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7401	0·11	0·10	7450	0·12	0·10	74123	0·65	0·62
7402	0·11	0·10	7451	0·12	0·10	74141	0·68	0·65
7403	0·11	0·10	7453	0·12	0·10	74145	0·75	0·72
7404	0·11	0·10	7454	0·12	0·10	74150	1·10	1·05
7405	0·11	0·10	7460	0·12	0·10	74151	0·65	0·60
7406	0·28	0·25	7470	0·24	0·23	74153	0·70	0·68
7407	0·28	0·25	7472	0·20	0·19	74154	1·20	1·10
7408	0·12	0·11	7473	0·26	0·22	74155	0·70	0·68
7409	0·12	0·11	7474	0·24	0·23	74156	0·70	0·68
7410	0·09	0·08	7475	0·44	0·40	74157	0·70	0·68
7411	0·22	0·20	7476	0·26	0·25	74160	0·95	0·85
7412	0·22	0·20	7480	0·45	0·42	74161	0·95	0·85
7413	0·26	0·25	7481	0·90	0·88	74162	0·95	0·85
7416	0·28	0·25	7482	0·75	0·73	74163	0·95	0·85
7417	0·26	0·25	7483	0·88	0·82	74164	1·20	1·10
7420	0·11	0·10	7484	0·85	0·80	74165	1·20	1·10
7422	0·19	0·18	7485	1·10	1·00	74166	1·20	1·10
7423	0·21	0·20	7486	0·28	0·26	74174	1·10	1·00
7425	0·25	0·23	7489	2·70	2·50	74175	0·85	0·82
7426	0·25	0·23	7490	0·38	0·32	74176	1·10	1·00
7427	0·25	0·23	7491	0·65	0·62	74177	1·10	1·00
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7430	0·12	0·10	7493	0·38	0·35	74181	1·90	1·80
7432	0·20	0·19	7494	0·70	0·68	74182	0·80	0·78
7433	0·38	0·36	7495	0·60	0·58	74184	1·50	1·40
7437	0·26	0·25	7496	0·70	0·68	74190	1·40	1·38
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7440	0·12	0·10	74104	0·40	0·35	74192	1·10	1·00
7441	0·60	0·57	74105	0·30	0·25	74193	1·05	1·00
7442	0·80	0·70	74107	0·30	0·25	74194	1·05	1·00
7443	0·95	0·90	74110	0·48	0·45	74195	0·80	0·75
7444	0·95	0·90	74111	0·75	0·72	74196	0·90	0·85
7445	0·80	0·75	74118	0·85	0·82	74197	0·90	0·85
7446	0·80	0·75	74119	1·30	1·20	74198	1·90	1·80
7447	0·70	0·68	74121	0·28	0·26	74199	1·80	1·70

Devices may be mixed to qualify for quantity price. Data is available for the above series of IC's in booklet form Price 35p

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CD4006	£0·80	CD4025	£0·18	CD4050	£0·46
CD4007	£0·17	CD4026	£1·85	CD4054	£0·95
CD4008	£0·80	CD4027	£0·48	CD4055	£1·60
CD4009	£0·50	CD4028	£0·80	CD4056	£1·15
CD4010	£0·50	CD4029	£0·95	CD4069	£0·32
CD4011	£0·18	CD4030	£0·46	CD4070	£0·32
CD4012	£0·17	CD4031	£1·80	CD4071	£0·20
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CD4017	£0·80	CD4041	£0·68	CD4510	£1·10
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CD4019	£0·45	CD4043	£0·78	CD4516	£1·10
CD4020	£0·95	CD4044	£0·78	CD4518	£1·10
CD4021	£0·85	CD4045	£1·15	CD4520	£1·10

AUDIO MODULE SALE

Type	Description	Normal Price	Sale Price
AL30A	10W RMS Power AMP	~~£3·65*~~	£2·95*
AL60	25W RMS Power AMP	~~£4·35*~~	£3·55*
AL80	35W RMS Power AMP	~~£6·95~~	£5·95
AL250	125W RMS Power AMP	~~£15·95~~	£14·45
SPM80	35V Power Supply	~~£3·75*~~	£3·10*
PS12	20–30V Power Supply for AL30A	~~£1·30*~~	£1·15*
PA12	Stereo Pre-Amp for AL30A	~~£6·70*~~	£5·95*
PA100	Stereo Pre-Amp for AL60/AL80	~~£13·75*~~	£12·45*
S450	Stereo F.M. Tuner	~~£20·45*~~	£18·65*
MPA30	Magnetic-Ceramic Pre-Amp	~~£2·85*~~	£2·55*
Stereo 30	Complete Audio Chassis 7W+7W RMS	~~£16·25*~~	£14·95*

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16171	10 Reed switches	40p*
16172	3 Micro switches	40p*
16176	20 Assorted electrolytics Trans type	40p*
16177	1 pack Assorted hardware nuts/bolts, etc.	40p
16179	20 Assorted tag strips and panels	40p
16180	15 Assorted control knobs	40p*
16184	15 Assorted Fuses 100mA—5 amp.	40p
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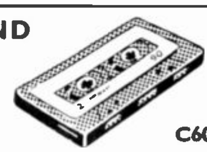

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Projects... Theory...

and Popular Features...

The electronics enthusiast seldom sticks just to constructing. A natural extension of one's hobby leads quite easily to the checking and repairing of sundry domestic electronic equipment like radios and audio systems.

Many an enthusiast has been propelled along this path by requests, if not demands, from friends or neighbours. It's a fact, once you're known to be interested in electronics, it won't be long before you will be approached to help out in a variety of ways, from fixing a plug on a smoothing iron to having a look at the "telly".

Having warned you, there are two choices. Be self-depreciating, and gently but firmly close the front door. Or, let your ego be flattered by the first approach and decide to make a name for yourself as the friendly neighbourhood repairman.

We don't encourage you to adopt the latter course without careful thought however.

Forgetting all about reputations to be made (or lost) in your neighbourhood, there remains the possibility of confining your servicing expertise to a smaller circle, within the home.

To help equip you for a start in this direction we offer this month the *Audiotest*. The purpose of this equipment will be evident from its title.

A never-failing source of interest and amusement is the electronic sound generator.

Things have moved far since those days when radio receivers were notorious for the unwanted grunts, howls and shrieks they emitted as the tuning and reaction controls were juggled with desperately in attempts to pick up the wanted station. A whole new art has been created, based on the employment of electronic sound producing and processing techniques.

No self-respecting TV cops and robbers drama dares to be presented without some electronic sound backing. And we all know how indispensable electronic effects are to science fiction films like *Star Wars*.

Those with only modest means can get into the act without much difficulty. For many intriguing sounds can be produced with a quite simple oscillating circuit. Apart from an amusement, this month's *Weird Sound Effects Generator* will be a useful instrument for the creative tape recording enthusiast, for with its aid not only effects but electronic music can be produced.

Fred Bennett

Our April issue will be published on Friday, March 17. See page 341 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. 7 MARCH 1978

CONSTRUCTIONAL PROJECTS

GENERAL FEATURES

Back issues of EVERYDAY ELECTRONICS (June 1977 onwards—October, November, December 1977 and January 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.

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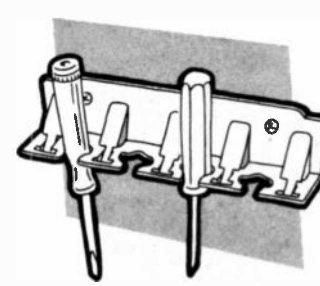
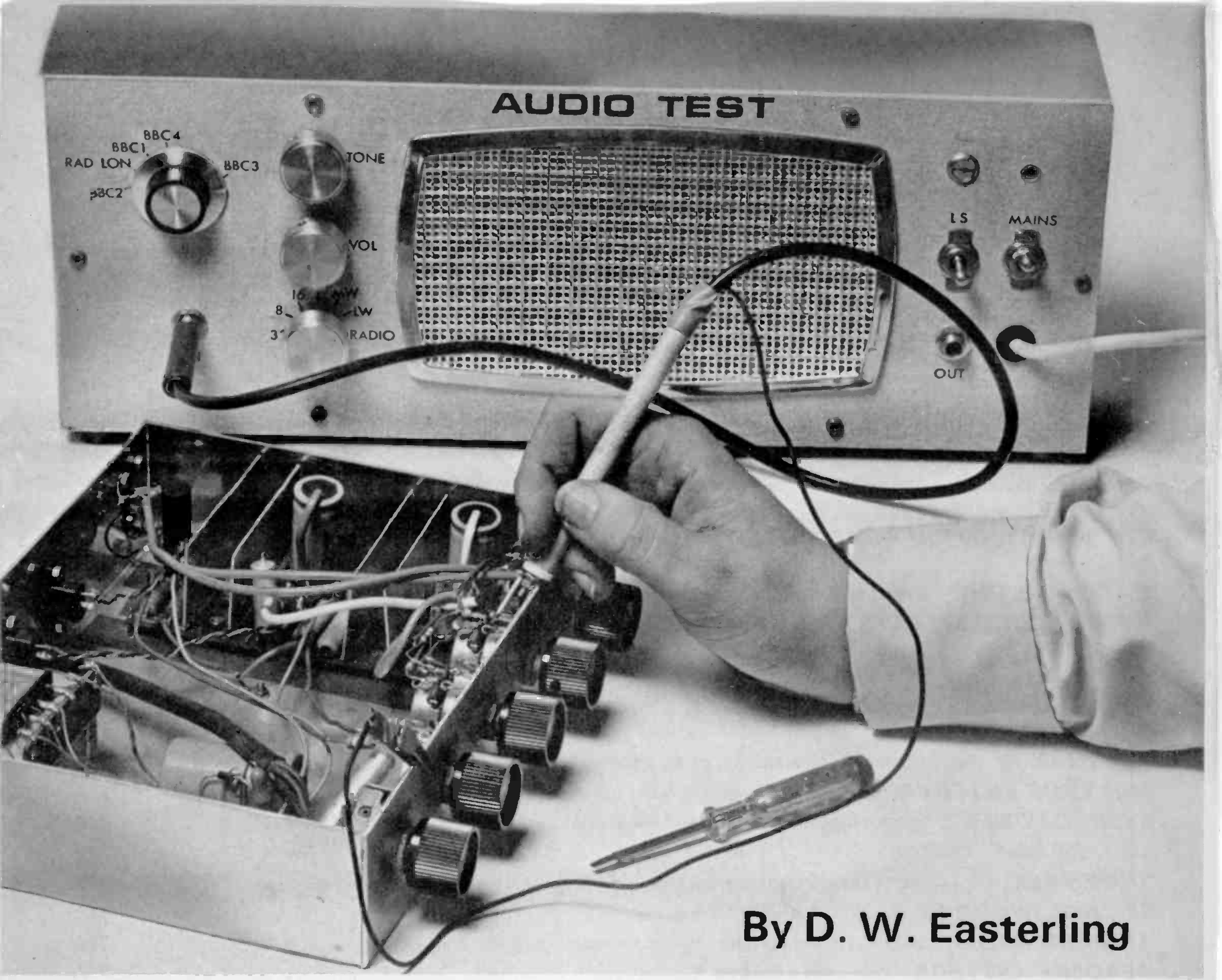


... see page 337



By D. W. Easterling

THE AUDIOTEST

A useful piece of audio test gear for the workshop incorporating a radio tuner

THE main purpose of the unit to be described is to provide a loudspeaker and loudspeaker amplifier stage for testing radio receivers, record players, tape recorders, pre-amplifiers and similar equipment having an output power not exceeding 10 watts. A simple radio tuner is incorporated as a speech and music source, and to provide entertainment in the workshop.

Since one side of the input and output connections are connected to earth, the unit is generally unsuitable for testing equipment having a transformerless mains-driven power supply, such as that typically used with domestic television sets.

FACILITIES

The facilities provided by the unit are best explained by reference to the front panel layout as shown in the photograph above. A single input jack socket is mounted below the tuning control. Load resistors across the input may be selected by the function switch to simulate various loudspeaker impedances ranging from 3 to 16 ohms.

A high input impedance is provided by a further position of the switch, and two more positions activate the radio tuner on either the medium or long waveband.

The output jack socket is at low impedance and is suitable for driving small loudspeakers and headphones as well as high impedance devices such as amplifiers and tape recorders. Provision is made to mute the built-in loudspeaker independently of the signal at the output socket.

COMPONENTS

Resistors
R1 4·7kΩ
R2 1kΩ
R3 680Ω
R4 100kΩ
R5 1MΩ
R6 470Ω
R7 10kΩ
R8 4·7kΩ
R9 10kΩ
R10 3·3Ω 10W
R11 8·2Ω 10W
R12 4·7Ω 10W
R13 10kΩ
R14 390Ω
R15 110Ω
R16 1·8kΩ
R17 47Ω
All ¼W carbon ± 5%

See **Shop Talk** page 342

Potentiometers
VR1 2·2MΩ carbon log.
VR2 2·2MΩ carbon lin.

Capacitors
C1 22µF 10V elect.
C2 350pF Jackson type 01
C3 0·1µF polyester
C4 0·022µF polyester
C5 10µF 25V elect.
C6 0·1µF polyester
C7 22µF 10V elect.
C8 0·01µF polyester
C9 1µF polyester
C10 2200pF plastic or ceramic
C11 180pF ceramic
C12 100pF ceramic
C13 0·1µF polyester
C14 470µF 25V elect.
C15 4700µF 25V elect.
C16 47pF polystyrene

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D1, 2, 3, 4 1N914 or similar silicon type (4 off)
D5 TIL209 light emitting diode
D6, 7 1N4001 or similar 1A silicon rectifier (2 off)
D8 OA91 germanium
TR1 BC108 silicon *npn*
IC1 ZN414 radio receiver i.c.
IC2 LM380 2 watt audio amplifier i.c. 14 pin d.i.l.

Switches
S1 2-pole 6-way rotary
S2 single pole on/off toggle
S3 d.p.s.t. mains toggle

Miscellaneous
T1 mains primary/12-0-12V 100mA secondary
SK1 standard jack socket with one break contact
SK2 standard jack socket
LS1 8 ohm elliptical (5×3in.) moving coil speaker
PL1 standard jack plug
Stripboard: 0·1 inch matrix 34 strips × 39 holes; plain matrix board: 0·1 inch matrix 35 × 24 holes; rubber grommets (4 off); mains cable approximately 1 metre; screened cable; connecting wire; aluminium for front panel; case materials; control knob (4 off); speaker grille to suit LS1; ferrite beads (3 off); co-ax. cable; material for probe; 14 pin d.i.l. socket.

START HERE FOR CONSTRUCTION

PROTOTYPE CASE

The cabinet assembly can be seen in the photographs, and employs an aluminium front panel fitted to a simple wooden frame which becomes the sides, top and base. Pegboard was used for the back panel. A metal front panel is convenient for mounting the controls and jack sockets, and provides partial screening. Full screening could not be used because of the built-in ferrite-rod aerial, therefore a metal box is ruled out. Plastic types are suitable if available in this size.

FRONT PANEL

The first step is to mark out and drill the front panel. The loudspeaker aperture is best traced out using the loudspeaker chassis as a guide, and then redrawing it to allow a 6mm margin for the mounting flange. The panel size is 400 x 150mm.

