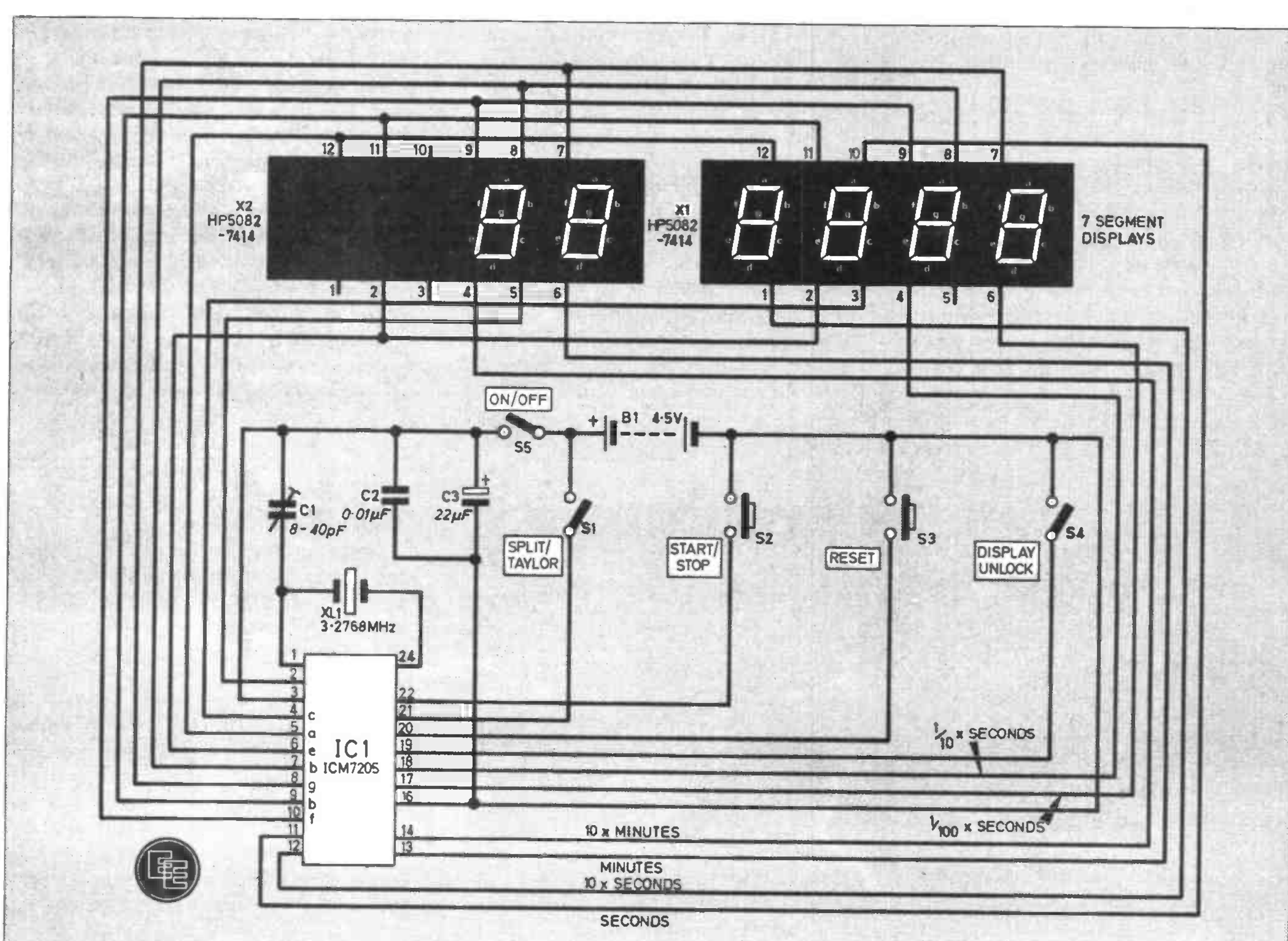


Fig. 1. (Below). Complete circuit diagram of the Chronostop.

Fig. 2. (Left). Simplified block diagram of the "chip", all of which is on a piece of silicon 2·5mm square!



Finally, the ICM 7205 contains gating logic and storage registers so that a "frozen" display can be viewed while the counters continue to run, and other circuitry to blank any leading zeros which would clutter the display on low counts.

COMPONENTS

See Shop Talk page 595

Capacitors
C1 8 to 40pF variable compression trimmer
C2 0·01μF ceramic
C3 22μF 6V tantalum

Semiconductors
IC1 ICM 7205 l.s.i. stopwatch i.c.
X1, 2 HP 5082-7414 four digit seven-segment display 12 pin d.i.l. (2 off)

Switches
S1, 2, 3, single-pole on/off miniature toggle (3 off)
S3, 4 single-pole push-to-make, release to break push button type (2 off)

Miscellaneous
B1 4·5 volt flat torch battery type Every Ready 1289
XL1 3·2768MHz quartz crystal
Stripboard: 0·1 inch matrix size 25 strips × 24 holes; plastic case approximate internal dimensions 126 × 66 × 32mm; filter material or coloured Perspex size 50 × 20 × 1 mm; self-adhesive card-guide (Doram) 60mm long; 18 s.w.g. aluminium for bracket; impact adhesive; single-core and multistrand p.v.c. covered connecting wire, preferably different colours; 8BA nuts, bolts and washers (4 off each), 8BA solder tags (2 off); 3mm thick Perspex or similar material for battery positioning and connector.

CONSTRUCTION starts here

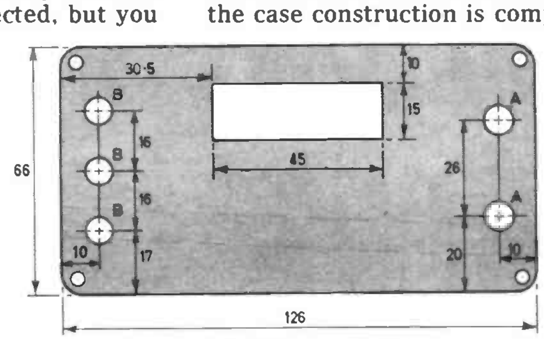
The ICM 7205, the seven segment displays, the crystal and the trimmer capacitor are all mounted on a piece of 0·1 inch matrix stripboard as shown in Fig. 3. After being cut to size, the board should be cleaned and the cut edges inspected for possible shorts. The track cuts shown should be made with the aid of a spot-face cutter or a 4mm drill, and then carefully inspected to ensure their effectiveness.

The ICM 7205 and the other components can be soldered to the board with the aid of a fine-tipped soldering iron and multicore solder. It is of course most important to orientate the three dual-in-line packages correctly before soldering them in, and care should also be taken not to keep the iron in contact with the joints for more than five or six seconds at a time. If a good joint seems to need longer than this, it is likely that the board has not been properly cleaned or that the soldering iron is faulty. In the prototype, Soldercon pins were used to hold the display packages, but IC1 soldered directly to the board.

The ICM 7205 is a CMOS device, and you may be wondering why we have not urged the usual anti-static measures normally required with other MOS chips in order to avoid gate-oxide breakdown. The data sheet on the ICM 7205 states quite categorically that *no* special precautions are necessary because the chip is fully protected, but you may feel safer to treat it like any other MOS device if you are a sceptic! We did not take any precautions and our chip suffered no damage. Some constructors may wish to use a 24 pin i.c. socket.

Wiring up is carried out in accordance with Fig. 3 using p.v.c. insulated single core wire, and it is always a good idea to check off each connection as it is made on both the layout diagram and the circuit diagram (Fig. 1). This procedure acts as a double check on your own work.

When the circuit board is fully wired, it should be laid aside while the case construction is completed.



ALL DIMENSIONS IN m.m. A–7·5 B–6·5

Fig. 4. Drilling details required for the front panel. Sizes for holes marked A and B depend on the components used.

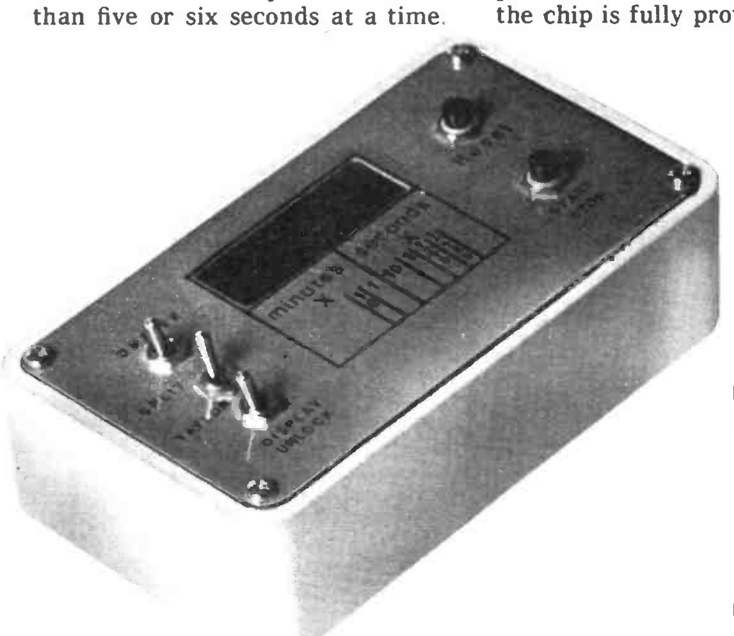
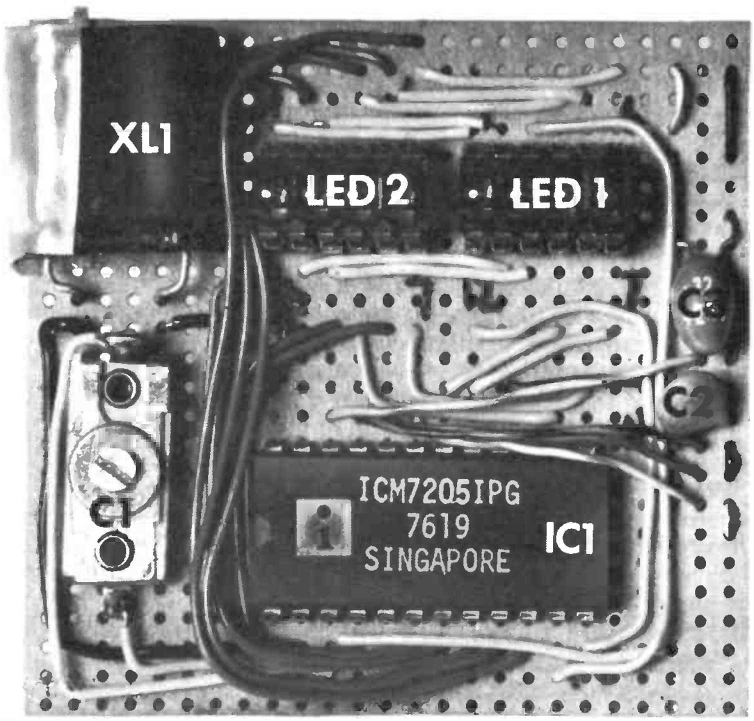


Photo of the completed unit.

CHRONOSTOP

COMPONENTS approximate cost £18 excluding case



Detailed photograph of the board, showing positions of the major components. Compare this with Fig. 3.

