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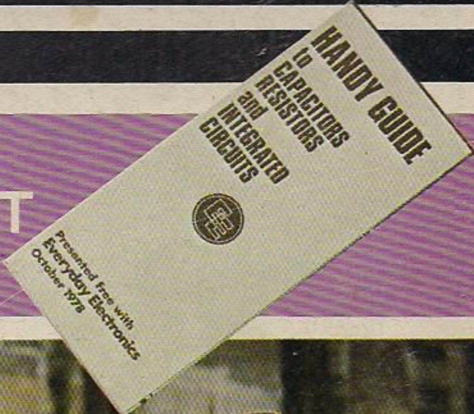

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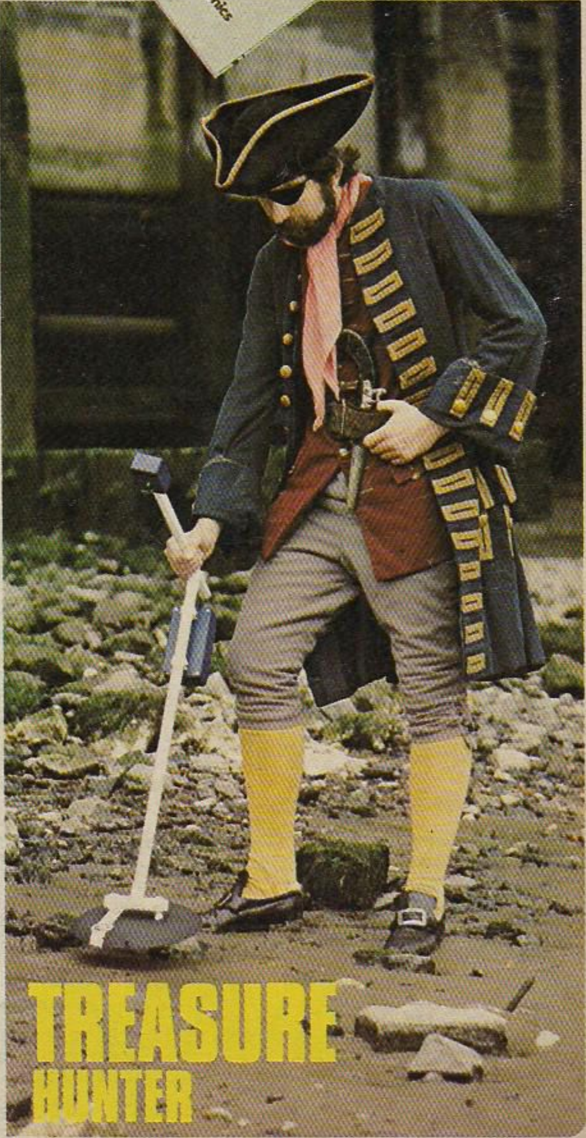

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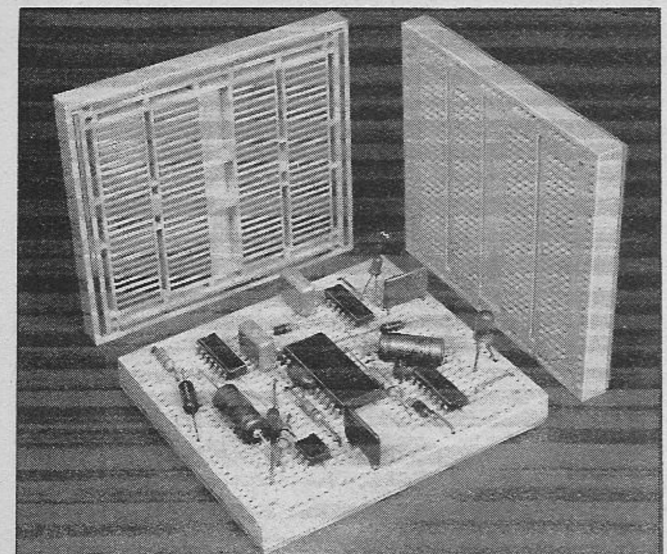

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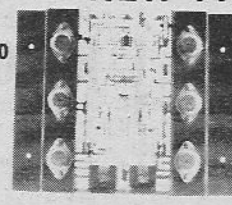

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Projects... Theory... and Popular Features...

The many different aspects of our hobby are well reflected in this month's contents. As a start the complete stranger to electronics is provided with a welcome mat in the form of *Square One*. In coming months this feature will provide a straightforward introduction to basic matters of electronic circuit construction.

Amongst the October constructionals will be found a *Mini-Module*. This is the first of a new series aimed at the beginner, although these simple but useful designs will often supply the answer to some immediate requirement and are likely to be of general or universal appeal. Another important point is that the *Mini-Modules* will serve to demonstrate a variety of building techniques, including the conventional *and* the non-conventional.

These latter *ad hoc* methods will inject a homely touch into construction, and we feel this is not at all out of place today when sophistication or professionalism is the general aim in project building. There are still occasions when the odd tin box, a few odd pieces of plastic board, and some nuts and bolts can be pressed into service to meet some need. Despite the abundance of specialised electronic hardware, it is no bad thing for the constructor to exercise his imagination at times and see just what can be achieved from odds and ends around the house. This encourages inventiveness, and who knows when improvisation may not be thrust upon one in some real emergency.

In the final effect, improvisation is often indistinquishable from planned design. For in some instances apparent "improvisation" leads to elegant results that could not be bettered. An example is right at hand in our *Treasure Hunter* where a sturdy but lightweight assembly has been constructed using standard plastic piping. The home constructor can easily make a handsome looking instrument following our example.

The performance of the *Treasure Hunter* is remarkably good, with a clear differentiation between ferrous and non-ferrous metals. It is perhaps worth reminding newcomers to treasure hunting that much depends upon the diligence and skill of the operator—as indeed with all instruments and tools.

The important part played by logic or digital circuits in modern electronics cannot be over emphasised. We strongly commend our new series *Doing It Digitally* to those who are not fully conversant with the theory or the practical use of logic. Not hobbyists alone, but those thinking of embarking upon a career in electronics will undoubtedly greatly benefit by study of this series.

Fred Bennett.

Our November issue will be published on Friday, October 20. See page 745 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. 14 OCTOBER 1978

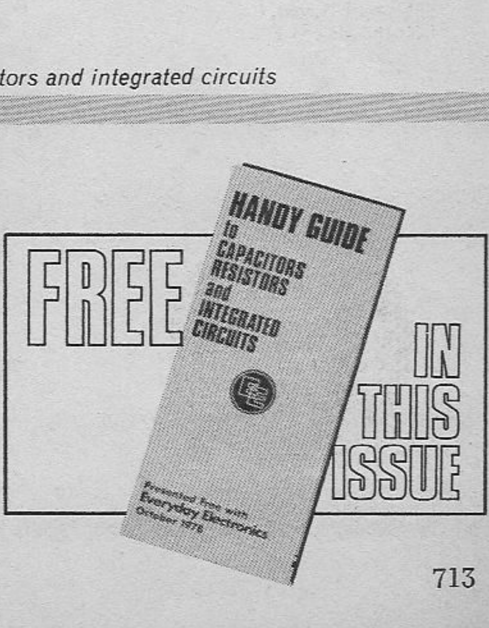
CONSTRUCTIONAL PROJECTS

GENERAL FEATURES

★ **FREE IN THIS ISSUE** **HANDY GUIDE** *to capacitors, resistors and integrated circuits*

Back issues of EVERYDAY ELECTRONICS June 1977 onwards (October to December 1977, January to March 1978 NOT available) are available worldwide 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.



ALTHOUGH developed as war-time mine detectors, metal locators have many diverse non military applications such as pipe finding, regulating traffic lights and even pinpointing sixpences in Christmas puddings, but easily the most popular use must be treasure hunting and several well publicised finds have accounted for the recent boom in sales.

Some types of metal locator often need constant re-adjustment of the controls and all too often instability can be mistaken for buried treasure. The Treasure Hunter described here, however, is as well suited to treasure hunting as it is to pipe finding and should hardly ever require alteration to the pre-set controls.

CIRCUIT DESCRIPTION

The circuit diagram for the Treasure Hunter is shown in Fig. 1.

The inductance of a coil of wire is largely dependent not only on the number of turns but also the "resistance" of the magnetic path.

This resistance is known as *reluctance* and is dependent on the core material—high for air, low for ferrous materials such as steel etc. The search coil, L1, is an air cored inductor so when a piece of ferrous material is brought near, the reluctance of the magnetic path is reduced and therefore its inductance is increased. Detect this change and you have the basis of a metal locator.

However, coins and other valuables are usually non-ferrous and as such do not affect the reluctance of the magnetic circuit, but luckily eddy currents induced in these metals divert energy from the search coil and consequently lower the inductance.

TUNED CIRCUIT

The search coil, L1 forms part of a tuned circuit in a Colpitts oscillator, TR1 and associated components. The inductance of the coil together with other components are adjusted precisely to operate at a frequency of 125 kilohertz. Hence any slight change in the inductance can cause a quite marked difference in output frequency.

The oscillator output is then passed through a high pass filter, comprising TR2 to TR4 with a cut-off frequency of 130 kilohertz.

After passing through the filter the signal is amplified by TR5 to compensate for the attenuation it suffers. The a.c. signal is then rectified and smoothed by TR6 to provide a steady d.c. output. This d.c. voltage is proportional to the

Treasure

A modern approach

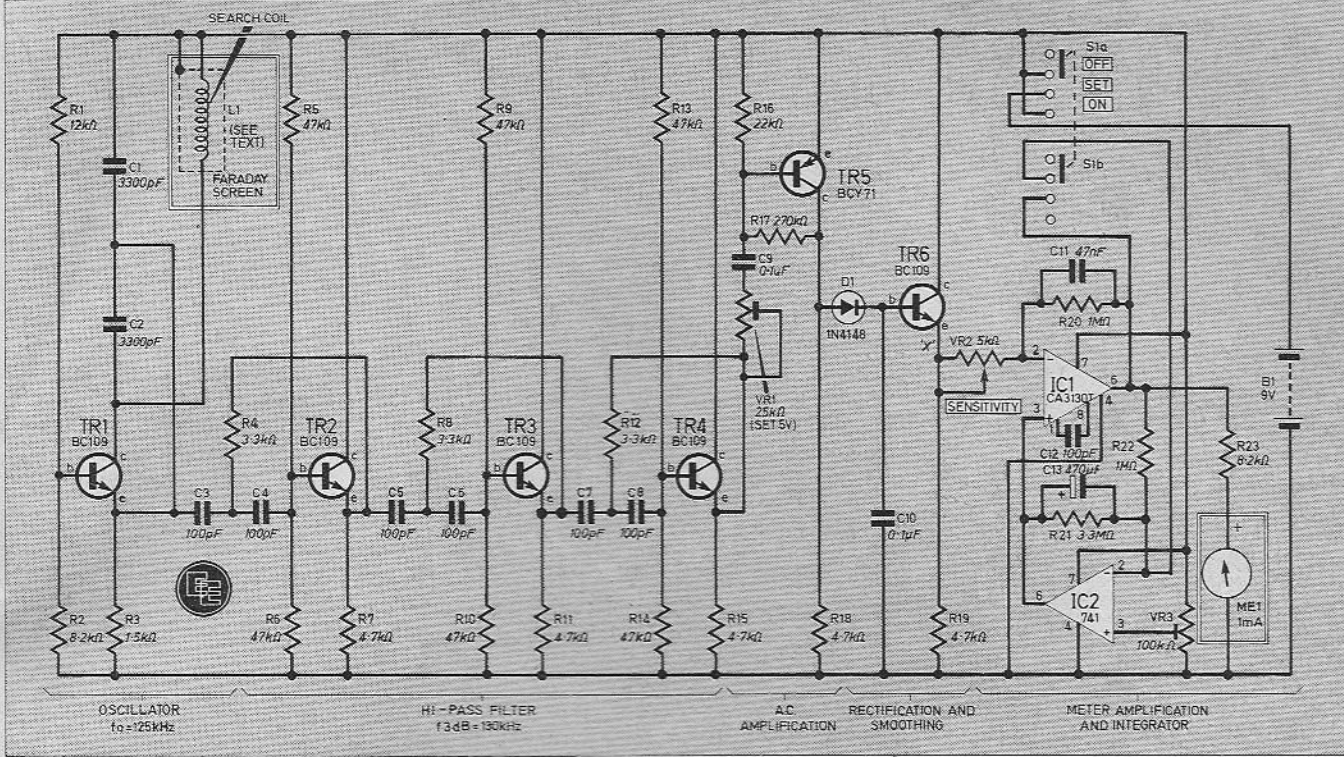


Fig. 1. The complete circuit diagram of the Treasure Hunter.

oscillator frequency, as the frequency rises so the voltage rises. The converse is true, when the frequency decreases.

Integrated circuit IC1 is a straightforward comparator, the reference voltage being obtained from IC2, and applied to pin 3 of IC1. The input signal is applied to pin 2, the output being taken from pin 6 and passed to the meter. The value for R23 is dependent on the rating of the meter. In the prototype this was 8·2kΩ for a 1mA movement.

The sensitivity is adjustable by varying the input voltage applied to pin 2. A front panel control, VR2 is provided for this purpose.

The three position switch provides both on and off, and also a SET position, the purpose of which will be described later.

Any long term change in oscillator frequency caused by ageing or temperature variations is compensated for by feedback action, but rapid changes are not, due to the integrator IC2.

So as the search coil passes over a piece of metal the meter will, initially, be deflected and then slowly return to its original position as feedback action takes over.

Hunter

to an age-old pursuit

BY N. HUNTER

CONSTRUCTION starts here

PRINTED CIRCUIT BOARD

All the components with the exception of the switch and VR2 are mounted on a printed circuit board as shown in Fig. 2a. Nothing is particularly critical about the layout, and could if desired be altered or indeed constructed on stripboard.

Begin by mounting the resistors and capacitors, taking note of the polarity of the electrolytic capacitor. Ensure that the components you have will fit on the board. It is preferable in this case to make or purchase the board before obtaining the components. Personal shopping will be easier in this respect than mail order, although not essential.

Next the two i.c.s can be mounted. Here it is advisable to use sockets. If the T-version of IC1 is obtained, some manipulation of the leads will be required to fit a d.i.l. socket. The remainder of the wiring to the switch and variable resistor can be completed as in Fig. 2b.

METER WIRING

The meter can now be wired up according to Fig. 3. The case used is a "Bimbox" type BIM4003 with dimensions 85×56×29mm although any case of similar dimensions may be used.

It is recommended that the reader use the best meter he can afford, because the ballistics of a sub-standard meter will seriously affect the sensitivity of the detector.

If a meter of less than 1mA full scale deflection is used then the output of IC1 must be loaded to prevent instability. To do this a resistor of 10 kilohms is connected between pin 6 and a convenient ground point on the p.c.b.

A scale also needs to be drawn and this is shown in Fig. 4. If this is traced onto thin white card it can then be stuck over the existing meter scale.

HANDLE CONSTRUCTION

The physical design of the Treasure Hunter is based on the use of plastic overflow pipe, this provides for easy assembly and a neat finish.

Details for the construction are shown in Fig. 5. Use is made of "T" pieces and mounting clips. It should be found that the pipe is a tight fit in the connecting pieces, if they do tend to come loose then a small amount of glue will be necessary.

Also shown are the positions of the meter box and electronics. These are attached to the clips using 4BA nuts, bolts and washers.

SEARCH COIL

Start construction of the search coil by drawing a 240mm diameter circle on a piece of 260-mm diameter plywood and nail panel pins at 50mm intervals around the circle. It is recommended that p.v.c. sleeving or similar be placed over the nails to prevent the possibility of the enamel being removed at the contact point with the nail, which could cause shorted turns via the Faraday screen.

On this former wind exactly 40 turns of 30 s.w.g. enamelled copper wire and secure with lengths of thread before carefully removing the nails. To protect the detector from stray capacitance to the ground wind a 38mm wide strip of aluminium cooking foil around the coil to form a Faraday screen. Overlap subsequent strips, maintaining electrical continuity,

COMPONENTS

Resistors

R1	12kΩ	R9	47kΩ	R17	270kΩ
R2	8·2kΩ	R10	47kΩ	R18	4·7kΩ
R3	1·5kΩ	R11	4·7kΩ	R19	4·7kΩ
R4	3·3kΩ	R12	3·3kΩ	R20	1MΩ
R5	47kΩ	R13	47kΩ	R21	3·3MΩ
R6	47kΩ	R14	47kΩ	R22	1MΩ
R7	4·7kΩ	R15	4·7kΩ	R23	8·2kΩ
R8	3·3kΩ	R16	22kΩ		

All ¼W carbon ± 10%

Potentiometers

VR1	25kΩ standard horz. preset
VR2	5kΩ carbon lin.
VR3	100kΩ standard horz. preset

See **Shop Talk** page 720

Semiconductors

TR1 to 4	BC109 silicon *npn* (4 off)
TR5	BCY71
TR6	BC109
D1	1N4148 silicon
IC1	CA3130 E, T or S operational amplifier
IC2	741 operational amplifier (8 pin d.i.l.)

Capacitors

C1	3300pF	C8	100pF
C2	3300pF	C9	0·1μF 20% polyester
C3	100pF	C10	0·1μF 20% polyester
C4	100pF	C11	47nF ceramic disc
C5	100pF	C12	100pF
C6	100pF	C13	470μF 10V elect p.c.b. mounting

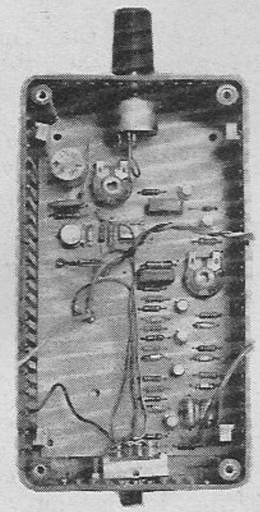
All ±2% polystyrene except where stated.

Miscellaneous

ME1	1mA moving coil meter
S1	2-pole 3-way slide switch
B1	9V PP6 battery or Duracell PP3
L1	search coil, 40 turns 30 s.w.g. copper wire, 240mm diameter

Bimbox type BIM4003 or similar, size 85 × 56 × 29mm; Bimbox type 2005/15 or similar, size 150 × 80 × 50mm; printed circuit board size 125 × 72mm; battery clip to suit B1; sockets to suit IC1, IC2; small round knob; 30 s.w.g. enamelled copper wire; approximately 31 metres; aluminium foil; length of lightweight screened cable; 22mm diameter plastic overflow pipe, lengths as required; two "T" pieces; six 22mm mounting clips; 6BA hardware; 260mm diameter coil cover plate, plywood and/or hardboard if required; edging strip.

Treasure Hunter



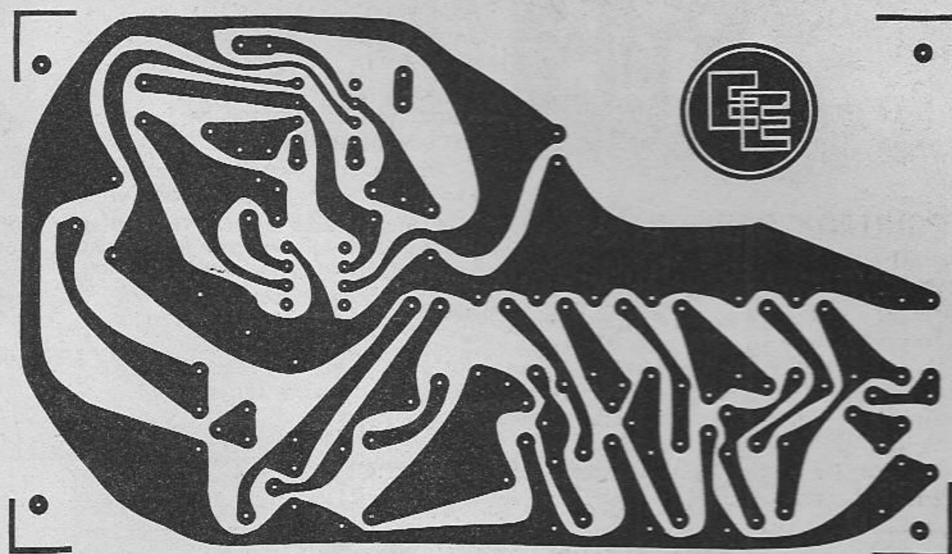


Fig. 2a. The printed circuit pattern to be etched shown full size from the copper side of the board. The black areas are the regions of copper to remain after etching.

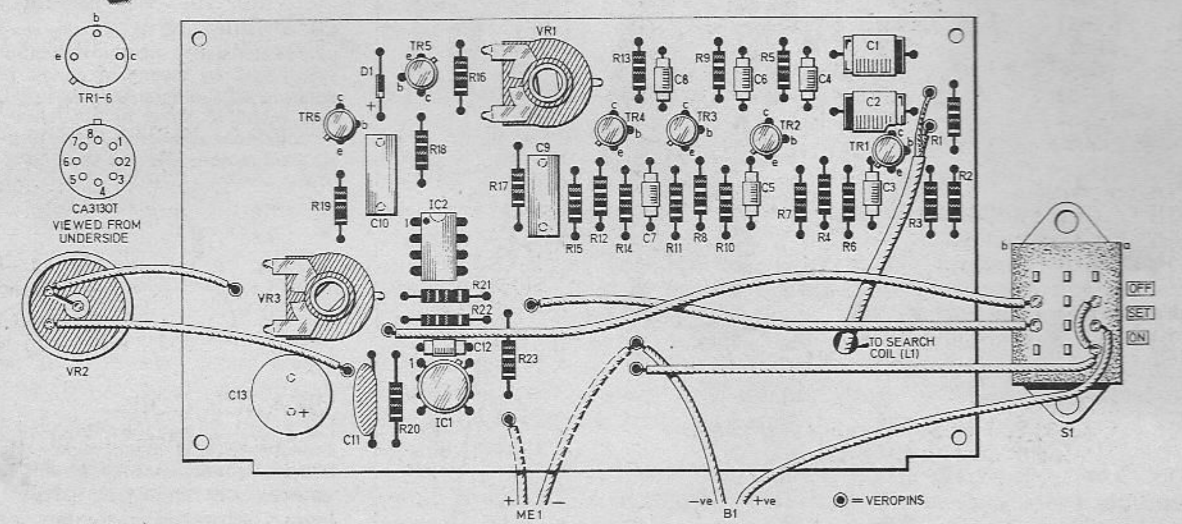
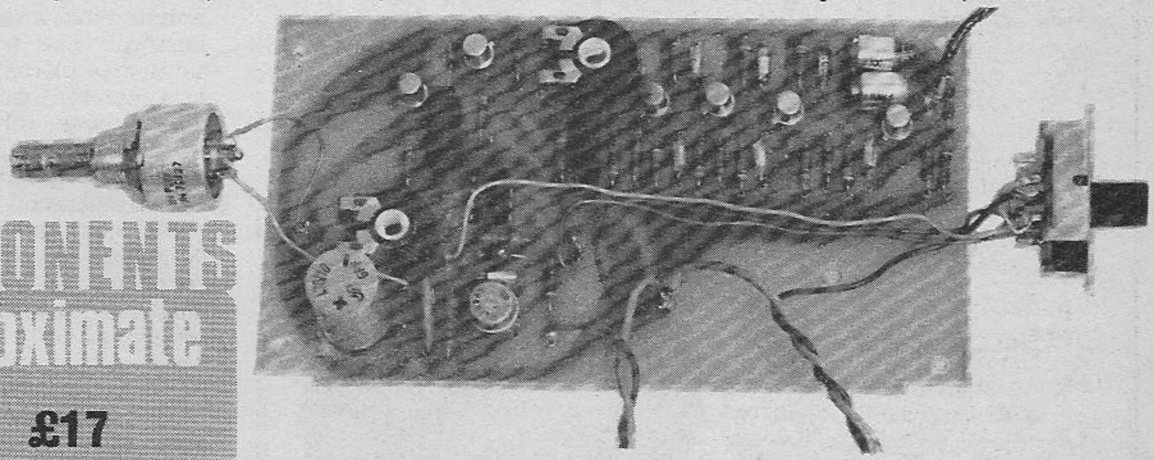
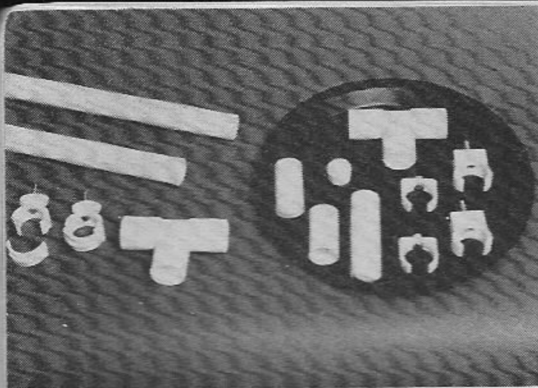


Fig. 2b. The layout of the components on the topside of the circuit board and details of wiring to other components.



COMPONENTS approximate cost £17

Photograph of the completed prototype board ready for installation.



All the plastic pipe fittings and coil cover used in the prototype.

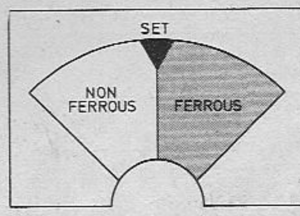
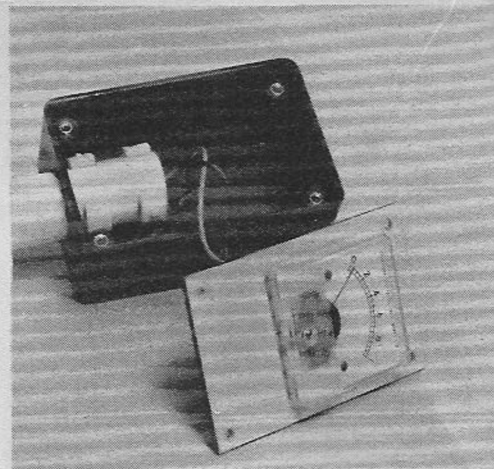
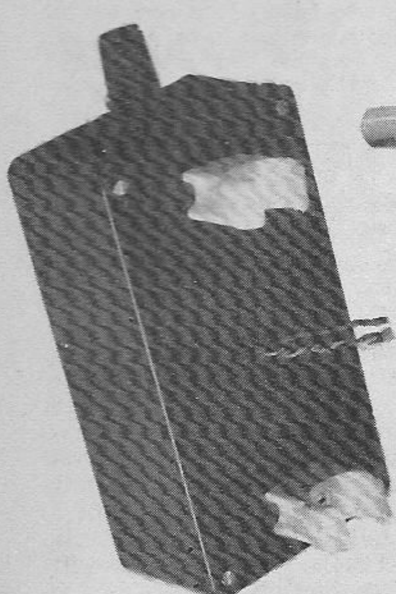


Fig. 4. A suggested meter facia showing **SET** position (mid-point) and ferrous and non-ferrous regions, preferably coloured differently for quick interpretation of deflection.





Photograph showing method of fixing main case to vertical limb by means of snap-on clips.