The method of cutting out the aperture depends on the tools available. Usually the simplest way is to drill a series of holes just inside the cut-out mark, and link them with cuts made by a small cold chisel. The edge may then be cleaned to the line with a half-round file. A metalised plastic grill was used to cover the aperture, and this is secured to the front panel by four pillars slotting into push-fit holes. Again, the component was used as a template to arrive at the correct hole location.

In the prototype the frame was made from 80 x 13mm planed timber with the joints mitred, glued and pinned, but the front panel is fixed with six small wood screws and glued before the joints become firm. Once the glue is dry, pin-holes, grain and cracks can be filled, and the whole assembly rubbed down ready for painting.

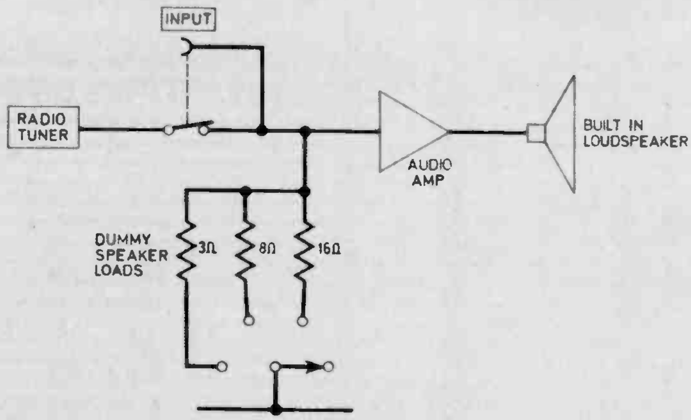
The completed Audiotest showing front panel control layout

The front panel was covered with Contact self-adhesive vinyl which forms an ideal background for dry-transfer lettering. For permanency, the lettering should be coated with a clear varnish; nail varnish was found to be ideal.

MAIN COMPONENT BOARD

Most of the components are mounted on a piece of 0·1 inch matrix stripboard size 34 strips x 39 holes. The layout of the components on the topside of the board is shown in Fig. 3 together with the underside of the board showing the breaks to be made along the copper tracks. Begin by making the breaks and then positioning and soldering in place the Veropins, link wires, resistors and capacitors. In the prototype, sockets were used for mounting the i.c. and the transistors, but this is not essential although the i.c. socket is recommended. When soldering the transistors and diodes, be sure to use a heatshunt on the legs being soldered so as to eliminate possible damage from the hot soldering iron. The connection between the board and other components are made at the board end to Veropins thus enabling the flying leads to be attached to the board after it has been fitted in the case.

HOW IT WORKS



The Audio Test consists of two completely separate units. The first is a simple radio tuner, and the second an audio amplifier. An i.c., the ZN414, is used as the radio together with coils for both medium and long wave bands. This section provides an audio source for testing amplifiers, as well as providing music for the workshop.

The amplifier is slightly unusual in that it has fixed resistors which are selected by a switch to replace the loudspeaker in the external equipment. Using this arrangement tests on an amplifier can be made, taking the output direct from the loudspeaker.

Other facilities exist that make the Audio Test most valuable in the testing of radios and amplifiers.

FERRITE AERIAL WINDINGS

The ferrite rod aerial used in the prototype unit used a rod with dimensions 100 x 10mm. The medium wave winding, L2 is about 20mm long and consists of a single layer of 30 turns of 42 s.w.g cotton covered wire. The longwave coil, L1 is made with the same wire but has 200 turns pile wound over about 10mm. The aerial is secured to the main component board by nylon thread, rubber grommets being slipped over the core to give support, see Fig. 3. Connection of the coils to the equipment board are made to Veropins.

POWER SUPPLY BOARD

The power supply is constructed on a small piece of plain matrix board size 0·1 inch pitch 35 x 24 holes. The layout of the components on this board is shown in Fig. 4 together with interconnection details on the underside. The transformer is bolted to the board using 4BA nuts, bolts and shakeproof washers, and when this assembly is complete is fitted to the case frame using three wood screws with rubber grommets between board and frame, Fig. 2.

The transformer used in the prototype had short stiff leads emerging from the underside forming the secondary winding. This is not essential as other types with flying leads can be employed and the leads fed to the appropriate connection points.

WIRING UP AND CHECKING

Care should be taken when connecting the mains cable to S3 and the transformer to ensure that there is no possibility of it shorting to the low voltage part of the circuit. A cleat fitted inside the cabinet will prevent strain on the electrical connections.

THE AUDIOTEST

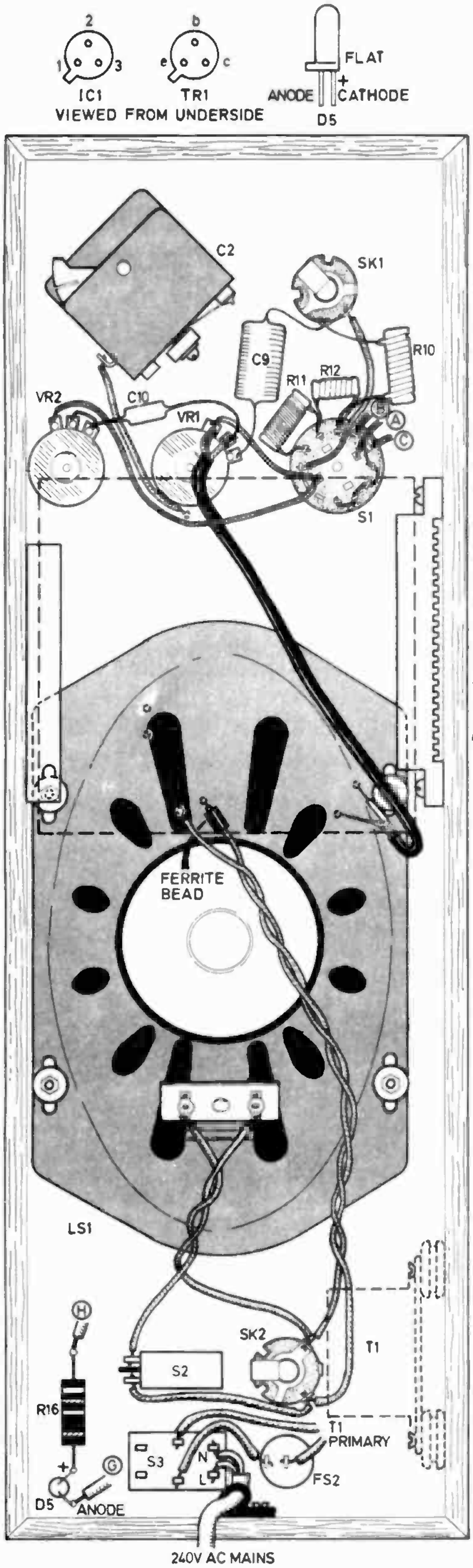


Fig. 2. Front Panel assembly, viewed from rear.

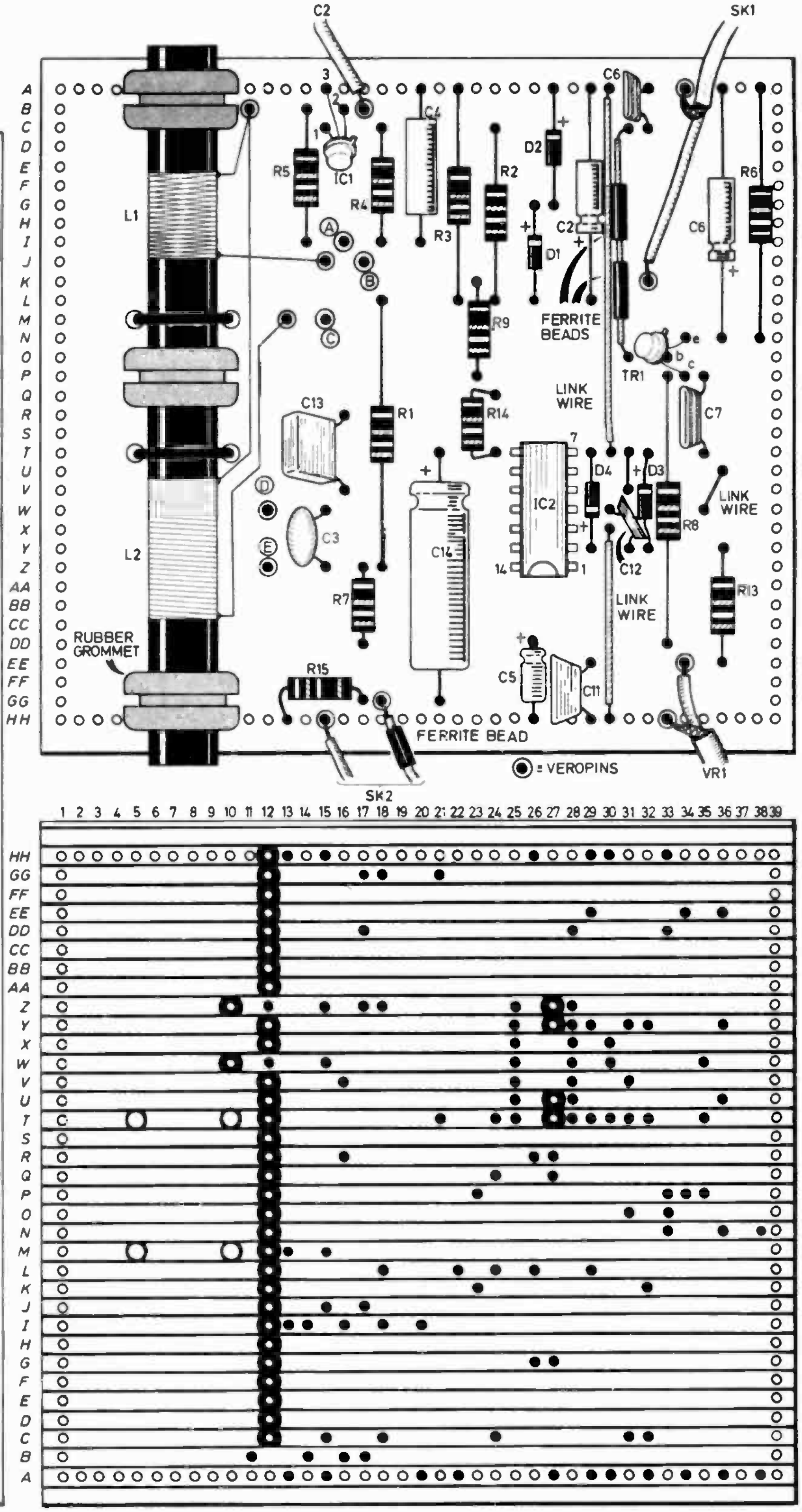


Fig. 3. Main component board layout, underside detail showing breaks in copper strips and interwiring to controls.

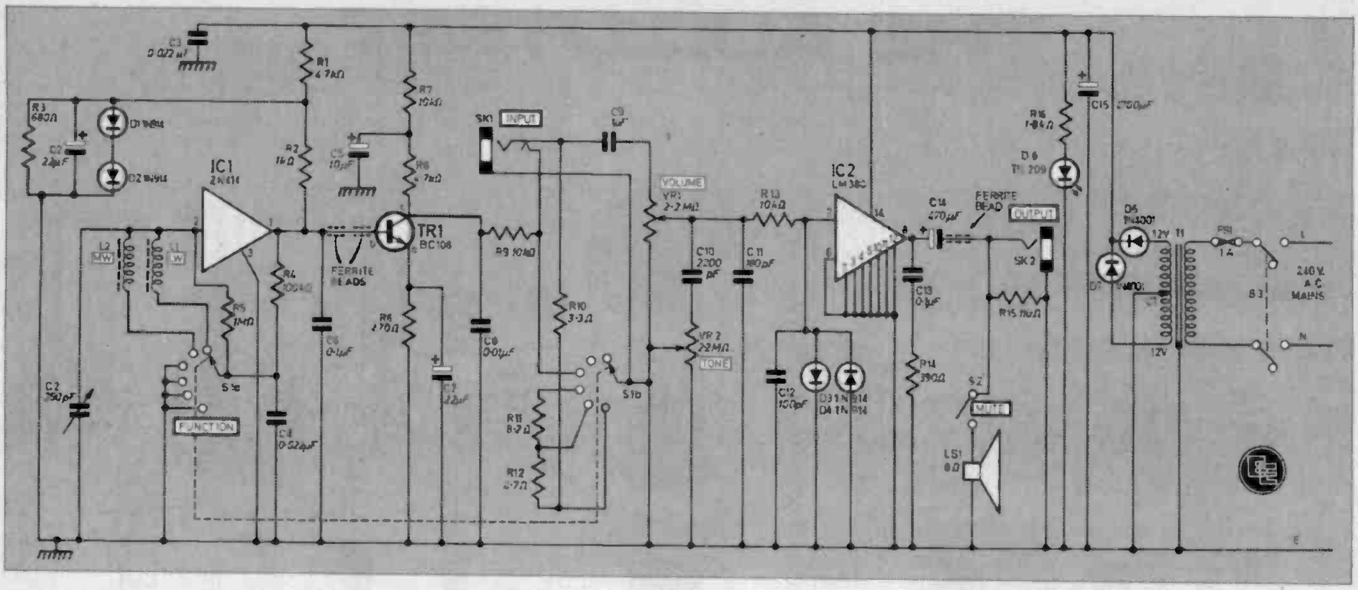


Fig.1. Complete circuit diagram, including power supply, for the Audiotest.

CIRCUIT DESCRIPTION

The complete circuit diagram is shown in Fig. 1.

Integrated circuit IC1 is the well known Ferranti ZN414 t.r.f. receiver i.c. and is tuned by the variable capacitor C2 and the ferrite-rod aerial winding L1 or L2, depending on the waveband selected by switch S1a.

Resistor R5 across the tuned circuit widens the bandwidth slightly, thus improving the sound quality. In difficult reception areas when sharper selectivity is required, it may be omitted.

Network R1, R3, D1, D2 and decoupling capacitor C1 reduce the supply to ICI to the required 1·2 volts, using the forward-voltage threshold of the diodes to provide regulation.

The output from IC1 is fed to the base of TR1, a voltage amplifier, r.f. being removed by the inclusion of C6 and the inductance of the ferrite beads. This amplifier stage is connected in the common-emitter mode with decoupling networks R7, C5 and R6, C7 establishing the correct d.c. working conditions.

Output from the collector is passed via R9, filter C8, and a screened lead, to the input jack socket, SK1. This arrangement automatically disconnects the radio tuner whenever the jack-plug is inserted.

DUMMY LEADS

Switch S1b applies the appropriate load resistance across the input when the amplifier circuit is being used to simulate a loudspeaker. This avoids having to use a specially wound transformer and facilitates control of the signal level to the built-in loudspeaker. The main purpose of R9 is to attenuate the radio signal whenever the tuner is not selected.

The input via SK1 is fed via d.c. blocking capacitor C10 to the volume-control and tone-control network VR1, VR2, C10. The tone control acts as a simple top-cut filter. The signal is then fed to the input of the power amplifier integrated circuit IC2, which has a fixed gain of 50.

The network C11, R13, C12 provides further r.f. and noise filtering, and diodes D3 and D4 protect IC2 against input overload. Attempts to over-drive the amplifier will produce distortion but should not damage the i.c. which has thermal protection.

The output of IC2 is coupled to the output jack, SK2, by C14, and via S2 to the built-in loudspeaker.