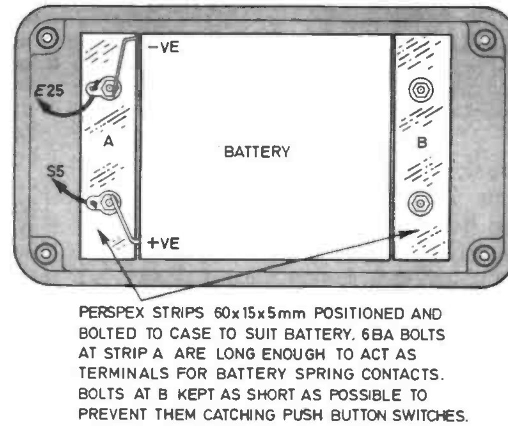
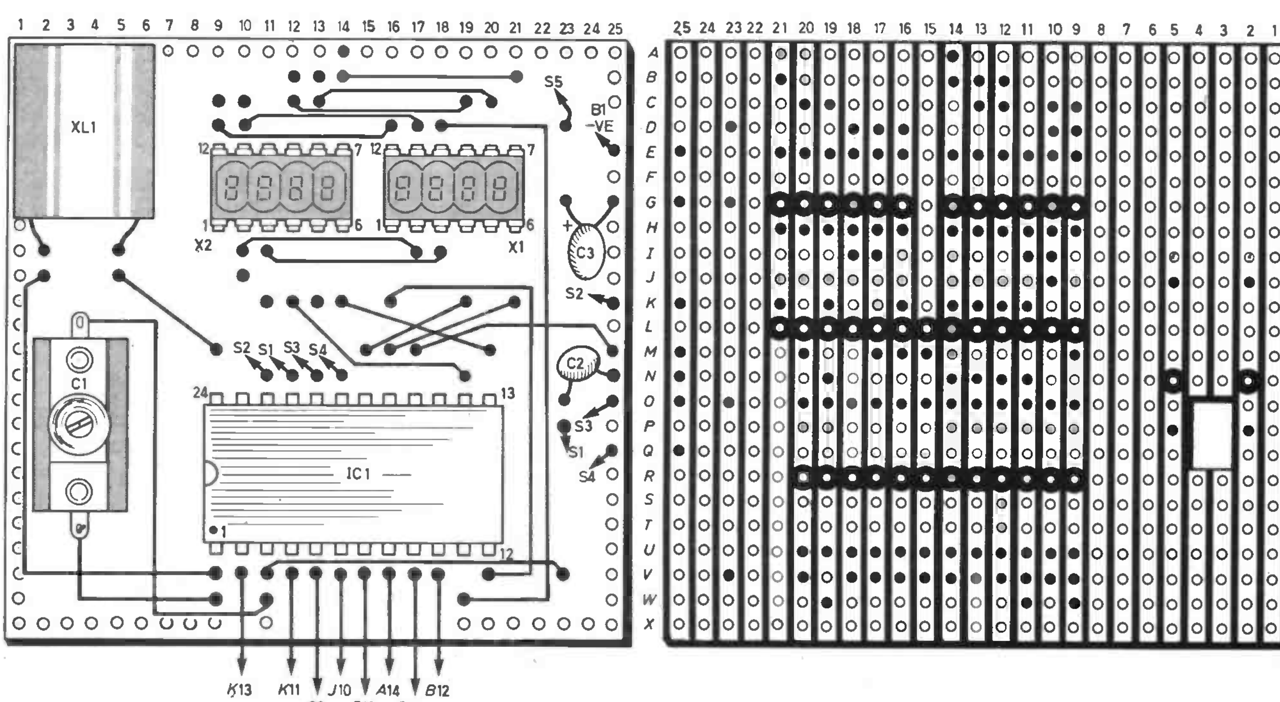


Fig. 7. How the battery is positioned in the case.

Fig. 3. Stripboard layout. The only breaks to be made are those under the i.c. displays and C1. Different coloured wires should be used to prevent any errors in wiring.



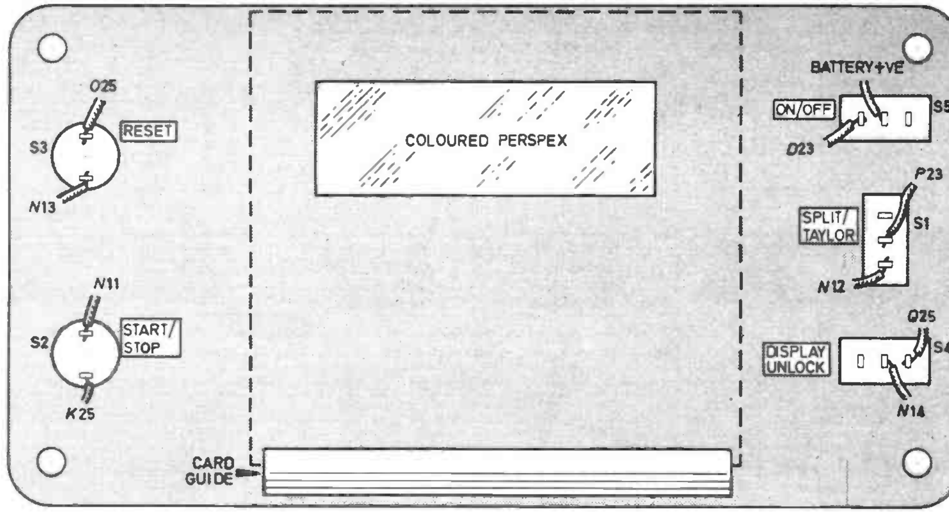


Fig. 5. Front panel wiring details, required for the Chronostop. It is advisable to use different coloured connecting leads when wiring to the board.

CASE

The prototype unit was built using a moulded polycarbonate box with a metal front panel with internal dimensions 126 × 66 × 32mm obtained from a local electronics retailer. Many firms advertise boxes of the same or a similar type, and provided they are large enough to house all the components, most boxes will be suitable even if they are of all-plastic construction.

Details of the front panel drilling are shown in Fig. 4, and Fig. 5 shows the way all the components, including the circuit board, are mounted on this panel to make a compact, solid, assembly.

A mounting bracket (Fig. 6) to support the component board, is made up from aluminium and a "self-adhesive-card-guide" section. The card guide holds the board quite securely and yet allows simple removal should this ever be necessary. The bracket is secured to the front panel with contact adhesive to remove the necessity for unsightly nuts and bolts.

The switches used on the prototype were general miniature toggle and push-button types available from many sources, and one of the advantages of the ICM 7205 is the fact that only simple switches are needed to correctly implement the various functions. This means of course that almost any other switches with the correct electrical format can be put into service if necessary.

Wiring up the switches and the circuit board can be carried out with either solid or flexible wire, although it would certainly be better to use flexible wire for the battery connections. A piece of red filter material, e.g. coloured Perspex, should be affixed to the inside of the front panel display cut out before final assembly. This gives a neat appearance and produces a high contrast, easy to read display.

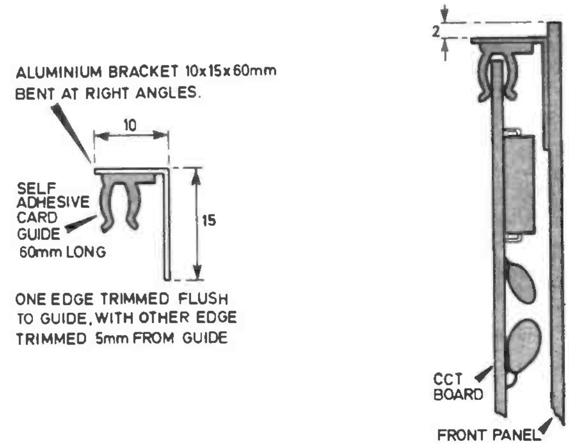
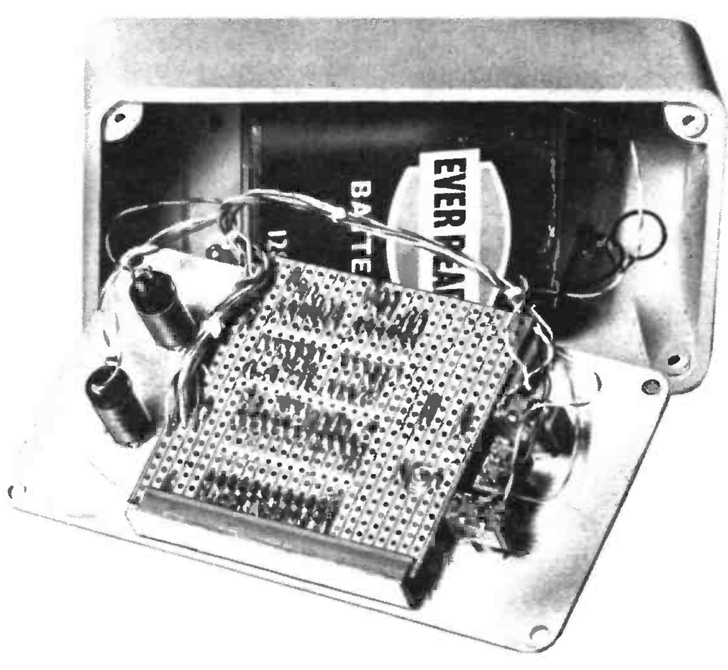


Fig. 6. Constructional details for the mounting bracket. This is fixed to the case using a strong contact adhesive.

BATTERY

The 4·5 volt flat torch battery is an economical power source for the Chronostop, and it is mounted in the body of the case supported by two Perspex strips fastened to the rear of the box with 8BA nuts bolts and washers. The two left-hand bolts are slightly oversized.



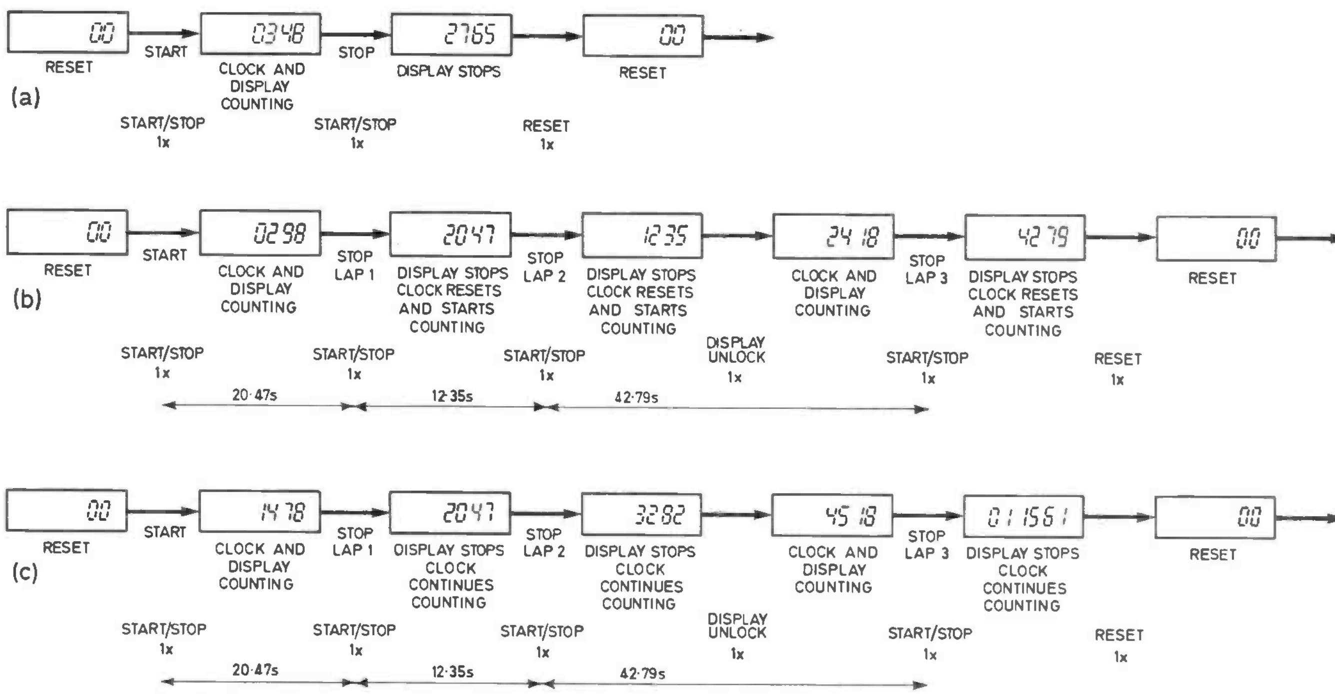


Fig. 8a. Sequential timing diagram when in the START/STOP mode; (b) TAYLOR mode, (c) SPLIT mode.

(length-wise), and have solder tags mounted under their nuts so that they may be used as battery contacts as shown in Fig. 7.

The front panel of the prototype was sprayed with three coats of automotive cellulose paint to provide a good colour background. Letraset lettering was applied to label the display and the controls, and finally a coat of clear polyurethane was used to achieve an attractive and durable finish.

USING CHRONOSTOP

When the unit is switched on, it automatically enters the RESET state which is indicated by a display of 00 on the two right hand digits. For simple single event timing, only the START/STOP and RESET buttons need to be used as shown in Fig. 8(a). The position of the SPLIT/TAYLOR and DISPLAY-UNLOCK switches do not affect the operation of the circuit and may be left in either position for this function.

When TAYLOR mode is selected multiple events (or laps) can be timed individually *without pause* by appropriate use of the START/STOP button, see Fig. 8(b). At the end of the first lap, depressing the START/STOP button sets the internal counters momentarily to zero but they continue to count (from zero) the *second* lap time. After the first STOP depression the display freezes the first lap duration while the internal counters run on. On the second STOP depression the display jumps to a new frozen display which represents the time period of the second lap and so on.

To obtain a running display during second or subsequent laps, the DISPLAY UNLOCK switch can be used. The whole operation can be terminated with the RESET switch at any time.