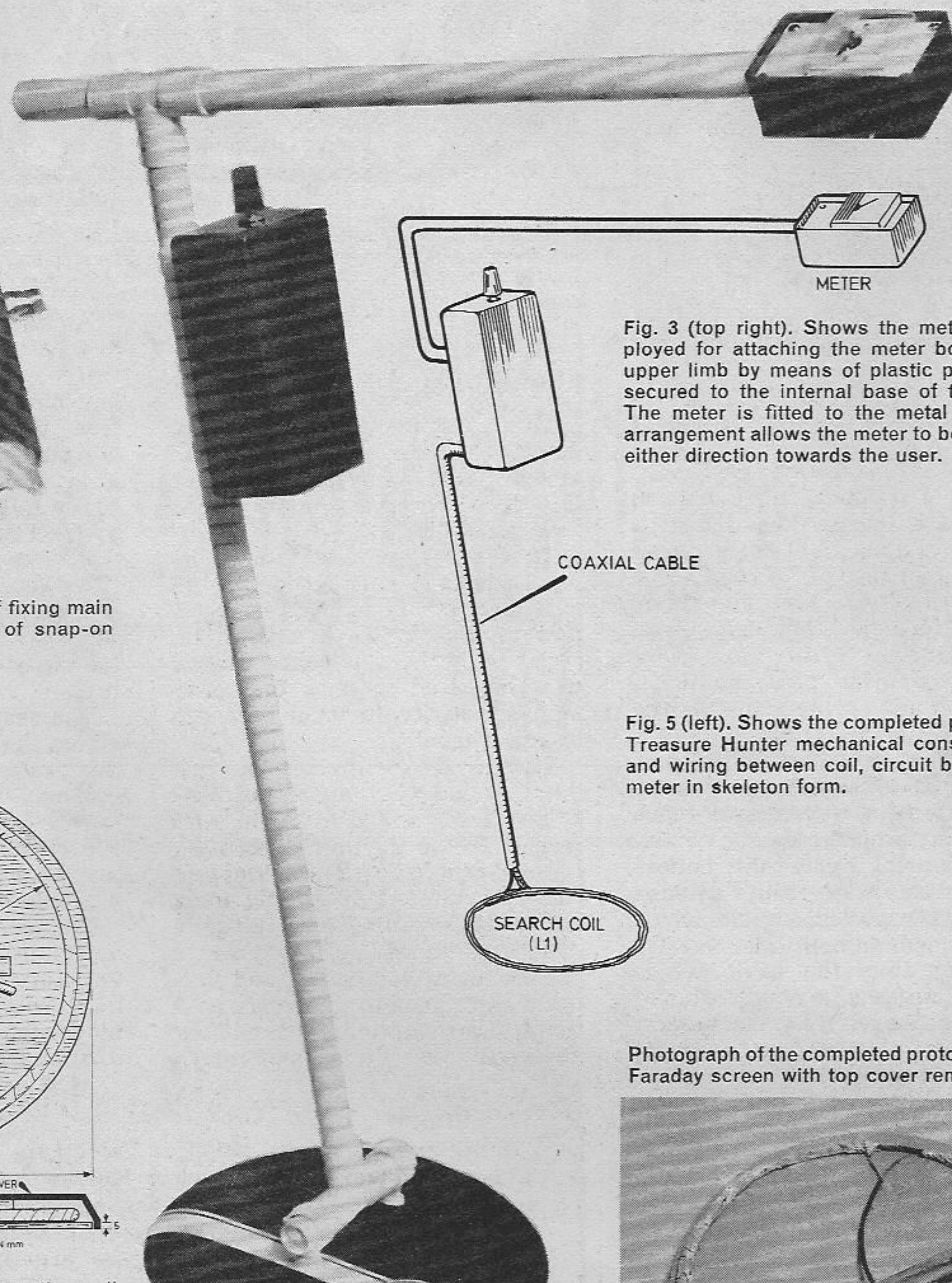


Fig. 3 (top right). Shows the method employed for attaching the meter box to the upper limb by means of plastic pipe clips secured to the internal base of the case. The meter is fitted to the metal lid. This arrangement allows the meter to be tilted in either direction towards the user.

Fig. 5 (left). Shows the completed prototype Treasure Hunter mechanical construction, and wiring between coil, circuit board and meter in skeleton form.

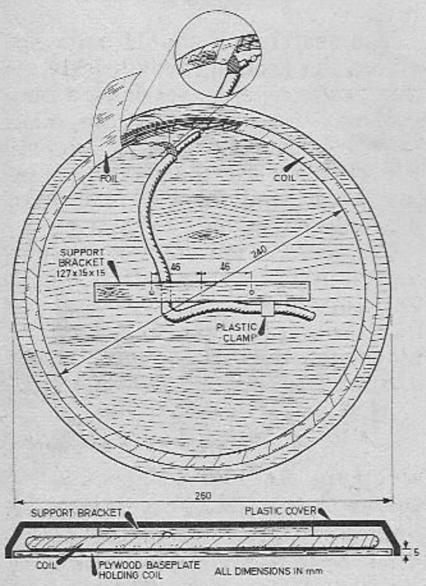
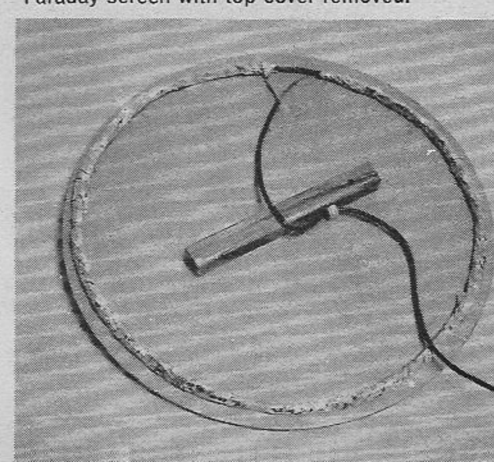


Fig. 6. Details for constructing the coil assembly. It is recommended that the underside be covered with Formica or similar laminate for protection.

Photograph of the completed prototype coil/ Faraday screen with top cover removed.



until the entire coil, less 25mm, is covered in foil.

The 25mm gap is necessary to prevent a shorted turn. Secure the finished screen with insulating tape.

Scrape the enamel from the last 25mm of the leads of the coil and check for continuity. The d.c. resistance should be 7 ohms. Check for open circuit between the screen and coil. Next wind one of the coil ends along with the braid of the coaxial lead around the twisted end of the screen, solder and insulated with tape.

Solder the other lead to the coaxial inner and again insulate with tape. Before going any further check the continuity of the coil and the Faraday screen with a multimeter or similar continuity tester.

SEARCH HEAD

A plastic "coil cover plate" was used in the prototype as shown in Fig. 6 and fits to the coil former (acting as a base plate) to completely enclose and protect the coil.

The completed coil including Faraday shield is glued centrally on the former.

With the screened cable fed through a grommet lined hole in the plastic cover, the latter is screwed to a length of batten glued to the upper face of the base plate, by means of the pipe clip fixing screws forming the coil pivot. Adhesive around the base plate outer edge will give additional strength and protection to the assembly.

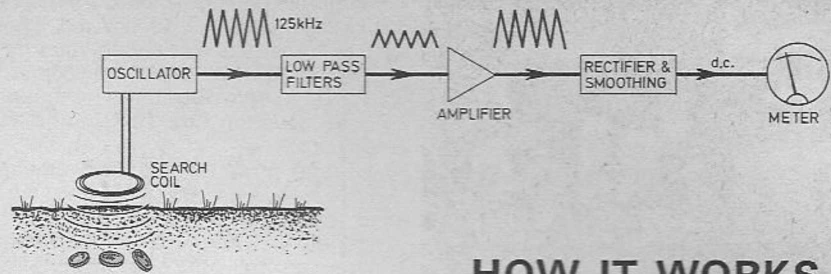
A small hole drilled in the lower T-piece allows the cable to pass up the inside of the tubing to reach the circuit board.

At this point it is worth mentioning that as the Treasure Hunter will be transported around it obviously needs to be dismantled. To allow for this, the cable which runs up inside the handle should be made longer than necessary. The excess can be pushed up inside the handle out of the way.

An additional length also needs to be allowed at the pivot point where the handle meets the cover plate.

As an alternative, two pieces of 3mm hardboard are cut into circular discs, each 260mm in diameter. A circular piece of 10mm plywood with a diameter of 235mm is also cut out. The coil is then positioned round the plywood and the two pieces of hardboard placed on the top and bottom to form a sandwich.

Edging strip 22mm wide is then attached round the perimeter. Once finished the entire assembly can be sprayed in a colour of your choice.



HOW IT WORKS

The inductance of a coil is dependent to some extent on the "resistance" of the magnetic field. This is normally termed the reluctance. The search coil forms part of the tuned circuit in an OSCILLATOR. When a piece of metal is brought near the coil the reluctance is changed by virtue of the magnetic field being deformed. This change in reluctance now affects the inductance of the coil which in turn changes the frequency of the oscillator.

This change after passing through a FILTER is amplified and rectified to give a proportional output which is then shown on the meter.

SETTING UP

The maximum sensitivity of the detector is set by the greatest amount of low frequency flicker the operator can tolerate when reading the meter.

This flicker, in most cases cannot be avoided and is due to the very high gains employed in detectors of this type. A resistor in series with the sensitivity control could be used to limit the maximum sensitivity. Its value is chosen by experiment.

With a d.c. voltmeter on test point X, and S1 to SET adjust VR1 to give a reading of five volts with respect to the 0V line. With S1 in the mid-position (SET) and the sensitivity control, VR2 at minimum. adjust VR3 to read half full-scale deflection on ME1. Switch S1 to ON, the meter will deflect and then gradually return to the centre position. With exceptionally non-linear meters the pointer may not return to the centre position. To overcome this problem, set the meter to read slightly more than half full scale. The unit is then ready for use.

IN USE

As the search coil is brought near a piece of buried metal the meter will deflect either to the left or right according to the composition of the metal. Non-ferrous objects such as coins, etc., will always cause the meter to deflect to the left. For small ferrous items such as nails, etc., the meter will deflect to the right.

Large ferrous objects may give a deflection likened to that of non-ferrous materials—so be prepared for the occasional misleading readings.

The search coil should be swept across the ground fairly briskly, as this produces a larger indication.

When the unit is in the most sensitive condition, large objects will produce a rapid deflection on the meter, and the unit may take a couple of seconds to recover.

The sensitivity control can be useful in avoiding small items in the search for larger ones and for most accurate pin-pointing of objects; always set the unit for the minimum acceptable sensitivity. ¤

OPERATING LICENCE

Under the terms of the Wireless Telegraphy Act 1949, a licence is required to operate this Treasure Hunter in the UK. This design meets with Home Office approval, operating on a frequency of 125kHz. As such no alteration should be made to the circuit which would change this frequency. A licence for five years costs £2·80 and is available from the Home Office, Waterloo Bridge House, Waterloo Road, London SE1.

By Dave Barrington

Mains Tester Screwdrivers

It's always handy to keep as many screwdrivers in your toolbox as possible, as they have the nasty habit of disappearing at the most inconvenient times.

Mains tester screwdrivers are no exception to the rule and the addition of two new C.K. mainstester screwdrivers from CeKa Works Ltd would not be amiss.

These screwdrivers are marked for 100-500 volt range and incorporate, in their plastic handles, "safety-sealed" neon assemblies. The two models available are a 5in and an 8in type and feature 2in and 4½in insulated blades respectively.

Both screwdrivers are supplied in protective plastic display wallets and retail at 51p plus VAT for the 5in model (No. 4949) and 85p plus VAT for the 8in model (No. 4962). For addresses of nearest stockists, readers should write to CeKa Works Ltd., Dept EE, Pwllheli, Gwynedd, North Wales.

Multimeter

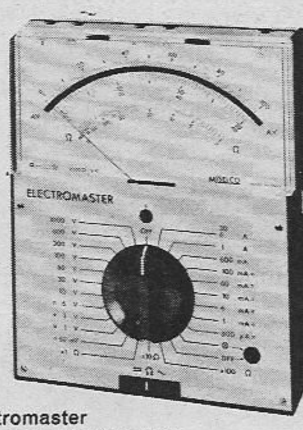
For the power engineer and electrical man who needs that little extra from his multimeter, Alcon Instruments are marketing the Miselco Electromaster multimeter from Italy.

A low sensitivity instrument (1kΩ/V a.c. and d.c.), the Electromaster offers a claimed accuracy of 1·5 per cent d.c., 2 per cent resistance and 2·5 per cent a.c. It has a wide 110 degree anti-parallax mirror movement and simple scaling. Only two switches select any one of 35 ranges.

In addition to the normal current, voltage and resistance ranges found in most meters, the Electromaster includes a simple neon-indicator continuity tester and a three-phase cyclic sense detector designed to identify the phase order of a three-phase supply.

Voltages covered extend from 60mV to 1kV d.c. and 10V to 1kV a.c. There are extended current capabilities from 600μA to 30A d.c. and from 600mA to 30A a.c. There are three resistance ranges covering 2kΩ, 20kΩ and 200kΩ f.s.d.

One-off price for the Electromaster Multimeter is £47·95, including VAT, and additional information on the complete Miselco test instrument range can be obtained from Alcon Instruments Ltd., Dept E.E., 19 Mulberry Walk, London, SW3 6DZ.



Electromaster from Alcon Instruments.

Wallchart

Readers who like to keep up to date on semiconductor devices might like to obtain a copy of the new Mullard FET Wallchart.

The chart gives design functions and lists basic parameters, various encapsulations used and names and addresses of distributors who handle these devices.

Copies of the Mullard FET *n*-channel wallchart can be obtained from Mullard Ltd., Dept E.E., Central Enquiry Handling Unit, New Road, Mitcham, Surrey. A large stamped addressed envelope would be appreciated.

Tone Booster

Last month we mentioned that the printed circuit board for the *Tone Booster* could be purchased from Davian Electronics.

We are happy to report that they are now able to supply a complete kit of parts, including p.c.b., for the sum of £3·56 including V.A.T. and postage.

Readers should write to Davian Electronics, Dept EE, 13 Deepdale Avenue, Royton, Oldham, OL2 6XD.

Constructional Projects

Judging by last year's response to the *Teach-In '78* series, the *TTL Electronic Test-Bed* project that has been specially designed for testing the circuits in our new major beginners series *Doing It Digitally* should be very popular.

In view of the importance of this new series we have circularised our advertisers regarding complete kits of components for both the *TTL Electronic Test-Bed* and the first six parts of *Doing It Digitally* and a special listing, together with prices, appears on page 754.

Probably one of the most popular projects published in this magazine has been metal locators. This month we present the *Treasure Hunter* and readers should have no difficulty in obtaining parts.

As the project is constructed on a printed circuit board it is wise to ensure that the components will fit the board before they are purchased. The preset potentiometers called for in this project were the Piher PT15. Here again any type can be used provided they fit the board.

The framework and housing of the search coil is fairly novel and worth further mention. To give it a "professional" appearance it was decided to use plastics overflow tubing and T-pieces, together with mounting clips. These are available through DIY shops or Builders' Merchants. Another alternative would be electrical conduit tubing with threaded connections.

During our investigations for a suitable search coil cover plate, Arrow Electronics have had a suitable cover made specially for the job and are also prepared to supply all components and hardware for the *Treasure Hunter* for the sum of £16·45. Readers should write to Arrow Electronics, Dept. EE, Leader House, Coptfold Road, Brentwood, Essex.

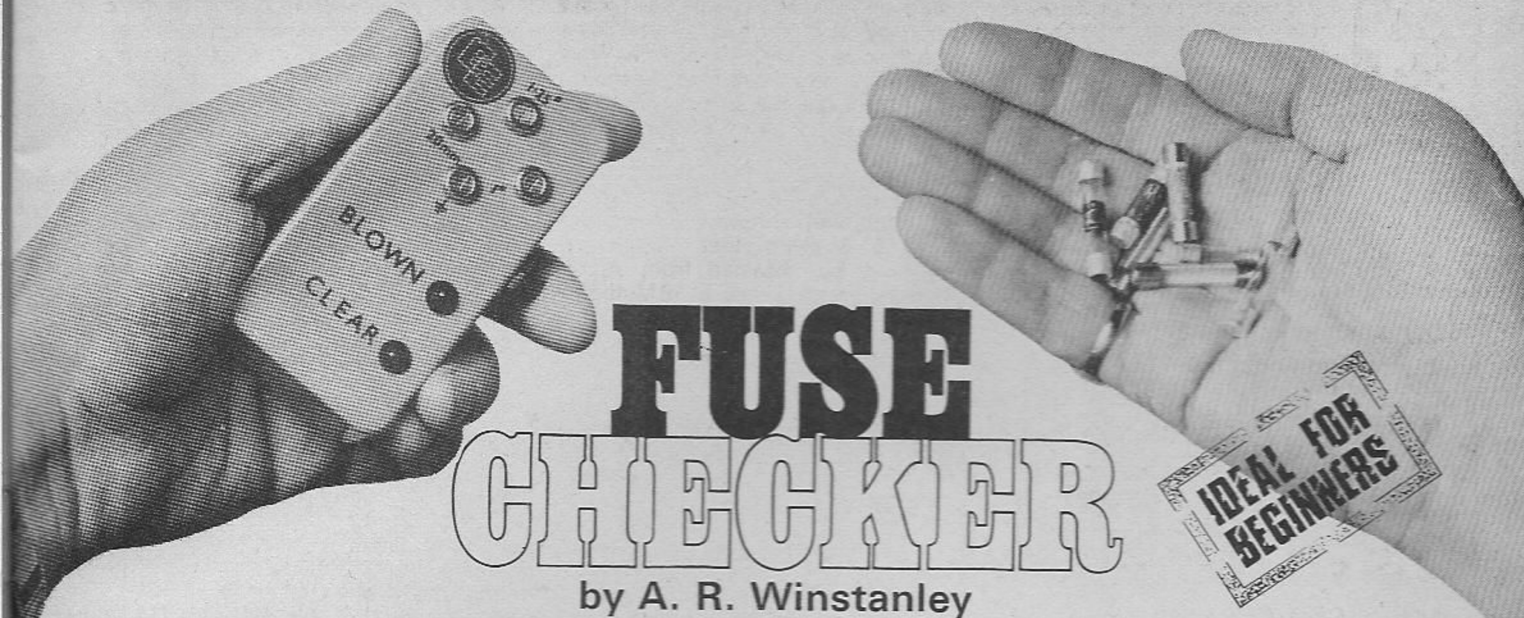
The plastic cases housing the detector circuit and the meter case are Bimbox types BIM4003 and 2005/15 available from Boss Industrial Mouldings Ltd., Dept. EE, Higgs Industrial Estate, 2 Herne Hill Road, London, SE24 0AV. Mail Order only.

Looking at the *CMOS MW/LW Radio* there should be no component problems. The ferrite rod and coil L1/L2, with mounting clips, is available from Ambit International. Any other standard medium/long wave coil can be used. The ferrite rod diameter is 9·5mm and 140mm long.

The tuning trimmer capacitor called for is available from Bi-Pak or Greenweld. The 60pF trimmer C2 is obtainable from Ambit International, 2 Gresham Road, Brentwood, Essex.

The only point to mention regarding the *Fuse Checker* is that when purchasing the l.e.d.s make sure that the mounting clips are supplied. The case used in the prototype is the BIM 2002/12.

Finally, a word about the *Mini Modules*. These projects have been specially designed to familarise the newcomer with various methods of construction and the components used have been taken from the "spares box". Readers should be able to find components from their own spares as tolerances are not critical.



FUSE CHECKER

by A. R. Winstanley

WE HAVE all probably come across the instance where we have a rather dubious fuse in our hand and we can not tell whether it is blown or not. This is especially the case with the ceramic types fitted in most plugs.

The normal course of action is to throw the fuse away and replace it with a new one, alternatively the more sophisticated of us might go for the good old battery and bulb or even the ohmeter. Normally by this time the fuse has rolled away into some inaccessible corner and so a new fuse might as well be fitted anyway! How many people have chased a fuse around the surface of a table with a pair of multimeter probes?

The unit described here has been designed to conveniently check all types of fuse generally used. These are the 1¼ inch and 20mm glass types, and the 1 inch ceramic fuse used in plugs.

Operation of the device is very simple; the fuse to be tested is placed across two studs on the case and a push button is pressed. If the fuse is intact then a light emitting diode designated CLEAR illuminates, and similarly if the fuse has blown, a corresponding light emitting diode glows (BLOWN).

There exists an argument that you do not need such a tester for glass fuses because you can see the fuse wire inside and tell whether it has melted or not. In certain cases this is of course perfectly true, but using the unit to be described is considerably easier and more certain than having to squint through a glass tube at a microscopically-thin strand of wire.

No doubt this checker will prove a boon to those whose eyes are not what they used to be, or those who generally discard questionable fuses regardless.

CIRCUIT DESCRIPTION

The circuit diagram of the Fuse Checker appears in Fig. 1. As soon as S1 is pushed, power is applied to the circuit, and one of the l.e.d.s illuminates.

Which one it is that glows, depends on the fuse under test. Assume firstly that the fuse is blown, therefore D3 cannot illuminate because its cathode is not connected to 0V. Current can however flow through R1, D1 and D2, which illuminates to show that the fuse being tested is blown.

Because D1 is carrying current, about 0·6V appears across it. Similarly approximately 2V appears across the illuminated l.e.d.

VOLTAGE ANALYSIS

Referring to Fig. 2 this shows how the voltages are split up across the various components. It can be seen that 6·4V is left across the resistor which limits the current flowing through the l.e.d. to a safe value, 29mA.

In the case of an intact fuse diode D3 is now able to illuminate

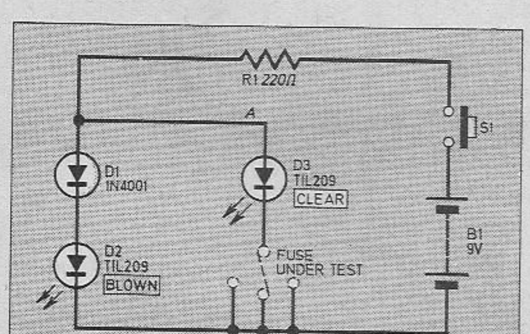


Fig. 1. Circuit diagram of the Fuse Checker.

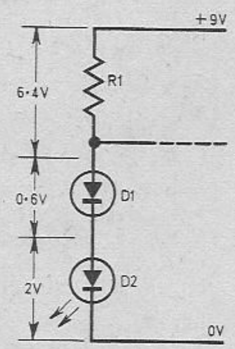


Fig. 2. Voltage analysis of the circuit with a blown fuse.

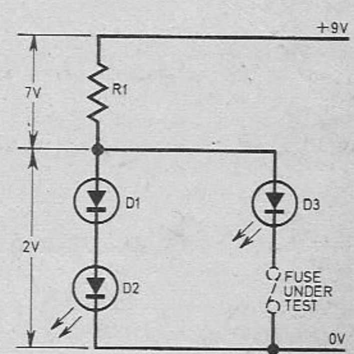
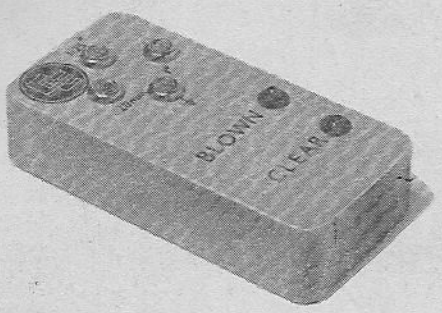


Fig. 3. Voltage analysis of the circuit with a good fuse.

FUSE CHECKER



COMPONENTS approximate cost £2.00

COMPONENTS

Resistors
R1 220Ω ½W carbon 5%

Semiconductors
D1 1N4001 silicon
D2 TIL209 red light emitting diode
D3 TIL209 green light emitting diode

Miscellaneous
S1 push-to-make release-to-break
B1 9V PP3 battery
Plastic case 100 × 50 × 25mm; 6BA hardware; four small screw cups; mounting clips for D2 and D3; connecting wire; battery clip to suit B1.

See **Shop Talk** page 720

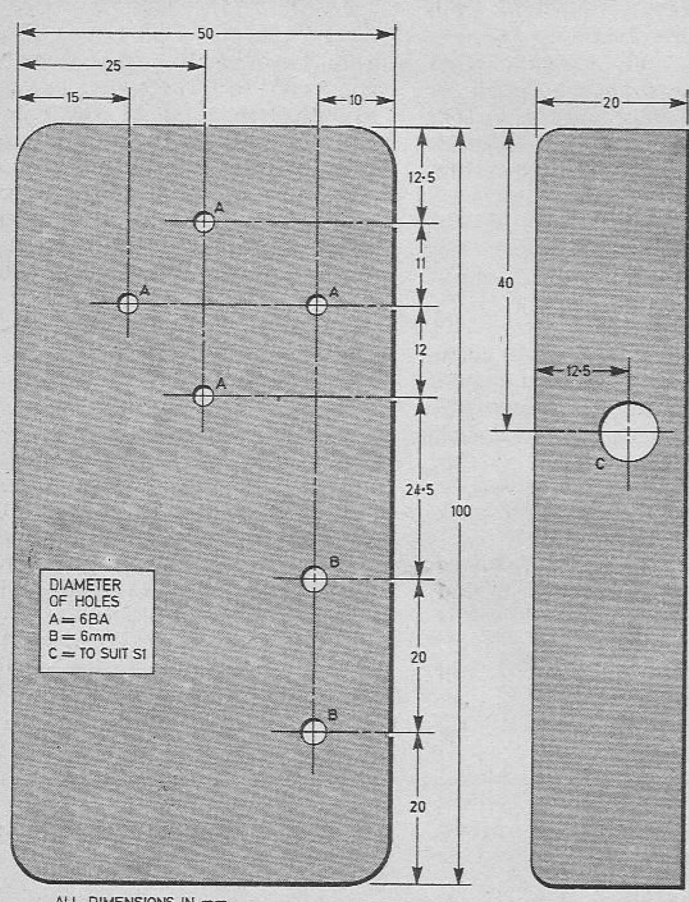


Fig. 4. Case drilling details. It is important that the distances between the four holes "A" are exact. Otherwise the fuses will not bridge them properly and may cause incorrect reading.

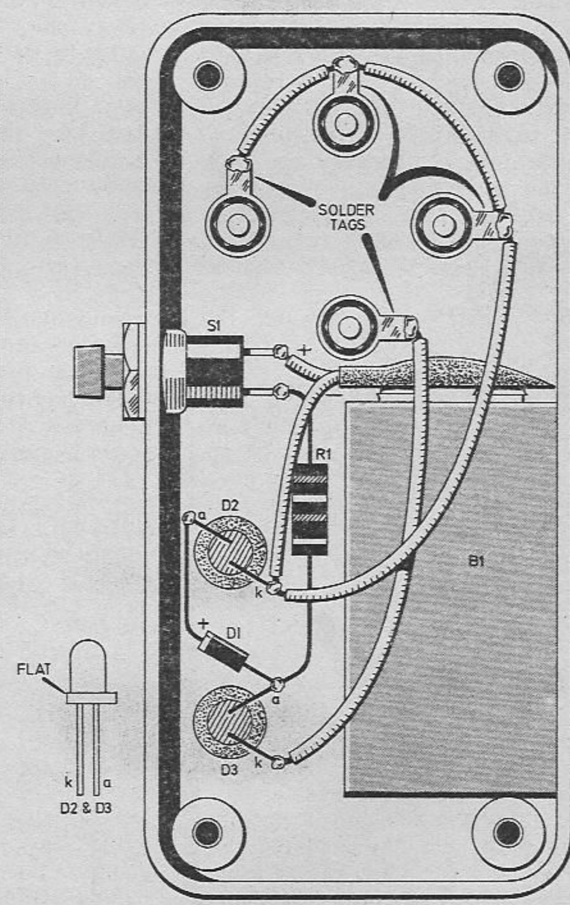


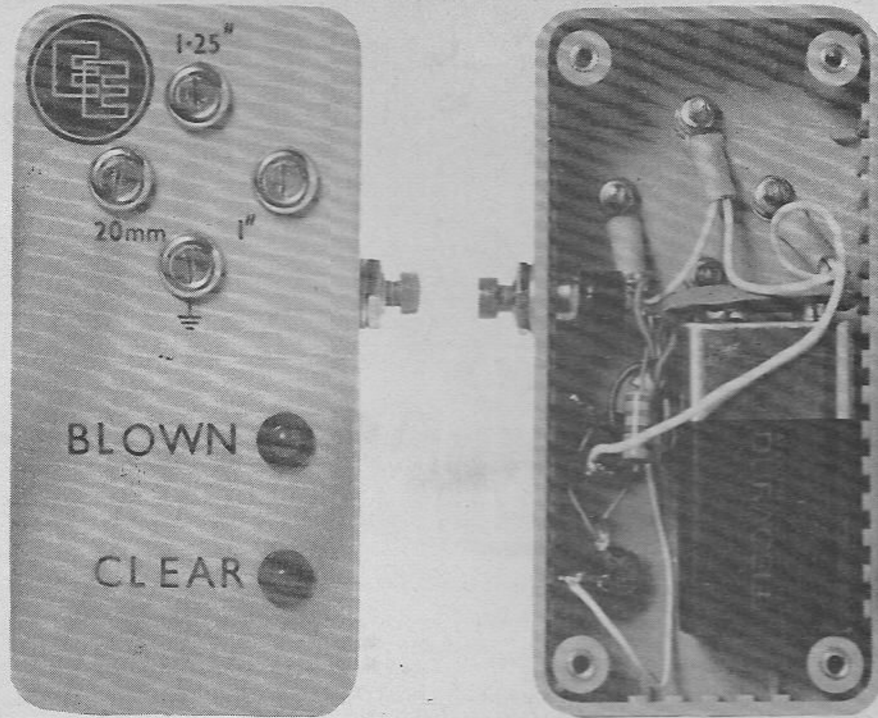
Fig. 5. Complete wiring details for the unit. Remember to solder the solder tags on to the wires before fitting them finally in place, otherwise the plastic case will melt from the heat of the iron.

because its cathode is taken through the fuse to 0V. As it is glowing, about 2V appears across it Fig. 3. But for D2 to glow, 2V must appear across it and a further 0·6V across D1, that is point *A*, Fig. 1 must be at 2·6V with respect to 0V.

However, with D3 glowing, point *A* is only at 2V and this of course is not enough to forward-bias D1 and D2. So if an intact fuse is checked, D3 illuminates and D2 is forced to extinguish, using a method called "current shunting"—D3 shunts current away from D1 and D2.

It will be seen from Fig 3 that the voltage appearing across R1 is now 7V and so a current of 31mA now flows through D3. As only 29mA flows through D2 when a blown fuse is connected, the CLEAR indicator will glow more brightly than the BLOWN lamp.