Network C13, R14 and a ferrite bead on the output line discourage parasitic oscillation which may occur when long external output leads are used. The output voltage and power delivered by IC2 will depend on the external load. Although the circuit will operate over a wide range of load resistance 4 ohms should be considered a minimum. Care should be taken, however, to ensure that no potential exceeding ±5 volts is fed from the load back to the amplifier. If necessary, an external non-electrolytic capacitor of appropriate working voltage and capacitance should be used.

POWER SUPPLY

The power supply circuit is a conventional double-diode full-wave rectifier driven by a step down mains transformer having a centre-tapped secondary winding. Smoothing is by electrolytic capacitor C15. The 4700 microfarad quoted is rather high and holds the unit operational for a second or so after it has been switched off. It could be reduced to 1000 microfarads with a slight increase in hum level. The light-emitting diode D5 and current limiting resistor R16 are included to indicate that power is being applied to the unit.

THE AUDIOTEST–POWER SUPPLY

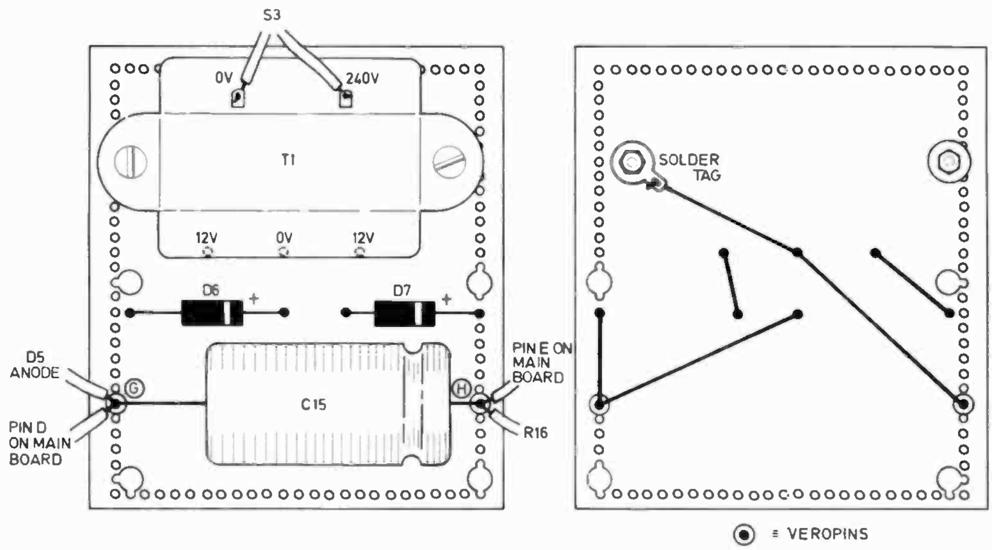
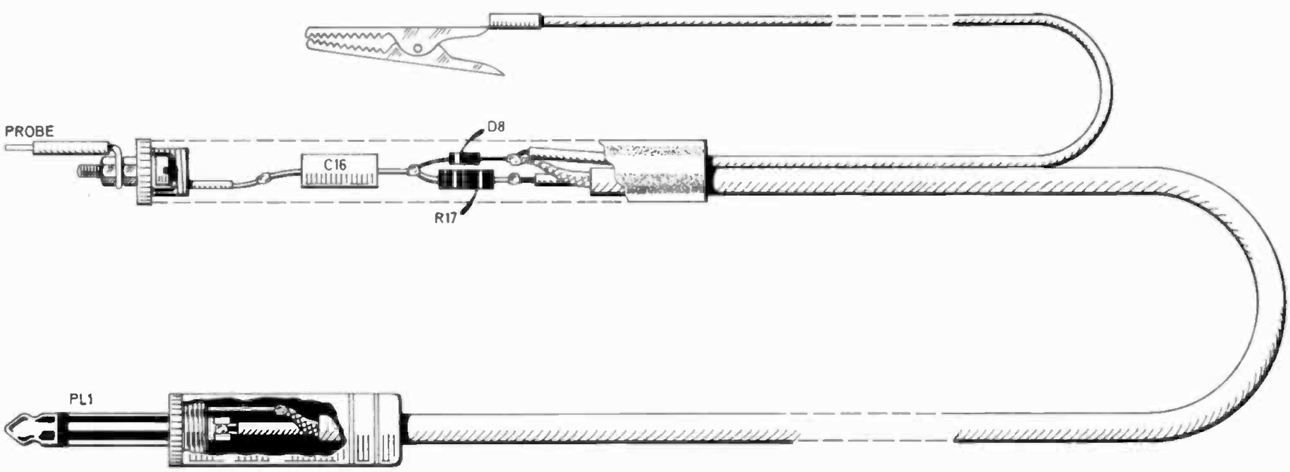


Fig.4. Power supply board component layout and underside wiring details.

THE AUDIOTEST–PROBE



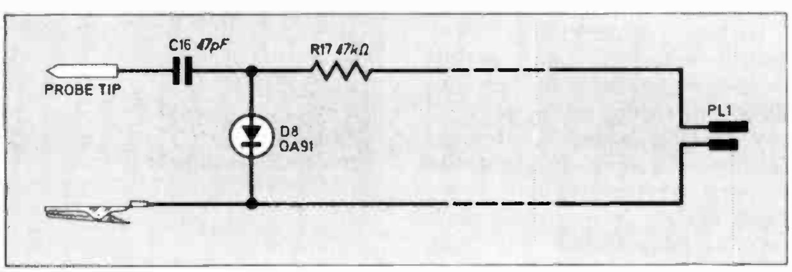
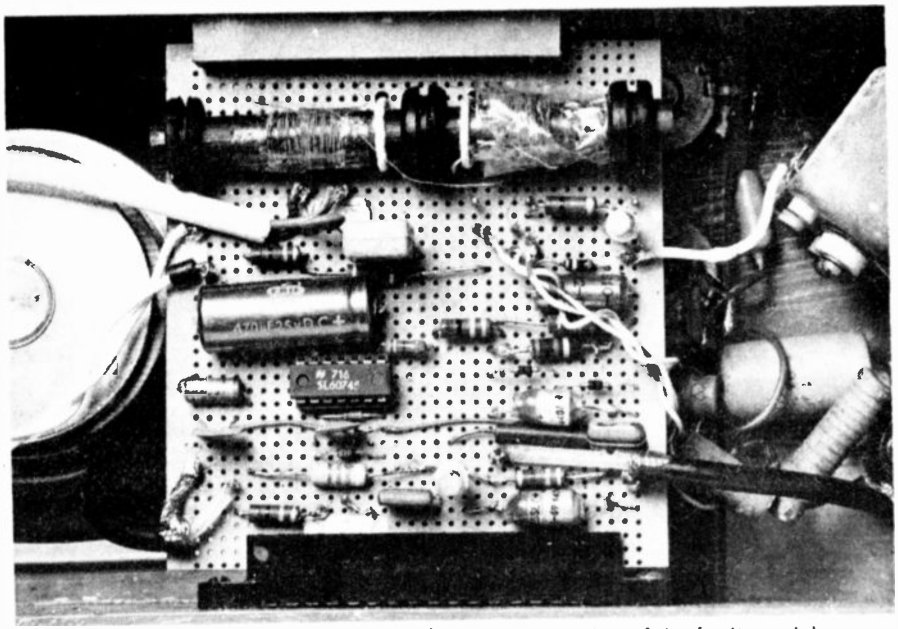


Fig.5. Circuit diagram and constructional details for the probe.



Close-up of the circuit board showing the mounting of the ferrite aerial.

With the front panel drilled to accept all the panel-mounted components these and the power supply board should be secured in place and interwiring carried out as in Fig. 2 and Fig. 4, with leads that are to connect to the board, of sufficient length to reach the latter when fitted in the case.

In the prototype, the board was held in position by means of p.c.b. slots that were taken from an old computer panel, but an alternative would be to use suitable hardwood mouldings obtainable from many timber merchants and d.i.y. stores.

It is a good idea to check the power supply and l.e.d. indicator before making connections to the circuit board. The smoothed output voltage should be in the order of 18 volts, and the l.e.d. should be at satisfactory brilliance.

If all is well, the main component board should be fitted in place and wired up according to Fig. 3.

The audio amplifier circuit can be checked by connecting, via SK1, a suitable test oscillator, or the phones output socket of a transistor radio, for example. The in-built radio should operate at the appropriate switch position. Unwanted oscillation may be cured by reversing the connections to the tuning coils, L1 and L2.

SIGNAL TRACING WITH THE UNIT

The unit is an ideal signal tracer especially when used with the probe shown in Fig. 5. The probe enables the r.f. and i.f. stages of a radio tuner to be checked (long, medium and short waves—not f.m.) as well as being suitable for low level audio stages. The small coupling capacitor restricts the low frequencies and makes the sound appear rather "toppy" but has the advantage of reducing mains hum which could be overwhelming under certain test conditions. The final assessment of a.f. signals should be made with the test point connected to the audio-test by a screened lead and not via the probe.

PROBE CONSTRUCTION

The probe consists of a small coupling capacitor, diode detector and filter resistor directly wired to the end of a length of screened aerial feeder. The whole assembly being subsequently slipped into a length of plastic tubing with a wire tip brought out through the end cap. The tube should be long enough to accommodate about two inches of screened cable in order to give it a place where it can be held without introducing stray pick-up. A separate earth return wire is also required. Construction details will be found in Fig. 5.

Signal tracing is simply a matter of working progressively along the signal path of the system under test from aerial, gramophone pick-up or recorder head to loudspeaker, with the object of locating the point where the normal signal is no longer detected and hence the faulty stage. A similar method can be used to trace distortion.

VOLTAGE CHECKS

Before attempting to signal trace it is wise to make voltage checks to ensure that power supplies are normal and metallic surfaces are either fully isolated or at earth potential. It is also a good idea at this time to visually inspect the system for signs of overheating or other damage. Finally, before using the probe, the earth return lead should be connected to the common or earthy line of the system under test—**NEVER TO THE MAINS LIVE OR NEUTRAL LINES.**

SUBSTITUTION

Once the faulty part of a sound system has been detected a further check can be made by substituting the Audiotest. The unit tuned to a suitable radio programme can be used as a signal source in place of the original tuner, record deck or recorder. The amplifier and loudspeaker can be similarly substituted.

Suppose that a faulty loudspeaker is suspected. replace it with the Audiotest and switch in the appropriate load resistor which should be a similar value to the impedance specified for the system loudspeaker. If distortion is still present try a higher load resistor, and if this is beneficial suspect the loudspeaker coupling capacitor.

Table 1: Approximate signal levels for various sources.

Source	Output
Probe at r.f. stage	1mV
Probe at i.f. stage Magnetic pick-up Recorder tape head	5mV
Crystal microphone	50mV
Ceramic pick-up	100mV
Crystal pick-up Radio tuner Preamp tone control	500mV
8 ohm loudspeaker at 0·5 watt	2V

Table 2: Audiotest input sensitivity and output voltage levels using the loudspeaker as the measuring device.

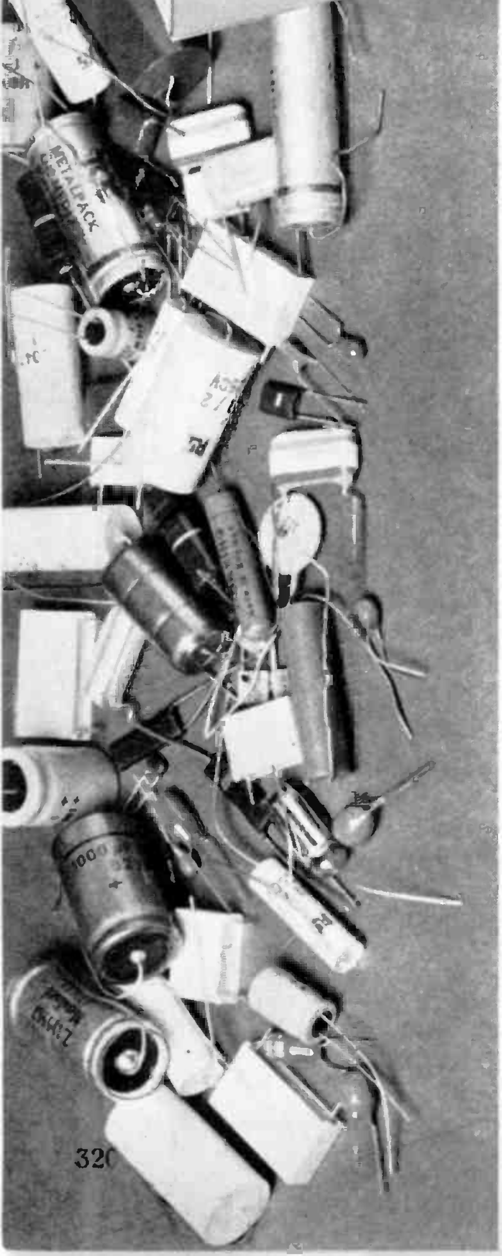
Sound level (Audiotest L/S)	Input sensitivity (VR1 at maximum)	Signal source output voltage
Just discernable	1mV	less than 10mV
Slightly louder	5mV	50mV
Comfortable	50mV	500mV
Loud	reduce VR1 as necessary	2V

Sometimes it is difficult to identify the connections to a DIN plug or socket. Standards are specified but not always adopted by the equipment manufacturer. In any case there may be a fault condition or some confusion over the switching arrangements. The connections can be quickly traced using the signal tracing and signal source facilities of the Audiotest.

Signal tracing can sometimes be applied to diagnose the cause of a low stage gain. A disconnected or unserviceable by-pass capacitor may introduce unwanted negative feedback. Decoupling circuits should be checked to ensure that no signal is detected at their junctions.

VOLUME

At all times the volume control of the Audiotest should be set to provide adequate signal level without overloading either the test set or the equipment under test. Tables 1 and 2 give some idea of the signal levels to be expected. ⌑



C-R SUBSTITUTION BOX

By P. C. O'Neil

START HERE FOR CONSTRUCTION

INTRODUCTION

When one is starting to equip a workshop with test equipment one of the first items to be purchased is a multimeter. The next likely item could either by an a.f. generator or power supply.

If all this expensive equipment is bought it is so easy to forget the usefullness of really simple equipment. One such item is the resistance/capacitance substitution box to be described here.

A substitution box is basically a selection of different *standard* value resistors and capacitors which can be connected into an external circuit and be used to replace that component of its entire function.

Typical examples are;

1. Finding the value of a damaged component in a circuit.
2. Finding the correct bias resistor for a transistor.
3. By using both the resistors and capacitors, the required *period* in a timing circuit may be found.

There are other uses of course but the three mentioned are the most popular. It can of course be very valuable to the professional circuit designer.

RATINGS

In such a design as this the voltage ratings and tolerances of the components become a slight problem. On one hand high tolerance and high voltage components could be selected, thus increasing the finished size and more important increasing the cost. On the other hand one can select standard components thus producing an inexpensive design and cutting down on the size.