The SPLIT mode differs from the TAYLOR mode in that lap times are *cumulative*, see Fig. 8(c). Depressing the STOP button after the first lap causes the display to freeze the time duration of the first lap as before, but subsequent depressions result in a frozen display of the *sum* of the preceding lap times. DISPLAY UNLOCK can be selected as before to give a running count if required, and RESET can be used at any time to terminate the sequence ready for a new run.

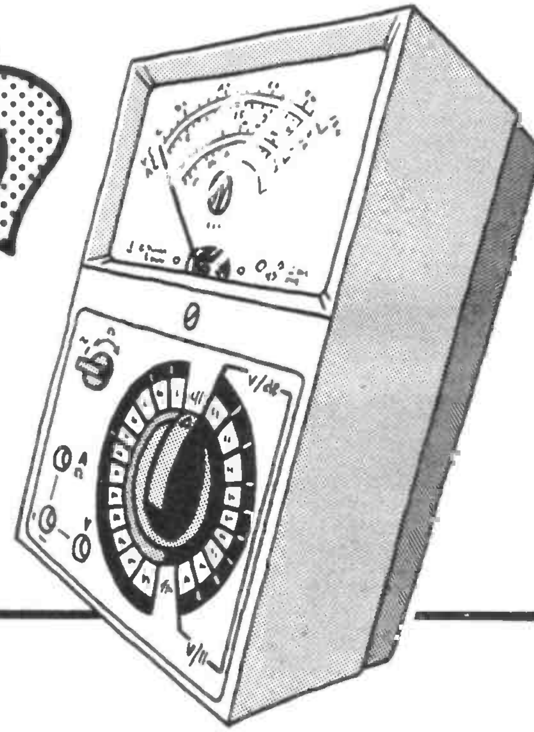
A toggle switch is used for the DISPLAY UNLOCK position, so that a running display can be held as long as necessary for "hands-free" operation. For shorter events, this facility might benefit from a push-button type of switch so that a quick look at the running time can be had without jeopardising the "freeze" facility at the end of a lap. Such a switch can be substituted directly if required.

LOW BATTERY INDICATION

As an added facility, the ICM 7205 has a "low-battery" output which can drive an l.e.d. lamp on when the battery voltage gets dangerously low. In Chronostop this output is connected to the decimal point input pin on the left hand display package, so that all four decimal points will come on when the battery voltage drops too low. Up to an hour of use can still be expected when this warning becomes active. ⌑

NEXT MONTH

Win an ELECTRONIC AVOMETER



Five valuable prizes to be won in our free-entry competition. Full details and entry form in next month's issue.

TONE BOOSTER

An add-on unit for the pop guitarist that will bring your guitar to life, producing a clean brilliant sound. Add "bite" to your performance with this easy to construct effects box.

R.F. SIGNAL GENERATOR

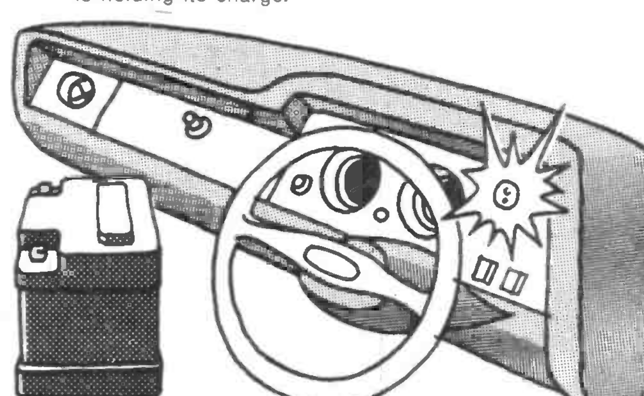
A useful addition to the beginners workshop is an r.f. signal generator. Covering from 150kHz to 30MHz, in 6 ranges. Alignment is simple due to the use of ready made coils.

SOUND/LIGHT UNIT

Give your music that psychedelic feeling with our one-channel sound to light converter. Modulates a light according to the amplitude of the music.

BATTERY STATE INDICATOR

Has your car battery ever let you down? Guard against this eventuality by incorporating this dashboard unit in your car and know at a glance the state of your battery, and if it is holding its charge.



Everyday ELECTRONICS

SEPTEMBER
ISSUE ON SALE FRIDAY, AUGUST 18

Everyday News

PROGRAMMABLE COLOUR TV

Recently unveiled at the National Panasonic trade show was a unique television. The manufacturers, Matsushita Electric, claim this is the first programmable television receiver to be introduced commercially anywhere in the world.

Using a push-button infra-red remote control, the viewer can programme the TV with up to 20 separate instructions. As the programmes are entered, the day and date, on and off times, and channel numbers are entered into the TV memory.

Come the day and time of each programme, the TV will switch itself on automatically and tune to the appropriate channel. A convenient way of ensuring that you don't miss your favourite programme.

Major features of the new TV:

Information about a programme can be stored for up to a year ahead.

Precision time is ensured by using a highly accurate quartz clock.

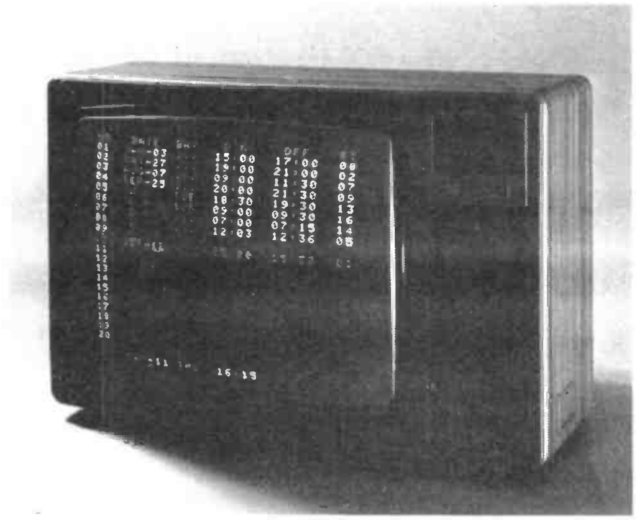
Up to 20 different programmes can be stored.

Mains power is automatically switched off one hour after the end of the programme.

Automatic tuning—the TV automatically finds the strongest station signal on each channel.

Has a 22-inch screen, and a powerful eight watts audio output.

At present no price is available. It is expected to be in the shops in Britain early in 1979.



School Science

The roving exhibition for schools entitled "School Science and Everyday Life" has just been updated by Project-Engineers and Technologists for Tomorrow (PETT) at Southampton University.

The exhibition consists of 10 working models, designed to give visitors an insight into ways in which simple science has been applied to solve domestic, industrial and medical problems. Each solution is based on a topic which the average school-leaver can expect to have met in his school science course.

Models range from monitoring movement of a crack in a concrete beam to conveying electric pulses to the heart, from transmission of telephone messages by means of light rays to automatic switching of an oxygen supply to a patient.

School Science and Everyday Life is available to schools and education centres on free loan.

With the advent of commercial fibre-optic telecommunications now imminent, Hewlett-Packard have developed a sensor for measuring light power.

COMPUTER STEEL

British Steel Corporation is using a powerful computer system to obtain the best price/mix of scrap and alloys for making stainless steel at Tinsley Park, Sheffield and Panteg in S. Wales.

The system has been developed by Scicon Computer Services and uses terminals at each plant linked by landline to a powerful scientific computer complex using Univac 1108 computers at Scicon HQ at Milton Keynes.

All the official calculations for places and timing of each stage in the marathon round-Britain cycling Milk Race were made on a Texas Instruments SR60A personal computer.

Advisory Service

An advisory service for mechanical engineering companies who have no in-house experience of electronic solutions to mechanical engineering problems has been set up by Gould Instruments Division (until recently better known as Gould Advance).

Simple electronic modules, say Gould, can often replace expensive mechanical precision assemblies, cutting costs and improving profitability.

THE ROYAL SOCIETY

As modern technology makes the idea of a machine with human-like abilities a reality, improvements in social standards make it imperative that dirty, dangerous or tedious jobs are in the future undertaken by robots. Thus of particular significance amongst the scientific exhibits at the Royal Society's annual Conversazione last May, was a demonstration of research work into robots carried out at the University of Warwick.

The work at Warwick includes a tracked vehicle with an on-board computer which uses data from a number of sensors—touch, sonar, photo-electric and motor loading—to assess the environment. This robot is capable of carrying out long sequences of unstacking — transfer — stacking operations in a crowded environment. Some smaller bucket-shaped robots designed to demonstrate the ability of small microprocessor-based robots were also demonstrated.

Another exhibit illustrating the versatility of electronics was related to investigations into the structure and dynamics of the Earth's magnetosphere. These investigations have been greatly facilitated at Sheffield University by specially designed equipment. "Whistlers" and other very low frequency phenomena are examined and analysed by a fast Fourier transform instrument. Output from the analyser is in digital form suitable for computer processing.

TAILOR MADE

Among new developments shown to selected customers recently by Racal-Redac was a system for eliminating waste of material in complex patterns cut from sheet material (cloth / metal / plastics) and another for designing mechanical engineering parts.

In both cases the designer can modify his designs at will through his graphics terminal using a light-pen held against the CRT display screen.

A nationwide mobile radio system to keep nearly 900 service engineers in immediate contact with their 41 regional depots is being installed by Hotpoint. Over 50 base stations will blanket the country and when fully operational the network is expected to handle up to 10,000 messages a day.

—ANALYSIS

OUR MICRO-AGE

I recently saw the assembly and testing of digital multimeters. Not toys but professional quality instruments for the professional engineer. Present production is 100 a day but I was told that the output could be increased to 140 a day with no increase in labour.

At the 100 a day production rate, single shift working, yearly output, allowing for a holiday plant closure is 25,000 units. Quite a lot of instruments. I had therefore thought to see a modest assembly line, a row of pretty girls each adding a few components.

Not so! She was pretty enough for my taste but quite alone and working at anything but a breakneck pace. She could easily fit in another 40 a day, perhaps might welcome an increase in pace. What's more she didn't need to know what she was doing.

She took component No. 1 from a row of bins and a spot of light on the bare printed circuit board showed her where to insert it. Then component No. 2 and the light spot moved to a new position and so on. By the use of i.c.s. the total component count is less than 50 per multimeter. When all the components have been "stuffed" into the p.c.b. it is put on one side and the whole day's production batched through an automatic flow-soldering machine in one operation.

With over 20 different voltage, current and resistance ranges to be checked and calibrated to an accuracy on some ranges as tight as ±0.2 per cent, I imagined I would see a fair team of test and calibration engineers. Again, not so! Two youths aided by automatic test equipment doing nearly all the work for them.

The direct labour force for assembly, test and calibration of instruments worth some £3million per year was thus, one female unskilled bench assembler and two semi-skilled technicians.

This is what modern electronics is all about and why prices of electronic goods continue to fall relative to other products. It is common today for an unskilled person to pick up an i.c. package, insert it on a board in a couple of seconds and thus wire in hundreds, even thousands of components at a stroke. Designers are already working on V.L.S.I. (Very Large Scale Integration) chips with 10,000 or more circuit elements, and are talking of the million element chip.

Microminiaturisation started a revolution in electronic technology. The result is a trend to micro-factories, micro-workforces and even micro-prices (e.g. the £5.00 calculator). Where will it all stop?

Brian G. Peck

What Price Intelligence

Engineers tired of re-setting signal sources to different frequencies, output levels, source impedance, different waveforms, will welcome a new programmable instrument from Hewlett-Packard. Up to ten complete instruments settings can be pre-programmed and then selected at will by pushing two buttons.

The only snag is that it costs £3,691, but not really expensive by H-P standards. Yes, it does use a microprocessor to "remember" the control settings and make it an "intelligent" instrument.

The conversion of the three million non-electronic cash registers in 16 West European countries to all-electronic models represents a market of some £2·5 billion over the next 10 years according to a market research study by Frost & Sullivan.

Ten Ferranti Argus industrial control computers, worth £1·5 million, have been ordered by the Soviet Union for use in a rubber plant. This brings the number of Argus computers installed in or on order for the Soviet Union to over 40.

All at sea

The Danish cadet training/cargo ship *Elsinore* will have on board a Redifon Maritime Radar and Navigation Trainer for the use of 30 instructors and 200 cadets. Using the coastline generator the cadets will be able to practice "conning" the ship into their home port, even though thousands of miles away.

Instructors can originate their own navigation exercises at will, including dangerous manoeuvres. The system will form a valuable class-room aid supplementing the real ship-handling exercises on deck and bridge.