This effect will become more noticeable as the battery begins to age.



External and interior photographs of the completed Fuse Checker.

CONSTRUCTION starts here

The prototype was built into an orange ABS box measuring 100 x 50 x 25mm. This was a convenient size which slipped neatly into the palm of the hand. Of course, any other case could be used, but in this particular instance it must be made of plastic or similar non-conducting material.

CASE DRILLING

Construction starts with the case which is drilled to take the four studs, the switch and two indicators Fig. 4. All necessary lettering should be carried out at this stage, and the case should then be sprayed with clear lacquer.

Fix the push switch onto the side of the case, and then mount the two l.e.d.s using the special clips provided with each one. The leads will need to be cut back to about 25mm. Also once the l.e.d.s are in place, it will not be possible to see the cathode identification notches on the bodies, and so the cathode lead must be identified with a mark before mounting onto the case. You could, for example, cut the cathode lead shorter than the anode lead.

WIRING

Next carry out all of the interwiring as shown in Fig. 5. Be careful not to overheat any of the components, especially the semiconductors. Constructors who do not have too much experience soldering semiconductors are advised to use a heatshunt on the necessary leads.

If there is any danger of wires shorting out, they can be insulated with p.v.c. sleeving, which is slipped over one of the leads before soldering, and then slid over the soldered joint.

There are four studs on the case which allow the testing of the three common sizes of fuse (one stud is common). The studs consist of 6BA countersunk screws with a small screw cup fitted under each head.

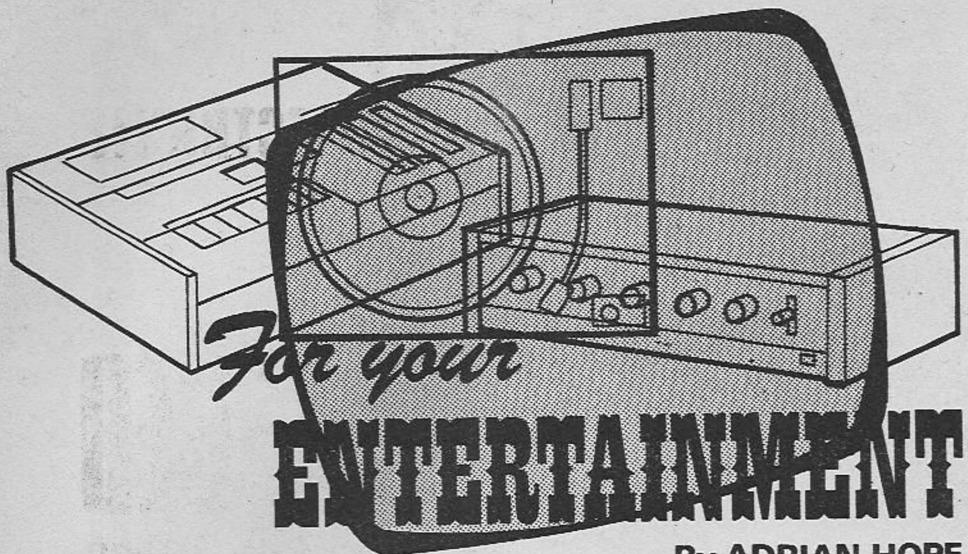
Connections to the studs are made by 6BA solder tags placed under the nuts. The connection to the solder tag should be soldered before the tag is placed under the nut, otherwise the heated solder tag would melt the case.

Finally check all of the wiring for any mistakes, making sure that the l.e.d.s have been soldered the right way round. Clip on the battery and push the battery into the case, where it fits snugly. A piece of foam rubber glued onto the inside of the removable lid of the case will hold the battery tightly in place when the lid is screwed down.

TESTING

Press the pushbutton without placing a fuse across the terminals; this will cause the BLOWN indicator to glow. Now hold a good fuse across the appropriately-spaced terminals. For example the common and one inch terminal for ceramic fuses, and press the switch. The CLEAR indicator will illuminate but of course the BLOWN l.e.d. should not. This completes the testing of the unit which is now ready for use.

A battery life in excess of one year could possibly be expected, but it would be wise to check the battery condition occasionally if the tester is not used for a long period. If neither l.e.d. illuminates, then this is a sure sign of battery failure. ⌑



For your ENTERTAINMENT

By ADRIAN HOPE

Development of Microwaves

A chart of the electro-magnetic spectrum, which lists all the radio, TV and radar frequency allocations, shows that the frequency 2450MHz is set aside for cooking rather than communication.

This frequency is the wavelength allocated for microwave ovens and it all began in the Summer of 1940. Two scientists in the physics department of the University of Birmingham, John Randall and Henry Boot finally achieved success with what they christened a "magnetron". The invention was patented and you can still read the original description and look at the original technical drawings as published in British patent no. 588 185 even though the patent is, of course, long since legally dead.

The magnetron was really a combination of an electronic valve and heavy duty magnet. In a manner which at the time of patenting even the inventors clearly did not understand, electrons emitted by the valve filaments were spun in spiral paths by the joint action of electrostatic and magnetic fields. The spiralling electrons hit a resonant frequency to produce a high power output of very high frequency, short wavelength radio waves.

Radar

One of the first magnetrons built by Randall and Boot oscillated to produce radio waves of 9·9cm wavelength. This was exactly what radar engineers had been praying for; a generator of high power, short wavelength signals that could be beamed up into the sky to reflect off relatively small moving targets, such as aircraft, and so give an accurate tell-tale indication of the target position. And that was how high resolution radar, which helped win us the war and enables aircraft to fly blind today, was born.

Microwave Ovens

Even by the time the war was over another interesting use of the magnetron had been discovered. As early as 1947 some hotels were experimenting with massive magnetrons to cook food and dry milk. This is possible because the microwave signals generated by the magnetron are soaked up by such organic materials and converted into heat.

One suggestion is that the microwave energy causes the molecules of the food to vibrate very rapidly and generate heat by mutual friction, rather as our hands get hot when we rub them together. A lump of meat will cook very rapidly when bathed in microwave energy.

Sadly it doesn't matter whether the meat is alive or dead. Recently an American lady tried to dry her pet poodle after a shampoo by putting it in a microwave oven. The poor creature died almost immediately, literally cooked alive. The owner's mistake was almost understandable. It is only the organic material which absorbs the energy and gets hot while everything else including the oven walls stay cold. Also the material gets hot internally and cooks from the inside out.

Microwave Cooking

All microwave ovens operate on the fixed frequency 2450MHz because this way they cause no interference to radar systems which operate on other micro-wavelengths.

It's likely that microwave cooking will become more and more popular as the price of electricity increases, because with all the heat generated inside the food, there is very high overall efficiency of energy conversion.

An oven which draws 1200 watts from the mains will beam 600 watts of microwave energy into the food and fully cook a 3lb leg of lamb in 22 minutes or a fillet of plaice in 2 minutes. Anyone (like myself) dismayed at the inefficiency of conventional electric cooking, where energy is first wasted on heating up an oven or ring and then again as it cools down after cooking, could well find the instant heating effect of a microwave oven a worthwhile investment.

Some points are worth bearing in mind, however. Not all foods cook well and taste good with microwave cooking. Also beware of putting even the smallest piece of metal in a microwave oven. Eddy currents will be generated that cause dramatic, but potentially very expensive, arcing.

Last but not least oven users should bear in mind at all times the very real danger of exposing any part of the human body to microwaves. Never, ever override the safety locks which are designed to prevent the magnetron from working when the oven door is open. It isn't just a question of burning your hands by exposing them to microwaves inside the oven cabinet; there is growing evidence that cataract eye damage can be caused from microwaves leaking out of a faulty oven.

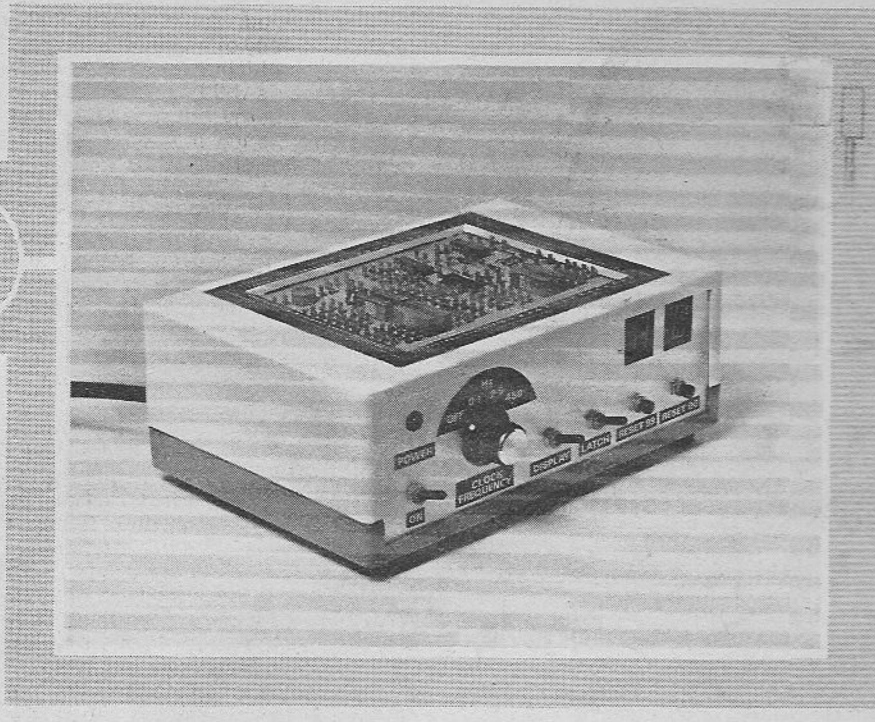
Lightning Arrest

A friend and I "collect" bureaucratic and technological absurdities. A recent thunderstorm reminded us of one of the best. New buildings often have a lightning striker "aerial" standing a foot or so proud of the highest point of the roof and connected to earth via a heavy duty feed down the building wall.

The idea, of course, is that if lightning strikes the building it will hit the nearest conductive path to earth, which is the striker. Fine. But almost without exception something happens after a new building has been completed. A firm of aerial contractors moves in and instals TV and F.M. radio aerials which stand many, many feet proud of the lightning striker.

In the old days aerials often used to have a lightning arrestor in the feed down to the radio set. These arrestors were often simply a T-junction with a small air gap to earth. The theory was that the lightning took the air gap route to earth rather than blitzing the radio set.

I've never seen a lightning arrestor on a modern aerial system and they certainly aren't widely advertised for sale. But with modern solid-state components it should be easy to design a much more reliable type with a controlled breakdown voltage. Enthusiasts might like to get working on the project this weekend.



TTL ELECTRONIC TEST-BED

By O. N. Bishop

To EXPERIMENT with logic integrated circuits one needs a method of mounting them temporarily and making electrical connections to them. A source of current is a basic requirement and a way of applying high and low voltages to the i.c. input terminals. Also one needs a means of detecting and displaying the states of the outputs of the logic gates. All these facilities and more are provided by the TTL Electronic Test-Bed.

Although this unit has been designed specifically for the *Doing It Digitally* series starting this month, many will find it an invaluable aid to logic experiments and system design in its own right.

Circuits may be constructed on the Test-Bed rapidly without the need for a soldering iron thereby allowing components to be re-used. Interwiring between circuit elements is accomplished by means of plug-in wiring and component leads.

MAINS OR BATTERY

The unit to be described here has a mains derived power supply unit but if desired this may be replaced by suitable batteries. Beginners may prefer to use a battery as this simplifies construction and there are no worries about having mains voltages on certain parts of the circuit.

On the other hand a circuit consisting of several TTL i.c.s. plus a display can draw a heavy current and batteries will not last long before needing replacement. The mains derived supply, though more expensive in the initial outlay, is more economical in the end if used for extensive experimenting and designing.

If deciding on the battery version, ignore the circuitry from the mains input up to decoupling capacitor C3 with the exception of S1 which should be placed in the battery positive lead.

CIRCUITRY

All the circuitry contained in the TTL Electronic Test-Bed is shown in Fig. 1 and is seen to consist of six distinct sections: power supply, clock generator, a latching circuit, two seven-segment displays including drivers, a group of three basic logic elements (a bistable, 2-input NAND gate and an inverter) and two counting elements. In addition an array of four l.e.d.s are included which can be used to monitor output levels of the gates.

All necessary inputs and outputs of these sections are available at pluggable sockets (pins) on the main "test-bed" board; also, certain parameters are controlled by switches on the front panel.

COMPONENTS approximate cost £24.00

POWER SUPPLY

The power supply section is a conventional full-wave regulated type producing a smooth 5 volt output under varying load conditions. When supplying 0·5 amp the prototype output voltage dropped by only 0·2 volt. A supply of 0·7 amps may be drawn without reducing the voltage sufficiently to affect the operation of the logic circuits.

The mains voltage is stepped down to 6 volts a.c. by T1 and is then rectified by the diode bridge to produce pulsed d.c. This is smoothed by C1 to produce a steady d.c. level of 7·8 volts $[(1\cdot4\times6)\text{ V}-0\cdot6\text{ V}]$ and is applied to R1 and D5, a 5·6 volt Zener diode which clamps the base voltage of TR1 at this value. There is a 0·6 volt drop across the base/emitter function of TR1 producing about 5 volts at the emitter which charges C2 to this level.

When a large current is drawn from the circuit, C2 begins to discharge, and the voltage at the

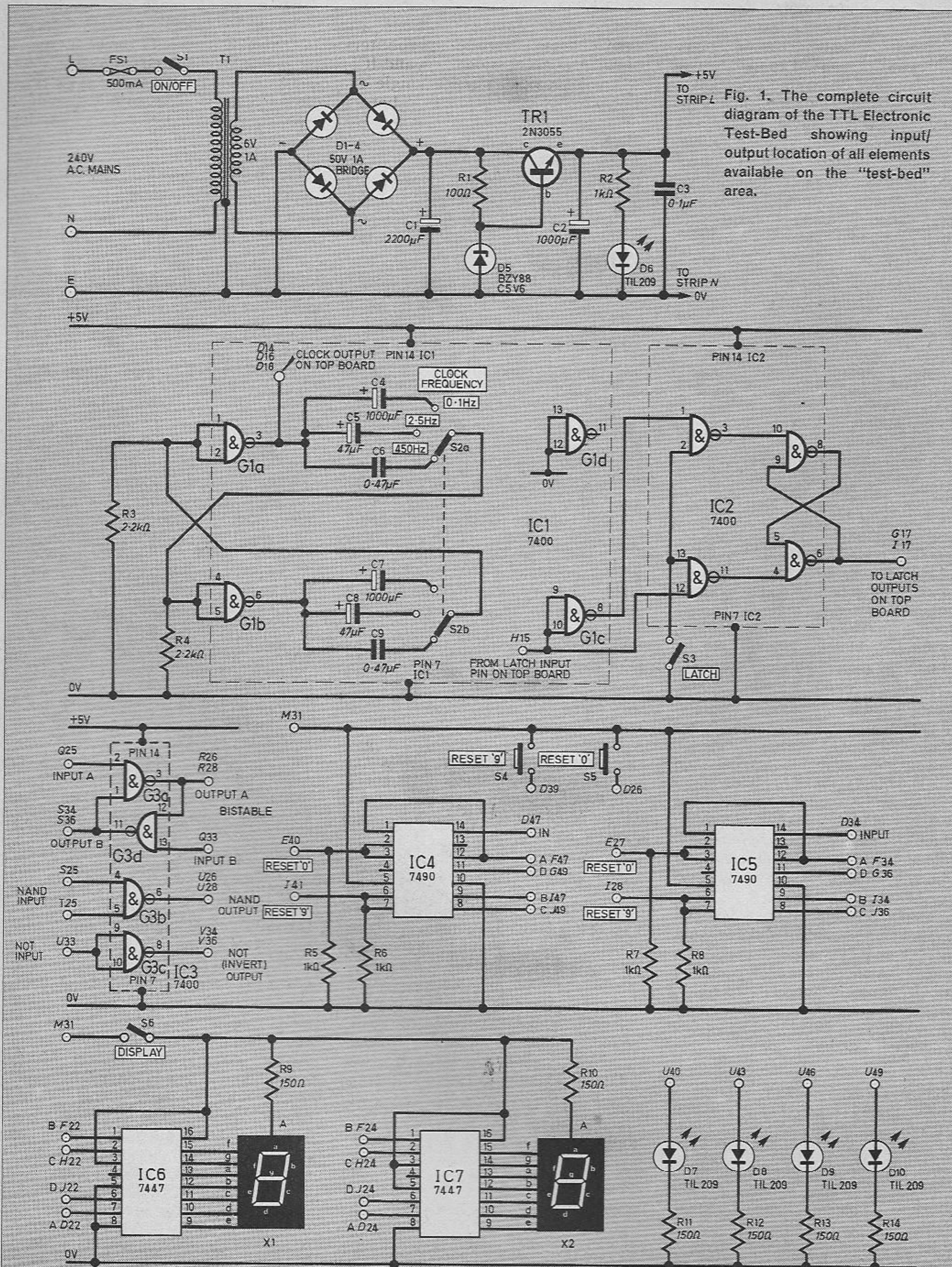


Fig. 1. The complete circuit diagram of the TTL Electronic Test-Bed showing input/output location of all elements available on the "test-bed" area.

emitter begins to fall. But the voltage at its base remains unaltered at 5·6 volts. Thus the base/emitter voltage tends to increase, causing the increased current to flow to the base thereby turning TR1 more fully on. This allows a larger current to flow to C2 and the load circuits, and restores the output voltage to 5 volts.

When a small current is being drawn, the output voltage tends to rise above 5 volts, but this tendency reduces the base/emitter voltage. Base current is thus reduced, TR1 is turned slightly off and less current flows through it. The effect is to restore the output voltage to 5 volts.

LOGIC CIRCUITS

The clock generator consists of two NAND gates of IC1 wired as inverters and cross-connected to form an astable multivibrator. The frequency of the output pulses is dependent on the values of the coupling capacitors and the resistors. In the prototype the frequencies were measured as 0·1, 2·5 and 450Hz for the three on positions. If other clock rates are required the capacitors can be changed or the numbers increased to suit.

The clock output is brought to three pins on the Test-Bed (*D*14, *D*16 and *D*18) to allow pluggable connections to inputs of other circuits.

The latch circuit is made up from five NAND gates, four of these located in one package IC2, and the fifth, G1c, from IC1 connected as an inverter. The output from this circuit follows the level at the latch input. When S4 is closed, the output maintains the level of the input at the time S4 is operated, regardless of further input level changes.

Input and output connections to the latch are available via pluggable pins on the test bed at location *H*15 and *G*17, *I*17 respectively.

The two independent 7-segment displays are each fed by the usual TTL decoder/driver i.c., 7447. The seven outputs from each of these i.c.s are wired to the displays. There are four inputs to each 7447 which receive a four-bit binary number. Inputs to these devices are provided on the Test-Bed at locations *F*22, *H*22, *J*22 and *D*22 for X1 and *F*24, *H*24, *J*24 and *D*24 for X2. Decoder IC6 is wired to suppress the display of digit "0" on X1.

The two counting sections are provided by decade up-counters type 7490 in locations IC4 and IC5.

These devices have a single input pin and the output is in binary code to indicate the number of changes from high to low received at the input. For example, if three pulses are inputted, the binary equivalent of three appears at the outputs *DCBA* (0011) where 1 represents a high level and 0 a low level.

The i.c.s. are wired in the count mode, with an inbuilt facility for resetting to zero or nine.

Detailed circuit operation of the logic circuits will be dealt with in the *Doing It Digitally* series as they occur.

CONSTRUCTION starts here

CONSTRUCTION

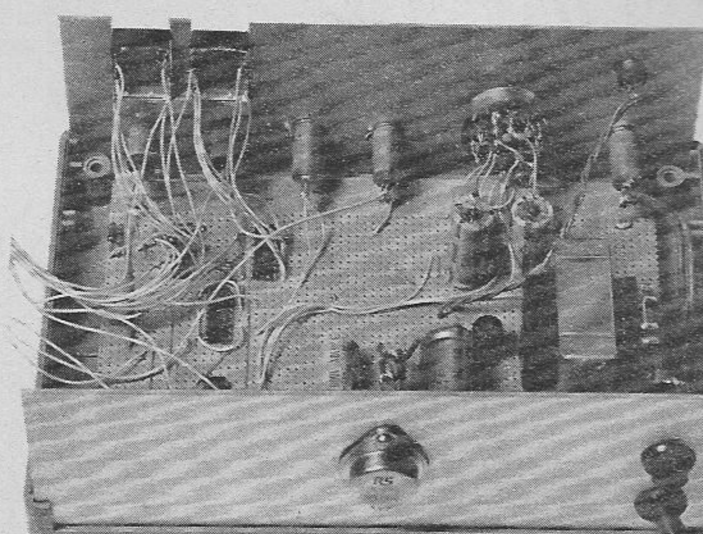
The TTL Electronic Test-Bed uses two pieces of stripboard in its construction, one board fitted to the base of the case holding the power supply unit, clock, latch and display decoder/driver circuitry. Controls for these sections are located on the front panel of the unit. The second board is fitted to the top of the case and holds the counting circuits, and the three basic logic elements for connection in experimental circuits. The top board is also fitted with i.c. sockets and Soldercon pins to allow solderless interconnections between devices.

Begin construction by preparing the front panel to accept the various controls and displays as shown in Fig. 2. The cut-outs for the displays should be made when the latter are at hand, and should be made just large enough to allow them to fit. A piece of aluminium angle is glued to the rear face of the front panel and positioned for the displays to be glued to this and fit flush in the display windows. A quick setting epoxy adhesive was found to be satisfactory in the prototype.

The back should next be prepared to accept the fuseholder, mains cable grommet and the power transistor TR1. It is important that a mica washer and insulating bushes are used when mounting TR1 to electrically isolate it from the back panel. The connection to the collector terminal of TR1 is internally connected to the transistor case. Connection to this is made via one of the fixings and a soldertag, see Fig. 3 for details.

LOWER BOARD

The layout of the components on the lower board is shown in Fig. 2. The breaks in the copper strips and the fixing hole positions for



Interior view of the finished unit showing front panel components wired to the lower circuit board.

the board and transformer are shown in Fig. 4. Make all of these breaks and then assemble the power supply components accordingly to Fig. 2. Note that Veropins are used for connections at the board to TR1 for ease which will become apparent later.

With the transformer used in the prototype, the two secondary windings were connected in parallel to provide a 6 volt 1 amp secondary. Also, the connections of the secondary to the board were made by tinned copper wire directly from board to secondary tags. This may not be possible with some transformers and may have to be made differently.

TESTING THE POWER SUPPLY

With the power supply wired up this may now be tested. When switched on the front panel l.e.d. should light up. With your voltmeter switched to read 10 volts a.c. full scale check that the output from the secondary winding of T1 is 6 volts a.c.

Remove the probes and set the multimeter to read d.c. volts and check that the voltage across C1 is about 7·8 volts. Now check the voltage across C2, this should be about 5 volts.

If it is wished to test the supply

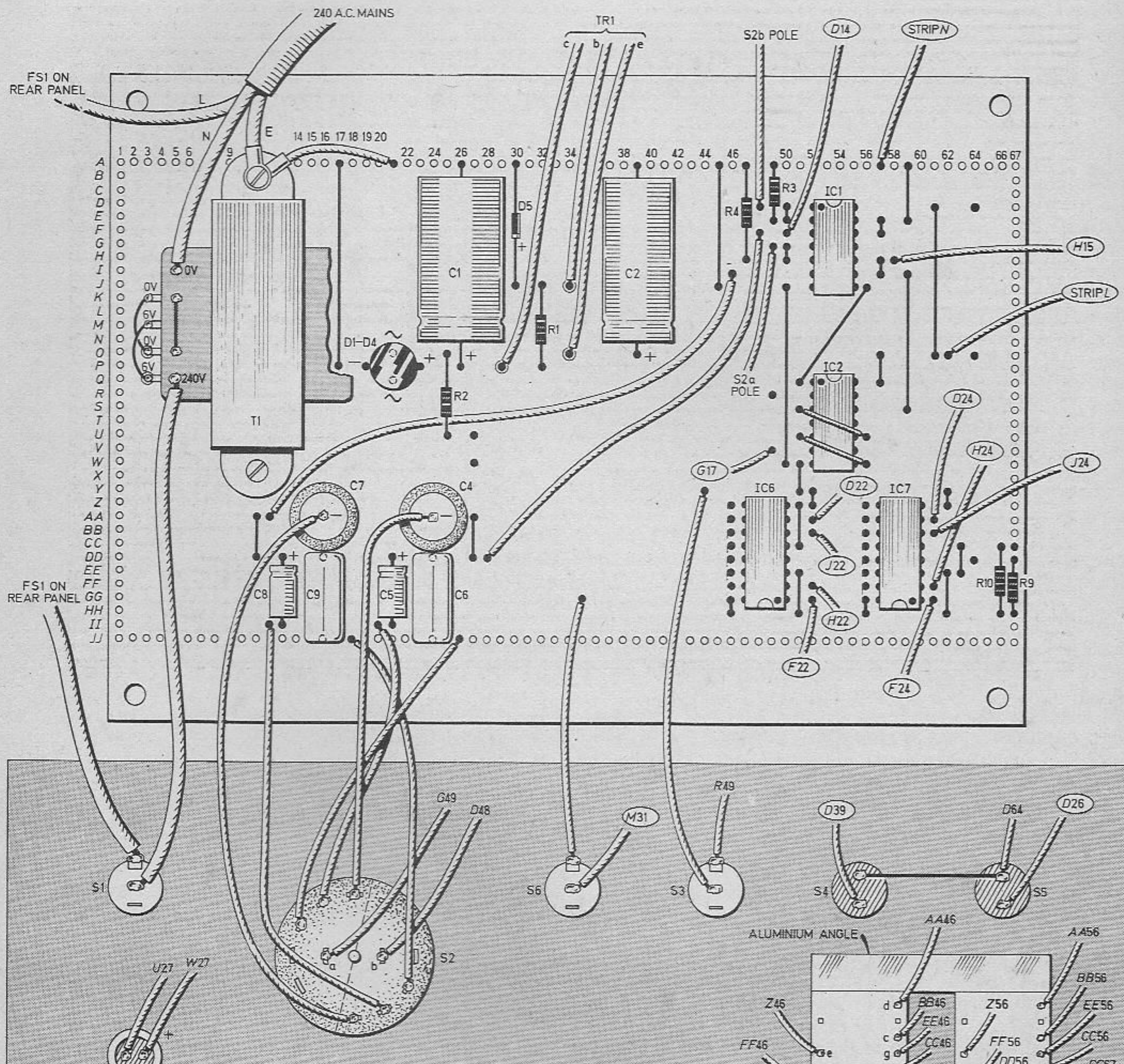


Fig. 2. The layout of the components on the topside of the lower board, front panel components and interwiring. The stripboard locations encircled refer to connection points on the underside of the top "test-bed" board.

under load, a 10 ohm 2·5 watt resistor may be connected across C2. The reading across C2 should not decrease by more than about 0·1 volt. A 6·8 ohm 3·5 watt resistor connected across C2 should not decrease the voltmeter reading by more than about 0·3 volt.

This circuit has voltage regulation but it does not have current limiting features. If too large a current is drawn (e.g. when there is an accidental short circuit in the load) voltage falls appreciably. The panel l.e.d. then glows only dimly, or not at all, giving warning that something is wrong which should be investigated immediately.

If all is well the remainder of the components may be assembled on this board and wired up to the front panel components. Some constructors and followers of *Doing It Digitally* may wish to use i.c. sockets to hold IC1, IC2, IC6 and IC7 and insert these at the appropriate time.

Suitable lengths of insulated wiring to reach the upper board when fitted should now be attached to the front panel and lower board, which can then be secured to the lower section of the case.