It is the last method which is adopted in this design. Standard capacitors with a reasonable voltage rating have been used, and resistors with the maximum tolerance required in most circuits. After all it is no good using 1 percent resistors when experimenting with a circuit and then using standard 10 percent types in the final

C-R SUBSTITUTION BOX

FOR GUIDANCE ONLY
ESTIMATED COST OF COMPONENTS
£3.75
excluding case

Resistors

R1 10Ω	R7 2·2kΩ	R13 22kΩ	R19 820kΩ
R2 47Ω	R8 3·3kΩ	R14 39kΩ	R20 1MΩ
R3 100Ω	R9 5·6kΩ	R15 56kΩ	R21 3·3MΩ
R4 220Ω	R10 8·2kΩ	R16 100kΩ	R22 10MΩ
R5 560Ω	R11 10kΩ	R17 220Ωk	
R6 1kΩ	R12 15kΩ	R18 560kΩ	

All resistors are ¼W carbon ±5%

Capacitors

C1 3·3pF silver mica	C9 22nF polyester	C17 33μF 40V elect,
C2 10pF silver mica	C10 47nF polyester	C18 47μF 40V elect.
C3 100pF silver mica	C11 100nF polyester	C19 100μF 40V elect.
C4 470pF polystyrene	C12 1μF 35V tant.	C20 220μF 40V elect.
C5 1nF polystyrene	C13 2·2μF 35V tant.	C21 470μF 25V elect.
C6 2·2nF polystyrene	C14 4·7F 35V tant.	C22 1000μF 16V elect.
C7 4·7nF polystyrene	C15 10μF 63V elect.	
C8 10nF polyester	C16 22μF 63V elect.	

Miscellaneous

S1, 2, 3, 4 1-pole 12-way rotary wafer switch (4 off)
S5, 6 2-pole 2-way minature slide switch (2 off)
Aluminimum case, 105mm×105mm×40mm or similar; four crocodile clips (3 off black, 1 off red); white card for front panel; four large round knobs; two grommets; connecting wire; solder.

See Shop Talk page 342

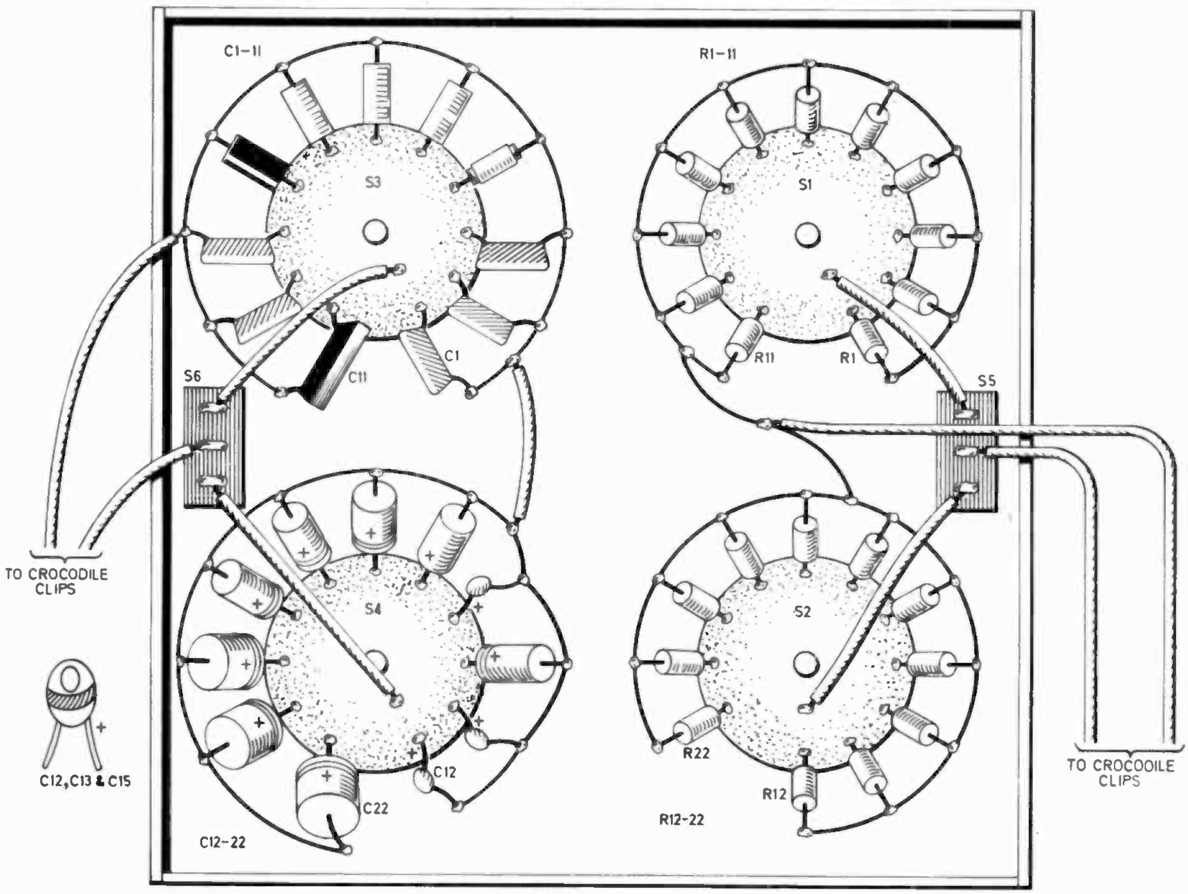


Fig. 2. Component layout and wiring for the C-R Substitution Box. Note that the components have not been drawn to size to make wiring easier to follow.

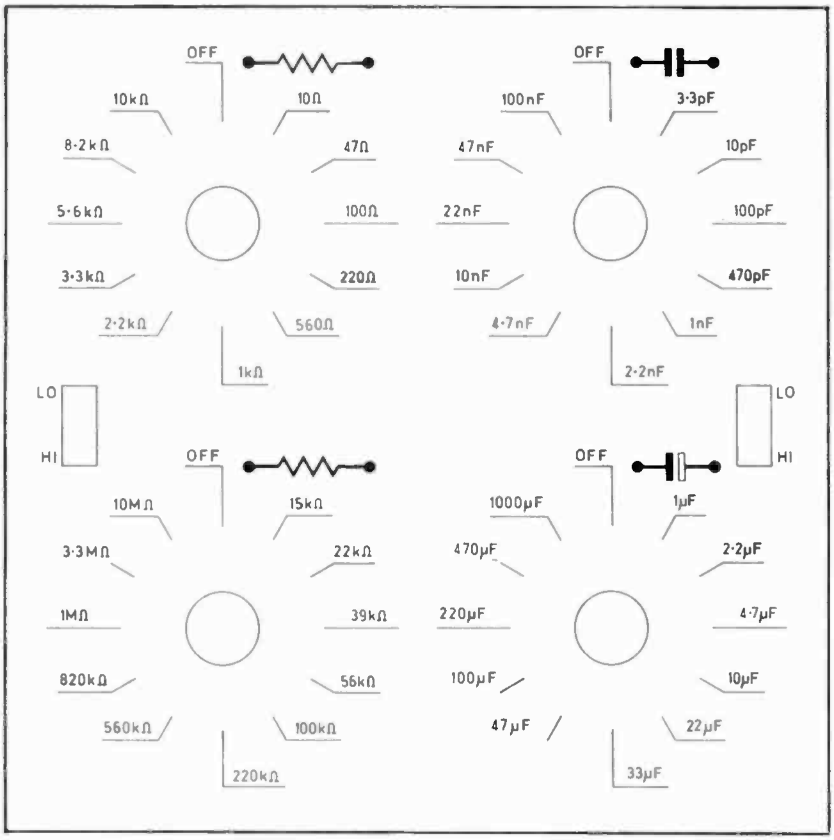


Fig. 3 Front panel layout shown full size.

design. The results will not be the same!

Follow the diagram in Fig. 2 and wire up the resistors first then the capacitors next. Be sure to identify the correct positions of each, mistakes at this stage could be confusing when the unit is used. The remaining wires can then be soldered, leaving a generous length for connecting to the crocodile clips.

Once wiring has been completed the front panel may be traced or redrawn on stiff white card using the layout in Fig. 3. The general arrangement can be seen from the photographs.

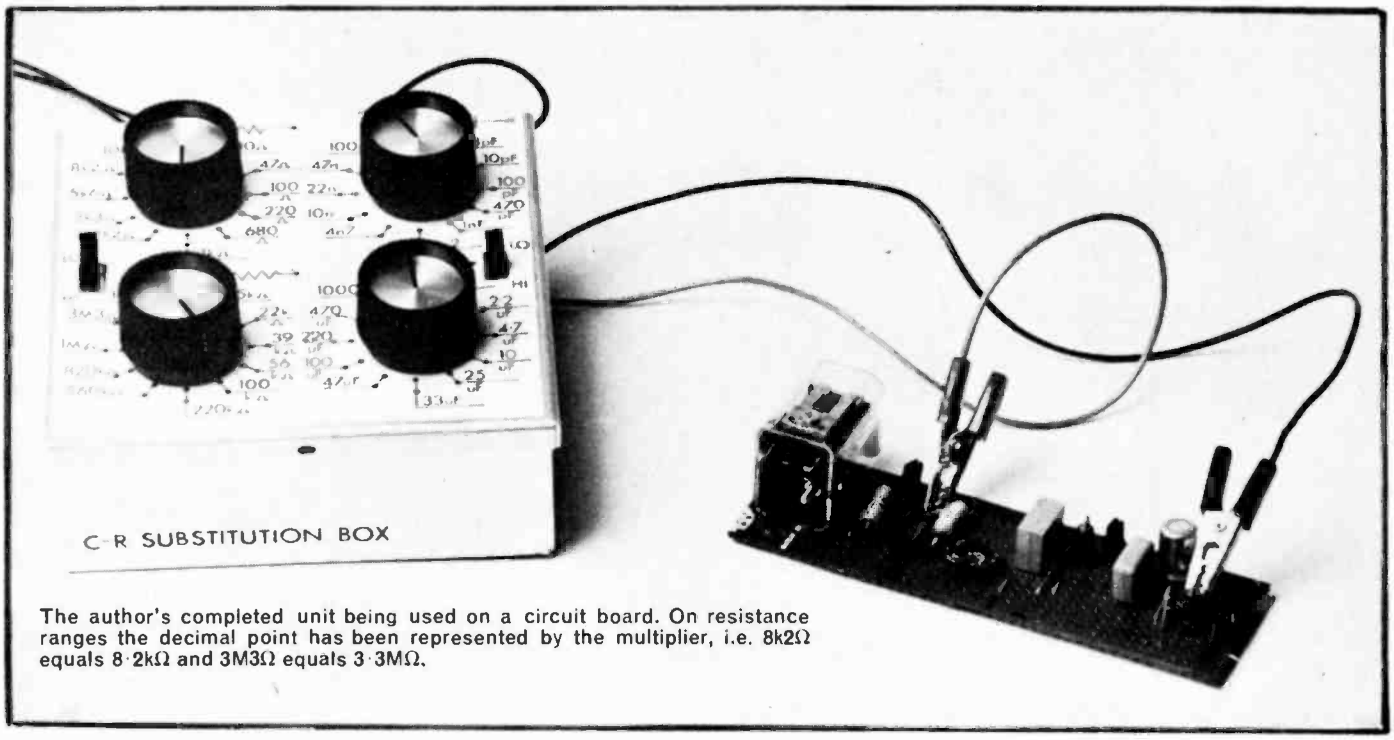
CIRCUIT DESCRIPTION

The complete circuit is shown in Fig. 1. It may be considered as two separate sections; resistors and capacitors. Each section consists of two 1-pole 12-way switches, each with one spare position which is used as the OFF position.

Each rotary switch may be selected by a single pole slide switch, which selects either HIGH or LOW values as required. These ranges are set out in Table 1.

The output from either switch is applied via crocodile clips to the external circuit. It is important to note that only one value component is selected at any one time, unlike some boxes which are called "decade" boxes.

When using the capacitor section the polarity of the electrolytic capacitors should be observed. With this particular unit both the resistors and the capacitors can be selected at the same time.



The author's completed unit being used on a circuit board. On resistance ranges the decimal point has been represented by the multiplier, i.e. 8k2Ω equals 8·2kΩ and 3M3Ω equals 3·3MΩ.