The *Elsinore* will help earn her keep by carrying commercial cargo as well as serving as a training ship.

BLEEP-BLEEP-BLEEP

Pocket pagers which bleep when the wearer is needed are not new. But Pye Business Communications is now installing systems which have three sorts of bleep for use in hospitals. A slow bleep for non-urgent calls, a standard bleep for fairly urgent and a special bleep for cardiac arrest.

Ally-Pally '78

Alexander Palace was once again the venue for this years RGSB Amateur Radio Exhibition, held on the 5th and 6th May.

As usual there were plenty of trade stands dealing in new and surplus equipment. Several organisations were evident, notably AMSAT UK (amateur satellite communications) and BATC (British Amateur Television Group), two very fast growing areas of amateur radio.

Films for the beginner were also shown, giving the newcomer an insight to the world of amateur radio.

Business for the trade appeared to be quite good, although several comments were heard concerning the rather excessive second-hand prices.

The Post Office cricket-by-phone service, now extended to over 125 centres, is expected to be another big money-spinner by the end of the season.

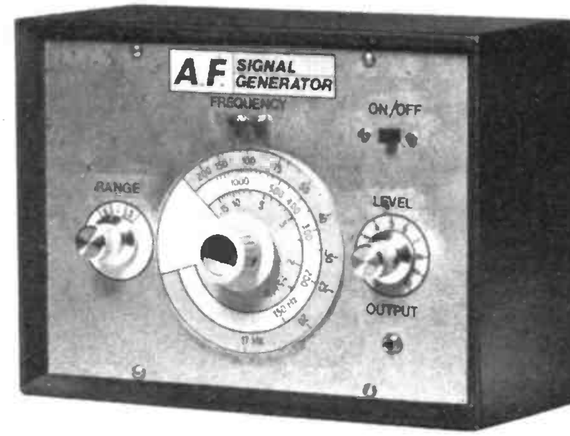
Last year cricket-lovers made over 22½ million calls to hear the latest scores. This year could break all records.

THE AGE OF VIDEO

The video age has arrived in the UK with the introduction, this month, of the Betamax home video system from Sony. This enables the TV viewer to record from the television, even to record one channel while watching another.

The machine can also be pre-set to record for anything up to three days in advance of a transmission, and the TV set does not have to be turned on.

AUDIO FREQUENCY SIGNAL GENERATOR



By F. G. Rayer

This instrument produces a signal whose amplitude remains constant within 1 per cent with a change of up to 3 volts in the battery voltage, and for any load, such as will be provided by an amplifier or other similar equipment. The output impedance is 1 kilohm.

Changes in amplitude do not exceed 2 per cent over the three ranges, which are 17 to 200Hz, 150 to 1500Hz, and 1·5 to 15kHz. The output was observed on an oscilloscope, and seen to be an excellent sinewave throughout.

For this level of performance it is not possible to adopt the simplest type of audio oscillator, but from the circuit in Fig. 1 it will be seen that few components are needed, bearing in mind the wide frequency range and output level stabilisation.

RANGE SELECTION

Ranges are selected by the 3-way ganged switch S1. Capacitors C3 and C6 are for the lower range with the middle range using C2 and C5 and the highest frequency range obtained with C1 and C4. There is no obligation to use precision values here.

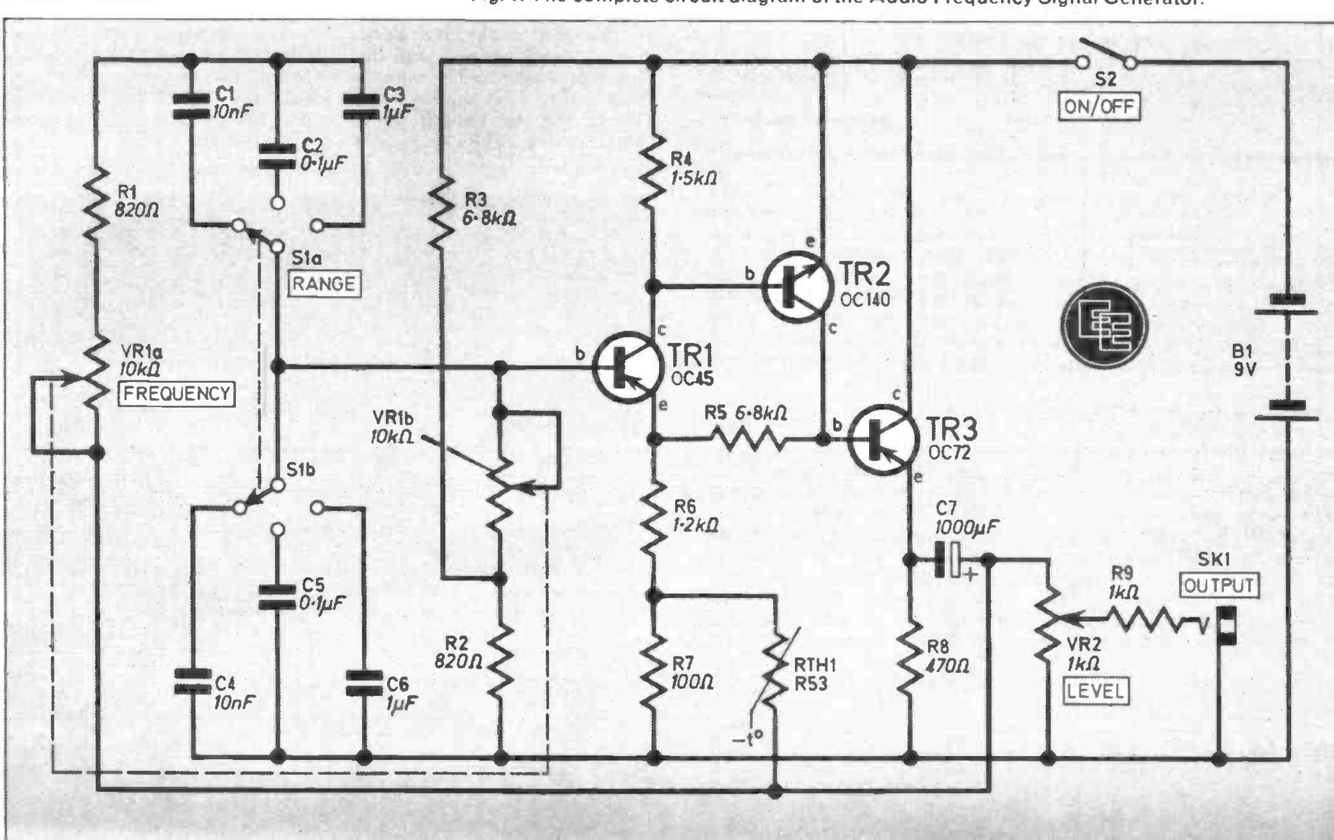
Frequency adjustment through each range is by a ganged linear potentiometer VR1, which has calibrated scales on the front panel.

OSCILLATOR CIRCUIT

The oscillator is a Wien bridge type, in which base input to TR1 is determined by the frequency selective network consisting of VR1a, with C1, C2 or C3 on the one hand, and VR1b with C4, C5 or C6 at the grounded side. As a result, feedback is only in the correct phase to produce oscillation at the frequency wanted. Resistors R2 and R3 are for base bias of TR1, through VR1b.

Transistors TR2 and TR3, with their associated components, are for feedback and stabilisation. Feedback is from TR3 emitter circuit (at C7) to potentiometer VR1a for the generator circuit, with coupling to TR1 emitter circuit via the thermistor RTH1 for stabilisation of the output. Without the thermistor, the level of audio output varies considerably with changes in frequency. With the thermistor, increased audio levels produce a drop in thermistor resistance value, raising the degree of feedback. Output across

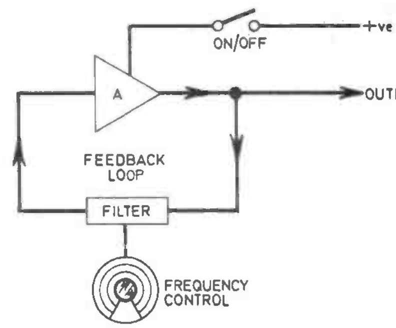
Fig. 1. The complete circuit diagram of the Audio Frequency Signal Generator.



VR2 is thus stabilised at 1 volt for all frequencies.

The amplifier TR2 is of *npn* type, but *pnp* transistors are used for TR1 and TR3. Operating conditions in each stage are determined by those in the other stages, and the transistors type numbers specified should be adhered to.

HOW IT WORKS



The A.F. Signal Generator can be considered as an amplifier *A* with frequency selective positive feedback.

Transients produced in the amplifier when the generator is switched on causes a small output from the amplifier which is fed to a **FILTER**. An output at a specific frequency is passed from here to the amplifier input such that the output is reinforced causing a larger output signal at this frequency to pass back through the feedback loop.

The amplitude of the signal rapidly reaches a maximum steady level dependent oncircuit values. The frequency of the oscillating signal is controlled by the **FREQUENCY CONTROL** which is part of the **FILTER**.

CONSTRUCTION starts here

CIRCUIT BOARD

The circuit board used in the prototype was 0·15 inch plain matrix board, approximately 100×70 mm (27×18 holes), and all components except VR2, S2, SK1 and R9 are mounted on it, as shown in Fig. 2. First drill holes for potentiometer VR1 and switch S1. At the same time it is wise to determine how the board will be fixed to the instrument panel. A clearance of about 6mm is necessary between board and metal panel. In the generator built by the author, the bush of the switch was long enough to allow a nut to secure the panel. But the potentiometer bush was too short for this, so board and panel were drilled for two 6BA bolts, hidden under the dial. Fitting is simplified by drilling through both the board and metal panel at the same time, and extra nuts or washers will provide the required spacing.

On the underside of the board, there are a few places where the wiring crosses. At these points some thin insulated connecting wire, or 22s.w.g. tinned copper wire with 1mm sleeving, will be needed. Soldered joints are close against the board.

If wished, a piece of card about the same size as the board could be put against the metal panel, though with reasonable care there will be plenty of clearance to avoid shorts against the case.

PANEL

The prototype case front panel measures 175×125mm and drilling details for this are shown in Fig. 3.

Secure the board and other components to the front panel and wire up according to Fig. 2. Output

COMPONENTS

Resistors

R1 820Ω	R4 1·5kΩ	R7 100Ω
R2 820Ω	R5 6·8kΩ	R8 470Ω
R3 6·8kΩ	R6 1·2kΩ	R9 1kΩ

All ¼W carbon ± 5%

Potentiometers

VR1 10kΩ + 10kΩ dual ganged carbon lin.
VR2 1kΩ carbon lin.

See **Shop Talk** page 595

Capacitors

C1 10nF plastic or ceramic
C2 0·1μF plastic or ceramic
C3 1μF polyester
C4 10nF plastic or ceramic
C5 0·1μF plastic or ceramic
C6 1μF polyester
C7 1000μF 12V elect.

Transistors

TR1 OC45 germanium *pnp*
TR2 OC140 germanium *npn*
TR3 OC72 germanium *pnp*

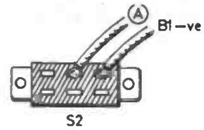
Miscellaneous

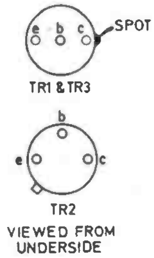
S1 2-pole 3-way rotary switch
S2 s.p.s.t. slide switch
RTH1 Thermistor type R53
SK1 3·5mm Jack socket
B1 9 volt type PP4 or similar

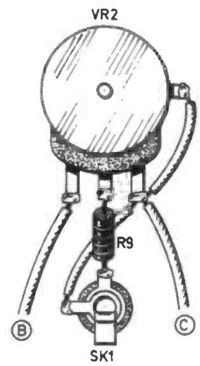
0·15 inch plain matrix board size 27 × 18 holes; battery connectors; knobs (3 off); case (see text); Perspex for tuning dial and marker; connecting wire; 6BA fixings.

COMPONENTS approximate cost £8·00 excluding case

AUDIO FREQUENCY SIGNAL GENERATOR







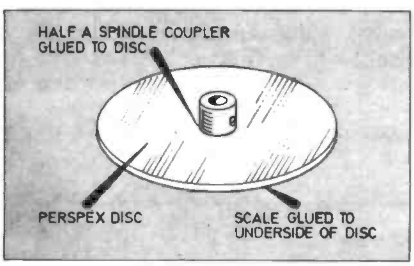


Fig. 4. Details for constructing the dial from a piece of Perspex and one half of a brass spindle coupler.