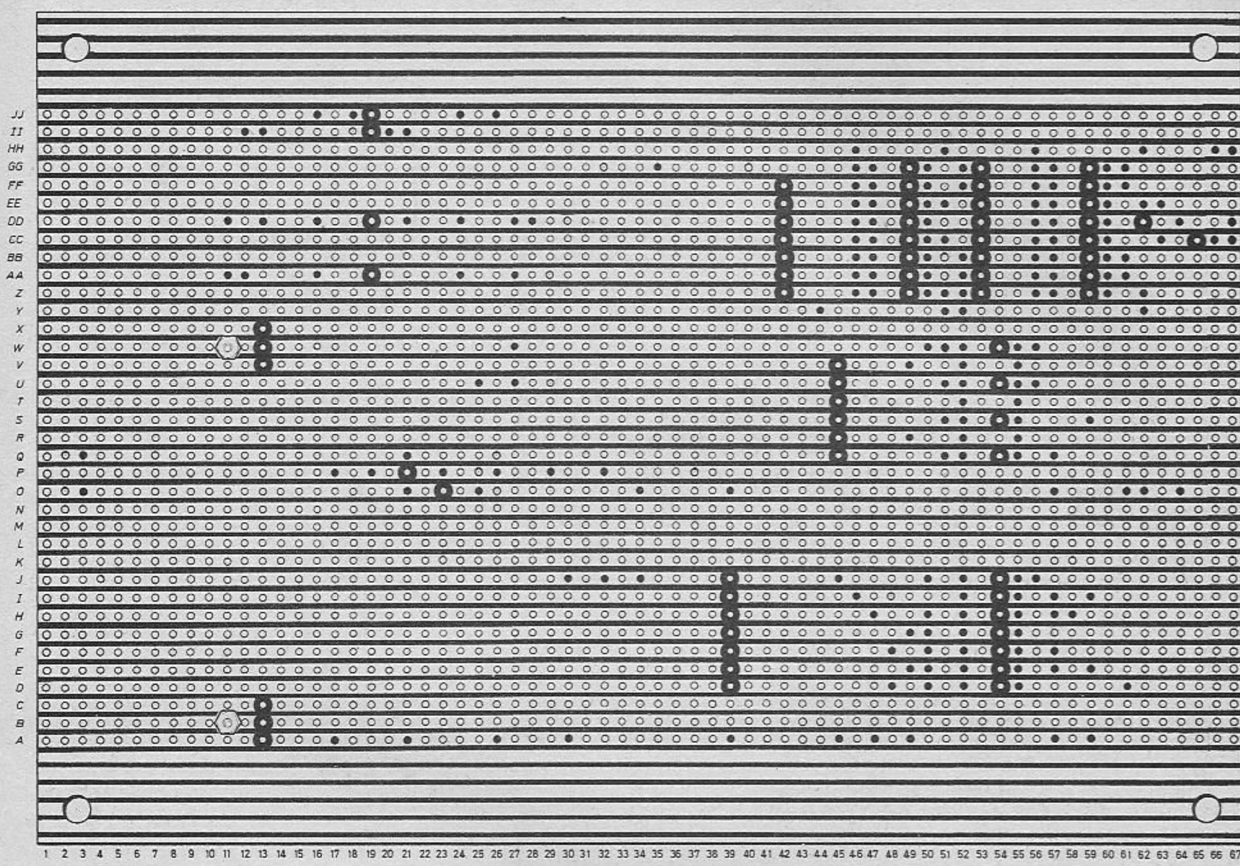


Fig. 4. The breaks and fixing holes to be made on the underside of the circuit board holding the power supply, clock and display section.

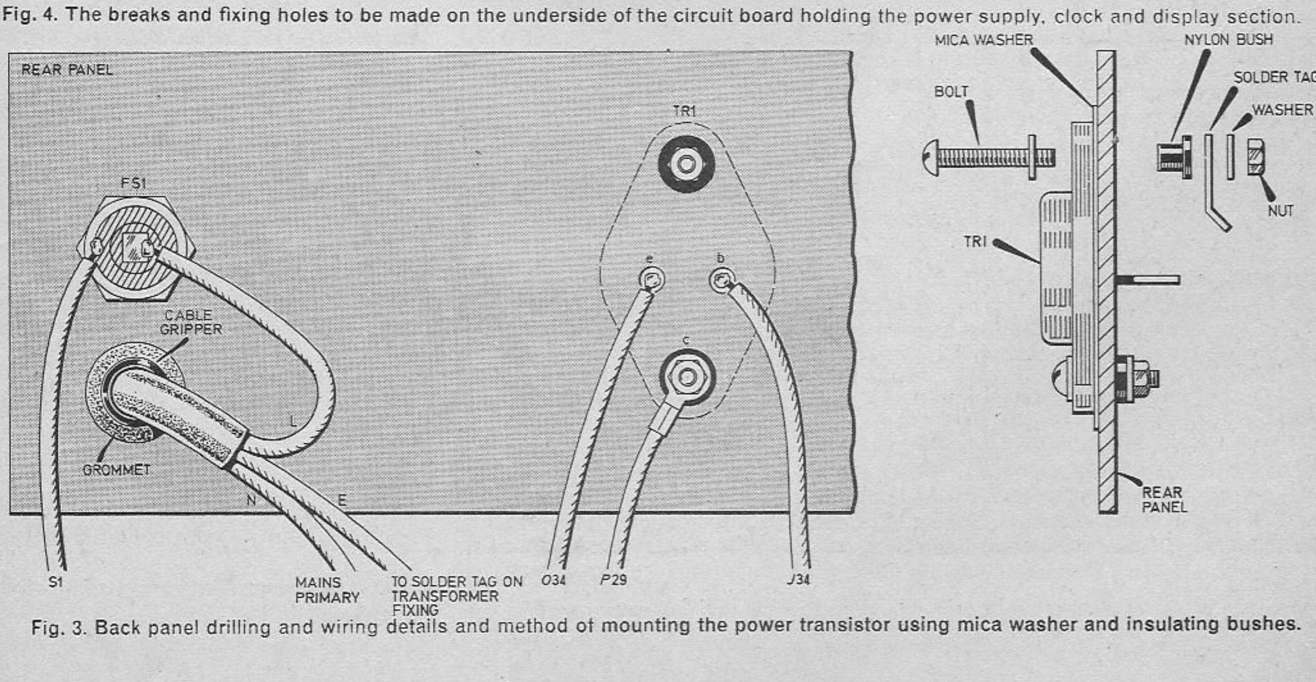
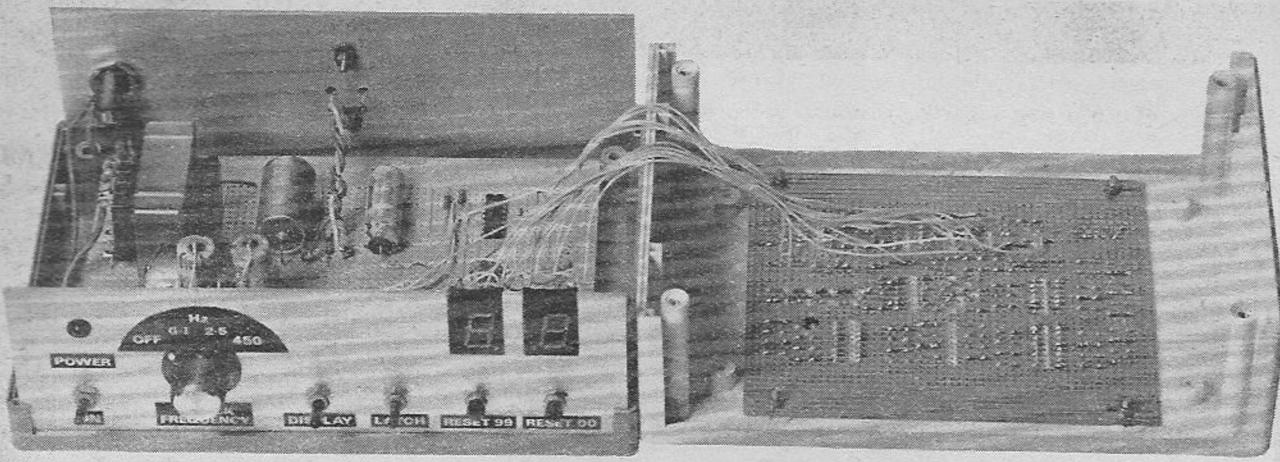


Fig. 3. Back panel drilling and wiring details and method of mounting the power transistor using mica washer and insulating bushes.



The completed TTL Electronic Test-Bed with top section removed to show interwiring between the two sections.

COMPONENTS

For a complete list of suppliers for this project see page 754.

Resistors

R1	100Ω	R6	1kΩ	R11	150Ω
R2	1kΩ	R7	1kΩ	R12	150Ω
R3	2·2kΩ	R8	1kΩ	R13	150Ω
R4	2·2kΩ	R9	150Ω	R14	150Ω
R5	1kΩ	R10	150Ω		

All ¼ watt carbon ± 10%

Capacitors

C1	2200μF 10V elect.	C6	0·47μF polyester
C2	1000μF 10V elect.	C7	1000μF 10V elect.
C3	0·1μF polyester	C8	47μF 10V elect.
C4	1000μF 10V elect.	C9	0·47μF polyester
C5	47μF 10V elect.		

Semiconductors

D1-D4	W005 50V 1A bridge rectifier
D5	BZY88C5V6 5·6V 400mW Zener diode
D6	TIL209 panel mounting l.e.d. including mounting bush/clip
D7-D10	TIL209 light emitting diodes (4 off)
TR1	2N3055 silicon *npn* TO-3 case-style
X1, X2	seven-segment display, common anode (2 off)

ntegrated Circuits

ICl,2,3	7400 quad 2-input NAND gate (3 off)
IC4,5	7490 decade up-counter (2 off)
IC6,7	7447 seven segment decoder/driver (2 off)

Switches

S1	s.p.s.t. miniature mains toggle
S2	2-pole 4-way rotary
S3	s.p.s.t. miniature toggle
S4,5	push-to-make, release-to-break button (2 off)
S6	s.p.s.t. miniature toggle

See Shop Talk page 720

Miscellaneous

T1 Mains primary/6 volt 1 amp secondary
FS1 20mm 500mA fuse and panel mounting fuseholder
Stripboard: 0·1 inch matrix, 46 strips × 57 holes and 46 strips × 67 holes; Verocase type 751411D; 16-pin d.i.l. socket (2 off); 14 pin d.i.l. socket; TO-5 or TO-18 type transistor socket; Soldercon pins (250 off); TO-3 mounting kit for TR1; knob with skirt and marker; sleeved grommet; three-core mains cable (2 metres); mains cable retaining clip or bush; single-sided Veropins (3-off); 20 s.w.g. tinned copper wire (1 metre); lightweight stranded insulated wire (5 metres); 4BA fixings; nuts, 6mm bolts, washers, solder tags (2 off each); 6BA fixings; nuts (6 off), 12mm countersunk bolts (4 off), 12mm cheesehead bolts (2 off), washers (8 off), solder tag; 6mm aluminium right angle bracket, 42mm long.

TEST-BED BOARD

The layout of the components on the top board and the breaks to be made on the underside are shown in Figs. 5a and b. Begin by making the breaks and drilling the four fixing holes and then mount three i.c. sockets and the transistor socket.

The sockets can then be used as reference for mounting the Soldercon pins; the latter are supplied joined together in strips of 50, spaced at intervals of 0·1 inch and can be detached from the strip by bending along a preformed line.

An easy way of mounting these pins is to deal with one column of the board at a time and use a length of 36 attached pins, and "plug" single pins on this according to the column being fitted.

Note that C3 is fitted across the supply rails on the underside of the top board, i.e. between strips *L* and *N*. Next fit the link wires and the eight resistors. The i.c.s on the top panel, can now be connected, either soldered directly to the board or in sockets. Conventional d.i.l. sockets cannot be used due to their overall size, but use can be made of Soldercon pins.

Finally connect the four light-emitting diodes paying attention to polarity. A small flat (index) on the plastic body is alongside the cathode (+) terminal.

The next stage is to cut a rectangular aperture in the top panel to allow access to the Test-Bed area when the board is fitted to the underside of the top panel. For neatness and quick location of connection points, countersunk bolts should be used and a reference grid glued in position around the perimeter of the cut-out.

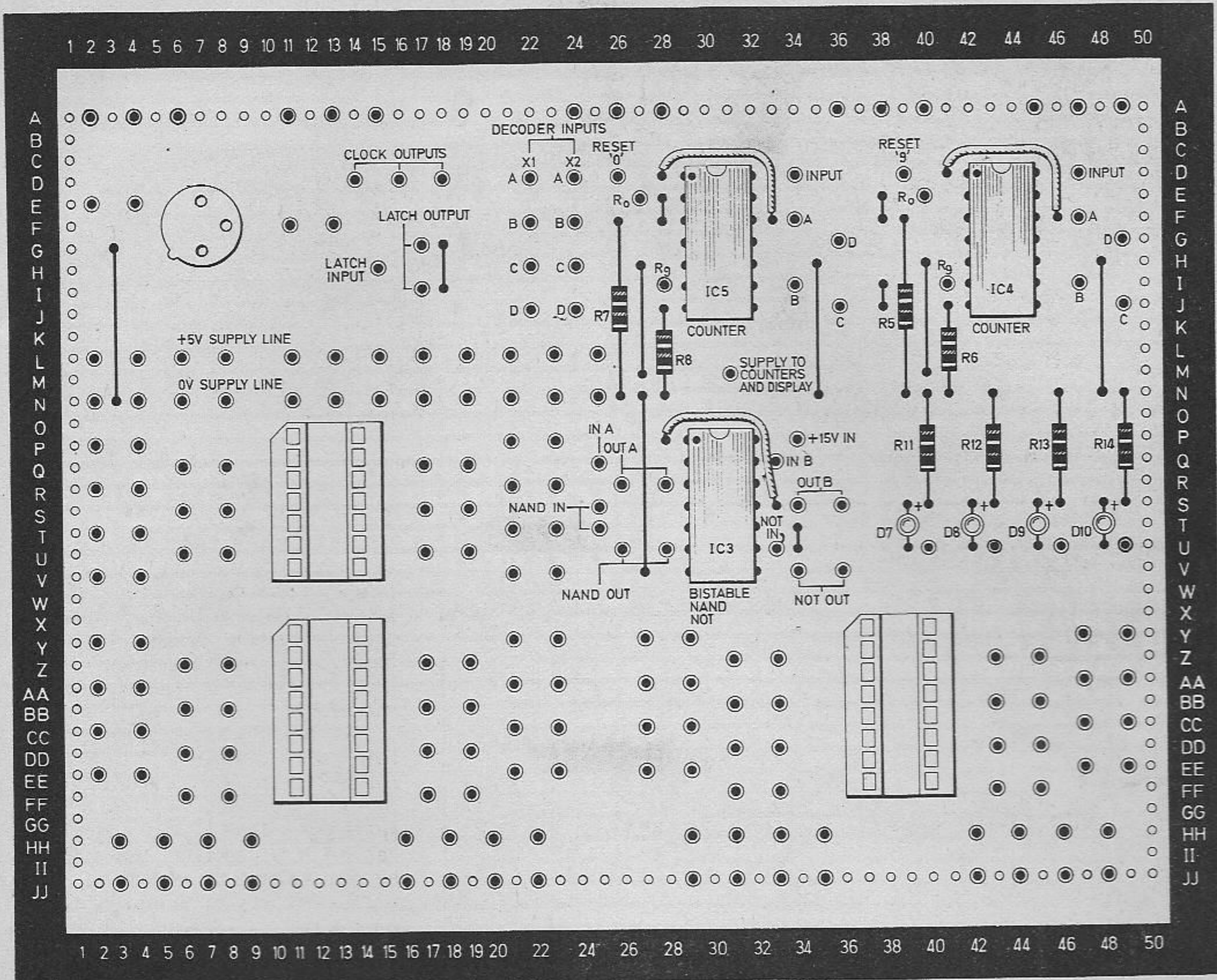


Fig. 5a. The layout of the components and connection pins on the topside of the "test-bed" and identification of the input/output pins to the logic sections.

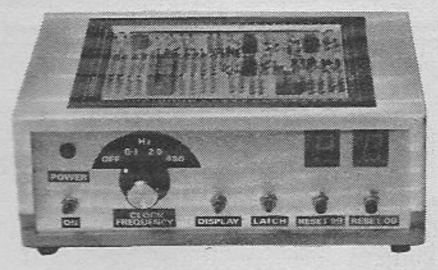
It only remains for the flying leads from the lower board and the panel mounted switches to be connected to the underside of the top board. Full details of these connections are shown in Fig. 2.

It is recommended that the top section of the case (with board fitted) is sited alongside the lower section when this wiring is carried out and the connecting leads kept as short as possible. The front panel controls can now be labelled as shown in the photographs.

TESTING

The power supply has been tested earlier, so assuming this is in working order we can check out all the other facilities in the unit.

With a lead, plugged into one of the l.e.d. sockets (e.g. *U*40) check that the l.e.d. lights when the lead is connected to any of the pins on strip *L*. Repeat for the other three l.e.d.s. A d.c. voltmeter connected across strips *L* and *N* should read 5 volts, *L* more positive than *N*.



The unit ready for use.

Clock

With the clock switched in the off position, connect in turn pins *D*14, *D*16 and *D*18 to any one of the l.e.d.s. The l.e.d. should light and remain on. Now turn S2 to its first position and the l.e.d. should turn on and off at regular intervals.

In the prototype, the l.e.d. turned *on* every 10 seconds and the scale marked accordingly, (0·1Hz). This can easily be timed with the aid of a secondhand on a wristwatch.

Advance S2 and note that the l.e.d. flashes much faster. If the number of flashes in say 10 sec intervals are counted, the frequency can be calculated and marked on the scale.

The last position of S2 should cause the l.e.d. to appear permanently on. In fact it is switching on and off faster than the eye can detect changes. To determine its frequency an oscilloscope or frequency counter is required. Alternatively, a crystal earpiece connected between *D*18 and strip *N* can be used and compared with a

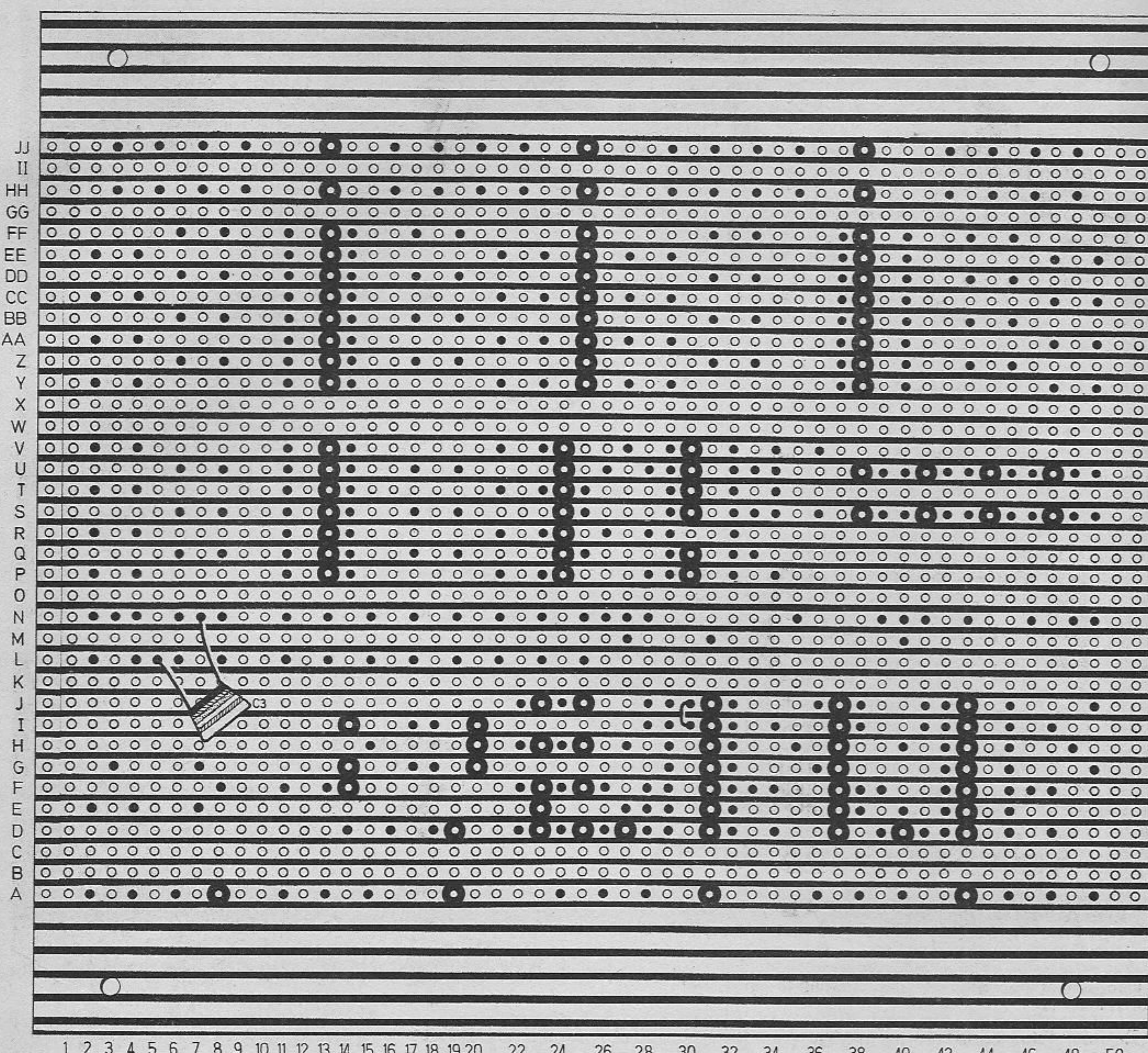


Fig. 5b. Shows the fixing holes and breaks along the copper strips on the underside of the "test-bed."

musical note on say a piano. In the prototype this frequency was measured to be 450Hz. Musical note A is 440Hz.

It is not essential to obtain these exact frequencies and any same order of magnitude frequencies are acceptable.

Latch

Set S2 to the 2·5Hz position and connect the clock output to the latch input (*D*14 to *H*15). Now connect latch output (*G*17) to one of the l.e.d.s. The l.e.d. should be flashing on and off.

Connect another l.e.d. to a second clock output (*D*16). The two l.e.d.s should flash in unison. Operate S4 and the first l.e.d. will remain on or off with the other continuing to flash on and off. Several operations of S4 will demonstrate this indicating the correct functioning of the latch switch, i.e. output can be locked at a level with the input to it changing.

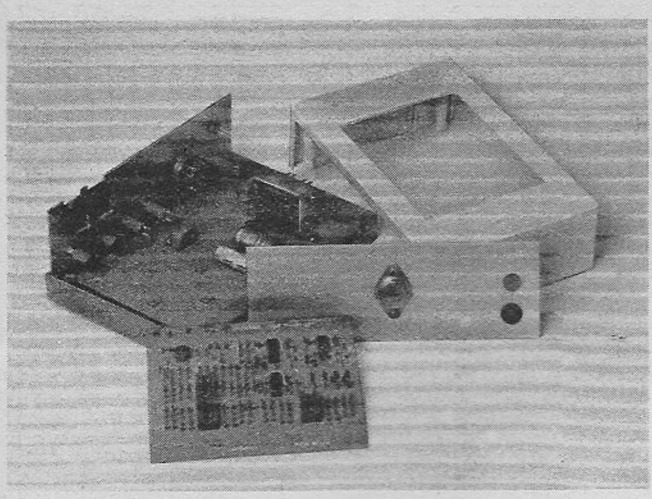
Decoder/Driver/Display

Make a connection between *M*31 and any pin on strip *L*. Set the clock frequency at 2·5Hz and connect the clock output in turn to the seven-segment decoder/driver inputs *D*24, *F*24, *H*24 and *J*24. Switch on and then operate S3; this causes X2 to flash on and off. Repeat this for X1 using locations *D*22, *F*22, *H*22 and *J*22. The only readable digit on either display will be a "seven" for locations *J*22 and *J*24.

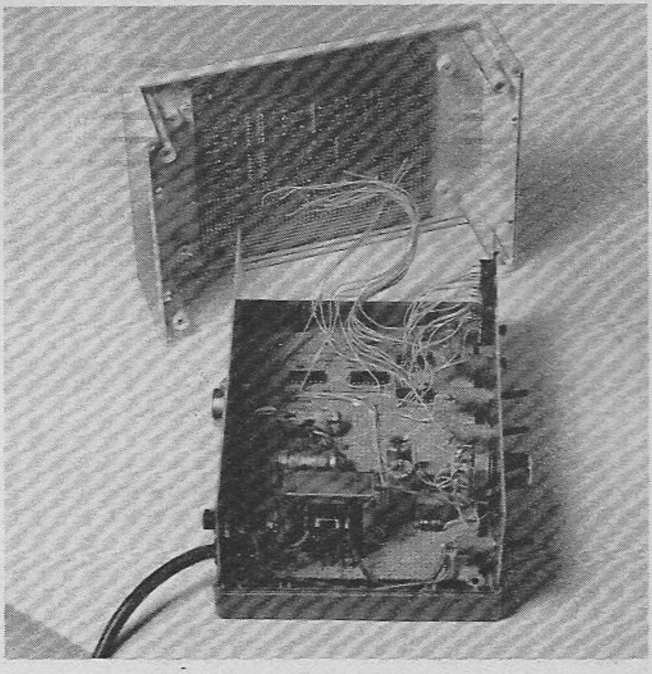
Counters

To test the counters, connect the binary outputs of IC5 to the l.e.d.*s*: *F*34 to *U*40, *G*36 to *U*49, *I*34 to *U*43 and *J*36 to *U*46. Connect *M*31 to strip *L*, clock output (*D*14 to IC5 input (*D*47) and switch on. The l.e.d.s can be seen to be counting in binary, D10 being the least significant digit and D7 the most significant digit.

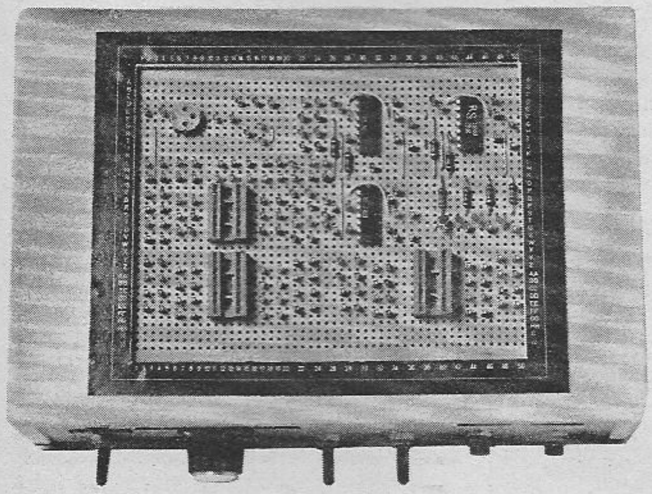
Repeat this procedure to test IC4.



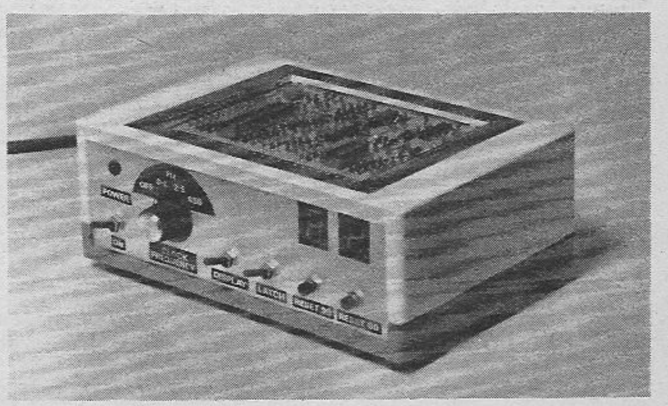
Photograph showing the TTL Electronic Test-Bed in the early stages of construction.



A final check for intact wiring before fixing the two sections together.



A plan view of the "test-bed" area showing the usefulness of the four-sided grid.



The finished unit ready for experiments.

Remove the connections to the l.e.d.s and place them in the decoder/driver input sockets: *F*34 to *D*24, *G*36 to *J*24, *I*34 to *F*24 and *J*36 to *H*24. Turn on S3 and note that X2 is displaying an increasing digit. Place the output leads from IC5 in the input sockets to X1 decoder/driver (*D*22, *F*22, *H*22, and *J*22) and observe the display on X1. This should be similar to that on X2 except that "O" appears as a blank and is not displayed. This is correct since it is wired to blank zeros.

Reset

Add to the existing wiring a lead from pin location *D*39 to *E*40, press S6 and display X1 should show a blank for as long as the switch is pressed. This blank condition will appear as a zero on X2.

Now connect a lead from *D*26 to *I*41 and press S5. A "nine" will be displayed on X1 for as long as S5 is pressed. This also applies to X2 when connection *D*26 to *I*28 is made.

Logic Elements

It only remains to check the three logic elements contained in IC3.

Connect a wire from strip *L* to *P*34 and *U*26 to one l.e.d. Turn on. The l.e.d. should not light. Connect a wire from the 0V rail, strip *N*, to *S*25 and then to *T*25. In each case the l.e.d. should light, demonstrating the action of a NAND gate. Remember that unconnected inputs assume a high input level.

Remove the wiring with the exception of strip *L* to *P*34 and connect *V*34 to an l.e.d. Make a connection between *U*33 and the 0V rail (strip *N*). The l.e.d. should light for successful operation of this NOT or INVERT gate.

Remove connections to the INVERT gate and make connections from *R*26 and *S*26 each to l.e.d.s to test the bistable. One l.e.d. will be alight and the other dark. If *R*26 is high (indicated by its connected l.e.d. being on) grounding *Q*33 will cause the states of the l.e.d.s to transpose. Now, grounding of *Q*23 will cause the l.e.d.s to transpose again.