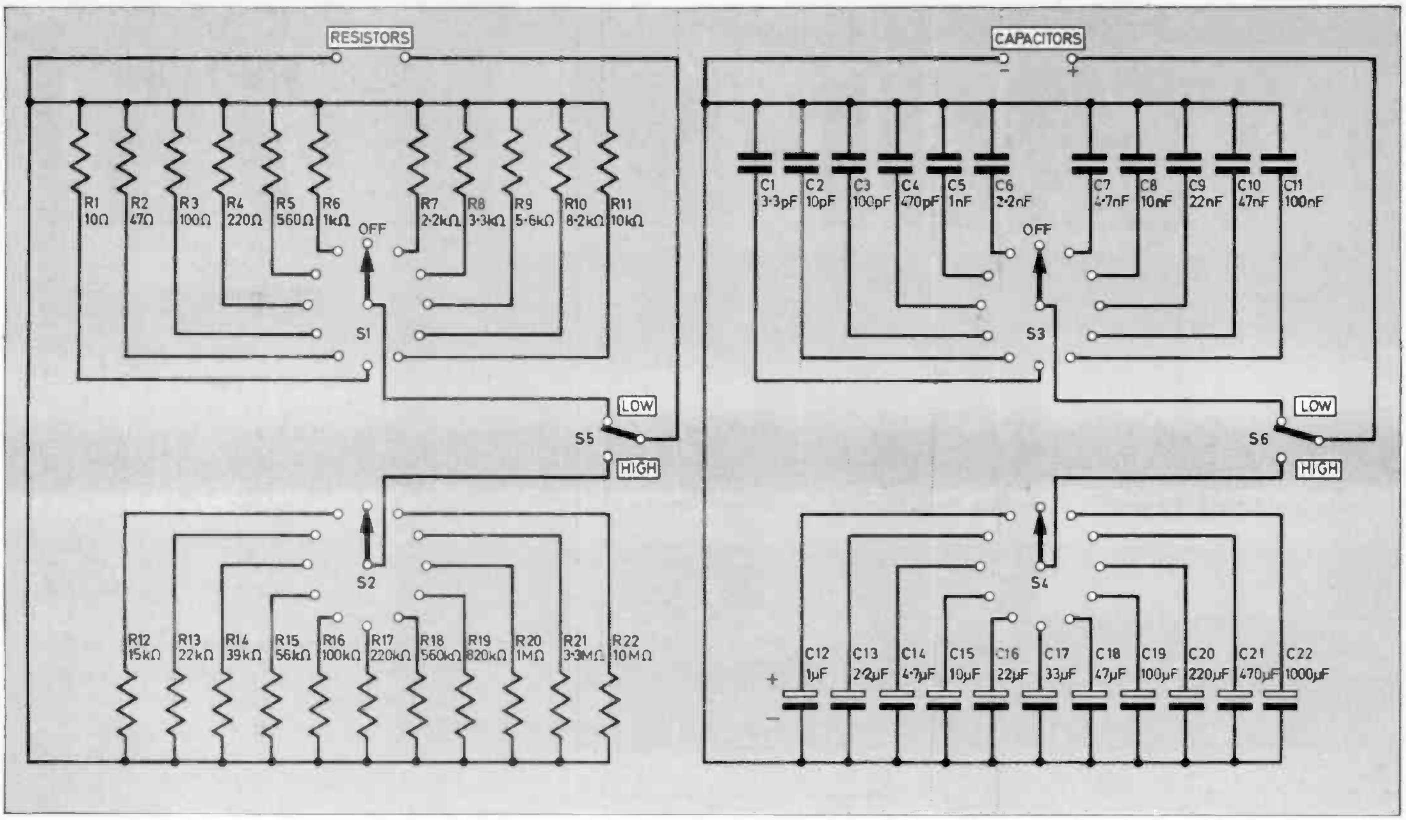


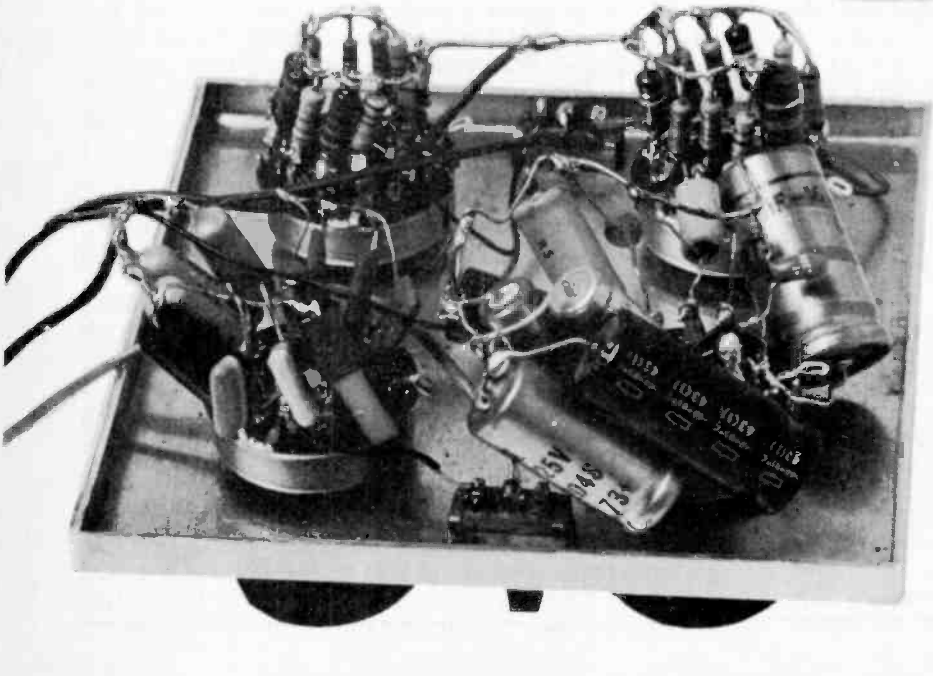
Fig. 1. Circuit diagram of the C-R Substitution Box.

Table. 1. R/C Ranges

	Resistors	Capacitors
Low	10Ω to 10kΩ	3·3pF to 100nF
High	15kΩ to 10MΩ	1μF to 1000μF

Ratings; Resistance—½W ± 5%
Capacitance—35 to 250V

Back of front panel showing wiring to range switches. Due to the size of some of the components it may be necessary to tilt them at an angle to fit into the area of the case.



OPERATION

The major uses have already been mentioned no doubt other uses could be found in time. Two important points should be noted. First the power rating, half a watt, of the resistors should not be exceeded. Secondly the voltage rating of the capacitors must be observed. In fact these two points should not cause any worry, since most of the circuits will probably be low voltage anyway.

Using the substitution box is very easy, just connect the clips into the circuit at the required point and set the switches to the required value, switch on the circuit and you're away! ⌑

TEACH-IN 78

Part 6

BY GEORGE HYLTON

AMPLIFIERS — CONDUCTANCE — GAIN

At the end of last month the amplifier was introduced. So far in talking about amplifiers only *input impedance* has been discussed. This as you have found is most important when using amplifiers, so much so that the *matching* of one stage to another is very important.

These two qualities are of course very useful, but mean nothing if the gain is not known.

This then is our subject for this month, to measure the gain of a practical amplifier which can be built using various modules.

MATCHING

When people talk of *matching* a signal source to an amplifier they usually mean making the input impedance of the amplifier high enough, so that sufficient signal voltage is actually delivered to the amplifier by the source. Practical transistor amplifiers of the usual kind in which the emitter is earthed have input impedances from a few kilohms to a few hundred kilohms.

An alternative transistor connection in which the emitter is not earthed directly can have an input impedance of several megohms, but no voltage gain. A field effect transistor, is one example.

Signal sources with very low internal impedances can be something of a problem, not because they are hard to match but because they usually deliver very small voltages. Transistors themselves generate small voltages in the form of electrical *noise* and these tend to interfere with small signal voltages. A typical example would be a microphone with an internal impedance of 30 ohms.

This might deliver only a few tens of microvolts. Fortunately the transformer comes to the rescue here. Remember that the voltage on the secondary can be different from the voltage on the primary. The two voltages are in fact in proportion to the number of turns. If the secondary has ten times the turns of the primary then the secondary voltage is ten times as great.

So $10\mu V$ from the microphone can in principle be increased to $100\mu V$ at the secondary Fig. 6.1. There is no need to stop at tenfold increase. In principle, any turns ratio can be used and therefore any voltage increase obtained.

Looking back from the amplifier into the secondary, the impedance seen is not 30Ω of the microphone but something much greater. It is in fact 30Ω times the turns ratio times the turns ratio again. So if a turns

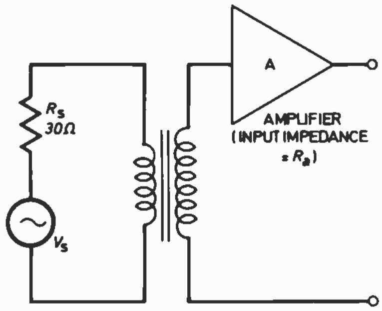


Fig. 6.1. Using a transformer, the output of a microphone, represented here by the generator symbol and internal resistance R_s, may be increased to a level dependent on the turns ratio of the transformer.

ratio of 10 is used to increase the signal voltage ten times the impedance is increased to $30\times10\times10=3000\Omega$. If the turns ratio were 100 the impedance would be increased $100\times100=10{,}000$ times.

It is this increased impedance which must be small compared to R_a. So there is a limit to the amount of step-up of voltage which can be used.

Similar considerations apply to the output end of an amplifier. There is a limit to the current and voltage which any particular amplifier can deliver. This determines the lowest load resistance which can safely be connected to the output. We shall look into this in more detail when we consider power amplifiers, but it is worth a quick look now.

VOLTAGE AMPLIFIERS

A common arrangement in voltage amplifiers Fig. 6.2a is to connect a d.c. load resistance R1 through which the collector current passes. This current increases or decreases in sympathy with the signals being amplified. These variations in current produce a varying voltage drop in R1. In a.c. amplifiers such as audio amplifiers these voltage variations are the output signal. They are often separated from the steady d.c. voltage at the collector by a coupling capacitor C which allows a.c. signals to pass but blocks d.c.

The capacitor transfers the output voltage to some kind of d.c. load impedance, R2.

If R2 is zero, there can be no voltage across it. If it is infinite, the voltage at the upper end must be the same as the voltage at the collector when there is no R2 there. But what about real values of R2, in between zero and infinity? To tackle this problem you need the right tools. In this case the tools are two ideas.

The first idea is about mixtures of d.c. and a.c. An amplifier, as we mentioned before, works by using the power of its battery to make enlarged copies of its input signal. The battery supplies d.c. The input signal is usually a.c. It is inevitable that d.c. and a.c. get mixed up in the process of amplification. But you are at the moment not interested in the d.c., but only in the a.c.

IDEAS

The idea you need to tackle this problem is that when mixed a.c. and d.c. flow in circuits which contain only resistance, inductance and capacitance the a.c. and d.c. have no effect on one another.

So you can forget about the d.c. and think only of the a.c.

The second tool is the knowledge that in a.c., which is periodically reversing its direction, the forward flowing bits contain the same average energy as the reverse flowing bits. What is true of the forward flowing bits, called positive half cycles, is equally true of the backward flowing negative half cycles, except that the direction of flow and polarity of voltage is reversed.

For the purpose of thinking about a.c. circuits you can concentrate on one half cycle, when the voltages, are positive, and think about the circuit in terms of d.c. polarities instead of reversing polarities. In effect you take a short exposure snapshot of the a.c., freezing its motion.

This may sound rather difficult, but you will see it is really quite easy when we apply these ideas to our circuit. We shall consider the transistor as a source of a.c. which flows out of the collector, through the circuit and back to the emitter. The directions of current and polarities of voltage are then as marked in the diagram

The current being a.c. can in effect pass through C so one path is via C and R2 and so back to the emitter. The other is through R1. If it goes through R1 it must still somehow find its way back to the emitter.

There is, in fact, an easy path via a component not shown on the diagram, the battery. Of course, the current has to flow backwards through the battery, but remember we are talking about a.c., not d.c. The battery offers such a low impedance to the a.c. signals

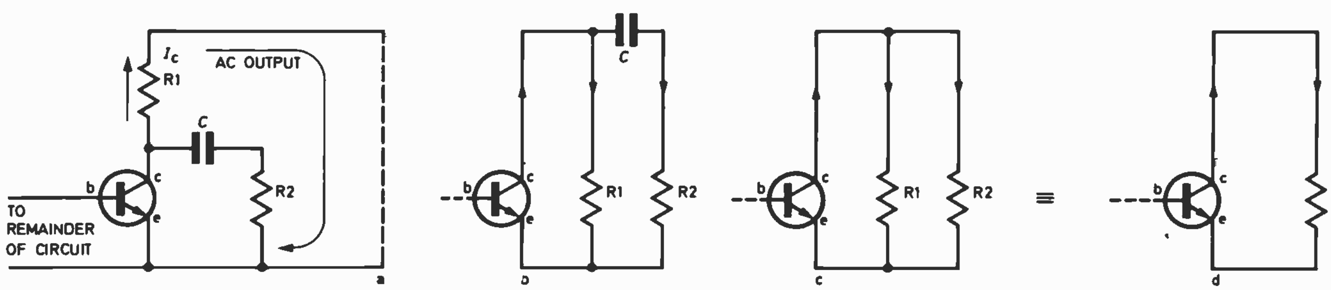


Fig. 6.2. The output from an amplifier is developed across resistor R1 as in (a). Because the battery has a low impedance to a.c. the two resistors can effectively be connected together as in (b). Now as C is effectively a short to a.c. the circuit can be simplified as shown in (c). We now have the situation where R1 and R2 are in parallel at a.c. and the *conductances* add together.

that for practical purposes it is a short circuit, as shown by the dotted line. This connects the top of R1 to the bottom of R2.

So as far as a.c. signals concerned we can redraw the circuit as in Fig. 6.2b, but even this can be simplified. If *C* has a very low a.c. impedance it too can be effectively a short circuit to a.c. So we end up with Fig. 6.2c.

This last circuit is a great help to understanding. The transistor can be regarded as a device which pumps out a current. It is clear that this current must divide between R1 and R2. If R2 is small, most of the current goes through it, but the voltage across it is low. If R2 is large, most of the current goes through R1 and the voltage is something close to what it would be if R2 were not there at all.

If we are stuck with particular values of R1 and R2, and we need to know the output voltage we have to know something about combinations of resistances connected together at both ends, like these. These are called parallel connections, for the obvious reason that the current divides and follows parallel paths, one through R1 and the other through R2.

Earlier in the series it became clear from measurements in your RESISTOR CHAIN that resistances in series just add together. This can not be true of resistances in parallel because by allowing more paths for the current to follow it can flow more easily. So the effect of connecting a resistance in parallel with another must be to *reduce* the resistance of the circuit as a whole.

CONDUCTANCE

Fortunately, though resistances in parallel do not add together, something else does. You can think of a resistance as something which conducts a current. A low resistance conducts current more readily than a high resistance.

If two resistances are connected in parallel then the conducting ability of the second is added to the conducting ability of the first.

The standard name for this conducting ability is **conductance**. So if you know the conductances of R1 and R2 you can add them to obtain the overall conductance of the combination. That is you can get a single quantity which takes both R1 and R2 into account. If this can be turned back into an equivalent resistance you are home and dry.

You can replace R1 and R2 by a single resistance *R* Fig. 6.2d, and Ohm's Law will then tell you what voltage is dropped across it by the current from the transistor. This must be the output voltage, since it appears at the right place in the circuit.

PARALLEL RESISTANCE

It turns out that the conductance of a resistance is just 1 divided by the resistance itself. The usual symbol for conductance is G. We can not use C because it is already used for capacitance. So in mathematical notation:

$$G=1\div R$$

If we have two resistances, R1 and R2,

$$G=1\div R1+1\div R2$$

In fact you can have as many resistances in parallel as you like and add up all their conductances. To turn the total value of conductance back into its corresponding resistance you divide 1 by the conductance. That is:

$$R=1\div G$$

To take a simple example; what is the effective resistance of 10, 100 and 1000 ohms, all in parallel? The corresponding conductances are 0·1, 0·01, and 0·001 which add up to 0·111. If this is now divided into 1 it comes to 9, as near as makes no difference. So the net resistance is 9 ohms. Practical resistance values are often less easy to turn into conductances. If you have a calculator it is simple. If not you can use a parallel resistance chart.

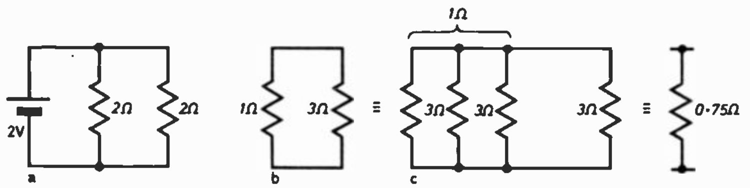


Fig. 6.3a. Two 2Ω resistors are in parallel, their total resistance is 1 ohm. Different values as in (b) can be thought of four resistors of the same value in parallel (c) giving the result as 0·75Ω.

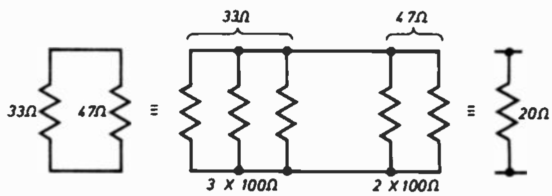


Fig. 6.4. Using an extension of the idea that odd values can be broken down into resistors of equal value. Here 33Ω and 47Ω resistors are connected in parallel. Each can be considered as so many 100Ω resistors. Using the method as found in Fig. 6.3c the answer is simply 100 ÷ 5.

EQUAL RESISTORS

Fortunately it is often possible to find the equivalent of two resistances in parallel by a simple trick. The basis of it is the fact that if *equal* resistances are connected in parallel their equivalent resistance is very easy to find. Take a look at Fig. 6.3a.

Here a 2V cell is connected to two resistances each of 2Ω. The voltage across each resistance is 2V, so the current in each resistance is 2V÷2Ω=1A. The total is therefore 2A. If you apply 2V to a single resistance and 2A flows then Ohm's Law, which says that; Resistance=Voltage/Current, shows that the resistance must be 1Ω.

Evidently, since the voltage and current is the same in each case, your two 2Ω resistors in parallel are equivalent to one 1Ω resistor.

In the same way you can show that *three* equal resistances in parallel are the same as a single resistance of one-third the value of one of the individual resistances. Similarly four in parallel are one quarter, five one-fifth, and so on. So ten 100Ω in parallel are the same as one 100Ω divided by ten, i.e. 10Ω.

To use this to work out resistances in parallel, you mentally turn the lower resistances into parallel combinations of the higher ones. What is the equivalent of 1Ω and 3Ω resistors in parallel? Fig. 6.3b. The 1Ω resistor can be thought of as three 3Ω resistors in parallel. The original 3Ω resistor thus makes up the fourth. So the circuit is equivalent to four 3Ω in parallel, which is 3Ω÷4 or 0·75Ω.