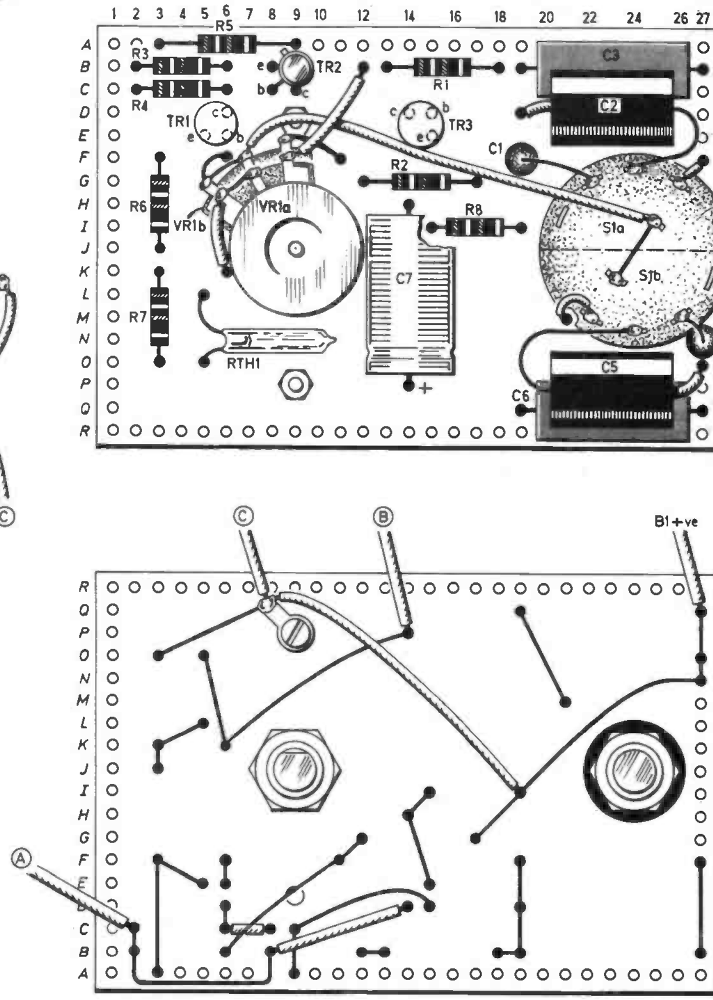
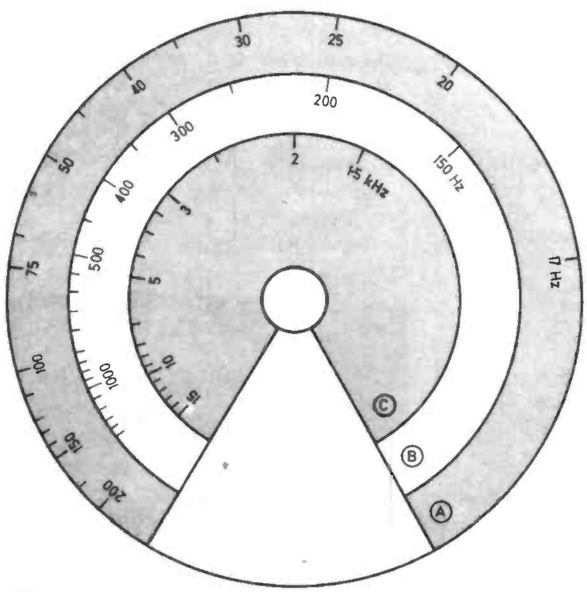
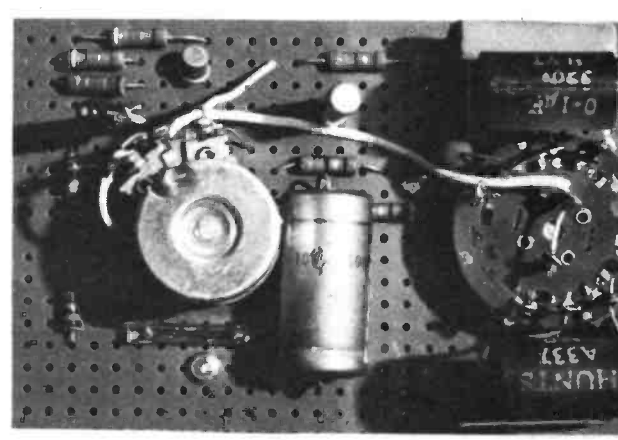


Fig. 2. The layout of the components on the plain matrix board and inter-connection wiring on the underside of the board. Top left shows the wiring around the level control and output socket and on/off switch in relative position on the front panel.



Ⓐ = RANGE 1
Ⓑ = RANGE 2
Ⓒ = RANGE 3

Fig. 5. Full size drawing of the scale used on the prototype unit. This may be cut-out or photocopied and then coloured and glued to the rear face of the Perspex dial as in author's unit.



Photograph of the component board ready for fitting to the front panel.

from the wiper of VR2 is to a 3·5mm jack socket. A 1 kilohm resistor (R9) in circuit here avoids possible virtual shorting of VR2 by low impedance loads when VR2 is set for maximum output.

The case used had internal dimensions of approximately 150×100×40mm. Alternatives to a ready-made case can be found in the use of "Universal chassis" parts or some kind of household tin or box. Any 9 volt battery can be used, the smaller batteries being adequate. A PP4 was used in the prototype.

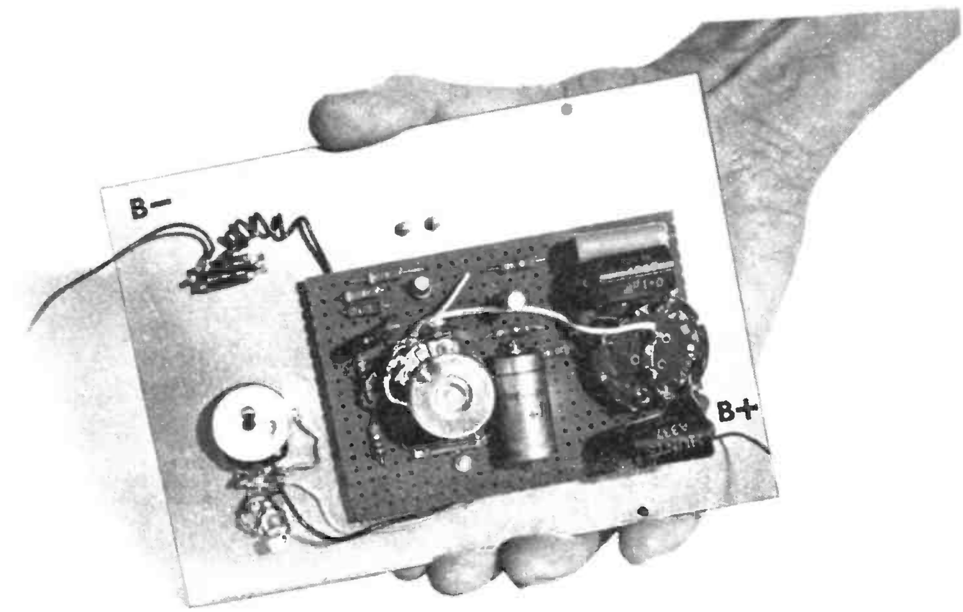
The tuning dial was made from a piece of 3mm thick clear Perspex of 75mm diameter. Half of a brass spindle coupler was glued over a suitably sized hole at the centre of the disc to allow fixing to the spindle of VR1. Another small piece of 1mm thick Perspex was used in the prototype fixed by 6BA nuts and bolts and sited immediately above the dial on the front panel. A line scribed on this provides a fine reference marker. See Figs. 3 and 4 for construction details of these parts.

CALIBRATION AND USE

For many purposes the scale shown in Fig. 5 can be adopted. This appears full-size. If an individually calibrated scale is wanted, this can be arrived at in various ways. Details of these are outlined below.

Generator

If a calibrated audio generator can be borrowed, couple its output



The completed unit removed from its case. The only item not fitted to the front panel is the battery.

and the output of the A.F. Signal Generator into an audio amplifier via two 47 kilohm resistors, or into separate amplifiers. Set the calibrated generator to various frequencies, and adjust the unit until the note is heard to be the same, and mark its dial. Repeat for as many different frequencies as required.

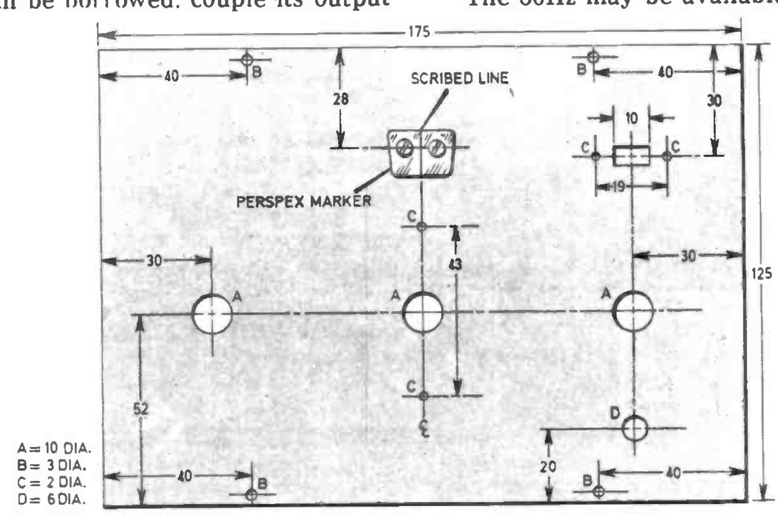
Oscilloscope

This is excellent for the lower frequencies, with 50Hz input to one set of plates, and the A.F. Signal Generator output to the other set of plates. The scope time base is not in use.

The 50Hz may be available from a scope calibration terminal, or can be from a low voltage mains transformer. Lissajou's figures are then produced.

The number of loops on these figures will indicate the ratio between the fixed frequency (50Hz) and generator frequency. Adjust the generator to produce a circle or oval, and mark the scale 50Hz. Readjust until a figure 8 is seen (this will be on its side, with the generator input to the usual scope input socket) and then mark the scale 100Hz (because there are two loops horizontally, for each vertical scan giving a 2:1 ratio). Proceed in the same way, three loops being 3:1, or 150Hz, four loops 4:1, or 200Hz, and so on. Eventually the loops are too numerous to count, and a reference frequency higher than 50Hz is needed.

The user of a scope will be familiar with the method, or will find details of this technique in the instrument operating instructions.



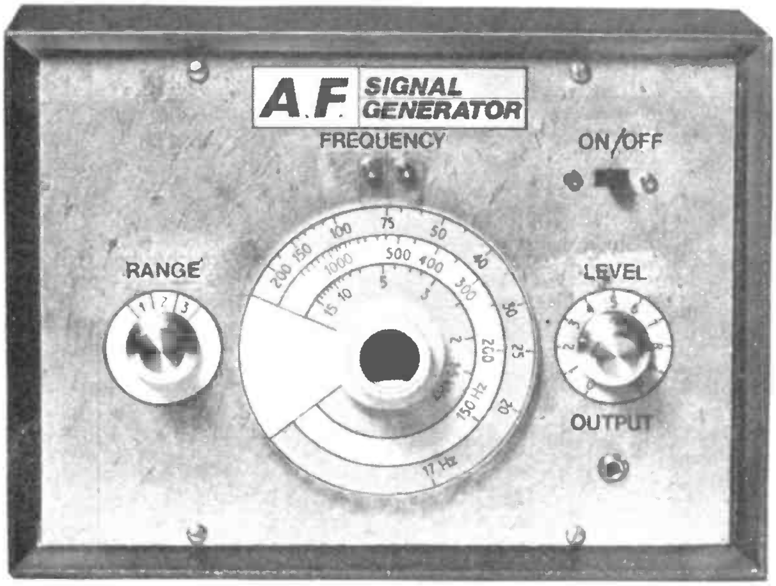
ALL DIMENSIONS IN mm

Fig. 3. Drilling details for the front panel of the case as used in the prototype. Note the small Perspex marker bolted in place on the panel.

Musical Frequencies

It is necessary to have a tuned instrument, a list of standard pitch and concert frequencies (available in musical reference books) and a musician friend who can say when the generator tone agrees with a selection of notes.

Octaves are a doubling of frequency—as example, if Middle C is 256Hz, the C below this is 128Hz, the C above is 512Hz, and so on.



Graph

For any individually calibrated scale a graph is very helpful. Set off frequencies against 360 degrees. Just a few plotted points will then allow the whole scale to be calibrated. Use an ordinary 180 degree protractor for this, or a 360 degree protractor if available.