If all the above tests have been successfully carried out, the TTL Electronic Test-Bed is complete and ready for use in logic experiments and the *Doing It Digitally* series. ☒

See overleaf for the start of this new series.

DOING IT DIGITALLY

PART 1

By O. N. Bishop

EVEN if you followed the previous series of the same name, you will find many new ideas in this new series of Doing It Digitally, including at the request of many readers details for building a two-digit numerical display.

If you are new to digital electronics, you can begin from the very beginning, here in Part 1.

All the experiments to be performed are carried out on the *TTL Electronic Test-Bed* (see page 725 for full constructional details of this unit). For brevity, this unit will be referred to as the "Test-Bed" from now on. This is considerably more complicated than its predecessor but this means that it can be used for more complicated and more interesting circuits.

INTRODUCING TTL

Advertisements in this magazine often include the initials TTL, and some readers may wonder what these initials stand for. The abbreviation TTL is short for transistor-transistor logic and TTL circuits are constructed by using specially-designed integrated circuits (i.c.s) in which transistors are coupled with other transistors so that the circuit behaves according to some predetermined logical pattern. Perhaps this explanation leaves the reader still wondering what it is all about, so let us look at it step by step.

First of all, what do we mean by logic? Secondly, how can transistors be made to behave according to logical rules?

LOGICAL STATEMENTS

Here is a logical statement: *If* the pond is frozen *and* you have skates, *then* you can skate on the pond.

This sentence states two conditions which must be met if you wish to skate on the pond. There might also be other conditions (for example, you must obtain the farmer's permission) but, to simplify the discussion, we will keep to only two conditions. To include three or more would not alter the logical principles involved.

Let us next analyse the statement, which we can see consists of three statements connected together:

statement A The pond is frozen
statement B You have skates
statement C You can skate on the pond

Our original statement has the form:

If A and B, then C

If A is true, AND if B is true, then C is true. But suppose A is *false* then you cannot skate on the pond for it is not frozen. Then C is false also. We can write this in logical form:

If $\bar{A}$ and B, then $\bar{C}$

The bars over A and C indicate that these two statements are false.

(1) Write the following sentence in logical form:

If the pond is frozen and you have no skates, then you cannot skate on the pond.

(2) Complete this logical statement:

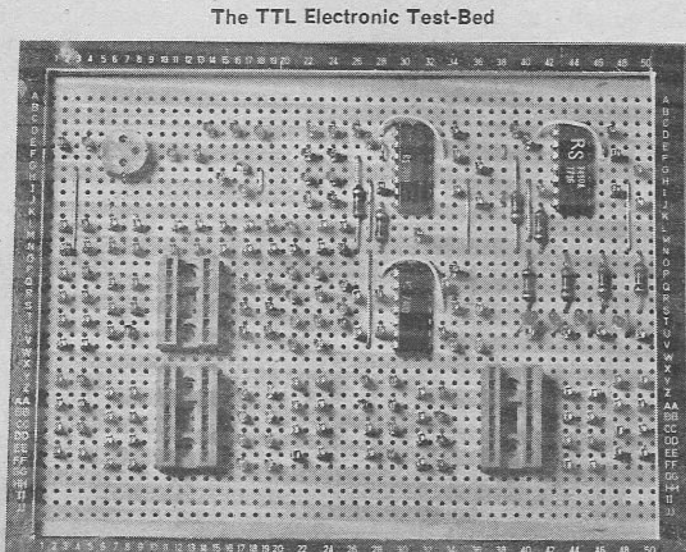
If $\bar{A}$ and $\bar{B}$, then . . .

LOGICAL "AND"

In the examples above we have seen the four possible ways in A, B and C, in true or false form, can be combined together to make a logical statement based on the operation AND. We can summarize the four situations in a *truth table* shown in Table 1.1.

It is easy to see from Table 1.1 that there is only one situation in which you can skate (first row, all statements true). If A is false, or

The TTL Electronic Test-Bed



B is false, or both are false (last row), you cannot skate (*C* is false).

Table 1.1. Truth table for AND

A	*B*	*C*
1	1	1
1	0	0
0	1	0
0	0	0

1 indicates "statement true"
0 indicates "statement false"

Our next problem is to find an electrical circuit that behaves according to the logic of the AND truth table. We call this an AND gate.

"AND" GATE

A simple type of AND gate is shown in Fig. 1.1. Truth is indicated by a "high" voltage (5 volt in this circuit). Falseness is indicated by a "low" voltage (0V). Inputs *A* and *B* can be made high or low according to whether statements *A* and *B* are true or false. The output of the gate tells you whether *C* is true or false. If *C* is true, output voltage is high and the l.e.d. lights. If *C* is false, output voltage is low and the l.e.d. is dark (off). Connect up the components on the Test-Bed to make this gate as shown in Fig. 1.2 and try various combinations of inputs; record the output (*C*) in a table by completing the following table.

Input		Output
A	*B*	*C*
H	H	
H	L	
L	H	
L	L	

H = high (5V) = true
L = low (0V) = false

Compare your results with the AND truth table, Table 1.1—the pattern is the same. You could now build an AND gate with, say, four inputs (*A*, *B*, *C* and *D*) and use it to discover under what conditions the output *E* is true (Answer on page 737).

Note that the logical operation is entirely independent of the subject matter of the statements. You can just as easily use the AND truth table or AND gate to work out the various logical combinations of:

statement A Today is 29 February
statement B 29 February is your birthday
statement C Today is your birthday

AND Gate circuit symbol

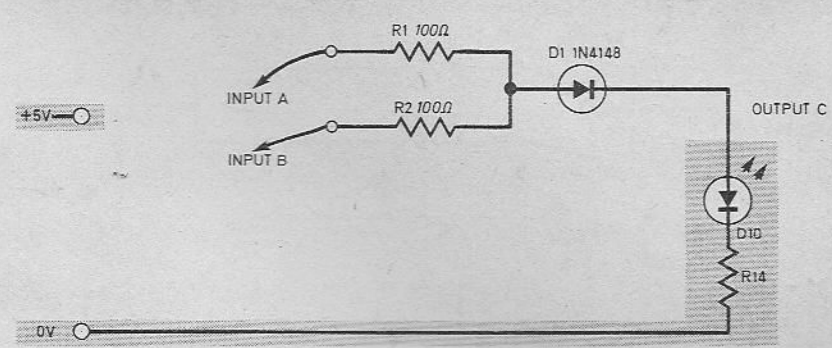


Fig. 1.1. The circuit diagram of a simple two-input AND gate constructed using a single diode

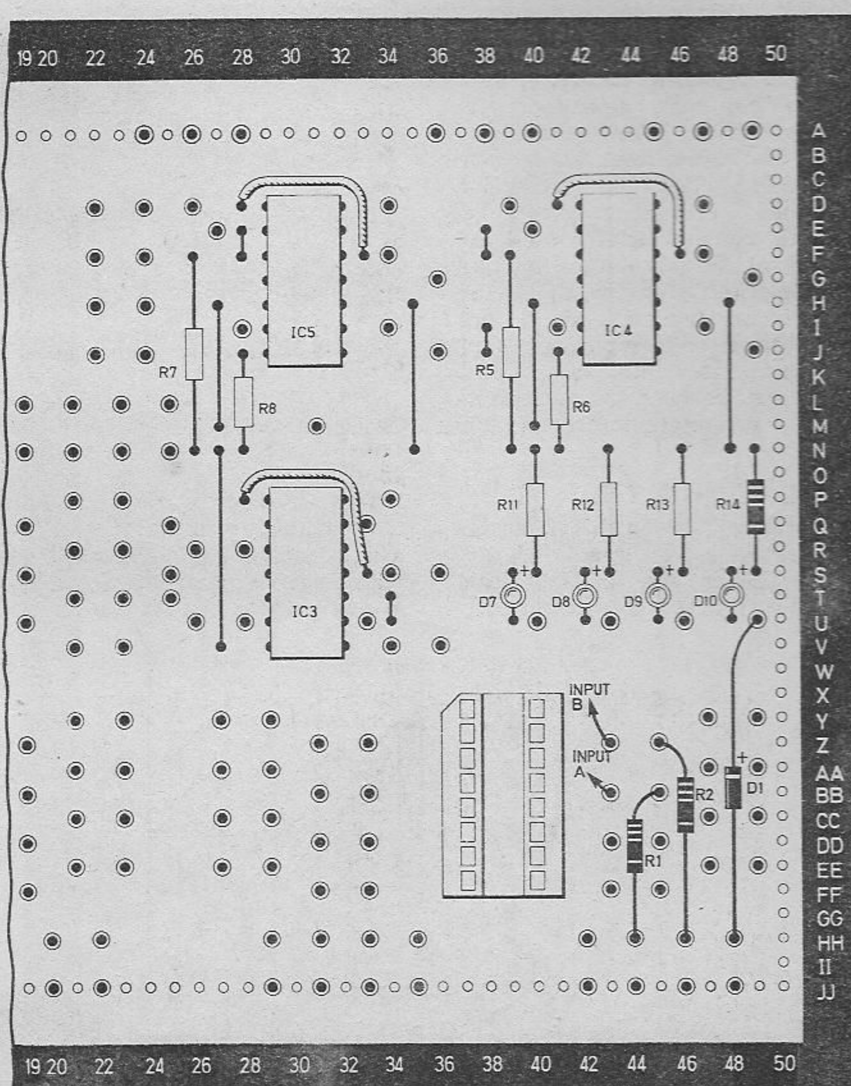


Fig. 1.2. The circuit of Fig. 1.1 wired up on the Test-Bed. The gate inputs are made via flying leads to either the +5V or 0V rails.

OR Gate circuit symbol

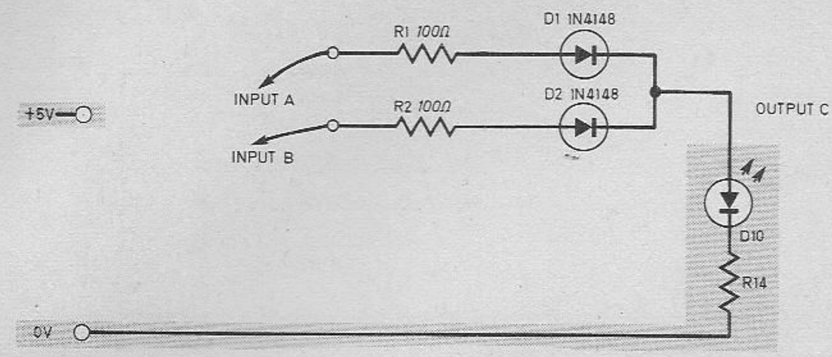


Fig. 1.3. Using two diodes to construct a two-input OR gate.

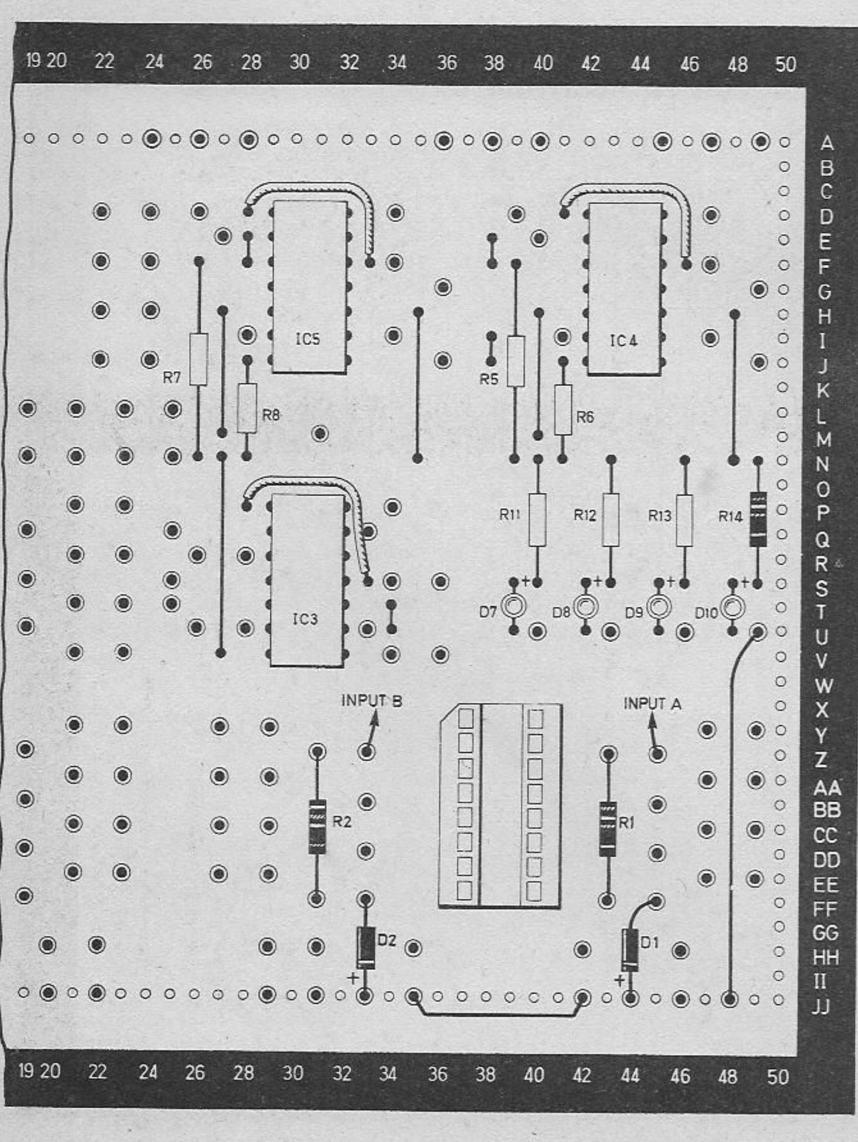


Fig. 1.4. The circuit of Fig. 1.3 wired up on the Test-Bed.

LOGICAL "OR"

Consider this statement:

If I receive a pay rise *or* I win the pools, *then* I will buy a new hi fi.

This has the form:

If *A* OR *B*, then *C*.

If *A* or *B* are both true, *C* is also true. Now test yourself by completing this truth table (Answer, p. 737):

Table 1.2. Truth table for OR

A	*B*	*C*
1	1	
1	0	
0	1	
0	0	

1 indicates "statement true"
0 indicates "statement false"

Once again, an OR truth table can have three or more conditional statements (*If* I receive a pay rise *or* I win the pools, *or* receive a legacy, *or* back a winner, *or* am offered a real bargain, *then* I will buy a new hi fi). In all tables the outcome statement (I will buy a hi fi) is false only if *all* conditional statements are false—i.e. the bottom row of our OR table—all zeros.

One way of performing the OR operation electronically is shown in Fig. 1.3. Check your entries in the truth table by building and using this gate on the Test-Bed as shown in Fig. 1.4.

LOGICAL "NOT"

The truth table for NOT (or INVERT as it is often called) is a very simple one, see Table 1.3.

Table 1.3. Truth table for NOT

Input *A*	Output *B*
1	0
0	1

Here we have two statements such that if one is true the other is false, and the converse. Such a pair of statements could be:

statement A This is a black-and-white TV set
statement B This is a colour TV set

Or a pair of numerical statements such as:

statement C The current passing is less than 100mA
statement D The current passing is 100mA or more.

The NOT, or INVERT operation can be performed by a transistor wired as in Fig. 1.5. When A is true, input A is made high. The transistor is on and conducts readily so that the voltage at B is low (B is false). The l.e.d. does not light or, at the most, glows dimly.

When A is false, input A is made low, switching the transistor off. Then output B is high and the lamp glows brightly, indicating that B is true. Check this on the Test-Bed as shown in Fig. 6.

TTL INTEGRATED CIRCUITS

The gates described above perform only the simplest operations and tell us things that we can just as easily work out in our heads. To perform really complex logic we need thousands of gates ready connected into logical units. This is where TTL comes in.

The microcircuits contained in the i.c.s. of the 7400 series may contain dozens or even thousands of gates already assembled into systems for performing complicated functions. Or a single i.c. may contain four or more identical gates of a simple kind, ready to be wired into logic circuits of your own design.

The circuitry of all the i.c.s is designed to give reliable, high-speed operation. The ready availability and cheapness of the 7400 series make these ideal for the home experimenter and constructor.

The aim of this series is to show you what these i.c.s can do, and how to use them in a wide variety of applications. Since their inputs and outputs can be indicated by the *digits* "0" or "1", according to whether they are "low" or "high", we refer to this branch of electronics as *digital electronics*, and to the 7400 series as digital integrated circuits. And the aim of these articles is to show you how to "do it digitally".

NOT (INVERTER) circuit symbol

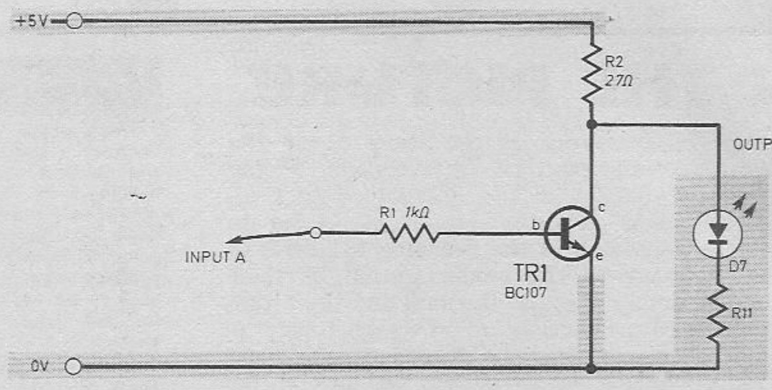


Fig. 1.5. The circuit diagram for a basic **NOT (INVERT)** gate utilising the inverting property between base and collector of a transistor wired in the common-emitter configuration.

Answers

(1) If $\underset{\sim}{A}$ and $\underset{\sim}{\bar{B}}$ then $\underset{\sim}{\bar{C}}$.
(2) If $\bar{A}$ and $\bar{B}$ then $\bar{C}$.
(3) Outputs of AND gate: from top to bottom, column C reads HLLL.
(4) 4-input AND gate: E is only true when A and B and C and D are all true.
(5) Outputs of OR gate: from top to bottom, column C reads 1110.

Continued next month

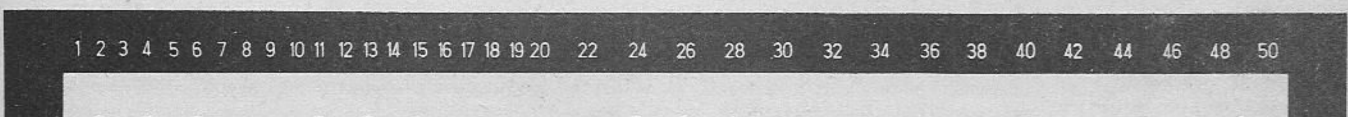


Fig. 1.6. The NOT gate of Fig. 1.5 wired on the Test-Bed.

Everyday News

IN THE PICTURE

Following on from our recent story about the Government subsidies and the involvement of the Department of Industry in the Microelectronics Industry. The DOI is making a grant of £4·5m to Mullard under Section 7 of the Industry Act 1972, to assist the company in the modernisation of their colour tube assembly plant at Durham and the establishment of a new production line at Simonstone.

This grant forms part of a £24m, three year investment plan to modernise the manufacturing facilities at the company's tube assembly plant at Durham, and to establish a new 20 inch 90 degree tube production line at their Simonstone plant.

By specialising in the production of 20 inch and 22 inch tubes, it is claimed that Mullard will be well placed to meet the growing demand within the EEC for tube sizes below 26 inches. Mullard is now the UK's only manufacturer of TV picture tubes, following the closure of the Thorn plant in 1977.

TALKING HAZARDS

Walkie-talkie types of personal communications in industrial environments such as petro-chemical plants can radiate signals which interfere with sensitive electronic process control equipment.

Studies are now being made by ERA's interference group with the support of the Department of Industry to see how much exposure to radiation the instruments can suffer without malfunction. The findings could be yet another nail in the coffin of advocates of unlimited use of Citizens Band radio.

NEWSPEAK TECHNOLOGY

No, not the Newspeak of Orwell's 1984. A new technique of speech processing developed by Brigadier Reg. King, Ministry of Defence, and a research team at Bath University led by Professor W. Gosling, promises elimination of redundant sounds and a compression of communications bandwidth that will allow four or five times the voice traffic over existing telephone lines.

Details are under wraps but a prototype equipment is expected to be completed in the next 17 months, hopefully earlier.

STARCHESS

Hitting the shops in time for the Christmas market is Starchess, a completely new TV game to be produced by Videomaster.

It combines the traditional chess game with kings, queens, bishops and a space-age battle. Old-fashioned knights and rooks are out. In come commanders, destroyers, starcruisers, superfighters and missiles, all in colour.

The game has a new dimension over chess in that one mode is to project the pieces into "hyperspace" after which they will land unpredictably on the board. So there could be a lot of luck as well as ordinary chess logic in winning—or losing.

✲ ✲ ✲

A spherical TV camera designed for use in helicopters has been designed by Marconi Avionics. Mounted externally on gimbals it enables stable pictures to be taken from long range and with high magnification. Although intended for military reconnaissance it could have general applications. The Heli-Tele made its debut at The Farnborough Air Show.

Shock Treatment

The world-beating EMI Scanner, which astonished the medical world when announced in 1973, has now run into financial difficulties with an operating loss of some £3 million according to recent reports. Reason is said to be big spending cuts in the huge US medical market.

However, EMI could recoup this amount and more from an important patents hearing, soon to be held in the USA, with EMI claiming damages for infringement by a rival US company. If successful, EMI could receive royalties from that and other competitors who have since jumped on the scanner bandwagon.

✲ ✲ ✲

Hughes Aircraft has built its 200,000th TOW anti-tank wire-guided missile, making it the most successful missile ever built. With a range of some two miles it is estimated that over a million miles of guidance wire have been wound on the bobbins in the missiles.

—ANALYSIS

VLSI — THE COST OF ENTRY

Suddenly, everyone is talking of Very Large Scale Integration (VLSI), tomorrow's super-circuits already in development in the United States and Japan but until recently hardly more than an interesting topic for discussion and speculation in Britain.

Then, after months of rumour, came the announcement of the formation of INMOS, Britain's answer to the VLSI challenge. INMOS, backed by £50 million of taxpayers, money through the National Enterprise Board, is planned as a high-flying company headed up by proven whizz-kids from the USA and Britain.

In parallel with the investment in INMOS, planned to project Britain into the mass market in competition with the dominant US companies, another £70 million is to be pumped by the Department of Industry into existing British semiconductor manufacturers such as Plessey, Ferranti and GEC in their more specialised activities. And another £15 million is to become available for application studies to help potential users to exploit the power of VLSI in their new products.

The DOI commitments have been universally welcomed. The investments, if sensibly used, will strengthen Britain's established semiconductor manufacturers in the world marketplace and improve the sales prospects of equipment incorporating the new technology.

But the formation of INMOS, planned to fight for shares in the perilous jungle of the mass-market where the name of the game is high volume production and savage price cutting, has raised more than a few industry eyebrows in astonishment.

Detractors of the scheme suggest that £50 million is peanuts for the sort of enterprise planned. That to get down to a competitive price, off-shore manufacture in low-cost labour areas will be needed and thus the prospect of 4,000 extra jobs in the UK is pie-in-the-sky. And that the projected 800 graduates and engineers to be employed will involve milking them from existing companies, thereby weakening established enterprises. On the plus side the troika of INMOS bosses all have a good track record, inspiring confidence.

As prototype production is to take place in the USA, presumably based on US technology, some observers believe the more sensible course would be teaming-up with an existing US volume producer as, indeed, is rumoured between GEC and Fairchild.

But full marks to INMOS for courage and imagination. Let's all hope that INMOS prospers, putting the doubters to shame

Brian G. Peck

Bursting the Bubble

The so-called bubble-domain memory, in development for the past ten years, could achieve a breakthrough in computer applications following a report that IBM have succeeded in making bubbles only 0·4 microns in size. This means that one square inch of garnet material could store 100 million bits of information.

Industry observers, however, suggest that large-scale bubble memory production is still as far ahead as 1985.

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The Motorola 6800 MPUs are now down to £5·06 in the UK for 100 plus quantities. The latest price cut, the fifth in 16 months, equal to halving the price every year, is attributed to unexpectedly high yields from the new four-inch wafer installation at Motorola's Scottish factory at East Kilbride.

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Getting The Message

An international telegraph message switching system that provides faster, more efficient communications for one of Japan's largest trading companies has been successfully completed ahead of schedule by the British Post Office.

Worth more than £200,000 a year to the Post Office, the computer-controlled system handles 2,500 messages a day flowing through the London office of C. Itoh & Co. Ltd. The messages are routed between the company's head office in Osaka and its premises in Nairobi, Stockholm, Prague, Madrid, Hamburg, Ankara and Kuwait.

With ILTMS (International Leased Telegraph Message Switching), all the circuits are now terminated on a switcher located at Post Office premises in London. This, it is claimed, has resulted in savings to Itoh of £10,000 in terminal equipment costs, as well as a 30 per cent saving in office space.

Cut Price

Fairchild has slashed the UK price of the F6800 8-bit MPU to £5·06 for 100 plus quantities, a reduction of some 50 per cent. Reason, says Fairchild, is the fantastic yield (i.e. far less rejects) from its new 4-inch MOS wafer production facility at San Jose, California.

Memory costs also continue to tumble. Colin Crook, a Motorola executive recently commented that the breakthrough of the 4k random access memory (RAM) in 1976 cut memory costs to 1 US cent a bit of memory. Today's 16k RAM works out at 0·5 cents per bit. By 1980 the 64k RAM will cost 0·16 cents per bit and by 1982, when the 256k RAM is expected to hit the market, the cost will be a miniscule 0·06 cents per bit. Talking of MPUs in general he referred to them as "computers by the millions for the millions".

The Post Office's TV information service, Viewdata, has been sold to the Netherlands. West Germany has already bought the know-how (a year ago) and other overseas sales are expected. The first public demonstration in the Netherlands was held at *Firato '78 International Radio and TV Show*, Amsterdam.

Hush-Hush Move

Best known for tiny man-packs and professional h.f. radios, Racal has now moved into mobile military communications satellite terminals with a handsome order from the Ministry of Defence.

The new equipment has come from the hush-hush Racal (Slough) company and is said to have been ordered in preference to that offered by another company long-established in comsat technology. The Racal equipment, using a dish only 1·5m in diameter, provides simultaneous duplex digital speech and telegraphy and can be set up and operational within minutes of arrival at the site.

The PA system at Wembley Stadium is to be renewed by Vitavox. To meet new safety regulations over 230 loud speakers are needed but how many kilowatts of audio will be needed to be heard above the roar of the crowds is not revealed. Completion is scheduled for August next year.

DOUBLE DUTCH

A £6 million giant cable, capable of carrying nearly 4,000 telephone calls at once, will more than double Britain's undersea telecommunications links with the Netherlands in 1980.

The cable will be used primarily for phone calls, telex messages and other communications between the UK and Netherlands, Belgium and Germany.

Early booking is advised for this year's annual British Standards Institution (BSI) Conference, *Company Standards — Why? What? How? Who?* It is to be held at the Royal Holloway College, Egham, Surrey, on September 28-29, and places will be limited.

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The Institution of Electrical Engineers is to organise a conference for Wembley Conference Centre, June 19-21, 1979, to run in conjunction with *Testmex*, the electronic test and measuring exhibition sponsored by the Scientific Instrument Manufacturers' Association (SIMA) and the Electronic Promotions Group, and organised by Trident International Exhibitions Ltd.

ALL AT SEA

In September 1977 Naomi James set out from Dartmouth in the yacht *Express Crusader* (owned by Chay Blyth) to sail around the world. The results are now maritime history.

An interesting piece of news released about equipment used during the voyage was the use of a Contax RTS camera. This was chosen because it was claimed to be the only camera with an infra red remote controller unit small enough to meet requirements. This combined accurate automatic exposure and electromagnetic operation made it an ideal choice for such an arduous voyage.

Amongst the most useful of integrated circuits currently available to the amateur is the CMOS logic range. In many digital applications these devices have advantages over other logic i.c. families, such as low current consumption and wide operating voltage range, and they are extremely versatile in that they can be used in applications that are not strictly digital in nature.

In fact they will work perfectly well in a number of applications that are in no way digital, and they often offer a perfectly viable alternative to the more usual linear circuits.

The simple broadcast receiver to be described here is an example of such a circuit. It is based on three amplifiers that are devised from three of the four gates contained in a CMOS 4001 quad 2 input NOR gate i.c.

With this receiver all the usual medium wave stations can be received, as well as the 200kHz transmission on long waves. In view of the coming frequency changes of BBC Radio 2 and Radio 4, the inclusion of long waves to the design is very useful. It means that no one will miss their favourite programmes on Radio 4 if they have a medium wave only receiver.

The radio has been designed using readily available components and has sufficient output to drive a crystal earpiece.

THE NOR GATE

A NOR gate has the circuit symbol shown in Fig. 1a and what is termed the "Truth Table" for this type of logic gate is shown in Fig. 1b. These both refer to a two-input gate (as used in this design) but gates can have more than two inputs, incidentally.