This trick cannot *always* be used, because sometimes the resistance comes in odd values which do not lend themselves to simple arithmetic. But it works in most cases, especially if an approximate answer is acceptable.

For example, what is the equivalent of a 33Ω resistor and a 47Ω resistor in parallel? Fig. 6.4. These values look very awkward. But 47Ω is not far from 50Ω, and 50Ω is the equivalent of two parallel 100Ω resistors. Also, 33Ω is very nearly the equivalent of three parallel 100Ω. So altogether the circuit is the equivalent of five parallel 100Ω which is of course the same as one 20Ω resistor.

PRACTICAL AMPLIFIERS

Let us get back to amplifiers. Consider the simple practical amplifier circuit of Fig. 6.5. This is for a.c. voltages and uses one transistor, two capacitors, and two resistors. The capacitors are to block d.c. while

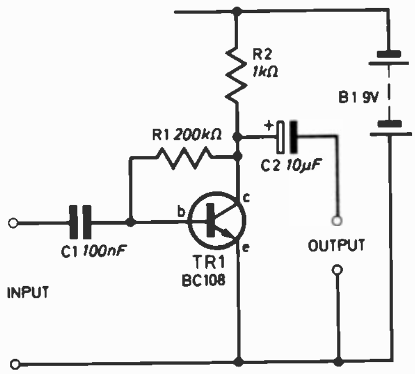


Fig. 6.5. A simple and practical amplifier circuit. This may be built using either of the NPN modules and the additional components shown.

allowing a.c. to pass. The transistor is turned on by a small current through the base, which flows via R1, often called the base bias resistor. It might seem more sensible to connect the top end of R1 to battery positive rather than to the collector.

However, the connection shown here has an advantage. The more base current flows, the more collector current flows. But the collector current flows through R2 and as it does so it produces a voltage drop. Because of this the collector voltage is less than 9V. So the voltage available for driving base current through R1 is less than 9V.

If for some reason the collector current increases the collector voltage falls, and this further reduces the voltage available to provide base bias current. The collector current therefore tends to stay put at something near its original value. The arrangement is in fact a form of negative feedback and tends to stabilise the collector current.

This is useful in counteracting the effects of temperature changes. More important, it helps the designer to get more consistent performance from transistors with different current amplifications.

At present, it is not possible to control the current amplification closely when transistors are manufactured. This is why your BC108 can have a current amplification of about 100 to 800. Some manufacturers restrict the "spread" of current amplification to some lesser range such as 120 to 450, and some divide their BC108 into three groups identified by letters A, B, and C. A usually signifies a current amplification of 125 to 260; B, 240 to 500; and C, 450 to 900.

The designer must take this variation into account. The bias system used here is a crude but useful way of reducing its effects.

A useful "rule of thumb" is to make R1 greater than R2 by the current amplification. For an amplification factor of 200, if R2 is 1kΩ then R1 should be 200kΩ. This has the effect of making the collector voltage set itself to about half the battery voltage. So R2 drops about half the battery voltage. It follows that the collector current must be half the battery voltage divided by R2. With our values this means a collector current of 4·5mA.

CALCULATIONS

In engineeering shorthand the battery voltage is written as; V_{cc}, the collector current as I_c and the current amplification as h_{FE}. So in shorthand form the rule of thumb can be written;

$$R2 = h_{FE} \times R1$$
$$I_c = V_{cc} \div 2R2$$

CALCULATING R1

Now build up the circuit of Fig. 6.5 using either of the two NPN modules. At this stage it does not matter which. Make temporary connections to R1. Short lengths of connecting wire with crocodile clips attached at each end will do.

For voltage amplification a collector current of about half a milliamp is suitable. The required value for R2 is then given by: 4·5V÷0·5=9kΩ. The nearest prefered value is 10kΩ.

If the value of h_{FE} is 100 to 800, then R1 must be in the range 1MΩ to 8MΩ. A reasonable compromise is 3·3MΩ, but with the aid of your VOLTAGE INDICATOR and RESISTANCE SUBSTITUTION BOX you can find a value which fixes V_{CE} as near as 4·5V as possible.

At the same time this enables you to deduce the h_{FE} value which is roughly R1÷R2, if V_{CE} is V_{cc}÷2. This is unlikely to give quite the same value as you measured in Part Four, but should be reasonably close.

Now repeat the experiment with the other NPN module. You will probably find that entirely different values are required for each module. In fact we found that we had to use a value for R1 of 1MΩ for one of the modules, and 3·3MΩ for the other, in order to get V_{CE} near to 4·5V.

These values for R1 imply that the h_{FE} in each case is 100 and 300 respectively.

If you can not get close to 4·5V because one resistance in your RESISTANCE BOX is too high and the other too low, then use the lower resistance. Once the values for both modules have been found solder actual resistors in place on top of the modules.

A single stage amplifier like this will give a voltage gain of about 200. Quite a high gain but not enough for our purposes. What we are going to do is experiment with using loudspeakers and earphones in reverse, as microphones.

LOUDSPEAKER DESIGN

A loudspeaker such as your 80Ω one is an electromagnetic device Fig. 6.6. A coil of very fine wire is attached to the back of the cone or diaphragm. This coil sits in the field of a powerful magnet. When a current is passed through the coil it sets up a magnetic field in the usual way. This field either assists or opposes the field of the permanent magnet, depending on which way the current is flowing.

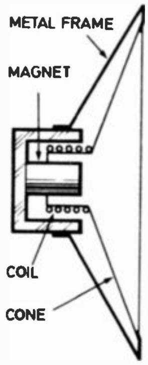


Fig. 6.6. Internal constructional details of a typical loudspeaker. Essentially a powerful magnet and a coil is used to reproduce electrical currents as sound waves.

The result is that the cone is pushed outwards for one direction of current and pulled inwards for the other. If the current is audio frequency a.c. the cone vibrates in sympathy with the current, and the resulting pressure on the air in contact with the cone is the beginning of a sound wave.

The device can also be worked backwards. That is, when a sound wave makes the cone vibrate, a voltage is induced in the coil.

If the loudspeaker is used as a microphone something else must be used to listen with. A crystal earphone could be used here.

If you connect the loudspeaker to the input and an earphone to the output of your single stage amplifier you should be able to hear something if a loud noise is made near the microphone e.g. by tapping it.

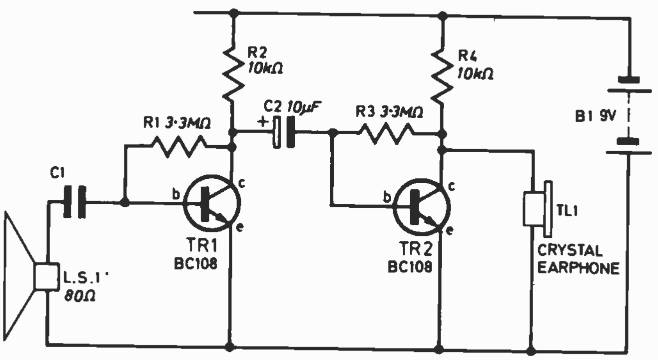


Fig. 6.7. In this circuit an extra stage is added to give more gain. This can be constructed using the two NPN modules. The resistors in the previous experiment being omitted.

Evidently more amplification is needed. This can be obtained by adding another stage of amplification Fig. 6.7. Since C2 blocks d.c. from the first stage it is not necessary to use a second capacitor for the other position. As a matter of fact it is not necessary to use an output capacitor for the last stage either. A crystal earphone does not allow d.c. to flow through. It is a capacitor itself.

So connecting it between the collector of TR2 and earth does not upset the d.c. conditions. A loudspeaker or a magnetic earphone would pass d.c. and rob the transistor of collector voltage. If you use a magnetic earphone it must either be connected between collector and battery positive or an output capacitor must be used. But only a high impedance earphone will be of any use.

The usual 8 ohm types supplied with the tranistor radios are no good. Large old fashioned ones from headphones are generally satisfactory.

Make the two stage circuit of Fig. 6.7 and experiment with it. You will probably notice a number of things. First, the amplification is much greater. Secondly, you hear a buzz, especially if you touch the wires of C1. Thirdly, the quality of the sound is poor. Fourthly, after a sudden loud noise the amplifier goes silent for a while.

MAINS HUM

The buzz is "mains hum". You might think that the mains has no place in a battery operated amplifier. However, minute mains frequency currents flow all over the house. When you touch the input terminal of the amplifier, mains hum is induced into your body and flows to earth.

On its way via your finger to earth it passes through the input of the amplifier, setting up a small voltage which thereby gets amplified to produce the hum.

It sounds more like a real humming noise in amplifiers whose speakers can reproduce very low frequencies. What you hear from your amplifier is mostly "harmonics", that is multiples of the mains frequency which get manufactured accidentally in various ways.

The distortion arises partly from the fact that neither your microphone nor your earphone is hi-fi. Each reproduce some frequencies better than others. Speech and music, which are mixtures of frequencies, do not sound natural. Undue emphasis of particular frequencies is called *colouration* of the sound.

WAVEFORMS

The jangly quality of loud sounds is also due to distortion of quite a different kind. The amplification is now so great that the a.c. from TR1 passing into the base of TR2 is greater than the d.c. base bias current in TR2. Fig. 6.8.

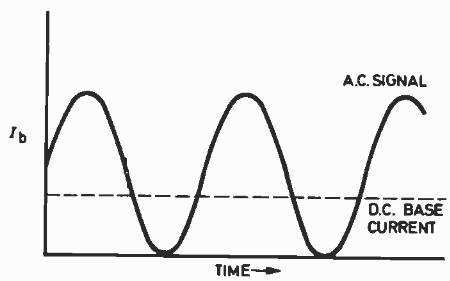


Fig. 6.8. Waveform obtained from the collector of TR1. Here the amplification is so great that it is larger than the base bias on TR2.

During one half cycle, say the positive half cycle, the a.c. and d.c. combine to make TR2 pass more collector current. But during negative half cycles a point is reached at which the a.c. just cancels the d.c. Fig. 6.9.

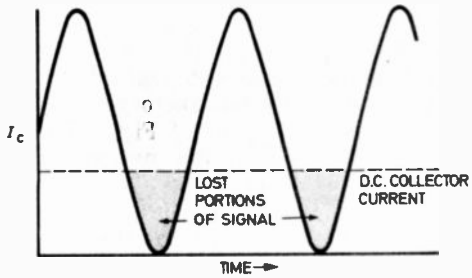


Fig. 6.9. We now have a situation where the a.c. collector current of TR2 is so large that any further increase is just cancelled out by the d.c. collector current.

At this instant the base current is zero so the collector current is zero. Any further negative swing of the a.c. can have no further effect. You cannot reduce the collector current to less than zero. The result is that the tips of the negative half cycles do not get reproduced at all. They just get flattened. This kind of distortion, called **peak clipping** is an example of *overloading*. The amplifier is being fed signals too big for it to handle.

On tests carried out with the amplifier, an oscilloscope was connected to the output. The resultant waveform which appeared on the screen was not a sine wave, or even clipped sine wave as shown in Fig. 6.9 but a *symmetrically* clipped sine wave: Fig. 6.10.

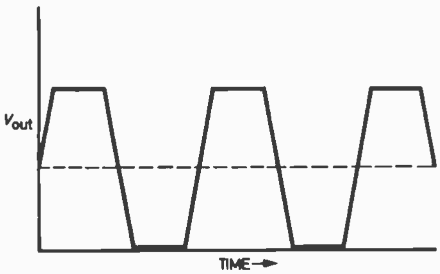


Fig. 6.10. The idea of overloading can be extended further when both positive and negative peaks are clipped resulting in the waveform shown here.

Why is this? Well, the overloading can only explain the cutting-off of collector current by the tips of negative half cycles of base signal current. Positive tips merely make the collector current increase. The solution to the problem lies in following this through to its logical conclusion. The current increases. What happens to the collector *voltage* when *it* increases?

If the collector current increases, the voltage drop in the 10kΩ collector load resistance increases. More of the battery voltage is used up in the 10kΩ resistor. The collector voltage *falls*. Now, the circuit is set up so that with no signals the collector sits at half the supply voltage, that is, 4·5V. The voltages can only fall to zero. Any further attempt to increase the collector current can have no effect on the collector voltage. Once all the battery voltage is used up in the resistor the collector can only remain at 0V.

We are in a familiar situation, peak clipping occurs. Only this time it is on the other peaks, so, we end up with double peak clipping.

OVERLOADING

Overloading is also the explanation of the silent periods which follow sudden large input signals. There is evidently a **time constant** at work somewhere and one component likely to be associated with it is the 10μF capacitor. If this somehow gets charged up by a strong signal so that its negative plate makes TR2 base so negative that TR2 is cut off, the amplifier stops working. When the 10μF discharges sufficiently, TR2 comes on again and the amplifier works once again.

The fact is that 10μF is too large a capacitance, if you change it to 100nF (0·1μF) you will find that the silent intervals disappear.

MEASUREMENT OF GAIN

Just how much voltage gain does the two stage amplifier provide? You can make an estimate by exploiting positive feedback. An amplifier like this with two stages each of which has its emitter earthed is non-inverting. Feedback from output to input is positive. If the amplifier has a voltage gain of 1000, then feeding back 1/1000 of the output will just make it oscillate.

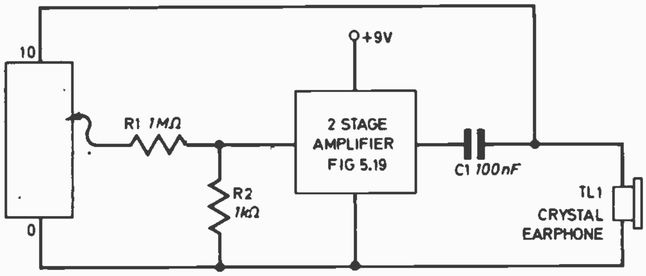


Fig. 6.11. Using the amplifier of Fig. 6.7 and the RESISTOR CHAIN, the gain can be measured by utilising *ratios*.

If you feed back the output of your amplifier through a voltage divider, and set the division ratio so that the circuit just oscillates then the ratio gives the gain.

A double divider Fig. 6.11 enables the ratio to be varied in a known way. The overall division is the product of the two divisions, that is the first one times the second, the second gives a ratio of about 1000.

The RESISTOR CHAIN gives ratios from 1 to 10. So, overall, ratios of 1000 to 10,000 are obtainable. Our amplifier oscillated (producing a rasping noise) with the RESISTOR CHAIN tapped at points 2 and above, but not on point 1. This indicates that the gain is over 5000 (tap 2 gives a division ratio of 5) but under

10,000 (tap 1 is 10). This was with a crystal earphone. If you use a magnetic earphone it may greatly reduce the effective load on TR2 and so reduce the gain.

You can connect it between the top of the 10kΩ and battery positive to avoid this. The amplifier gives quite a respectable gain, but should it not be higher? We said that a *single* stage amplifier should have a gain around 200. On this basis two similar stages should give 200×200=40,000, which is a lot more than the measured gain.

UNKNOWN IMPEDANCES

What has gone wrong? A careful inspection of the circuit shows us that there are several examples in it of impedances which are in parallel in just the right way to reduce the gain. First the RESISTOR CHAIN, which has an impedance of 10kΩ, is in parallel with the 10kΩ load of TR2 Fig. 6.11. This reduces the effective load to 10kΩ/2=5kΩ and halves the output voltage.