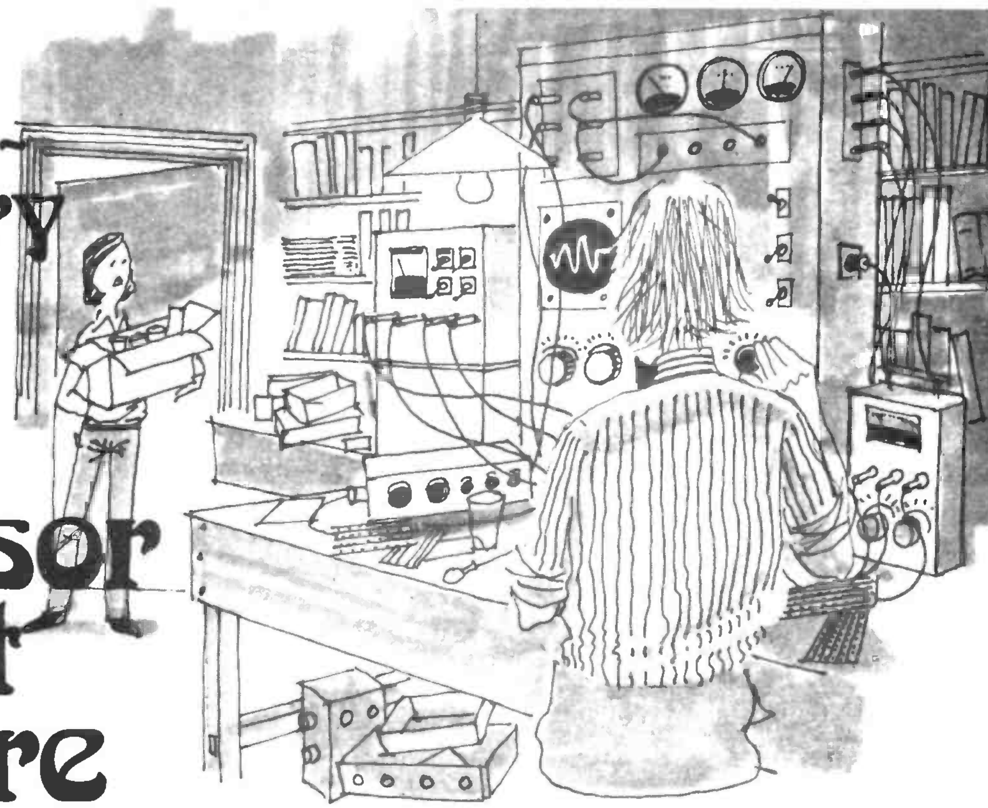
IN USE

The generator can be used whenever an adjustable audio frequency is required. Its main utility is in testing audio amplifiers. Do not expect the full frequency range to be audible with an inexpensive amplifier-speaker system! Instead, the signal will fade away and probably cease to be heard at all at very high and very low frequencies (a scope would show the signal still produced, at expected amplitude from the generator).

The generator is also useful for sinewave inputs to check an amplifier output without distortion, for the adjustment or setting of tone selective circuits, and for similar purposes.

Crossword No. 6—Solution

The Extraordinary Experiments of Professor Ernest Eversure



by Anthony John Bassett

As THE Prof. completed his diagram for modification of the output stage of an AC30 amplifier Bob could see that by means of this modification the Prof. had totally avoided the risk of damage to the amplifier from breakdown of the cathode decoupling capacitor. In the modified circuit this capacitor is not used and has been removed from the amplifier!

AUTO BIAS

"Many valve-type audio power amplifiers use an *auto bias* output where the cathodes of the output valves are decoupled by means of an electrolytic capacitor in parallel with each cathode resistor," the Prof. told Bob.

"The situation of these capacitors is usually a strenuous one as in many amplifiers they not only have to withstand the many electrical conditions and fluctuations which occur within the amplifier, but they are also often placed in a hot area of the amplifier, such that in some amplifiers the capacitor is in close proximity to the hot output valves and the cathode bias resistors which also run hot. Each time the amplifier is used the capacitor is heated to a high temperature and under these conditions failures are frequent.

It is often a good idea to remove the capacitors and the auto-bias cathode resistors and replace them with an adjustable bias circuit like thus (Fig. 1). By doing this we remove a number of potentially troublesome components from the circuit, and allow the bias current of each output valve to be individually controlled. This gives a number of advantages over the *cathode auto bias* circuit, and also over the *fixed bias circuits* which are also quite popular".

"What are the differences between fixed bias, Prof., and auto bias and adjustable bias?"

"I will draw a sketch of each, Bob, and explain them to you".

BIASING METHODS

The Prof. quickly drew a number of small sketches on a sheet of paper (Figs. 2 a, b, c, d). (Auto bias transformer-coupled, auto bias capacitor-coupled, fixed bias capacitor-coupled and adjustable-bias capacitor-coupled.)

"In both the auto bias circuits which I have drawn out (Figs. 2a, b), the control-grid of the valve is at chassis potential. Current flows from the cathode to chassis by way of the cathode resistor and a voltage develops across this resistor. This voltage biases the valve and automatically sets the current to a particular level for each valve.

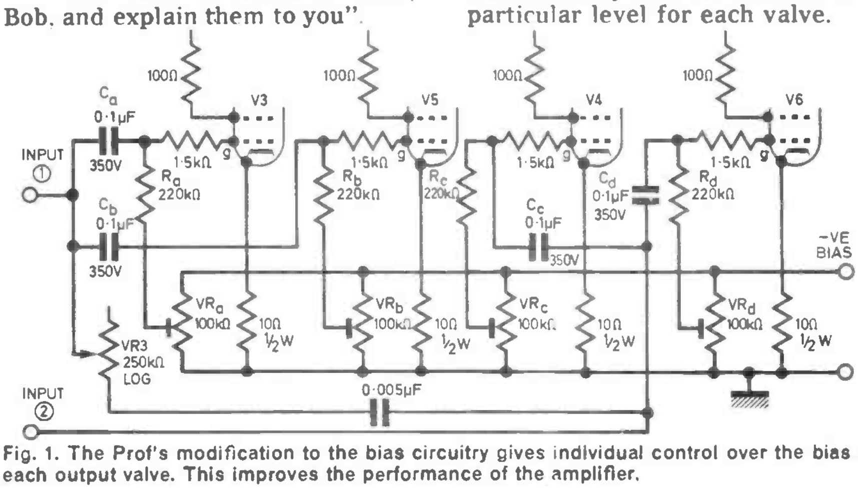


Fig. 1. The Prof's modification to the bias circuitry gives individual control over the bias of each output valve. This improves the performance of the amplifier.

A big advantage of this method is that it is inexpensive; it is also reliable if good components are used and they are kept cool in use.

Where the bias voltage required by the valve is large, a large voltage is dropped across the resistor, and if it is a power valve a large current may flow. The resistor then dissipates appreciable power and may become hot. So this method is inefficient and wasteful when used in high-power output-stages.

A much more efficient method which is used in high power output stages is the fixed bias circuit (Fig. 2c) with a capacitor-coupled input. Here the cathode is connected to the chassis, and the grid is supplied with the negative bias from a fixed negative voltage source, by way of a high-value resistor. There is no cathode resistor to dissipate power, and no cathode decoupling capacitor to give trouble.

However, with this circuit trouble may often be experienced due to variations in the characteristics of the valves, especially when replacement valves are fitted."

Bob was very puzled by this last statement from the Prof.

"Why should replacement of the output valves give trouble?" he asked; "I would have thought that, when it became necessary to replace the output valves, the new valves would be better than the old ones, and that this would solve problems, not cause them. How can this be?"

"The answer to the question," the Prof informed Bob, "lies in the wide variations between the characteristics of individual valves. Even when they are new, no two valves are identical in their performance, though they may be closely matched. When one considers the differences between valves from different manufacturers, and different countries of origin, the differences may be wide indeed.

INDIVIDUAL BIAS

The valves can then be biased individually to the required operating current. A cathode resistor is connected from the cathode of each valve to the chassis and this is of low resistance, often about 10 ohms or maybe less and does not become hot. Usually a decoupling capacitor is not needed with such a low value of cathode

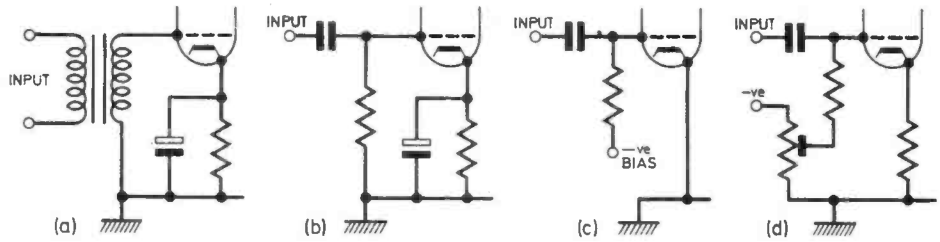
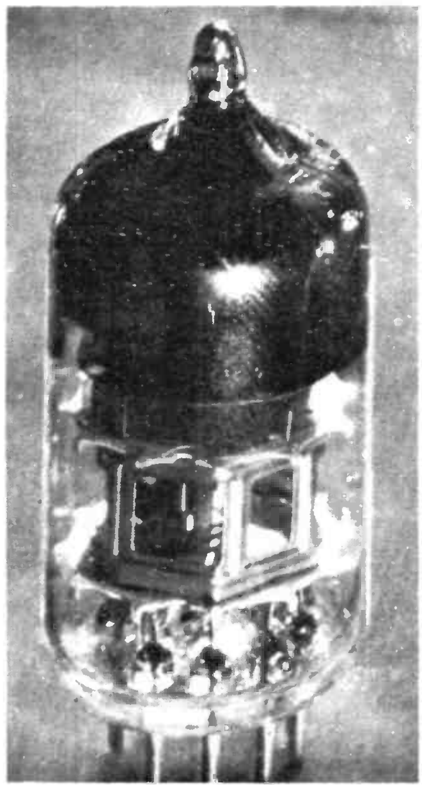


Fig. 2. Various types of bias commonly used with valve audio output stages: (a) autobias transformer-coupled (b) autobias capacitor-coupled (c) fixed bias capacitor-coupled (d) adjustable bias capacitor-coupled.



For those readers who have grown up with transistors and integrated circuits—this is a valve, the subject of the Prof's current experiments.

resistor. So the presence of the cathode resistor in this circuit does not have the disadvantage shown in the auto bias circuits.

By connecting a millivoltmeter in parallel with the cathode resistor we can measure the voltage across it. If we know, from use of Ohm's law, which voltage corresponds to the required current, then the preset resistor can be used to adjust the negative bias on the valve until the correct current level is reached. By reducing the negative bias temporarily to a lesser value, a higher current should flow, and this can be used to test the cathode of the valve for adequate election emission."

"Could this problem be solved by using only valves which match the ones fitted by the maker in the first place, Prof?"

"Yes, this is one possible solution, but it presents a number of practical difficulties; it may be difficult to obtain such valves at the time and place when they are needed. If new valves are bought, then carried around along with other band equipment until they are needed, it may be found that when the time comes to fit them, the characteristics are not so close to the original and it may be too late to fit another replacement under the guarantee.

The most serious variation in valve characteristic is the variation in standing current, the current taken by the valve under *no-signal* conditions of fixed bias. A very useful method of overcoming this is to modify the circuit to give each valve individual adjustable bias (Fig. 2d).

Of course after this has been done the bias should be immediately set back to its correct level, or excessive current could flow in use of the equipment."

To be continued

PLEASE **TAKE NOTE**

QUAGMIRE *(July 1978)*

Resistor R5 in the components list should be 330Ω, not as given. In Fig. 4b. the lead from *M28* should go to *J23*, not *I23* as shown. In Fig. 1. the connection from IC5 pin 3 (gate G5b) should go to IC6 pin 11. The layout of Fig. 4b. is correct.

ELECTRONICS at the BRITISH ARMY EQUIPMENT EXHIBITION

The Plessey Supertalk PTR2411 v.h.f. manpack/vehicle radio.

Some 400 overseas visitors representing 70 countries came to examine the goods British firms have to offer, on display at the British Army Equipment Exhibition held at Aldershot last June. Under the auspices of the Ministry of Defence Sales Organisation, the Army Royal Ordnance Factories and some 250 commercial firms combined to present the largest array of military equipment ever to be exhibited in one place.