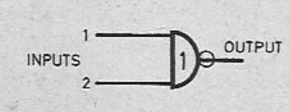
In logic circuits the inputs and outputs of the various devices can only be in one of two stable states: **high** (logic 1 or virtually equal to the positive supply rail voltage) or **low** (logic 0 or virtually at the negative supply rail voltage).

TRUTH TABLE

A truth table simply lists what output states are produced by all the possible input state combinations. Thus, for example, if one input of a NOR gate is low and the other is high, the output will be low, as will become apparent by refering to Fig. 1b.

By connecting the two inputs together, as in Fig. 1c, a NOR gate will act as an inverter. In other words, the output will always assume the opposite state to the common input. A CMOS gate does not have built-in trigger action, and so if the input of an inverter is gradually increased from zero, the output will not suddenly go from logic 1 to logic 0 when the input voltage exceeds some critical level. Instead, the output voltage will remain unchanged until the input reaches about 50 per cent of the supply potential.

The output will then begin to swing negative at a rate about 50 times greater than that at which the input is taken positive until it is fully negative. Further increasing the input voltage then has no effect.



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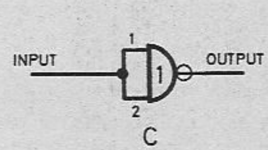
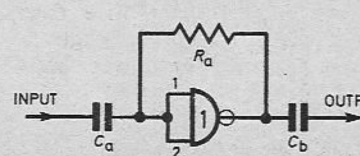


C

INPUT 1	INPUT 2	OUTPUT
LOW	LOW	HIGH
LOW	HIGH	LOW
HIGH	LOW	LOW
HIGH	HIGH	LOW

B



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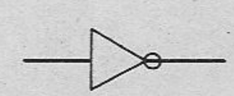

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Fig. 1a. Circuit symbol for a 2 input NOR gate. (b) Truth table for a 2 input NOR gate (c) Connecting the two inputs together produces an inverter. (d) Adding a resistor between the input and output biases the inverter as an amplifier. (e) Equivalent circuit of (d) which shows an invertering amplifier.

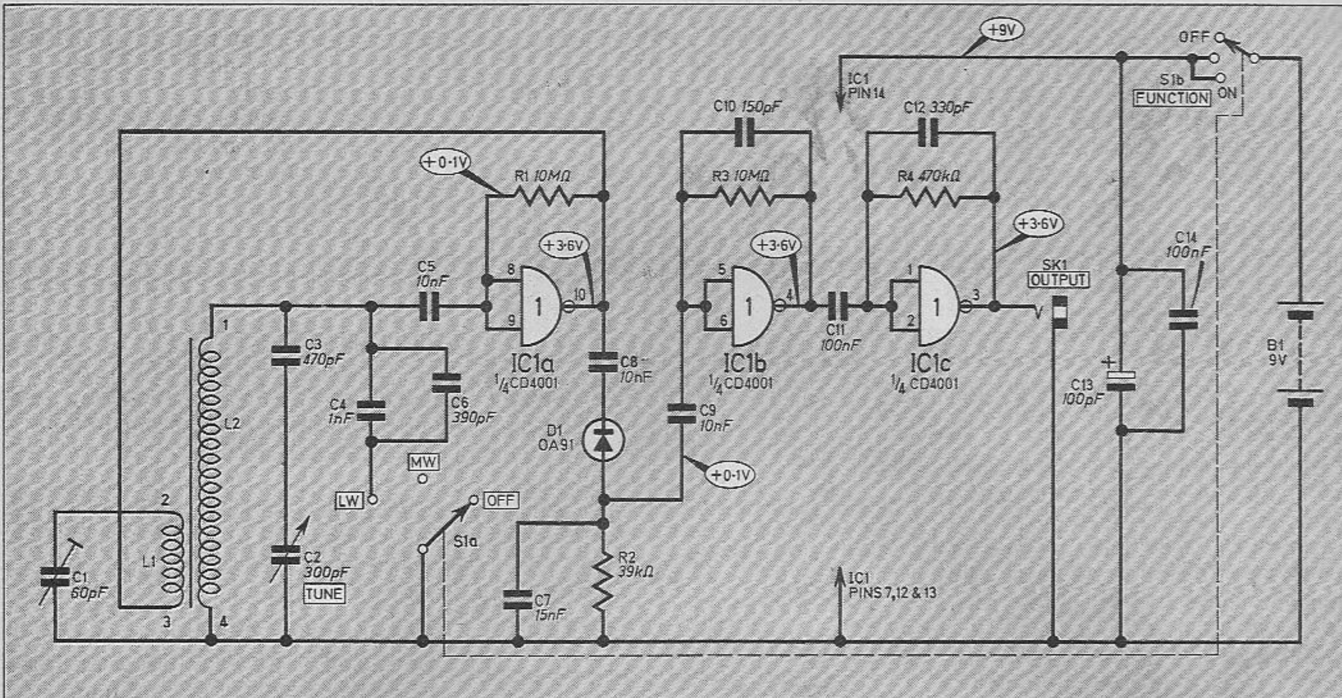


Fig. 3. Circuit diagram for the MW/LW Radio. Voltages are measured with the function switch in the MW position.

A CMOS inverter can be biased to act as an amplifier simply by connecting a resistor between the input and output, as shown in Fig. 1d.

When power is initially applied to the circuit the input will be low and so the output will start to swing positive. The input impedance of CMOS devices is extremely high being typically about 1 million megohms, and so the input will be taken to virtually the same voltage as the output due to the coupling through R_a, and almost irrespective of the actual value of R_a.

When the input and output voltages reach about 50 per cent of the supply voltage, the input starts the transition from logic level 0 to logic level 1. The input and output voltages stabilise at the point on the input/output voltage characteristic where the two voltages are equal. A possible CMOS inverter input/output voltage response and the bias point is shown in Fig. 2.

FEEDBACK ACTION

A negative feedback action stabilises the biasing. A rise in the output voltage will cause a similar rise in the input voltage which tends to pull the output voltage back down to its original level. Similarly, a decrease in the output voltage will reduce the input voltage and tend to bring the output back to its original potential.

By coupling an input voltage to the inverter via a d.c. blocking capacitor, C_a, the input will be forced either side of its static level, and an amplified and inverted signal will be produced at the output. This is extracted by way of the d.c. blocking capacitor C_b.

The circuit has a voltage gain of about 50 times and an input impedance roughly equal to R_a divided by 50.

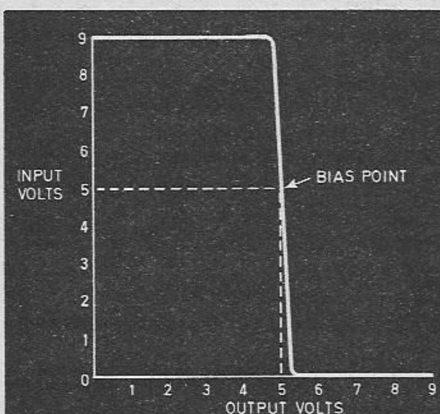


Fig. 2. Possible input/output characteristic curve for a CMOS inverter.

CIRCUIT DESCRIPTION

Referring to Fig. 3, this shows the circuit of MW/LW radio. Coil L2 is the tuned winding of the ferrite aerial and C2 is the tuning control. This variable capacitor has slightly higher capacitance than is needed in order to tune L2 over the medium wave band, and so series capacitor C3 is used to effectively reduce the maximum capacitance of C2.

In the long wave band position of S1, the additional capacitance of C4 and C6 is shunted across L2. This enables the set to tune to the 200kHz l.w. transmission.

REGENERATION

Signals picked up by the ferrite aerial are coupled to the input of a CMOS amplifier stage. Some of the output from this amplifier is fed back to the ferrite aerial via L1 and C1. This technique is known as "regeneration", and it boosts the sensitivity of the circuit by sending some of the signal back to the input to be amplified for a second time. It also increases the selectivity of the set, which is its ability to separate two or more closely spaced signals. This happens because there will be more signal feedback at the centre of the receiver's frequency response than there will be at the edges of the response. The gain at the centre of the response therefore receives the greatest boost.

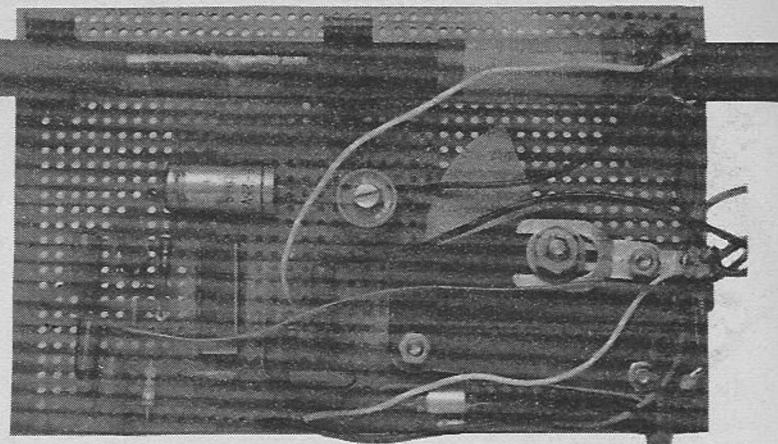
The trimmer C1 controls the amount of regeneration applied to the circuit, and must not be adjusted for too much feedback as this would cause the circuit to break into oscillation and prevent proper reception.

Most of the output from the first amplifier is fed to an ordinary a.m. detector and r.f. filter stage which comprises D1, C7 and R2. The audio output from this stage is fed to two stages of audio amplification, each stage being based on a CMOS inverter. C10 and C12 reduce the upper frequency response of these two amplifier stages, and this aids the stability of the circuit and gives a better signal-to-noise ratio. The crystal earpiece is fed direct from the output of the last amplifier stage, therefore no output d.c. blocking capacitor is needed.

The two remaining capacitors, C13 and C14 are supply decoupling capacitors and on/off switching is provided by S1b. This is ganged with wavechange switch S1a, and there are three positions: OFF, MW, and LW.

The circuit is based on a CMOS CD4001 quad gate. One of the four gates is unused and its inputs are tied to the negative supply rail. This is necessary as stray pick-up could otherwise operate these inputs and cause an increase in the current consumption. It is even possible that pick-up of static charges could otherwise damage the i.c.

As the three gates that are used have their inputs wired together so they act as simple inverters rather than gates, the 4011 quad 2-input NAND gate will also work in this circuit.



Layout of components on the perforated board. It is recommended that an integrated circuit socket be used to save direct soldering to IC1 pins.

CONSTRUCTION starts here

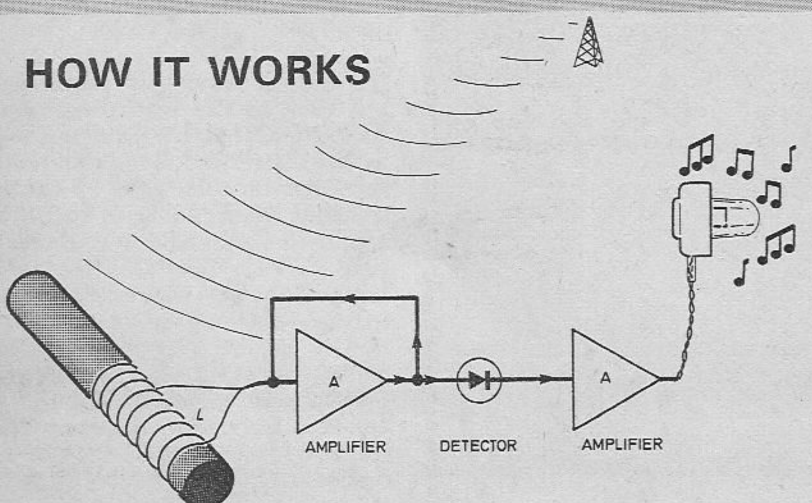
The small components plus the ferrite aerial and C2 are assembled on a plain 0·1inch matrix s.r.b.p. panel which has 42 by 28 holes. When a panel of this size has been cut out using a hacksaw, a 10mm diameter mounting hole for C2 is drilled at the appropriate place, as are each of the two 6BA clearance (3·2mm diameter) mounting holes for the ferrite aerial.

The ferrite aerial is mounted on a couple of plastic clips and each of these is held in position by a 6·3mm long 6BA bolt and mounting nut.

Next the small components are mounted on the panel in the positions shown in the constructional diagram Fig. 4, and their leadout wires are bent flat against the underside of the panel. The leads are then soldered direct to one another, this wiring also being shown in Fig. 4.

Capacitor C3 is the only exception, and this is wired straight between C2 and the aerial. To complete the panel, connect the negative battery clip lead and insulated leads about 125mm long where connections from S1 and SK1 will eventually be made to the panel. Also wire C2 and the ferrite aerial into circuit using insulated leads which should be kept reasonably short and direct.

HOW IT WORKS



Signals from a radio transmission are induced into the ferrite aerial. This signal is then fed into an amplifier where some of the output is fed back to the input and amplified a second time. This process is called regeneration and greatly improves the sensitivity of the radio.

The signal is then passed to the detector which demodulates the r.f. and provides an audio frequency output. This relatively weak signal is then amplified by two stages of amplification to bring it to a sufficient level to drive an earpiece.

CASE

A plastic Verobox type 65-2520J having approximate dimensions of 150×80×50mm is used as the case for the prototype. Any case of about the same size should also be suitable, but a metal case must *not* be used. This would screen the aerial and present any significant amount of signal being picked up.

A 10mm diameter mounting hole for C2 is also drilled in the front of the case, and the mounting bush and nut of C2 are used in effect, to

COMPONENTS approximate cost £6 excluding case and earpiece

COMPONENTS

Resistors

R1	10MΩ	R3	10MΩ
R2	39kΩ	R4	470kΩ

All ¼W carbon ± 5%

Capacitors

C1	60pF ceramic trimmer	C8	10nF polyester
C2	300pF solid dielectric variable	C9	10nF polyester
C3	470pF polystyrene	C10	150pF ceramic plate
C4	1nF polyester	C11	100nF polyester
C5	10nF polyester	C12	330pF ceramic plate
C6	390pF polystyrene	C13	100μF 10V elect.
C7	15nF polyester	C14	100nF polyester

Semiconductors

IC1 CD4001 quad 2-input NOR gate
D1 OA91 germanium

Miscellaneous

B1 9V PP3 battery
S1 2-pole 3-way rotary switch
SK1 3·5mm jack socket
L1/L2 Ferrite rod and coil
Verocase type 65-2520J or similar, size 150 × 80 × 50mm; matrix board 0·1inch matrix 42 × 28 holes; battery clip to suit B1; crystal earpiece with 3·5mm plug; one large round-control knob; one small round knob; plastic mounting clips for L1/L2; connecting wire; socket to suit IC1.

See **Shop Talk** page 720

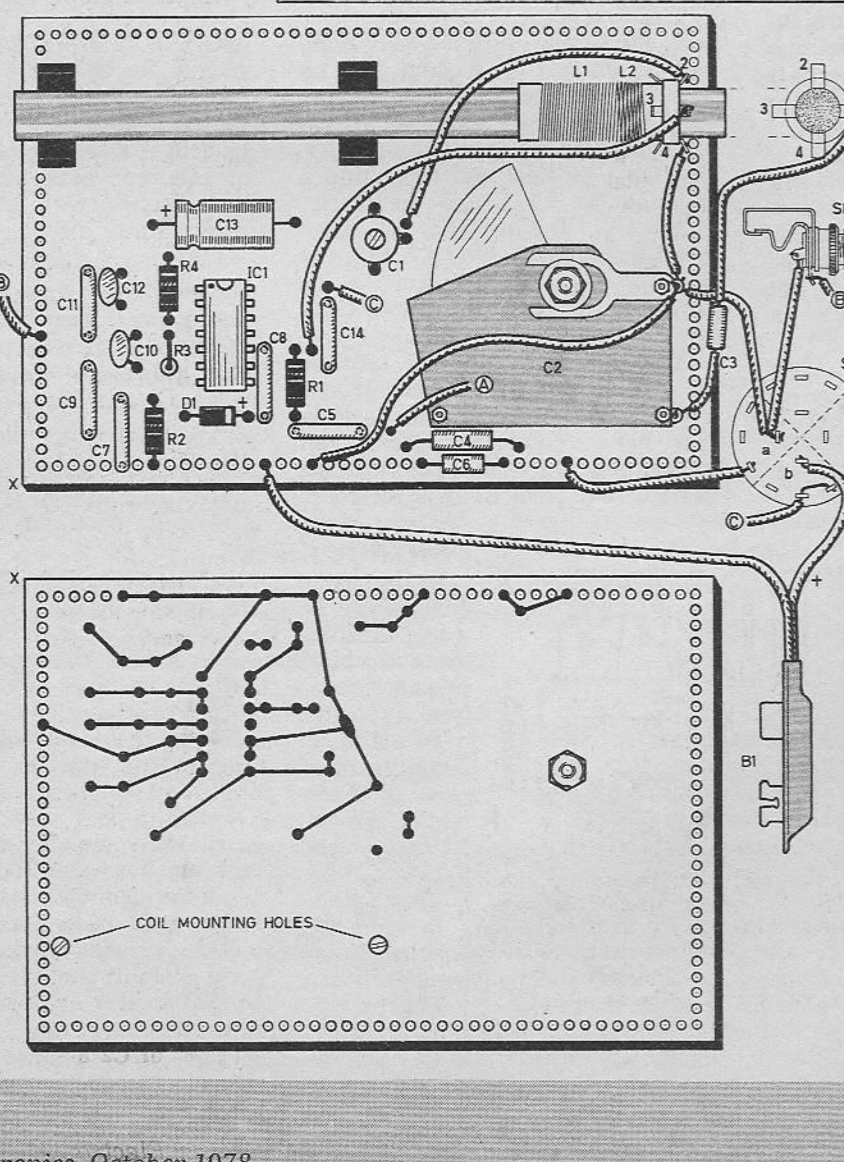


Fig. 4. Wiring details for the unit. Remember that ICI is sensitive to damage by static, and as such precautions should be taken against this. The use of an i.c. socket is advised. Remember to use an earthed soldering iron and try not to touch the pins. Insure also that any wires do not foul the moving vanes of the variable capacitor.

bolt the component panel to the front of the case. Some washers should be placed over the mounting bush between the component panel and the case to act as spacers. Otherwise the component panel could easily be damaged as the mounting nut of C2 is tightened.

Do not mount the component panel in a position too far to the right of the case (when viewed from the front) as this might leave insufficient room for S1.

The function switch, S1, is mounted half-way up the right hand side panel of the case and is slightly offset towards the rear of the case. It requires a 10mm diameter mounting hole. Socket SK1 is a 3·5mm jack type and is mounted just above S1. Most 3·5mm jack sockets require a 6·5mm diameter mounting hole.

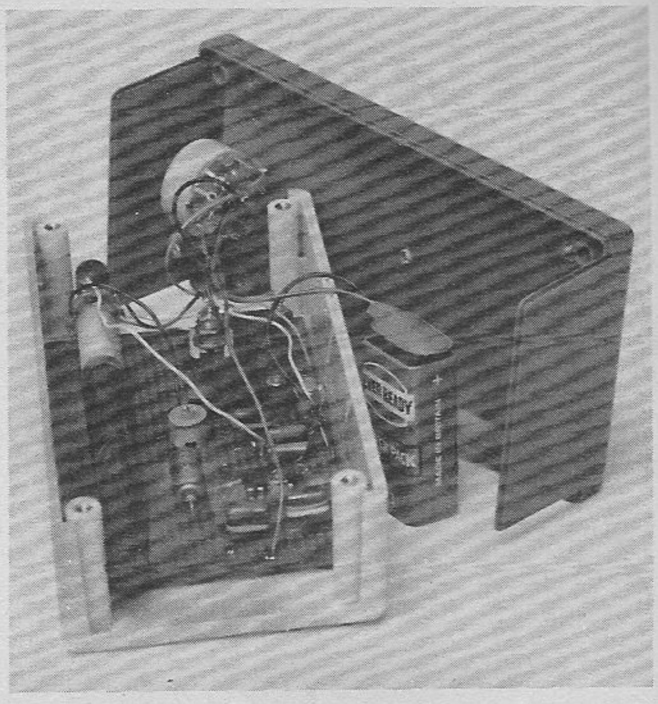
Once the component panel, S1, and SK1 have been mounted in the case, the remaining point-to-point wiring is completed and this is all shown in Fig. 4. Note that coil L2 is the smaller of the two windings on the ferrite coil, and connects to points 2 and 3 as shown in the layout.

The PP3 battery fits into the vacant space on the left hand side of the case and it is advisable to use some foam material to help keep the battery firmly in place. The current consumption of the set is about 4·5mA and this ensures a long battery life.

ADJUSTMENT

With C1 at about minimum capacitance and the set switched to the m.w. band, any stations that are received will almost certainly be only very weak. Increasing the capacitance of C1 should increase the strength of the received stations, but too much capacitance will cause the set to break into oscillation.

This will either cause a note of varying pitch to be produced as the set is tuned across a transmission, or in an extreme case there will be a high level of of background noise and a total absence of other signals.



The completed CMOS LW/MW Radio. The wavechange switch is mounted on the side of the case top.

The trimmer will finally be set for the highest capacitance that does not result in oscillation at any setting of C2. However, first set it to give reasonably good sensitivity, and then by trial and error find a position for L1/L2 on the ferrite rod which enables the full m.w. band to be covered by C2, and the 200kHz l.w. transmission to be tuned in when S1 is switched to the l.w. position.

There is quite a lot of latitude here, and this adjustment is not critical. When a suitable position has been found the aerial coil should be glued in place on the ferrite rod. Then C1 is adjusted to optimise performance. The best setting for C1 alters slightly when the back of the case is placed in position, and so it is a good idea to drill a small hole in the centre of the rear panel so that C1 can be adjusted with the rear panel screwed into place.

Like most simple t.r.f. receivers the set has no automatic gain control, a.g.c. If overloading occurs on strong signals it is possible to use the directional property of the ferrite aerial to obtain a reduction in signal strength merely by rotating the set to find a position that nulls the signal to some degree. ☐

BRIGHT IDEAS

SLIDER SLOTS

I have developed a method of cutting perfect slots for slider type variable resistors in Formica, that, with care, can also be applied to Perspex, Paxolin, ABS, etc.

The accepted way of cutting Formica is with a Stanley knife, and the special blades they produce for scoring, number 5194. If two of these blades are clamped together in the same holder, with spacing shims as required, two parallel cuts can be made, from one to three or four millimetres apart to suit.

There are many types of Stanley knife holder, and some may not be suitable for two blades, but alternative holders should not be too difficult to devise.

K. Croft, Broadstairs, Kent

CONTROL KNOBS

As the cost of control knobs for homemade electronic devices can be quite high, I wonder if other readers would consider the following as a money saving tip, using old bottle caps as knobs. The types of cap most presentable are the screw on black bakelite or plastic type, typically found on medicine bottles etc.

To make the knobs, fill the inside of the cap with 5-minute plastic filler to the top. Insert the cut off piece of a used potentiometer spindle into the filler, while it is drying, ensuring that it is smeared with Vaseline to prevent the filler sticking to it, also that it is centred and upright. When the filler is dry the dummy spindle can be removed, and excess removed.

In order to ensure a good tight fit, the spindle to which the knob is being fitted, assuming plastic, can be slightly scored with a hot object, or if the tools are available, a hole drilled, tapped, and a headless screw inserted for tightening.

J. N. Moore, Cork, Ireland

A FEAST FOR CONSTRUCTORS

Menu

SUBSCRIBERS TELE-TEL METER

An ingeniously designed electronic calculator to display the cost of your telephone call as it is accumulating. Don't leave it to chance!

AIR FRESHENER

A silent fan controlled by a timing circuit sends a stream of odour-neutralizing vapour into the furthest corners of the room.

Extra 8 page Supplement Constructional Methods

Illustrating the use of electronic hardware, materials and tools.

HOT LINE

An amusing game for young and old alike.

AUDIO EFFECTS OSCILLATOR (mini-module)

Our low-cost Mini Module project lets you create you own sounds.

Everyday ELECTRONICS

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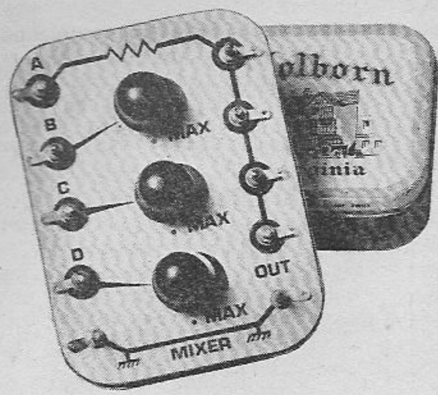


MINI~MODULES

By George Hylton

Handy "Beginner" projects based on simple circuits and featuring a variety of building methods.

1 PASSIVE MIXER

AUDIO mixers are useful gadgets. If you are putting on a show or tape-recording a commentary for your holiday slides you may want to mix voice and music, fade in a sound effects disc and so on. For general experimenting, too, a means of mixing audio or d.c. signals is often required.

The mixer described here is about the simplest which will give a reasonable performance. It is a passive mixer, that is it contains no amplifying devices (and therefore requires no power supplies). In fact it is merely a collection of volume controls whose outputs are connected together via resistors which prevent one control from affecting the others too badly.

This kind of mixer attenuates all signals: the output is always less than the input. But this loss can always be made up by an amplifier somewhere in the system.

Another essential element in a complete audio chain is a master volume control to adjust the level of the combined signals after mixing. Most amplifiers have one already, though there is no objection to connecting one to the output of this mixer if desired.

THE CIRCUIT

The circuit (Fig. 1) is really self-explanatory. Each of the three controlled inputs (*B*, *C*, and *D*) goes to a volume control. The outputs of the three volume controls are combined via 100kΩ resistors. There is also an uncontrolled input (*A*) for signals which come from a source which already has its own level control. (If required, more uncontrolled inputs can be added. All that is required is to provide each one with a 100kΩ resistor to the common output.)

Passive mixers can interact in two ways. First there can be feed-through from one input to the others. This is not usually important, but if necessary can be reduced by driving the inputs from low-impedance sources such as emitter-followers. Second, the level of one signal at the output changes when the level of one of the other signals is adjusted. The effect is not large. In

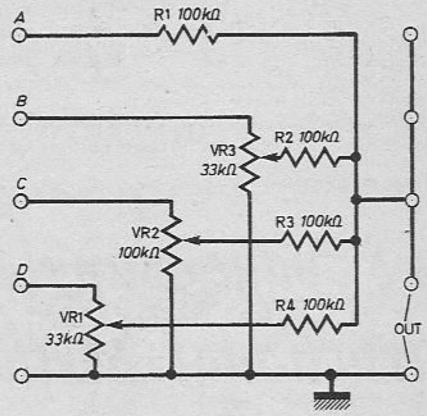


Fig. 1. Passive mixer circuit.

the worst case the change can reach about 3dB (33 per cent), but will generally be a lot less.

This second type of interaction can be reduced by increasing the combining resistances, at the expense of increased loss of signal, or reducing the volume control resistances.

No coupling capacitors are included; this is for economy and to permit the mixing of d.c. signals. They can be added if desired, and the minimum usable value for hi-fi audio will be 100nF (0·1μF).

None of the resistor values are critical. If the signals come from low-impedance sources the value of the volume controls can be reduced.

COMPONENTS

Resistors
R1–4 100 kΩ carbon film. 5% ¼W (4 off)

Potentiometers
VR1,3 33kΩ carbon track log (2 off)
VR2 100kΩ carbon track log

Miscellaneous
Metal box about 100 × 70mm, at least 20mm deep: 2-ounce rectangular tobacco tin or Norman AB9. Formica or cardboard; 6BA bolts, nuts, earth tag washers and fibre washers. Small knobs (3 off).

A value of ten times the signal source resistance is acceptable; for example, if the signal comes from a tape deck whose pre-amp has an output impedance of 1kΩ then the volume control can be as low as 10kΩ.

It is not necessary for all the controls to have the same track resistance. If the output is to be connected to a high impedance load such as an amplifier with a high input impedance the combining resistors can be increased. A reasonable rule is that each combining resistor can be as high as three times the load impedance; for example a 100kΩ load would permit the values to be raised from 100kΩ to 300kΩ (or 330kΩ which is a preferred value).

CONSTRUCTION

A mixer like this should not be used with very low-level input signals such as the direct output of a microphone. On the other hand it will probably have to be used from time to time with fairly small signals and for this reason it is advisable to house the circuit in a metal box to provide a measure of screening.

The prototype circuit was fitted into a two-ounce rectangular tobacco tin, with the tin itself connected to the common or earthy side of the audio system. A number of other circuits, similarly housed, were screwed to a wooden baseboard so that they could be hooked up in various ways to form a simple audio effects system.