The part of the RESISTOR CHAIN between the tap and earth is "shunted" by the 1MΩ+1kΩ divider. The input impedance of TR1 (i.e. between input and earth) is in parallel with the 1kΩ resistor, reducing its effective resistance and therefore increasing the division ratio to something over 1000. The input impedance of TR2 is in parallel with the 10kΩ load of TR1.

Since we do not know the input impedances of the transistors we cannot estimate their effect on gain. One thing we do know about (the values of the RESISTOR CHAIN resistances and the 1MΩ and 1kΩ resistors) should tell you, without bothering to do any sums, that the effect of the 1MΩ+1kΩ on the RESISTOR CHAIN ratio is negligible, because very little current will be taken from the RESISTOR CHAIN by the 1MΩ resistor. If our original guesstimate of 40,000 was right, then the effect of the RESISTOR CHAIN across the 10kΩ load brings down the gain to 20,000 and the other factors must reduce it to less than half this.

Later, when we explore the characteristics of transistors in more detail, you will be in a better position to estimate the effects of their input impedances. Let us leave it for now, and do some more experiments. First, substitute your 100kΩ POT for the two voltage dividers, R1 and R2 and see how the frequency of oscillation varies as the knob is turned.

Disconnect the POT and connect the amplifier input terminal to the positive of the battery.

Do you hear anything? Can you think why the circuit is behaving as it does?

Next month we shall continue with amplifiers and discuss some of the more important parameters to be considered when designing amplifiers.

QUESTIONS

6.1. A transistor collector load resistor drops 3 volts. The voltage gain of the transistor is about;
a. 30
b. 120
c. 300

6.2. A transistor has an h_{FE} of 100, and an I_c of 100μA. Its a.c. input resistance is approximately;
a. 25kΩ
b. 10kΩ
c. 250Ω

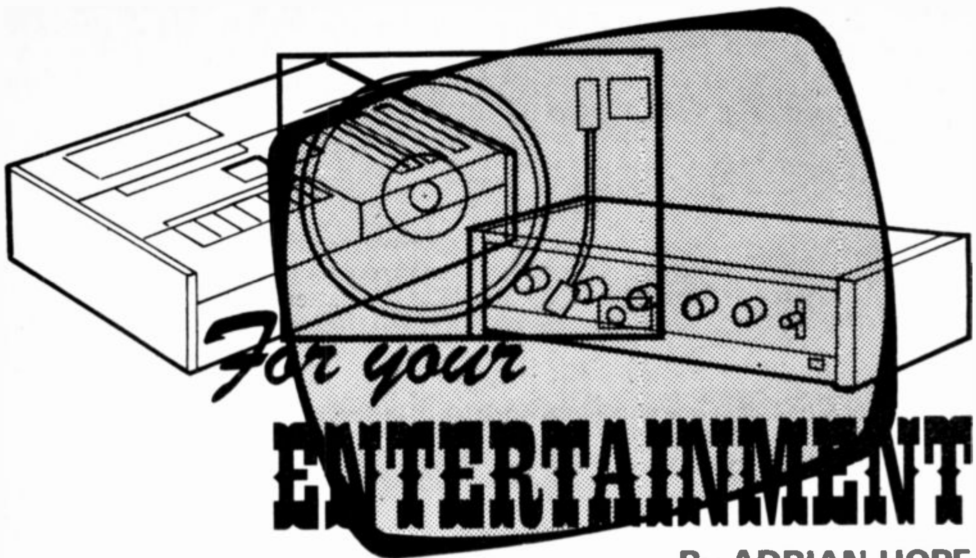
6.3. Noise is thermally generated in;
a. inductors
b. resistors
c. capacitors

6.4. A gramophone pickup delivers 10mV to a pre-amplifier which then drives a power amplifier. If the power amplifier needs 300mV to produce full output, the gain required in the pre-amplifier is;
a. 10
b. 30
c. 300

6.5. A TV film crew is filming a speaker at a conference from the back of the hall. The sound recordist combats the noise of the audience by;
a. using a directional microphone
b. increasing the amplifier gain
c. inserting a sharply tuned filter

ANSWERS *(To part five)*

1. positive (a)
2. a voltage or e.m.f. (b)
3. L and C in series (b)
4. all the field of one passes through the other (c)
5. very low (a)
6. 1·33Ω (c)
7. 220 (a)
8. 48Ω (c)



For your ENTERTAINMENT

By ADRIAN HOPE

Pioneers

IN THE field of audio electronics the work of two pioneers has quite shamefully been underestimated, misunderstood and misinterpreted.

It was in 1933 that Major Edwin Armstrong of Columbia University invented and patented the principles of modern f.m. radio. He demonstrated multi-channel multiplexing just a year later. But it wasn't until the early Sixties, some five years after Armstrong's suicide, that f.m. and stereo multiplexing was authorised in the U.S.A.

Likewise, EMI engineer Alan Blumlein never really saw the fruits of his 128 patents in action. Whereas Armstrong died of frustration, in 1954, Blumlein was killed by an accident in 1942. The Halifax bomber in which he was testing the H2S radar system that helped win the War crashed in the Wye Valley and all on board were killed.

Armstrong's life and work is publicised by the Armstrong Memorial Research Foundation at Columbia University in New York City. But no such "official" body has ever sought recognition for Blumlein in the U.K.

Blue Plaque

The situation has, however, changed recently for the better, due mainly to the enthusiasm of Blumlein's official biographer, F. P. Thompson, who encouraged the Greater London Council to commemorate Blumlein's last London home at No. 37 The Ridings, Ealing, with a traditional blue plaque. The official unveiling was followed by a ceremony sponsored by Blumlein's original employers, EMI.

The ceremony took place almost to the day 35 years after his death, and ten years after the publication in the June 1967 issue of *Electronics and Power* of an article by engineer, B. J. Benzimra. This article meticulously researched and tabulated all 128 of Blumlein's patents, and probably triggered all the current interest.

Stereo Quad

Of these, British Patent No. 394 325, which was filed in 1931, is perhaps the most significant, for it laid the foundation to all modern stereo sound. Every stereo record in the shops today has its left and right channels cut in the single groove as suggested by Blumlein.

In January 1934 the invention was put into practice at EMI's Abbey Road studios when Sir Thomas Beecham took time out of a mono recording session to let the young Blumlein make a test version of some sections in stereo. Sadly, these historic recordings have never been issued or made public, although some are now in the hands of the British Institute of Recorded Sound in London, who may well play some at public demonstrations.

It's fascinating to see how even now, despite the flurry of interest that came with the unveiling of the Blumlein plaque in the centenary year of recorded sound, the man's work still continues to be underestimated and misinterpreted. In April the *Telegraph Magazine* was censured by the Press Council for belittling Blumlein by suggesting that his work was so secret that no one had ever heard of him and that there was thus comedy in the idea of erecting a blue plaque to such a man.

Then, in his speech at the official unveiling of the plaque, Sir Alan Hodgkin perpetuated an erroneous myth which has passed into audio folklore. Referring to the recent quadraphonic broadcasts made by the BBC, Sir Alan spoke of Blumlein's original stereo work and suggested that "Not only did his patent specification refer to the invention of stereo: it also included an outline of quadraphonic and ambisonic techniques."

In fact, although Blumlein paved the way to such modern techniques as the NRDC's Ambisonics surround sound system, by describing sum and difference techniques of signal handling, Blumlein did *not* specifically invent and describe "quad". But with the text of the speech released by EMI and quoted *verbatim* by newspapers round the world, Blumlein is now assured a place in history as the inventor of quad.

It's ironical, because it's probably one of the few aspects of modern audio that Blumlein didn't invent.

Television Games

The price of television tennis, football, shooting and race games is now dropping like a stone, just as the price of calculators plummetted once the basic chips had been developed and put on the market for manufacturers to incorporate in their own brand name machines.

In a previous column we warned about the risk of buying too early and thus spending too much on a t.v. game, and personally I have no doubt that the price of games will drop further as more and more new chips and games are developed. Already programmable games are on sale, which makes the basic style seem very tame.

Another development soon will be devices which connect with an audio tape recorder, (cassette or reel-to-reel) and enable you to take part in pre-taped sports, such as racing and target shooting, complete with a soundtrack of advice, sound effects and music.

But, sorry to be a wet blanket, here's another word of warning. Do beware of tube burn. I have talked with several t.v. engineers and without doubt there is a risk of damaging the cathode ray tube of a t.v. set if a game puts a fixed field pattern on the screen for hours on end at high brilliance and contrast. And, of course, this is just what might happen during the school holidays.

Because the beam current of a colour set is fairly low, there is less risk likely with a colour t.v. than with a black-and-white set. And there is least risk of all with a colour game that puts a single colour field pattern on a colour t.v. screen, because this way the beam current is reduced even further.

But if you use a black-and-white game with a black-and-white set, don't play on the same static field pattern for too long. Change for instance from ping-pong to football and back again every quarter hour. And reduce brilliance and contrast, using the set controls.

Do you think you have fast reactions?

Test yours against opponents with this easy to build reaction game.

By R.A. Penfold

CATCH-A-LIGHT

INTRODUCTION

MODERN electronics readily lends itself to the production of simple but amusing games, many of which could not be accomplished using more traditional materials. The electronic game described below is for two players and is a competitive test of their reaction speeds.

GAME BASICS

A set of six lights forms the basis of the game. These are arranged in the pattern shown in Fig. 1, and have been numbered in the diagram for the convenience of this explanation.

The game begins by one player throwing a switch, which causes lights 3 and 4 to blink on and off at a rate of several times per second. As one light turns on, the other switches off. After a few seconds this process ceases with one light remaining on and the other turned off.

Each player has two push button switches, one player's switches operating lights 1 and 2, and the other player's switches operating lights 5 and 6. If, for instance, light 4 remains on at the end of the blinking process, the two players must try to switch on whichever of their lights is nearest to light 4 by depressing the appropriate push buttons.

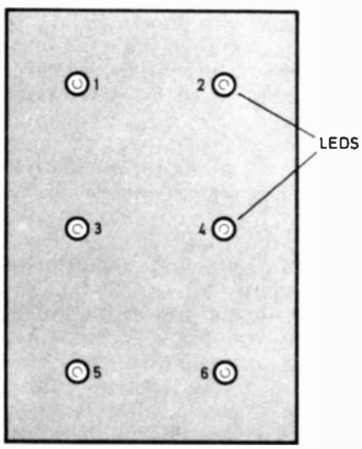


Fig. 1. Layout of the light emitting diodes on the front panel.

If the player operating the upper set of lights manages to get lamp 2 on first, he is the winner of that round. There can be no argument as to who is the winner, as once a player turns a light on, the light at the other end of the row is blocked and cannot be switched on until the winning light is extinguished.

There is obviously no effective way of cheating at this game, since to do so it would be necessary to anticipate both the end of the blinking period and the random matter of whether light 3 or 4 is the one which will remain on at the end. The game is thus purely a test of the skill and reaction speeds of the two players.

MULTIVIBRATORS

The winking light part of the circuit is based on two forms of multivibrator circuit, the astable and bistable types. The basic circuit diagrams of these two types of multivibrator are shown in Figs. 2a and 2b respectively.

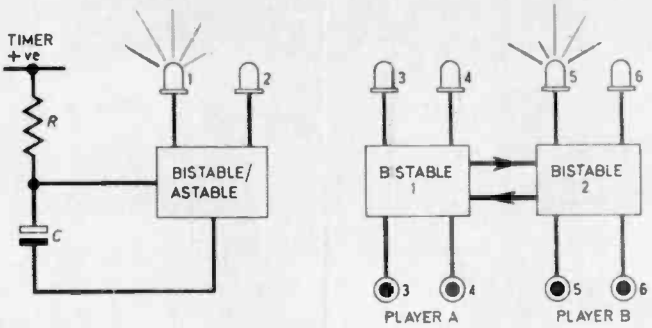
ASTABLE

An astable circuit operates in the following manner. When the supply is initially connected both transistors will receive base currents and will begin to turn on. Due to inevitable circuit imbalances, one transistor will begin to turn on faster than the other. For the sake of this explanation we will assume that TRa turns on faster than TRb. As TRa turns on, a negative signal will be fed via C_a to the base of TRb. This will hold TRb in the off state while base current via R_b turns TRa hard on.

When TRa is turned fully on, no further signal will be developed at its collector and transmitted to TRb base via C_a. The charge across C_a will quickly die away and as TRb now starts to receive base current via R_c, it begins to turn on. As it does so, a negative signal is fed via C_b to the base of TRa, thus turning TRa off. This sends a positive pulse to the base of TRb by way of C_a, quickly turning TRb hard on in the process. As a result of this regenerative action TRa now becomes turned off and TRb becomes turned on.

The charge across C_b then quickly dies away and this process continues with both transistors continuously changing state.

HOW IT WORKS



A simple timing circuit consisting of *R* and *C* provides a variable timing period to the combined bistable/astable. This part of the circuit produces random flashing of two l.e.d.s. At the end of each period this circuit will stop and only one l.e.d. will remain illuminated. Whatever l.e.d. remains on, either 1 or 2, the players press their switches corresponding to that l.e.d. In the case shown this is 3 or 5.

As one switch is pressed, say 5, the associated l.e.d. illuminates, at the same time the bistable "latches" on in one state thus preventing the other l.e.d. from turning on. Due to the "cross coupling" between the two bistables, the other bistable is prevented from turning on.

Thus the circuit indicates which player has "caught the light" first.

BISTABLE

A bistable operates in a similar manner, except that as it is d.c. coupled it latches with one transistor turned off and the other turned on. Referring to Fig. 2b, when the supply is initially connected both transistors will begin to turn on, and again one will turn on faster than the other at the outset. If, for example, TRc begins to turn on faster than TRd, TRd will be starved of base current as the collector potential of TRc quickly falls. TRc on the other hand, will be able to draw plenty of base current from the collector of TRd and in consequence it will quickly turn hard on. In doing so it completely starves TRc of base current, and the circuit will rest with TRc turned on and TRd turned off.

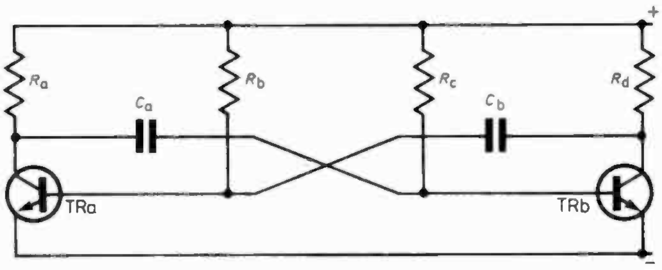


Fig. 2a. Basic astable multivibrator circuit.