The importance of this "shop window" is clear when it is appreciated that defence orders are expected to contribute £900m to the UK balance of payments during the current year. Also, thousands of jobs are dependent upon the defence equipment industry.

RADIO COMMUNICATIONS

A prime requirement of any military organisation is an efficient communication system. Backbone of British military combat communications is the Clansman VRC353, claimed to be the most advanced v.h.f./f.m. vehicle system in the world. It is installed in a wide range of armoured or soft-skinned vehicles. The frequency range is 30 to 75·975MHz and 1840 channels are provided at 25kHz channel spacing. Frequency selection is by digital synthesiser. Power output is 50W. This equipment is now in full production at Marconi Space And Defence Systems Ltd.

The VRC353 is operationally compatible with the Clansman v.h.f. manpack transceivers shown by Racal Communications Ltd.

British firms also had on show their own "commercial venture" communications equipments, designed independently but specifically for a military role.

In this category is the Plessey Avionics and Communications "Smalltalk" PTR 1851 V.H.F. Military Pouch Radio. This radio is inconspicuous in use and light in weight. It has eight programmable channels and covers the 30 to 76-MHz military v.h.f. band. A larger Manpack/Vehicle radio "Supertalk" has a main role as a command radio at battalion, regimental, company, or platoon level.

A new generation of manpack h.f. transceivers was shown by Racal. Claimed to be half the size and half the weight of many similar equipments, the PRM4021 and PRM4031 transceivers weigh only 7kg (15·5lb).

The lightweight and small size is achieved by the use of advanced

The Racal UK/VRQ301 mobile v.h.f./f.m. radio station designed for tanks with limited turret space.

The Ferranti Laser Target Marker used by ground forces to designate targets to supporting. strike aircraft.

thick film techniques coupled with both linear and digital integrated circuits.

The PRM 4021 covers the 2 to 16 MHz frequency range with 140,000 channels, and the PRM 4031 provides 284,000 channels in 100Hz steps throughout the 1·6 to 30MHz frequency range.

ENCODING EQUIPMENT

The security of military communications is of vital concern. Advanced digital techniques have been employed to produce elaborate encoding of speech, c.w., or facsimile signals prior to transmission by line or radio.

Both Marconi and Racal had on show extensive ranges of equipments which exploit these techniques for encoding information that is to be transmitted.

Marconi offer a range of their "Cryp" equipments, for maximum long-term security for various kinds of transmission. One of these is the Cryptiex, designed for use with h.f. radio circuits.

A Crypflex equipment is required both at the transmitting and the receiving end. Each equipment comprises: A vocoder; a cryptographic unit; a multitone moden, and a power unit.

At the transmitter the vocoder converts speech into digital data in the form of a continuous stream of binary bits. At the receiver it re-converts the data stream back into speech.

The cryptographic unit employs an encrypting sequence generator to produce another data stream of binary bits. The bits in this stream are in an indiscriminate order, and it is of immense length and complexity. The two streams are combined, to produce a data stream that is so complex that it is virtually impossible to break by any form of crystanalysis.

The Racal range includes the MA4014B Audio Encryption Unit. This employs the latest time division multiflexing and frequency dispersion techniques to provide 40,000,000,000 code combinations. Over 600,000 internally selectable code keys are available, each of which is programmed by 64,000 codes selected by front panel switches.

AUTOMATIC MORSE

The MA4230 Automatic Morse Sender is a portable hand held unit with a full alpha-numeric keyboard. Messages are entered into the internal memory character by character. The output is an audio tone which complies with the international Morse code. Thus Morse messages can be sent or received by operators having no knowledge of the Morse Code. A further security advantage is that detection of deployment of troops by an intercepter by reading an operator's individual characteristics is thus eliminated.

The associated MA4231 Automatic Morse Reader is able to read incoming Morse messages of between 10 and 160 words per minute. These are stored in a 1000 character memory and can be recalled and processed either on a single l.e.d. display or on a separate printer.

This microprocessor controlled unit is designed to receive MA4230 transmissions and other automatic Morse transmissions, as well as normal keyed traffic.

COMPUTER FAULT FINDING

An important aid to the rapid diagnosis of faults in electronic equipment is the microprocessor controlled Computer Aided Fault Finding System, MICRO-CAFF RTL 5M. This enables anyone with a basic knowledge of test equipment to rapidly and logically pinpoint equipment defects. This equipment has been developed by Racal Automation Ltd., and has been ordered by the British Army to align, test and diagnose Clansman radio equipment at a Central Command Workshop.

The diagnostic programmes are recorded on "floppy" discs, capable of storing 250,000 characters.

MICRO-CAFF RTL 5M consists of three units:

1. A visual display unit providing all instructions for the operator to perform.
2. A keyboard which generates a total of 16 characters, providing for an algorithm selection in addition to the simple "yes/no" operator functions.
3. A control unit incorporating the floppy disc drive and microprocessor circuitry.

LASER TARGET MARKER

A laser target marker and ranger is in production for the British Army by Ferranti. This operates by directing pulses of infra-red energy from a neodymium-doped YAG laser at a target. Range is then measured by determining the time interval between transmission and reception.

A marked target seeker has been included in this equipment for use in conjunction with a forward air controller equipped with a compatible laser target marker. When the aircraft approaches the target, the marker is switched on. The marked target seeker in the aircraft automatically detects and tracks the laser energy scattered by the target, driving the pilot's head-up display to indicate target position to him in elevation and azimuth.

R/C TARGET AIRCRAFT

A large-scale model aircraft using standard commercial radio control techniques and equipment was exhibited by Aero Electronics Ltd. Called the Snipe, this model aircraft is designed for use as an aerial target for AA gunnery practice, and also has an additional role as a surveillance vehicle, in which case it carries a camera pod.

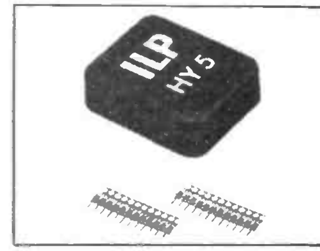
Flight commands are transmitted to Snipe through a compact hand held radio control unit. The radio range is in excess of three miles.

A built-in fail-safe system automatically closes the engine throttle and ejects the recovery parachute in the event of radio interference or loss of control signal.

Snipe has a wing span of 2·5m and a length of 2·1m. Average flight duration is 45 minutes. Speed: 128 m.p.h. ⌑

15—240 Watts!

HY5
Preamplifier



The HY5 is a mono hybrid amplifier ideally suited for all applications. All common input functions (mag Cartridge, tuner, etc) are catered for internally. The desired function is achieved either by a multi-way switch or direct connection to the appropriate pins. The internal volume and tone circuits merely require connecting to external potentiometers (not included). The HY5 is compatible with all I.L.P. power amplifiers and power supplies. To ease construction and mounting a P.C. connector is supplied with each pre-amplifier.

FEATURES: Complete pre-amplifier in single pack—Multi-function equalization—Low noise—Low distortion—High overload—Two simply combined for stereo.

APPLICATIONS: Hi-Fi—Mixers—Disco—Guitar and Organ—Public address

SPECIFICATIONS:
INPUTS. Magnetic Pick-up 3mV; Ceramic Pick-up 30mV; Tuner 100mV; Microphone 10mV; Auxiliary 3-100mV; Input impedance 4·7kΩ at 1kHz.
OUTPUTS. Tape 100mV; Main output 500mV R.M.S.
ACTIVE TONE CONTROLS. Treble ± 12dB at 10kHz; Bass ± at 100Hz.
DISTORTION. 0·1% at 1kHz. Signal/Noise Ratio 68dB.
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APPLICATIONS: Updating audio equipment—Guitar practice amplifier—Test amplifier—audio oscillator.

SPECIFICATIONS:
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INPUT SENSITIVITY 500mV. FREQUENCY RESPONSE 10Hz-16kHz—3dB.
SUPPLY VOLTAGE ± 18V.
Price £5·22 + 65p VAT P&P free.

HY50
25 Watts into 8Ω

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FEATURES: Low Distortion—Integral Heatsink—Only five connections—7 amp output transistors—No external components

APPLICATIONS: Medium Power Hi-Fi systems—Low power disco—Guitar amplifier

SPECIFICATIONS: INPUT SENSITIVITY 500mV
OUTPUT POWER 25W RMS into 8Ω LOAD IMPEDANCE 4-16Ω DISTORTION 0·04% at 25W at 1kHz
SIGNAL/NOISE RATIO 75dB FREQUENCY RESPONSE 10Hz-45kHz—3dB.
SUPPLY VOLTAGE ± 25V SIZE 105 50 25mm
Price £6·82 + 85p VAT P&P free

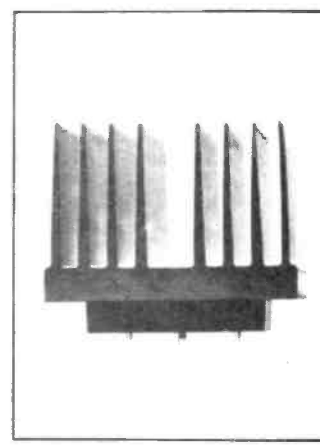
HY120
60 Watts into 8Ω

The HY120 is the baby of I.L.P.'s new high power range. Designed to meet the most exacting requirements including load line and thermal protection this amplifier sets a new standard in modular design.

FEATURES: Very low distortion—Integral heatsink—Load line protection—Thermal protection—Five connections—No external components

APPLICATIONS: Hi-Fi—High quality disco—Public address—Monitor amplifier—Guitar and organ

SPECIFICATIONS
INPUT SENSITIVITY 500mV.
OUTPUT POWER 60W RMS into 8Ω LOAD IMPEDANCE 4-16Ω DISTORTION 0·04% at 60W at 1kHz
SIGNAL/NOISE RATIO 90dB FREQUENCY RESPONSE 10Hz-45kHz – 3dB SUPPLY VOLTAGE ±35V
SIZE 114 50 85mm
Price £15·84 + £1·27 VAT P&P free.



HY200
120 Watts into 8Ω

The HY200 now improved to give an output of 120 Watts has been designed to stand the most rugged conditions such as disco or group while still retaining true Hi-Fi performance.

FEATURES: Thermal shutdown—Very low distortion—Load line protection—Integral heatsink—No external components

APPLICATIONS: Hi-Fi—Disco—Monitor—Power slave—Industrial—Public Address

SPECIFICATIONS
INPUT SENSITIVITY 500mV
OUTPUT POWER 120W RMS into 8Ω LOAD IMPEDANCE 4-16Ω DISTORTION 0·05% at 100W at 1kHz.
SIGNAL/NOISE RATIO 96dB FREQUENCY RESPONSE 10Hz-45kHz – 3dB SUPPLY VOLTAGE ±45V
SIZE 114 50 85mm
Price £23·32 + £1·87 VAT P&P free.

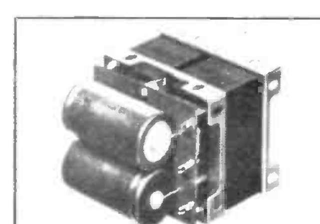
HY400
240 Watts into 4Ω

The HY400 is I.L.P.'s "Big Daddy" of the range producing 240W into 4Ω! It has been designed for high power disco address applications. If the amplifier is to be used at continuous high power levels a cooling fan is recommended. The amplifier includes all the qualities of the rest of the family to lead the market as a true high power hi-fidelity power module.

FEATURES: Thermal shutdown—Very low distortion—Load line protection—No external components.

APPLICATIONS: Public address—Disco—Power slave—Industrial

SPECIFICATIONS
OUTPUT POWER 240W RMS into 4Ω LOAD IMPEDANCE 4-16Ω DISTORTION 0·1% at 240W at 1kHz
SIGNAL NOISE RATIO 94dB FREQUENCY RESPONSE 10Hz-45kHz – 3dB SUPPLY VOLTAGE ±45V
INPUT SENSITIVITY 500mV SIZE 114 100 85mm
Price £32·17 + £2·57 VAT P&P free.



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LETTERS

A Shocking Affair

Just what does your Mr. Adrian Hope, "Entertainment" February issue, think he is doing by suggesting we check the earth continuity of our domestic sockets with a multimeter between the earth pin of the socket and a water pipe?

Has it not occurred to him that if the main distribution board's earthing lead were not connected, if an earth leak occurred in any piece of domestic equipment the earth terminals of the aforesaid sockets could well be at full mains potential.

A shocking affair indeed!

Mr. J. Clements,
Coventry.

Mr. Hope replies . . .