Many of the projects in this Series will fit into similar containers. A suitable commercial box is the "Norman" AB9, an aluminium box which measures approximately 100×70mm, which is slightly smaller than the tobacco tin, but is, at 70mm, quite a bit deeper, which is sometimes an advantage.

Whatever box you use, remember to leave as much space as possible between the volume controls so that you can operate two adjacent controls at the same time.

A problem with metal cases is that the input and output connections require to be insulated from the case. The neatest solution is to fit screened input and output sockets, such as the appropriate types of DIN socket. However, where perfect screening is not needed (as when the signal levels are above about 30mV and come from lowish impedance sources, say below 10kΩ) illustrated (Fig. 3).

FEED-THROUGH CONNECTIONS

Drill clearance holes in the case for all the "live" inputs (the "earth" terminals can go straight to the case) and stick a strip of Formica or similar insulating board over the holes on the inside of the case. Drill small holes through this board in the centres of the clearance holes. Through connections can now be made with nuts and bolts (for example, 6BA).

On the outside the insulation can either be another strip of Formica with holes to take the bolts or you can use an insulating washer for each connection, as in the prototype.

The stems of the bolts, if long enough, can be used as posts to connect crocodile-clipped leads, which are very handy for quick interconnections. For more permanent connections, give each bolt a washer-type "earth tag" on both the inside and the outside. These tags take soldered connections.

Although only one common output terminal and one common "earth" are needed it is more convenient to use multiple terminals as shown.

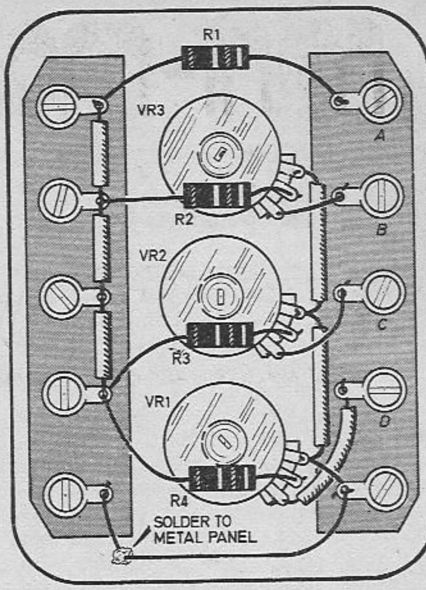


Fig. 2. Underside of panel with all wiring details.

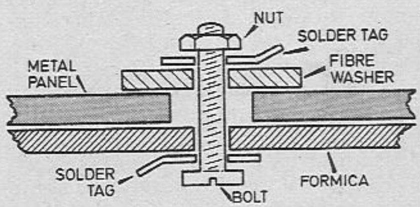


Fig. 3. Do-it-yourself feed-through connectors.

WIRING UP

There are no wiring problems. The potentiometers and the resistors are simply wired up to the various tags as shown in Fig. 2. It is advisable to check that the lid really does make connection with the container. Tobacco tins have a strip of sealing compound which tends to prevent this. If necessary run a separate earth to the main part of the tin. Note also that although the inside of a tin may look like bare metal it is usually covered with lacquer, which should be scraped away to enable earth connections to be made.

USING THE MIXER

As stated, it is advisable to avoid mixing signals of very low level, because this aggravates hum, noise and any scratchiness in the controls. Ideally, signals should be 100mV or over. If your signal comes from a low-level device such as a microphone build a separate pre-amplifier for it.

Given signals of adequate strength you can combine them to your heart's content. One point of definition, however: this is a linear mixer. It is not a "mixer" in the sense of a device (such as the 'mixer' in a superhet receiver) which produces intermodulation between signals. A modulator to perform that sort of mixing, at audio of course, will be described later in the Series.

Next Month: Audio Effects Oscillator.

EE CROSSWORD No 8 BY D.P.NEWTON

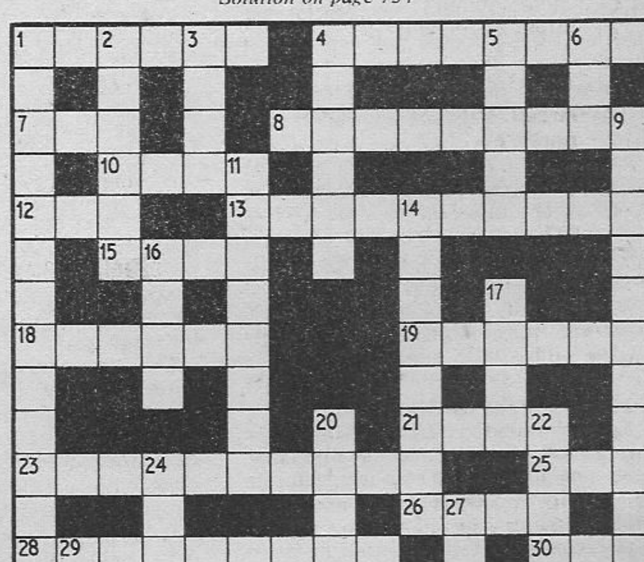
ACROSS

1 Previous, a kind of core.
4 A radio is hardly this and yet it is.
7 There's some tar about an animal.
8 A car part, in a shockingly, empty sort of way. (3 words)
10 Bring a case to singular conclusions. (Anag.)
12 The final stage finds itself put in this position.
13 Cybernetic device to obtain thermal equilibrium.
15 About a neat eruptive.
18 The earth.
19 An event of the religious calendar is a terminal for this zero amplitude.
21 Applications.
23 A means of putting across h.f. noise.
25 Time, gentleman, shortly.
26 A tape loop can be used for this effect, on reflection.
28 Overhead telephone conversations in an angry sort of way.
30 Decay.
31 Functions, as might an amplifier.
32 The wire at the head of the line?

DOWN

1 Having a powerful attraction for like material.
2 An electric motor should be able to do this.
3 A peripheral effect with capacitors.
4 A bolt buffer with cleansing properties.
5 Expanses of fresh water.
6 A global conductor.
9 A voltage divider.
11 Component of high quality used for comparison.
14 Greatly dampens the effects of static electricity.
16 A round trip.
17 This could be one.
20 On balance, useful indicators on a dial.
22 Potentially, energy is in this form.
24 Is Ron about, for a negative but polite response? (Anag.) (2,3)
27 Central to the coil.
29 Tear off from a ripple.

Solution on page 754



RADIO WORLD

By Pat Hawker, G3VA

RADIO BROADCASTING and two-way radio communication were among the first successes of the electronic revolution—and still, for many of us, have a firm place among the better things that have come out of this technological age. But sometimes, I fancy, we all expect technical changes and "breakthroughs" too often, too rapidly. In practice, old-established techniques seldom fade away or are superseded completely, as the wave-length reshuffles on BBC Radio next November 23 show.

All change!

Medium and long-wave a.m. broadcasting has been with us for over 50 years. For ages we have been urged to change first to v.h.f./f.m. then to stereo, and most recently to surround-sound (quadraphony). Yet it is clear that even today most radio listening is done between 187-571 and 1053-2000 metres. Now in something of a *volte-face* we are being told we need radios covering l.w., m.w. and v.h.f. (not to mention "all-band" radios for short wave bands).

What the BBC regards as its main channel of news and information is to shift to 1,500 metres (200kHz) with no duplication on v.h.f. over quite extensive periods of the day.

200kHz can of course provide virtually national coverage of the UK by day and night. But it does have problems. The short ferrite-rod aerials are not very efficient but even more annoying is the amount of interference from the line-time bases and switched-mode power supplies of colour TV sets.

For years radio amateurs have been complaining to little effect of the whiskers of interference that extend right up to above 30MHz. But how will the ordinary listeners respond when, after buying new three-band radios, they find that the rasping buzzes they are liable to experience on l.w. come from the neighbour's telly?

Defining Interference

A high-level international committee has been busy re-defining precisely what "interference" is all about. Finally they have come up with: "the effect of unwanted energy due to one or a combination of emissions, radiations, or inductions upon reception in a radio communication system, manifested by any performance degradation, misrepresentation, or loss of information which could be extracted in the absence of such unwanted energy." Golly is this, like interference, a matter of misplaced energy?

Rather more down to earth is a recent publication in the United States of an excellent 32-page booklet prepared by the Federal Communications Commission called "how to identify and resolve radio-TV interference problems" and packed full of information for listeners, viewers and dealers on how to identify and cure the various forms of electrical and radio interference and to distinguish these from receiver tuning and multipath (ghosting) problems. Home remedies such as high-pass filters are well described and illustrated, and there is technical information for servicing technicians.

One reason for this publication is the increasing amount of interference experienced in the States from 27MHz "CB" (Citizen's Band) transmissions. Similarly, TV manufacturers are being encouraged to design receivers less susceptible to strong local transmissions. The Americans clearly believe that CB interference is serious—but that it can be reduced without adopting the defeatist attitude of banning CB.

Wireless Telegraphy Acts

The British Government, on the other hand, has made it clear (for example in the recent White Paper on "Broadcasting") that it intends tackling the increasing amount of illegal CB operation here by further restrictions to be written into the Wireless Telegraphy Acts. It seems likely that new legislation will make it much easier for the authorities to bring prosecutions (and gain convictions) for illegal operation whether this is pirate broadcasting, bootleg 'amateur' operation or the use of those 27MHz transceivers.

One amendment, the White Paper hints, will be to stop sale of (as well as the import of) equipment designed to operate on frequencies which, it claims, could not be authorised in this country and are likely to cause interference.

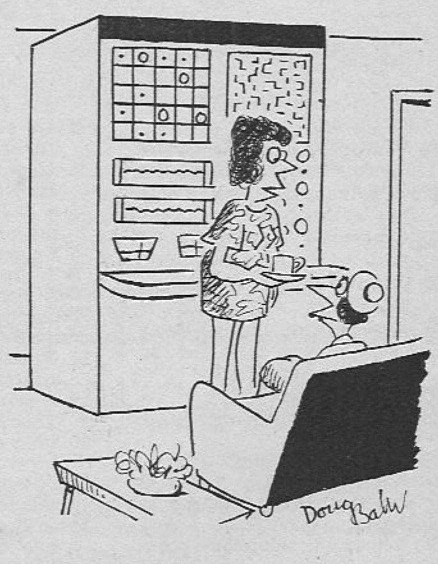
It looks as though we may end up with some pretty restrictive Acts, rigorously enforced. CB can be a shambles, but at the same time it does fulfil socially useful functions in many countries. One seldom hears complaints, for example, of CB operation in West Germany or in a number of the East European countries where users seem to respond to the need for self-discipline and a sense of responsibility.

The New RAE

It is also, surely, high time that we ceased erecting such formidable barriers to gaining an amateur radio licence in this country. More than 10 years ago we were promised a form of "beginner's licence" but the original idea was poorly thought out and never came to anything.

Next May, the Radio Amateur's Examination is being remodelled along "multiple-choice" lines in which the candidate is given four possible answers to each question and has "only" to indicate which is correct. But the sample questions recently released by the City and Guilds of London Institute make it quite clear that the technical standard remains high and that very detailed knowledge of licence conditions will be required.

Since amateur radio is intended for "self-training" should not newcomers be encouraged to learn by experience (and then perhaps take the final examination) rather than be discouraged by having to pass quite a stiff (and not always relevant) examination before they are permitted to venture "on the air"?



"What does It do? It hides a big stain on the wall."

ELECTROVALUE Buying Guide

Section 3

If you have bought before from Electrovalue, you will know just how large and varied our stocks are. For those who have yet to know, we are publishing a series of five ads. month by month to give up-to-date information and prices on the most important items we carry. These ads. will appear in stepped rotation in five journals—Pr. Wireless, Pr. Electronics, Everyday Electronics, Electronics Today Intntnl. and Elektor, so that the complete series will be available each month. In this way, no matter which journals you read, BY DETACHING AND SAVING THESE PAGES, YOU WILL BUILD UP A VALUABLE AND COMPREHENSIVE MONEY SAVING CATALOGUE.

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7403	14p
7404	18p
7405	14p
7407	22p
7408	18p
7409	18p
7410	14p
7413	22p
7414	60p
7420	14p
7430	14p
7440	14p
7442	54p
7443	60p
7444	60p
7447	70p
7450	14p
7451	14p
7453	14p
7454	14p
7460	14p
7470	24p
7472	24p
7473	23p
7474	23p
7475	45p
7476	32p
7480	41p
7482	61p
7483	58p
7485	74p
7486	27p
7490	40p
7491	71p
7492	46p
7493	40p
7494	66p
7495	57p
7496	63p
74100	73p
74104	40p
74107	27p
74121	27p
74123	51p
74141	54p
74151	60p
74154	1·60
74190	94p
74191	94p
74192	94p
74193	94p

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4001	19p
4002	19p
4006	96p
4007	19p
4008	80p
4009	54p
4010	54p
4011	19p
4012	19p
4013	40p
4014	96p
4015	1·14
4016	40p
4017	80p
4018	88p
4019	64p
4020	96p
4021	88p
022	83p
4023	19p
4024	90p
4025	19p
4026	1·75
4027	58p
4028	95p
4029	1·23
4030	54p
4041	84p
4042	80p
4043	93p
4044	93p
4046	1·28
4049	48p
4050	48p
4060	1·33
4069	19p
4070	19p
4071	19p
4072	19p
4081	19p
4082	19p
4510	1·28
4511	1·36
4514	3·30
4516	1·37
4518	1·25
4520	1·25
4543	1·30
4583	1·28

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7107	£13·60N
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7905	1·65
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7915	1·65
CA3130	99p
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NE555V	32p
NE566A	76p
S041E	2·69
S041P	1·15
S042E	3·45
S042P	1·30
S566B	4·57
SAJ131	2·38
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SAJ205	4·10
SAJ410	1·05
SAS201A	2·08
SAS211A	2·08
SAS560	2·14
SAS570	2·14
SAS580	2·22
SAS590	2·22
SN76013N	1·81
SN76013ND	1·66
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LD57C green*‡	42p

code * 5·1mm dia not 2·9mm
code ‡ extra-bright

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* *Cannot be repeated*

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IN one of the first articles I wrote for EVERYDAY ELECTRONICS, I remember saying we tried to prevent many components from disappearing altogether, by buying large quantities. Regrettably this is no longer possible due to inflation. I am amazed when I hear Uncle Jim on the box telling me it's in single figures when I have just paid double the price for some articles I last bought two months ago! Perhaps he is talking about the increase per month!

The fact that some of our suppliers are remarkably short sighted in their sales technique does not help matters either! I bought two soldering irons last week. Now that probably seems a small number for a retailer to purchase, but they retail at over £16 and are very slow sellers. I then noticed we had been given no discount. When we remonstrated with them, they were quite off hand, and said in effect "Oh! you give us an order for £150 and we will think about discount."

With a crowd of Paul's youngsters to feed I could not let this go unchallenged. I told them that with thousands of components to purchase from many different suppliers such orders were an economic impossibility. So that's another item lost to the retail market.

Let me at this point reassure you: we never give up without a real struggle, and I could cite several instances where prices became too high and finally we decided we would make our own. Etching kits, short wave kits and large resistor packs being cases in point.

Welcome Return

Having said all this, it is nice to be able to report on a component that re-appears on the market after a long absence. My old friends Home Radio are now offering the famous Eddystone 898 Dial for sale once more, though I fancy it is only for a limited period. I think it finally went off the market because it was too expensive to produce. For one thing all the gearing is made in Switzerland. Although it sells around £16, it is a magnificent example of the dial makers art.

Still on the subject of disappearing items, I was very pleased to see that EVERYDAY ELECTRONICS recently had a project for a *Resistor and Capacitor Substitution Box*. A short while ago these were being produced commercially but now they have now gone the way of all slow selling lines.

One thing I always like to receive is constructive criticism and if the comments are fair I will always do my best to carry out any suggestion to improve our service.

Supplier A and Supplier B

Now a favourite ploy of a dissatisfied customer is to compare your service with that of another supplier. I have nothing against that, after all you have to have some yardstick. What customers sometimes do not realise is that the comparison is not always a fair one. Let me give a hypothetical case.

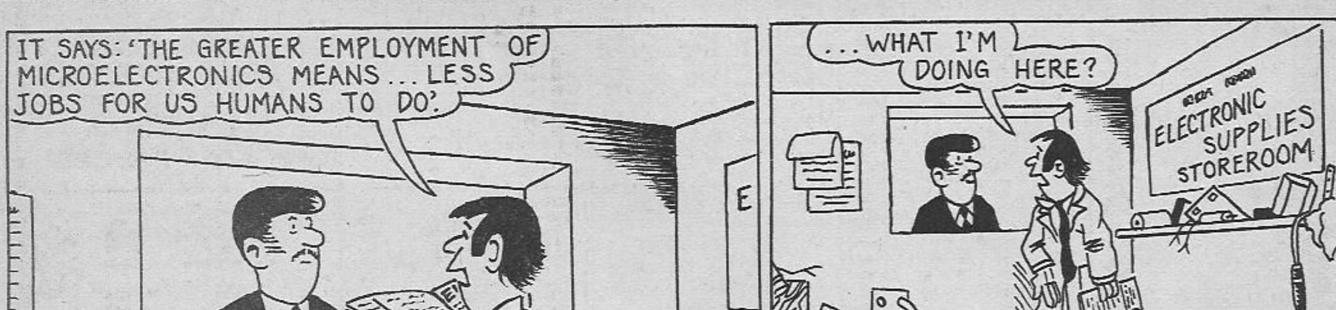
A customer is making a certain project and among the list of items he requires are two unusual ones, perhaps a $1\mu F$ 1 per cent capacitor and a special ceramic filter. Searching around he finally finds a supplier (lets call him "A") who has these and so he sends for them, but not wishing to desert his usual retailer, he sends the rest of the order to him, consisting of perhaps a few ordinary resistors and capacitors (we will call him "B").

Now "A" finds the demands for these two unusual items very small, keeps very small stocks and occasionally runs out. When this happens, there may be a six weeks delay by the maker before delivery. "B" has sent off our customer's order by return, but all our customer gets from "A" is a letter telling him of long delay. The result, customer blows his top, writes to "A" about his poor service and says why can't he be more like good efficient "B"!!

Ah well, its a hard life and who shall escape calumny? Who indeed!

JACK PLUG & FAMILY...

BY DOUG BAKER



SQUARE one FOR BEGINNERS

ARE you a newcomer to electronics? If so, a very warm welcome to you from SQUARE ONE. This feature will introduce you to all the essential facts about home construction of electronic circuits. And if you are still hesitant and not quite sure that electronics is the hobby for you, just look through this issue and see the kind of exciting projects you soon will be able to build yourself.

But after you have scanned the other pages of EVERYDAY ELECTRONICS, you should return to SQUARE ONE and get acquainted with the basic facts of electronic circuit construction. Nothing to be frightened about—we make it all so easy for you!

THE CIRCUIT DIAGRAM

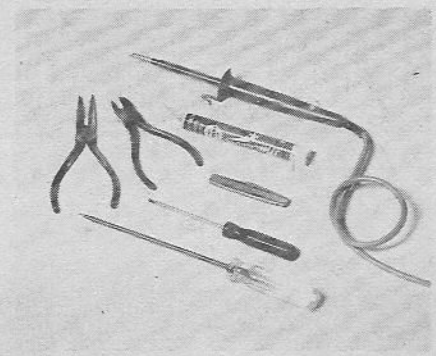
The circuit diagram is the key to any electronic design. From this alone it is possible for the experienced to build a working model. But it is obviously far easier and quicker if there is a detailed plan for the actual layout of the components and all wiring to follow. All projects in EVERYDAY ELECTRONICS are fully covered in this fashion, so that it really becomes simply a question of following the diagrams.

Needless to say the newcomer should not embark immediately upon the larger kind of projects. He should "cut his teeth" on the simple designs: like the *Fuse Checker* in this issue, and the *"Mini-Module"*.

ESSENTIAL TOOLS

A few tools are required. A couple of small screwdrivers, with say 3mm and 4mm tips, a pair of pointed-nose pliers, wire cutters, a pocket knife and of course a soldering iron. This should be a small instrument with a power rating of between 10 and 30 watts. A bit (that is the business end of the iron) size 2mm or 3mm will be satisfactory for most general work. All these soldering irons are available with detachable bits, and a range of bits is provided in sizes from 1mm upwards. This versatile type of instrument will be most valuable as you become more experienced and ambitious in constructional work.

Soldering is performed with resin-core solder. This resembles tinned wire and is in fact made in sizes corresponding to the standard wire gauge (s.w.g.). For most work, 18 s.w.g. or 20 s.w.g. solder will suit. Buy the type that is described as suitable for radio or electronic work. This means, in fact, that it will be composed of 60 per cent tin and 40 per cent lead.



A basic tool kit for circuit construction.

MOUNTING COMPONENTS

Electronic circuits are generally assembled on pieces of plastics board. The trade description for this material is synthetic resin bonded paper, abbreviated to s.r.b.p. (A similar material which has been around for many years is known by its trade name Paxolin.) A superior type of board is also available made of glass fibre. This is more expensive than the standard s.r.b.p. board and its use only warranted in special applications, usually for printed circuits.

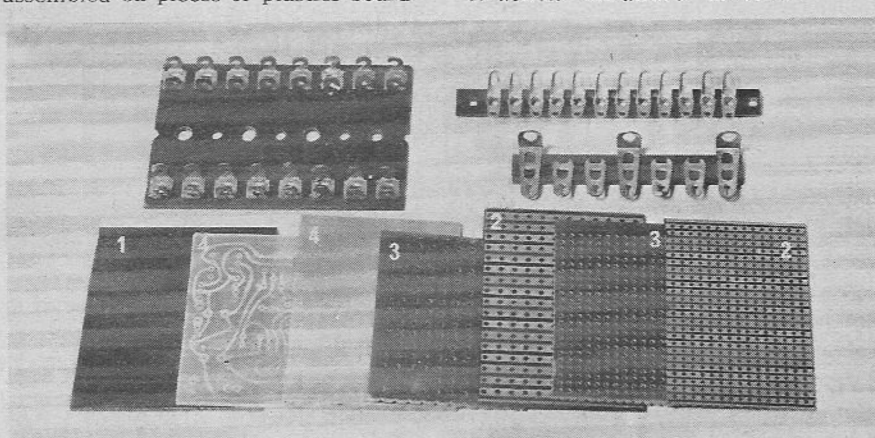
This plastics (s.r.b.p.) board is commonly available in four forms:

1. Plain board.
2. Plain on one side with copper strips on the other, and perforated with 1mm holes on a 0·1 inch or 0·15 inch matrix. Proprietary name Veroboard, but often referred to simply as "stripboard".
3. Plain perforated board, with 1mm holes on a 0·1 inch or 0·15 inch matrix.
4. Plain on one side, and copper clad on the other. This is used for making printed circuit boards (p.c.b.s) which, briefly, involves the etching away of unwanted copper, leaving just the circuit pattern of the required design.

In addition to the above-mentioned, other methods of assembling electronic components are sometimes used. Such as, for example, tagboards (group boards) and tag strips (the body material being s.r.b.p. in both cases).

There are also "solder-less" methods where terminal blocks play a useful role. Screwed connections are ideal for experimental work and for "temporary jobs", but soldered connections are essential for all serious construction work that is intended to have permanency.

So far we have discussed tools and circuit assembly materials. The all-important question of electronic circuit components is next on the agenda and will be looked at next month. *Also note that a special supplement in the November issue will describe construction "hardware" in detail.*



Group board, tag strips, and a variety of s.r.b.p. boards.

EE SPECIAL REPORT

Crystal Set

THE humble crystal set is often the first real project the newcomer to the world of electronics builds. There is real fascination in hearing a radio programme on completion, and this first achievement provides a thrill that is rarely overshadowed by more advanced activities in radio or electronics.

With this undeniable fact in mind, Home Radio has produced a simple crystal set especially for the beginner. It is based on the classic circuit arrangement, but modern components are used throughout. We received a specimen set in kit form together with all the necessary instructions.

Perhaps the hardest part of the construction is the winding of the coil. At times the coil is likely to spring off the ferrite rod causing much frustration! Details of the coil are given in the instructions, and we found that the length of wire supplied was sufficient for 40 turns. The instructions advise that sleeving be used on some of the wires, though the sleeving is not supplied with the kit. No other real problems were encountered.

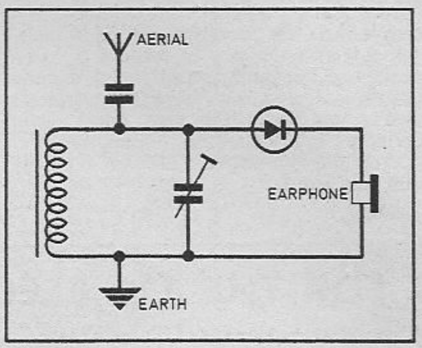


Fig. 1. The circuit diagram for the Crystal Set.

ASSEMBLING THE KIT

As the set is aimed at the beginner the design must, of course, be fool-proof and easy to build. To this end, there are no soldered joints to make, and all connections are made to a terminal block. However, if the case recommended is purchased at the same time, there are then just two points to be soldered.

Total building time was around 40 minutes from unpacking the kit to trying out the set. We built our's into the recommended case which entailed some soldering, but no doubt this could be avoided if the aerial and earth sockets came ready-wired.

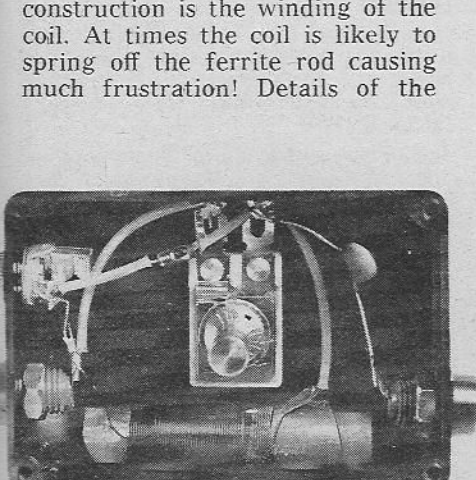
RESULTS

The set was tried by a member of our staff at home in Essex, the particular site having good reception of all the local stations.

The first test was with a length of aerial wire as suggested, about 20 feet long. The earth was attached to the water main. Reception with this set-up was rather disappointing, only the local Radio 4 signal being received. However, later at night the strength increased and other stations became audible.

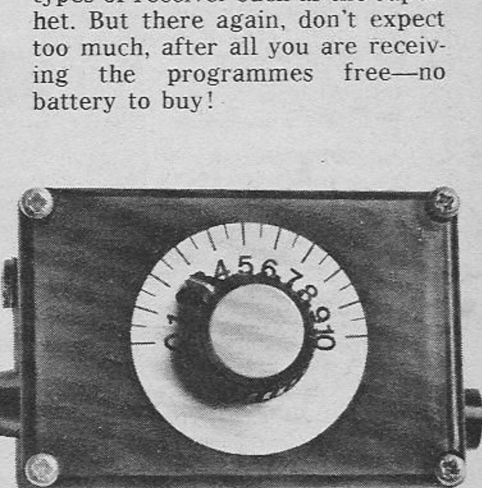
A further test was carried out using about 300 feet of wire for an aerial, and a rather efficient earth system, comprising about 15 square feet of conductor buried in the ground. Results with this set-up were better, all the local stations being received as well as a few foreign stations.

All in all, the set performed quite well but, of course, not as efficiently as many of the superior types of receiver such as the superhet. But there again, don't expect too much, after all you are receiving the programmes free—no battery to buy!



Cost of basic parts including earphone but excluding case	£1·80
Black plastic case with dial, knobs, spindle, sockets and plugs	£2·08
Postage	£0·85
	Total £4·73

All prices include VAT. Available from: Home Radio (Components) Ltd., 234-240 London Road, Mitcham, Surrey CR4 3HD.



LETTERS

Speed Problem

Regarding Paul Young's request for information concerning the "speed of electricity", I think I can throw some light on the subject.

Given a perfect piece of wire with neither inductance nor capacitance, the speed of electricity will be very close to the speed of light (e.g. rather in the way force is transmitted by the Newton Ball experiment).

However, the characteristics of wire are such that inductance, capacitance and frequency are a real consideration. These factors of inductance (L) and capacitance (C) also combine to give impedance, (Z).

The "speed of electricity" is more properly called the "velocity of propagation," (v_p) and is proportional to $1/Z$. So to calculate that velocity in a given cable, and given that we know the Velocity Propagation Factor (F_v), (which we can get from the manufacturers data) we multiply the speed of light (c) by F_v:

$$v_p = c \times F_v$$

To take a simple example of your TV fly lead, $F_v = 0{\cdot}66$, $c = 186{,}224$ miles/sec.,

$$v_p = 186{,}224 \times 0{\cdot}66$$
$$= 122{,}907 \text{ miles/sec.}$$

House wiring, on the other hand has an F_v of 0·01 giving a $v_p = 1{,}889$ miles/sec. for a 1 metre length of 1·5mm twin and earth cable.

D. R. Coomber,
Leeds.

Mini Case

I have found a useful small plastic case for the *M. W. Mini* (EE August 1978). It is the case which house the "Points for Cars". You can normally get them from the local garage free if you offer to pay for them. That is what I found anyway.

If you do use this box, you will have to knock 2 rows off the matrix reducing it to 11 by 5 instead of 13 by 7 because the box is slightly smaller.

Michael Read (age 12½),
Berks.

Rabies

Clamp microphones to all incoming cars, fuselages and hulls, and feed the signal to an analyser and computer. The heart-beats, including foetal, should always agree with the listed number of passengers.

Historical?, impossible, or feasible?; Accountants, shut up.

The passengers would not be subjected to a scanning beam. The idea is not hindered by knowledge.

J. Cairney,
Edinburgh.

Rapid Transistor Check

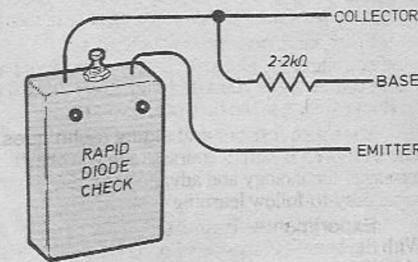
I recently built the *Rapid Diode Check* published in the January issue and have found that a very simple addition will enable it to test transistors in one check.

If a 2·2kΩ resistor is taken from one probe and connected to another crocodile clip, this forms the "base" connection. The probe that this was taken from becomes the "collector" connection and the remaining probe the "emitter" connection, see Fig. 1.

If the l.e.d. to which the base resistor is connected lights, the transistor is *pnp*. If the transistor under test is *npn*, the other l.e.d. will light.

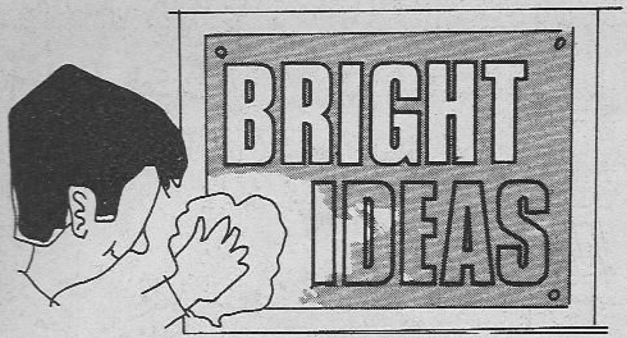
If both or neither l.e.d.s light, the transistor is unserviceable.

T. D. Allen,
Poole,
Dorset.



Crossword No. 8—Solution

1 F	O	2 R	M	3 E	R		4 W	I	R	E	5 L	E	6 S	S
E		O		D			A				A		E	
7 R	A	T		G		8 A	S	P	A	R	K	G	A	9 P
R		10 A	C	E	11 S		H				E			O
12 O	U	T			13 T	H	E	R	14 M	O	S	T	A	T
M		15 E	16 T	N	A		R		O					E
A			O		N				I		17 C			N
18 G	R	O	U	N	D				19 S	I	L	E	N	T
N			R		A				T		U			I
E					R		20 S		21 U	S	E	22 S		O
23 T	R	A	24 N	S	D	U	C	E	R			25 T	I	M
I			O				A		26 E	27 C	H	O		E
28 C	29 R	O	S	S	T	A	L	K		O		30 R	O	T
	I		I				E			R		E		E
31 O	P	E	R	A	T	E	S		32 L	E	A	D	E	R



Readers' Bright Ideas; any idea that is published will be awarded payment according to its merit. The ideas have not been proved by us.

MAKING PCB's

I have devised my own method for making printed circuit boards which is easier and more accurate than the carbon paper technique and certainly cheaper than UV methods. It is especially good for copying foil patterns printed in magazines and books, but will also copy home-made patterns drawn full-size on paper with a fairly soft pencil.

It is possible to obtain from stationers, clear plastic, self-adhesive film, as used for covering maps and books etc. Cut a piece slightly bigger than the p.c.b. Peel off the backing paper, lay the film over the design, rubbing *very gently*.

Carefully peel off the film and place it on the copper side of the board, rubbing it on hard. With a sharp craft knife, cut off the excess round the edge of the board. If you look at the board you will be able to see a feint copy of the design on the film. Carefully cut round the pattern. Peel the unwanted film away, and rub the remainder on hard.

The board is now ready for etching, as the plastic film acts as etch resist. Repairs can be done before etching using an etch-resist pen.

J. Preston,
Bolton,
Lancs

CIRCUIT BOARD HOLDER

Fixing a circuit board in a case can often cause problems, but I have found a simple, efficient method that will also absorb shocks.

It consists of a strip of foam with an adhesive back, the sort you can stick around doors for stopping draughts, which can be stuck in the case by peeling off the backing paper and sticking the case to form rails for the circuit board to slide into.

I have found this method useful on many occasions.

T. Kempton,
Tunbridge Wells.

COMPONENT PROTECTION

For preventing electrical contact between metal cased transistors in tightly packed circuits, a coating of clear nail varnish can be used. In this way the type numbers can still be seen.

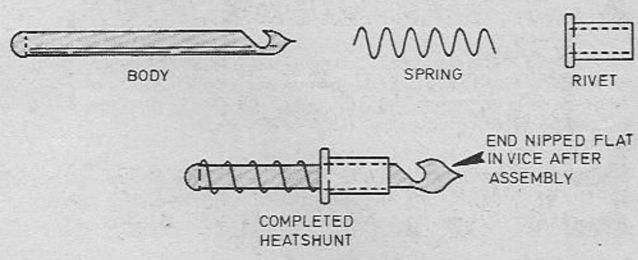
J. Winter,
Angus,
Scotland.

HEAT SHUNT

I often find when soldering a delicate component, that a heat shunt is very difficult to use. This is especially true in awkward situations. I have solved this problem by making a small heat shunt using a pop rivet. The arrangement is shown in the diagram.

First the rivet is dismantled and a small slot cut at an angle at the pointed end of the body. Next a spring, one from an old ball-point pen is very suitable. This is placed over the body and the rivet pushed into place. The end of the body is nipped in a vice to prevent the rivet from springing off.

T. Witherwick,
N. Humberside.



CARDBOARD CABINETS

For a temporary loudspeaker "cabinet"—or a permanent housing, with suitable outer covering, heavy corrugated cardboard boxes are hard to improve upon.

For an eight inch speaker, a box of about 250 x 300 x 400mm seems to be an appropriate size. A hole of the correct diameter can be cut easily with an art knife, round a template borrowed from the kitchen.

A "reflex" hole is cut below the main aperture, size about 140 x 50mm, and all edges of the box are secured firmly with masking tape or similar, both inside and out. Holes are made for the nuts and bolts, and large washers used when fixing the speaker, to ensure a fairly sturdy finished item.

The incredible thing about corrugated cardboard loudspeakers is that this material appears to be relatively free from internal resonances, and gives, to all intents and purposes, a flat response through all the bass frequencies.

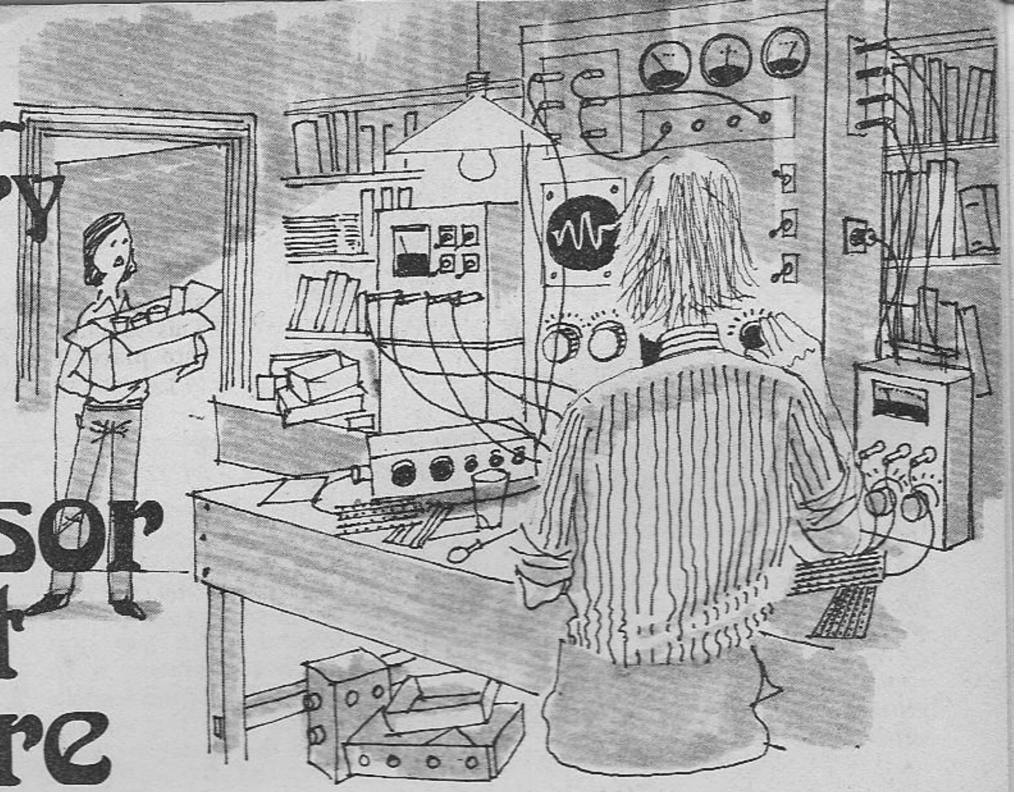
I have used cardboard box cabinets for speakers handling up to 10 watts without any ill effect, and until recently, a stereo pair were in use wedged between books in a bookshelf, the exposed fronts being covered with chiffon scarves.

Boxes can be picked up from any friendly store, the heaviest being those used for carrying glass containers, and if you search carefully by the supermarket exit, you might even be lucky enough to find a pair of plain boxes, unprinted.

It makes a change from teak veneer, anyway.

K. Croft,
Broadstairs,
Kent.

The Extraordinary Experiments of Professor Ernest Eversure



by Anthony John Bassett

Bob has suggested to the Prof. that in order to improve the efficiency of a valve amplifier and allow it to run cooler, the valve rectifier might be replaced by silicon rectifier diodes. The Prof. has agreed that this could be possible, but warned Bob that certain precautions should be taken if this modification is to succeed.

"I have come across a number of amplifiers which have been modified in this way and are operating without trouble after several years. Their owners are of course very pleased by this and it does appear to be a worthwhile modification. However, the increased efficiency and instant action of the silicon rectifiers, which do not need time to warm up like a thermionic valve rectifier, do present some problems which must be tackled if we are to succeed.

LIKELY PROBLEMS

Before applying this modification to the AC30 amplifier, let us consider these problems in general, as similar factors apply to other valve amplifiers which we might want to alter.

Due to the much lower internal resistance of the silicon rectifier when it conducts in the forward direction, the reservoir capacitor in the amplifier charges much more rapidly and the peak voltage attained is likely to be considerably higher than the voltage reached using a valve rectifier. This higher h.t. voltage is also passed on to the main smoothing capacitor by the low-resistance path of the h.t. smoothing choke, and to the output valves by way of the output transformer and grid 2 bias resistors.

So if we fit the silicon rectifiers then switch on the amplifier without further precaution, the reservoir and smoothing capacitors are likely to take an excessive leakage current. They could then become hot and blow open, or simply blow the fuses of the amplifier. To prevent this from happening, we must either replace the capacitors with new ones of higher working voltages, or else reform them to ensure they will accept the higher peak voltage without trouble.

In the AC30 amplifier the h.t. voltage is about 320 volts, but when we replace the GZ34 rectifier valve with two silicon rectifiers type BY127 the peak voltage appearing across the reservoir capacitor C39 in Fig. 1 will probably rise to a little over 400 volts. Fortunately, the rated voltages of C39 and also the smoothing capacitor C40 are both 450

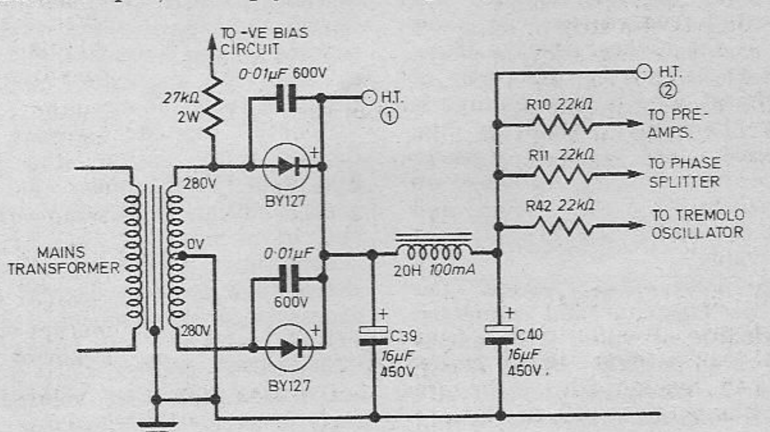


Fig. 1. H.T. supply with GZ34 rectifier valve replaced by two BY127 silicon diode rectifiers and two 0·01uF 600VW disc ceramic capacitors. Heater windings not shown (compare with Fig. 2 last month's issue).

volts, so we should not need to replace them—but simply reform them to handle a voltage higher than the peak which might be reached".

MEASURING THE PEAK H.T. VOLTAGE

"Prof., you estimate that the peak h.t. voltage produced will be just over 400 volts, and yet the working voltage of the capacitors is 450 volts. Is there a way in which we might measure the peak voltage which is produced by this particular power supply, without risk of damage to the capacitors?"

"Yes, Bob, we can measure the peak voltage which is likely to be produced by the particular transformer-rectifier combination we intend to use by removing the reservoir capacitor and temporarily replacing it with a high voltage capacitor as shown in Fig. 2.

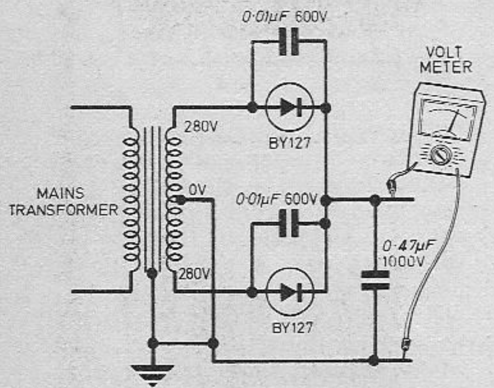


Fig. 2. Using a high voltage capacitor and voltmeter to check the peak no-load voltage of a transformer/rectifier combination.

By measuring the voltage which appears across this under conditions of no-load, that is with the remainder of the circuit disconnected from it, we can know what is the highest voltage likely to be encountered in this part of the circuit. The highest voltage is likely to occur here in the moments just after switch-on before the valves have warmed up sufficiently to draw current and cause the voltage to fall below its peak value".

The Prof. disconnected the reservoir capacitor and connected a capacitor of value 0·47 microfarad rated at 1000 volts as shown in Fig. 2. When he plugged into the 250 volts a.c. mains supply and switched on, the voltage across the 0·47 microfarad capacitor rose to a value of 420 volts.

"This is the peak voltage we are likely to encounter" the Prof. told Bob, "and as I surmised it is above 400 volts, but below the rated working voltage of 450 volts for the reservoir and smoothing capacitors. I will re-form these to ensure that they will both have the capability to operate at the higher voltage after so many years of use at below their rated maximum voltage".

REFORMING CAPACITORS

Using a high-tension supply unit of about 600 volts output the Prof. carefully set up the circuit of Fig. 3, for re-forming the 450 volt electrolytic capacitors.

He re-formed each of the capacitors in turn by placing them in the circuit of Fig. 3 and switching on. In each case the voltage reading of the meter rose gradually to give a reading of slightly more than 450 volts. The Prof. then switched the charge/discharge switch S2 over to discharge the capacitor and when the reading on the meter dropped near to zero, the capacitor could be removed from the circuit.

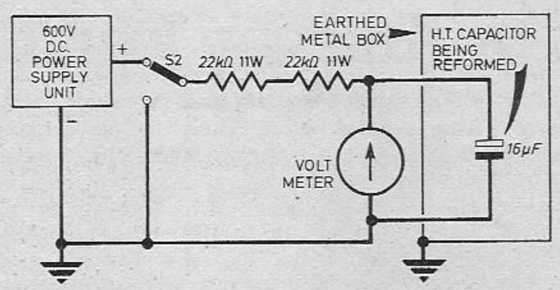


Fig. 3. Circuit used by the Prof. to re-form h.t. smoothing and reservoir capacitors of VOX AC 30 amplifier. Note the precaution of placing the capacitor being formed within a metal box, which should be earthed. This is in case the capacitor becomes faulty and bursts its seal during reforming.

"Those capacitors were reformed quite easily", the Prof. told Bob. "They appear to be in good condition so we will put them back in the amplifier.

Sometimes where a capacitor shows high leakage current it is necessary to use a variable power supply and bring the voltage up slowly to the required value from a much lower starting voltage. In such a case the capacitor may become warm, and the power supply should then be switched off until it has cooled down.

Because of the risk of the case bursting, a capacitor should be enclosed in an earthed metal box whilst being reformed.

FRINGE BENEFITS

"Prof", queried Bob, "won't the higher h.t. voltage be passed on to affect other parts of the circuit such as the pre-amplifiers, tremolo oscillator and modulator, and the phase splitter?"

"You're right, Bob, this could be a problem; however, I have here some smoothing resistors of a higher value than those which are already in the circuit and these should limit the h.t. voltage and current which is supplied to these parts of the amplifier and keep them within a suitable range of operation."

Bob took the three 27 kilohm 1 watt resistors and used them to replace the 22 kilohm resistors R10, R14 and R42 which were already in the amplifier to smooth the h.t. supply to the pre-amplifiers and other parts of the amplifier. He re-connected the reservoir and smoothing capacitors.

"With this higher h.t. voltage it will be necessary to change the bias on the output valves, Bob".

Bob moved the bias presets to a position which would give more negative bias, then switched on the amplifier. After a few minutes time the valves had warmed up and he re-adjusted the bias in the way the Prof. had shown him. Now when he tested the AC30 amplifier it sounded even louder and more *punchy* than it was before.

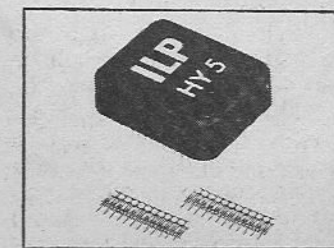
"It sounds great, Prof." he exclaimed loudly through the microphone, "now all we need to do is install the pre-amplifier/treble-booster which the owner wanted in the first place!"

"Yes, Bob, also the alternative protection circuit for the output-transformer; and if we construct the built-in valve tester he mentioned, it should just about wrap up the job!"

To be continued

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.
OVERLOAD. 38dB on Magnetic Pick-up. SUPPLY VOLTAGE ± 16-50V.

Price £6·27 + 78p VAT P&P free.

HY30
15 Watts into 8Ω

The HY30 is an exciting New kit from I.L.P. It features a virtually indestructible I.C. with short circuit and thermal protection. The kit consists of I.C., heatsink, P.C. board, 4 resistors, 6 capacitors, mounting kit, together with easy to follow construction and operating instructions. This amplifier is ideally suited to the beginner in audio who wishes to use the most up-to-date technology available.

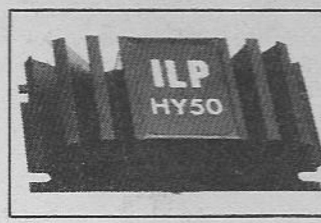
FEATURES: Complete Kit—Low Distortion—Short, Open and Thermal Protection—Easy to Build.

APPLICATIONS: Updating audio equipment—Guitar practice amplifier—Test amplifier—audio oscillator.

SPECIFICATIONS:
OUTPUT POWER 15W R.M.S. into 8Ω: DISTORTION 0·1% at 1·5W.
INPUT SENSITIVITY 500mV. FREQUENCY RESPONSE 10Hz-16Hz—3dB.
SUPPLY VOLTAGE ± 18V.

Price £6·27 + 78p VAT P&P free.

HY50
25 Watts into 8Ω



The HY50 leads I.L.P.'s total integration approach to power amplifier design. The amplifier features an integral heatsink together with the simplicity of no external components During the past three years the amplifier has been refined to the extent that it must be one of the most reliable and robust High Fidelity modules in the World.

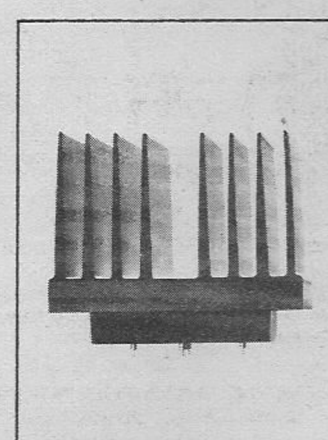
FEATURES: Low Distortion—Integral Heatsink—Only five connections—7 amp output transistors—No external components.

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 £8·18 + £1·02 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 100Hz-45kHz—3dB SUPPLY VOLTAGE ±35V.
SIZE 114 50 85mm.

Price £19·01 + £1·52 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 £27·99 + £2·24 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.

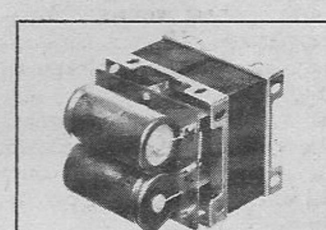
FEATURES: Thermal shutdown—Very low distortion—Load line protection—No external components.

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 £38·61 + £3·09 VAT P&P free.

POWER SUPPLIES



PSU36 suitable for two HY30's **£6·44** plus **81p** VAT. P/P free.
PSU50 suitable for two HY50's **£8·18** plus **£1·02** VAT. P/P free.
PSU70 suitable for two HY120's **£14·58** plus **£1·17** VAT. P/P free.
PSU90 suitable for one HY200 **£15·19** plus **£1·21** VAT. P/P free.
PSU180 **£25·42** + **£2·03** VAT.
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Gain and Decibels

A BRADFORD reader, E. Pilkington, writes to say that he "keeps stumbling across statements such as 'op. amps gain is often 10,000 on open loop, which is often expressed as decibels: a voltage gain of 10,000 is 80dB'. Just what are these decibels and how do they tie in with electronic equipment? I even have a range of decibels on my multimeter, which is meaningless to me."

Well now, this is by no means the first time *Down To Earth* has looked at this topic. No doubt it won't be the last, either. As new readers come along subjects like this need to be given another airing.

The trouble with decibels is that they were designed to do one job but are frequently used for something else. Let's begin at the beginning. The "bel" part of "decibel" is really someone's name in disguise. It comes from Bell, that is, Alexander Graham Bell, the telephone pioneer. Not surprisingly, then, decibels have to do with telephone systems. To be precise, with telephone *lines*.

As telephone "signals" pass along a line they get fainter. Suppose you want to find out how *much* fainter. One way would be to apply a steady signal at one end (say 10V) and get somebody to measure what comes out at the distant end (say 1V). You could then compare this line with another by using the same test voltage.

Unfortunately you would soon realise that the results of these tests were not a very reliable indication of the efficiency of lines. The reason is quite a familiar one. Telephones respond to electrical *energy*. Voltage is not a reliable index of energy. Ten volts into 10,000 ohms drives 1mA. Ten volts into 100 ohms drives 100mA. There is 100 times as much energy being expended in the second case as in the first, even though the voltage is the same.

To compare the efficiency of telephone lines it is necessary to know how much of the energy put into the line reaches the distant end. To do this we have to measure *power* rather than voltage or current. Also, it is the *percentage* of energy lost along the line that matters, not the amount.

If you put in 100mW and get out 10mW then 10 per cent has got through. The same line, with an input of 200mW, would deliver 20mW, which is still 10 per cent. So the actual power levels don't matter. It's the comparative levels (the relative levels) that give the true indication.

An Indication of Efficiency

Decibels are just a means of saying what the efficiency of transmission of a line is, without getting bogged down in actual voltage, current, or power. The real unit is not the decibel but the bel. If one-tenth of the input power arrives at the distant end the line has a "loss" of 1 bel. Since this is rather a large loss it is now universal practice to use decibels instead: 1 bel = 10 decibels. So the line in question has a loss of 10 dB.

If two such lines are joined, to make one longer line, the losses add up: 10dB + 10dB = 20dB. To restore the strength of the signals to its original value it is necessary to amplify them at the distant end. The amplifier must compensate for the 20dB loss. That is it must have a *gain* of 20dB. So it is really quite natural to measure gains in decibels.

The question is, how are the gains in decibels related to the gains in ordinary numbers. We've been told that 80dB means a voltage gain of 10,000. But a voltage gain of 100,000, that is, ten times as great comes out not as 800dB but as 100dB. Evidently the gain in dB doesn't go up in proportion to the "real" gain.

To see what is happening, look again at those telephone lines. A loss of 10dB means that one-tenth of the *power* gets through. Joining two such lines together gives 20dB. How much power now gets through? The answer is, one hundredth: the first line reduces it to one-tenth, and only one tenth of what gets through the first finally emerges from the second. One tenth of one tenth is one hundredth.

If there were three 10dB lines the signals would suffer a total loss of 30dB and this must correspond to one thousandth of the input. Every 10dB of loss means that the power must be divided by 10.

Voltage Gain

In the case of amplifiers we are generally interested in the *voltage* gain rather than the power gain. However, decibels are defined in terms of power. To make it possible to work with voltages instead it is necessary to resort to a piece of "legal fiction".

Suppose that the input voltage of the amplifier appeared across a known resistance. This would enable us to work out the input power. Now suppose that the *output* voltage appears across an *equal* resistance. We can now work out the output power.

How is power related to voltage? If the voltage is increased tenfold then the current is also increased tenfold. Ten times the voltage combined with ten times the current gives a *hundred* times the power. In decibels a hundred times the power means an increase of 20dB. So a *voltage* gain of 10 is equivalent to a power gain of 100, hence 20dB for every time the voltage amplification is increased tenfold. A *voltage* gain of 10,000 is $10 \times 10 \times 10 \times 10$ and each "$\times$ 10" adds 20dB. Thus 10,000 = 80dB.

Of course real op-amps may have input and output signals which appear across *unequal* resistances. In practice, however, this doesn't usually affect the voltage gain, so it's still legitimate to express it in dB. Why bother? Well, it does avoid big numbers and it does make it easy to compare gains at a glance. Otherwise there's not much point to it, for everyday purposes.

Multimeter dB Range

The "dB" scale on a multimeter is marked in the dB values which correspond to voltage or current rather than power. Doubling the voltage increases the power 4 times and thus adds 6dB. You'll find that if you compare the dB scale with voltage readings that doubling the voltage always adds 6dB. Doubling the *power* adds 3dB.

By another fiddle, the dB scale can be used to measure the "power" kind of dB as well. This is done by arranging for a particular resistance to be switched in place, inside the meter, to absorb power when the meter is set to "dB". The meter is then absorbing a known power when it reads "0dB".

For example, a meter may be marked "0dB = 1mW in 600Ω". This means that when the meter pointer is at "0dB" there is a 600Ω resistance inside the meter and it is consuming 1mW from the signal source.

At least, that is what it *should* mean. Unfortunately some meter makers assume that the 600Ω already exists, outside the meter, so they don't need to provide it. The meter is then just a (fairly high impedance) a.c. voltmeter on the "dB" range. Since 1mW in 600Ω creates a voltage drop of 0·775V you may find this voltage quoted on the meter. (In this case there probably *isn't* an internal 600Ω resistance.) Other values of resistance may also be used, in some meters, for example 5000Ω or 15Ω.

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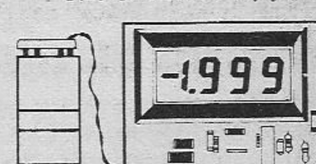

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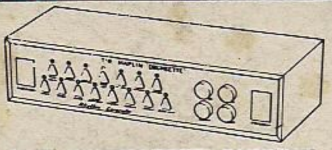

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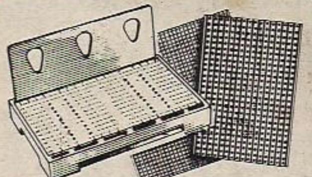

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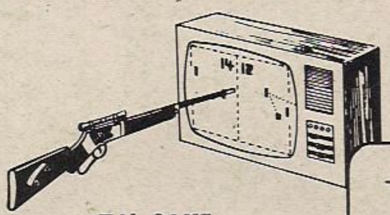

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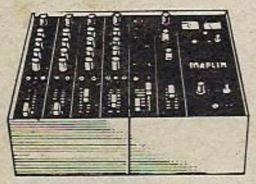

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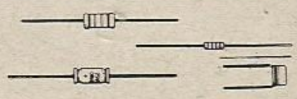

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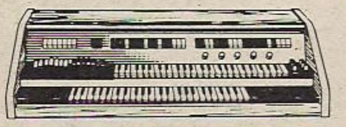

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