Well, if the earthing to my main distributor board were disconnected and if a fault developed on a piece of equipment to leak mains to the floating earth circuit, I for one would be only too pleased to sacrifice a multimeter to the cause of finding out, before I was killed by touching an "earthed" appliance with wet hands in the kitchen or even bathroom!

A Probing Time

With reference to Mr. A. M. Heritage's letter (*Bright Ideas*, April Issue) concerning the "Probe-less Continuity Tester". The idea for an automatic on/off switch is a step in the right direction but why have an on/off switch at all?

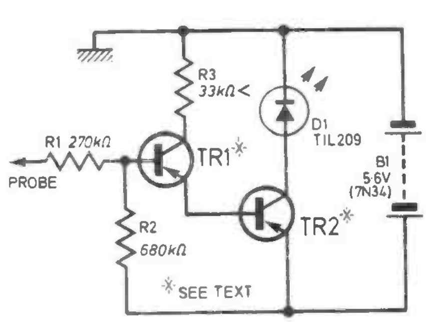
By including another resistor (*R2*) earthing the input when no bias is applied the quiescent current of the probe can be dramatically reduced.

Using a couple of low leakage transistors from my spares box I constructed the circuit shown below. The probe sits on the shelf drawing less than 1/10 of a microampl (immeasurable on my meter) and 8 to 10mA when used.

By varying the resistor values I'm sure any suitable gain low leakage transistors could be used.

The probe has passed a current through 5 people, in series, and still the l.e.d. has lit—I wonder if this is a record?

G. S. Wills,
Peterborough.



Power Controller Interference

Having read with interest your selection entitled *Popular Circuits* which appeared in the April issue of Everyday Electronics, I noticed that no form of interference suppression was included in the "Mains Power Controller", circuit No. 5.

As the function of this circuit is to switch the mains partway through each half-cycle to the load, harmonics of 100Hz will be generated causing a small amount of radiated interference and a large amount of mains-borne interference on long, medium and short wave bands.

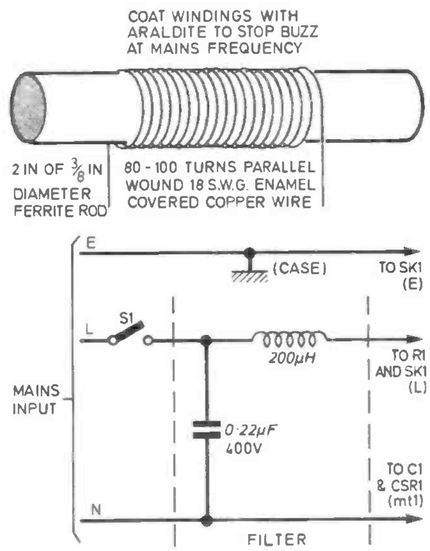
To overcome these problems I suggest the following remedies:

(1) Screen the circuit by constructing in a metal box, this being connected to earth.

(2) Construct an inductor of around 200μH, see below, and fit it in the half-*T* filter as shown.

This will reduce any interference through the mains wiring by 95 per cent.

P. R. Greenbaum
Grays, Essex.



Encapsulated Heat

Concerning the letter about encapsulation of circuits in Plasticraft by P. G. Sherwood in the June issue.

Two possible reasons for the radio ceasing to work are:

(1) whilst setting, Plasticraft generates a certain amount of heat which may damage some of the components.

(2) the transistor may tend to get slightly warm, but due to the heat insulation properties of plastics their temperature will slowly increase with very little actual heat loss.

D. Clarke,
Rugby.

Hydrostatic Malfunction

A possible answer to the radio that ceases to work (*Readers Letters*, June issue) after a time because it has been encased in potting resin could be this:

On curing (setting) the resin will shrink and induce a pressure on the components enclosed within.

This obviously is not of sufficient magnitude to affect the performance of the radio until it has been turned on for a time.

Due to the slight heating effect that the passage of electric current has on resistors, coupled with the very poor thermal conductivity of the plastic, the resistors will try to expand and any expansion will, of course, be prevented by the very firm resin, causing considerable pressure to be imposed on the resistors in the circuit.

Excessive pressure on a material will always cause its ohmic resistance to decrease, thus altering the effective values of the components in the circuit, causing it to malfunction after a short time.

On cooling, the radio will naturally function once more. The temperature rise may be less than one centigrade degree, but the hydrostatic pressure imposed by the expansion will nevertheless by very high.

J. P. Berry, B.Sc.,
Goldthorpe,
Yorks.

Heat Dissipation

With reference to Mr. P. G. Sherwood's problems with encapsulation, I would think the trouble lies in the fact that plastic is a very poor conductor of heat (when compared with free air). A transistor which is running near its limit can become quite hot—and we all know what happens to a transistor that becomes too hot.

The ability of a block of material to dissipate heat is dependent on a number of factors—about the only one which the constructor can control is the ratio of surface area to volume. The higher the ratio $\frac{\text{Area}}{\text{Volume}}$ the greater the dissipation.

It will also be seen that for a given volume, the best shape is a thin slab, like a slice of bread, or (even better) it should be possible to cast the resin in a finned shape—pretty *and* functional (take a look at a heat sink).

Any components suspected of producing heat in an unacceptable quantity should be embedded near the surface of the plastic or should have a lump of metal (e.g. a bolt) embedded so one end is near the offending component and the other near the surface, this provides a sort of thermal short circuit.

A hot component may affect itself or a near-by component and will probably discolour the plastic around it after a while. If this effect is noticed (the resin usually turns yellow) a hole can be drilled to just pass the heat source to allow a bolt to be threaded into the block.

I. Newman,
Kent.

We thank all the many other readers who have sent ideas on this subject. Regretfully we cannot publish all received.

A Good Test

I have just made the *Mains Tester* described in the May issue and found it most useful. I found that it can be made much easier by not using the Veroboard and the clear and opaque resin, but instead using the whole of the existing plug and drilling three holes in the cover for the neons to shine through.

The neons and their resistors are simply connected to the pins as you would a cable. The live wire has to be soldered to the fuse carrier but that is all there is to do. Using this method the pins do not have to be glued as the cover keeps them in place.

J. Farr,
London, W8.

GEORGE HYLTON brings it down

Chemists and Superconductors

MANY years ago I went to a lecture about the future of electronics. Since it was given by an eminent engineer I expected him to tell how engineers would be shaping the development of electronic technology. Not a bit of it. Instead he said very firmly that the future of electronics lay in the hands of . . . "the chemists".

His point was that advances in engineering nowadays nearly always depend on the development of new materials. It is the chemist, who creates the new materials, to whom the engineer must look for help. In electronics, for example, the first transistors required a new material in the shape of ultra-pure germanium. Later came ultra-pure silicon, and later still materials like those which have made light-emitting diodes possible.

I've often reflected on the wisdom of that lecturer. When he spoke, integrated circuits were just a dream and the l.e.d., the laser and many other commonplace devices hadn't even been thought of. They all exist because chemists have produced the materials which have made them possible.

Superconductivity

Superconductivity has a long history. Back in 1911 a Dutch physicist, Kamerlingh-Onnes, investigated the effects of very low temperatures with the help of some new ideas in refrigeration. He discovered that lead and mercury lose all their electrical resistance when cooled to within a few degrees of absolute zero.

At first sight it seemed that here was a discovery with exciting engineering possibilities. Imagine an electrical circuit with no resistance therefore no losses. In particular think what superconductivity could do for the electromagnet.

Electromagnets are a universal tool of electrical and electronic engineering. Yet they are all totally inefficient. To energise an electromagnet, current is passed through its coil. To make enough current flow there must be enough driving voltage to overcome the resistance of the wire in the coil. The power which has to be supplied to drive the current through the coil is totally wasted. It just heats up the coil. If the coil had no resistance no voltage would be needed, and once the right current was flowing the coil could be short circuited, allowing the current to go round and round for ever without any power loss, creating the magnetic field all the time.

By substituting a superconducting coil for an ordinary one the electromagnet would undergo a dramatic increase in efficiency, a sudden, spectacular leap from an efficiency of 0 per cent to an efficiency of 100 per cent.

Well, not quite. To keep the coil cool enough a supply of liquid helium is needed and so there is power consumption by the necessary refrigerator. Despite this little inconvenience the idea of a superconducting electromagnet still held great attractions, if not for the engineer then at least for the physicist, who is very interested in finding out what happens to matter when it is subjected to very strong fields.

Unfortunately, as Kamerlingh-Onnes soon realised, it wouldn't work. Not that the basic idea is wrong. It isn't. The trouble was that, as the early experiments showed, superconductors cease to superconduct when subject to strong magnetic fields. So it would have been useless to try to make a superconducting electromagnet since it would be put out of action by its own magnetic field.

New Ideas

The end of a good idea? Not quite. Was there perhaps some metal or alloy or other material which would, when superconducting, be able to withstand a strong field? Clearly a job for a chemist. Not the sort of chemist who mixes stuff in test tubes and makes bad smells but a physical chemist who knows about crystal structures, electronic conduction in solids and that sort of thing.

The best answer, so far, is to make a superconducting electromagnet coil from thin strands of niobium-tin alloy embedded in copper. Practical superconducting electromagnets are in use in physics labs in many parts of the world (notably at the Clarendon Lab. at Oxford).

But is it possible to find materials which superconduct at higher temperatures, and avoid the need for that expensive helium freezer? Best of all, is there some substance which will superconduct at room temperature?

The search continues and recently the idea arose that it might be possible to make a substance which superconducts in one direction, say lengthwise, while remaining an ordinary conductor in other directions. Physical chemists produced theoretical reasons for believing that special crystalline compounds might have the right properties.

Nobody has made a room temperature superconductor, yet. But some important steps along the way have been taken. Materials that conduct lengthwise but not crosswise have been found.

They are not superconductors and they still have to be cooled, though not always to liquid helium temperatures. Indeed, if some of them are cooled too much their resistance begins to rise again, an interesting finding which will keep physical chemists busy for some time yet.

Josephson Junction

Meanwhile, engineers have attempted to make a virtue of necessity by turning the ability of a field to destroy superconductivity into something useful. By deliberately applying a field it is possible to switch a superconductor to a conductor.

Switching like this has widespread use in computing. Research at Cambridge has thrown up a superconducting circuit element called the Josephson junction which looks as if it may give computer engineers something they have long needed; memory stores of immense capacity combined with rapid access. And cheap, too . . . once you've paid for the refrigeration.

But the refrigeration has also got cheaper over the years. This has already been exploited by radio engineers. The great enemy of ultrasensitive receivers is the noise generated in the receiver itself, by heat. Special low-noise amplifying devices cooled by liquid helium have been used for many years at satellite communications stations. So all the apparently academic work on low temperatures has produced useful spin-off elsewhere.

Just as a parting thought for any reader who is not convinced of the debt we already owe to chemists, just look inside any bit of electronic equipment. You will see conductors of copper purified by a chemical process, and numerous bits of plastic, including insulation on wires, all the products of the inventiveness of the chemist. And by the way, if it's battery-operated gear, the battery is an electrochemical device.

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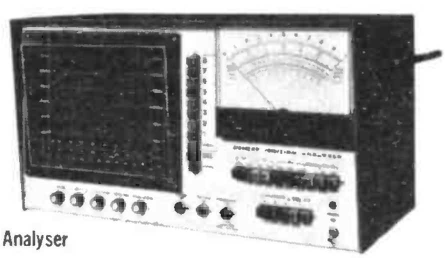

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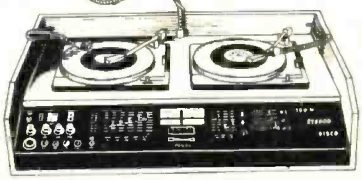

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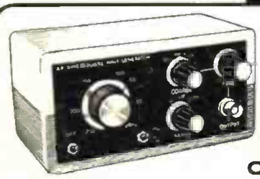

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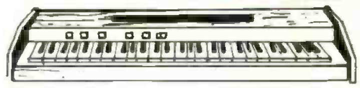

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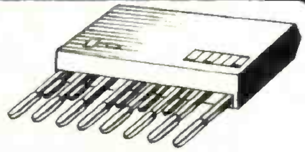

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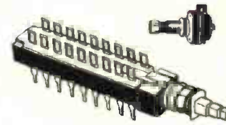

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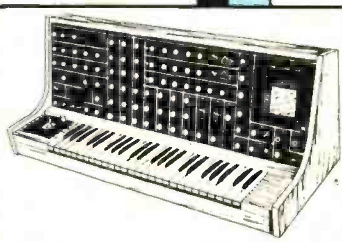

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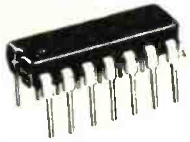

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