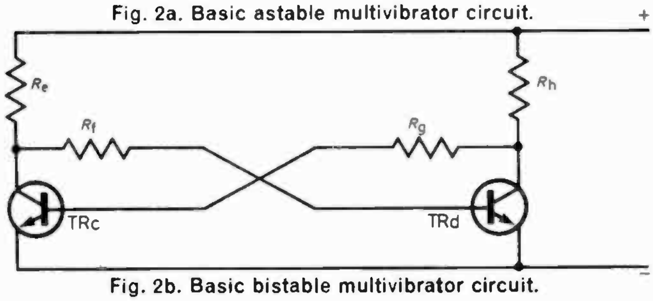
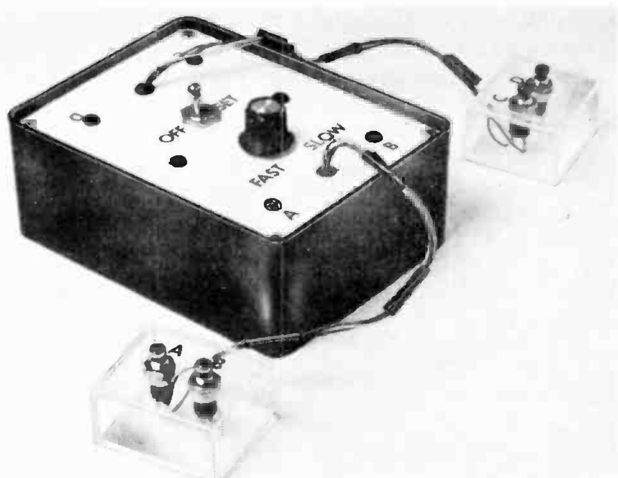
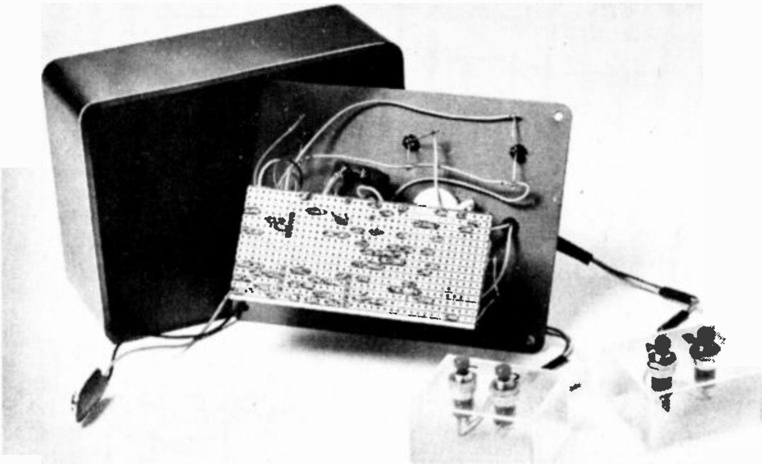


Fig. 2b. Basic bistable multivibrator circuit.

The completed Catch-A-Light reaction tester.





Rear view showing the circuit board mounted on the front panel.

START HERE FOR CONSTRUCTION

Begin construction by cutting a 16 strip width of 0·1 inch matrix Veroboard from a 3·75 inch length of board, using a hacksaw. Then referring to Fig. 4, make the 14 cuts in the copper strips, and solder in all the components, leaving the transistors until last. The components are fairly closely spaced and care must be taken to avoid short circuiting adjacent copper strips with blobs of excess solder.

With the exceptions of the push button switches and battery, the remaining components are mounted on the front panel of the case. The author used an inexpensive plastic case having a steel front panel, but any case of a similar size (130×100×50mm) should be suitable.

Two small cases are used to house the push button switches, one box for each player's switches. A couple of commercially made plastic boxes are used on the prototype, but if suitable ready made boxes cannot be obtained, suitable containers can be made from wood or aluminum. The containers do not even have to have a full six sides, and can be very basic.

WIRING

The final wiring of the unit is also shown in Fig. 4. The component panel is positioned behind D2, D5 and D6, with its component side facing the front panel. Thick insulated single strand wire (about 16 to 18 s.w.g.) is used to connect the panel to VR1 and S1, and provided these leads are kept as short as possible they will provide a firm mounting for the panel. The rest of the circuit can then be wired up according to Fig. 4.

To avoid mistakes, use a different colour connecting wire for each switch when wiring in S3 and S5, and also when connecting S2 and S4. These are connected to the main unit by leads about 20cm long. It is advisable to fit the front panel holes for these leads with grommets if a metal panel is used.

The battery fits beneath D1 and D3, and some foam rubber can be used to hold it in place more firmly if it is found to be at all loose.

Components

Resistors

R1 10kΩ	R10 27kΩ
R2 4·7kΩ	R11 2·7kΩ
R3 2·7kΩ	R12 2·7kΩ
R4 68kΩ	R13 27kΩ
R5 68kΩ	R14 27kΩ
R6 68kΩ	R15 2·7kΩ
R7 68kΩ	R16 2·7kΩ
R8 2·7kΩ	R17 27kΩ
R9 10Ω	

All resistors are carbon ¼W ± 5%

Potentiometer

VR1 100kΩ Lin.

Capacitors

C1 100µF 10V elect.
C2 2·2µF 10V elect.
C3 2·2µF 10V elect.

Semiconductors

TR1, 2, 3, BC109 silicon *npn* (3 off)
TR4, 5, 6, 7 BC108 silicon *npn* (4 off)
D1 to 6 TIL209 red light emitting diode (6 off)

Miscellaneous

S1 d.p.d.t. standard toggle switch
S2 to 5 push to make, release to break push switches (4 off)
B1 PP3 9V battery
Stripboard 0·1 inch matrix 37 holes by 16 strips; battery clip; case type M3 or similar size, 130mm×100mm×50mm; two small boxes to suit S2 to S5; small round knob; grommets as required; connecting wire; mounting clips for l.e.d.s (if not supplied); solder.

See Shop Talk page 342

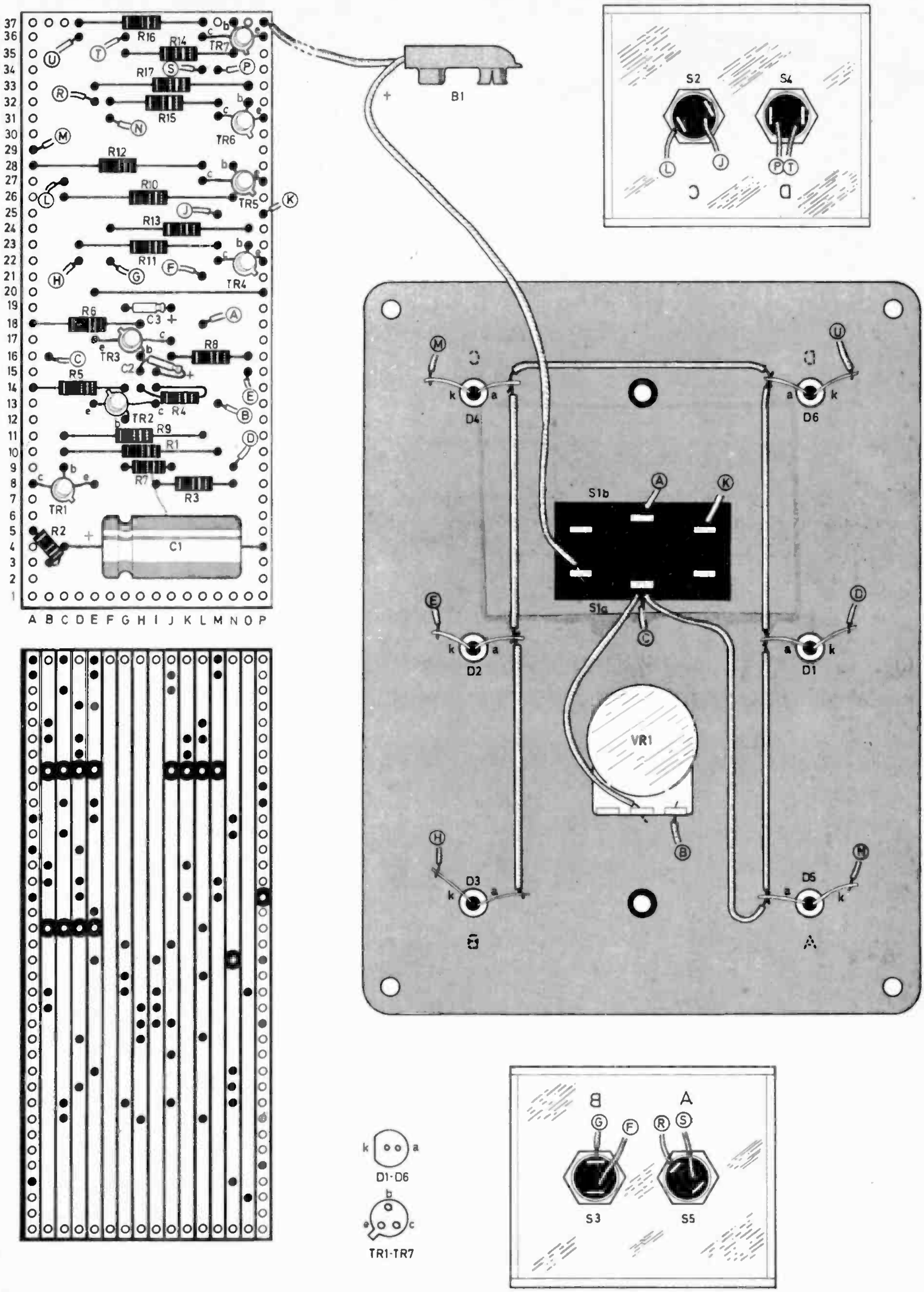


Fig. 4. Interwiring details, component layout and underside of the stripboard showing breaks in the copper tracks. Wires from the reaction switches and front panel mounted components should be connected to their corresponding letters on the circuit board.

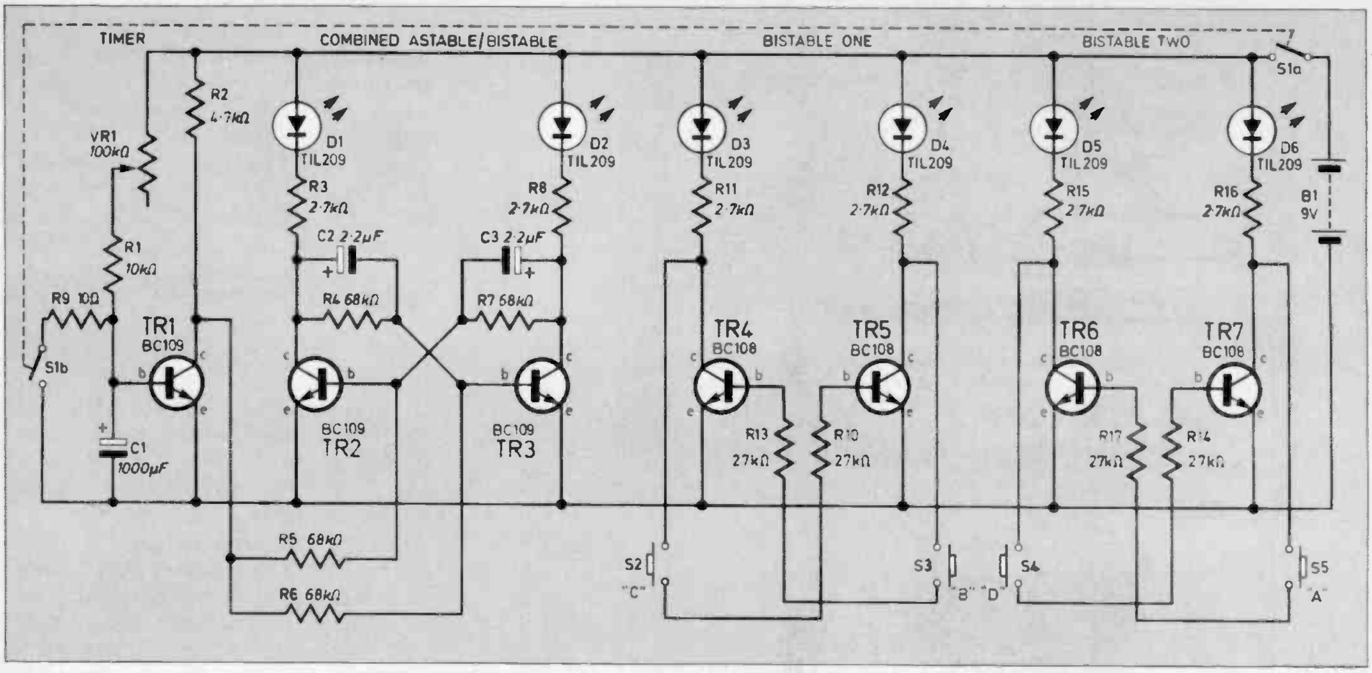


Fig. 3. The complete circuit diagram for the Catch-A-Light.

CIRCUIT DESCRIPTION

The complete circuit diagram of the reaction game appears in Fig. 3.

Transistor TR1 is used as a time switch, and when the supply is connected C1 charges via R1 and VR1. Normally there is virtually the full supply voltage at TR1 collector, but when about 0·6 volts is developed across C1, TR1 will turn on and its collector voltage will fall to almost zero.

BIAS

For the period that TR1 collector is high, TR2 and TR3 will operate as an astable multivibrator with base bias current being provided via R2, R5, and R6. Resistors R4 and R7 have no significant effect on the circuit yet.

As TR2 and TR3 repetitively turn on and off, their l.e.d. loads, D1 and D2, will flash on and off. When TR1 turns on, the base bias via R2 is cut off and the circuit will no longer operate in the astable mode. It will, instead, operate as a bistable multivibrator with R4 and R7 providing the cross coupling. These cause the circuit to latch in whichever state it was in when the bias was removed.

For instance, if TR2 is on and TR3 is off when the bias is removed, bias current flowing through R7 will hold TR2 in the on state while TR3 will be unable to receive any base current from TR2 collector and so remains off.

Thus, when the supply is turned on, D1 and D2 will flash on and off for a few seconds until TR1 turns on, whereupon the oscillation ceases with one of the l.e.d.s remaining on.

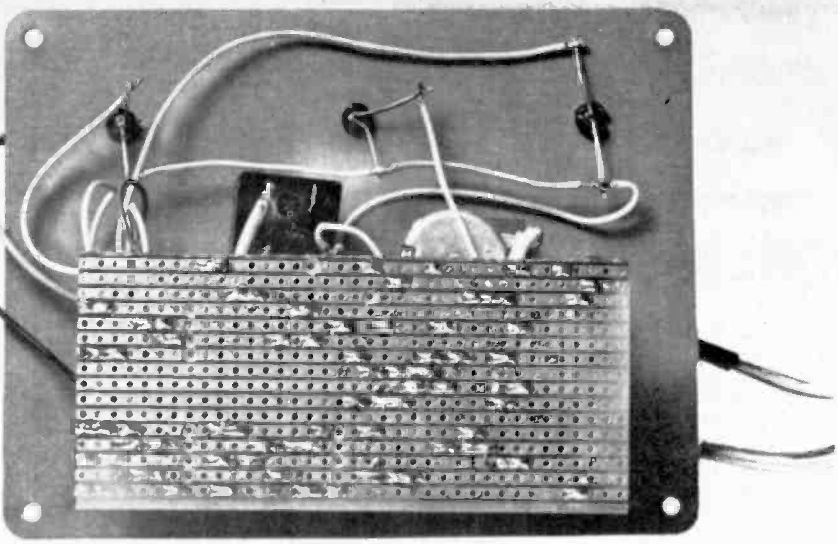
TIMING

The timing period can be varied from about 2 to 12 seconds using VR1. It is largely a matter of chance whether it is D1 or D2 which remains on at the end of the timing period, but with VR1 at any given setting the circuit is likely to be imbalanced in favour of one or other of these. Altering the timing period at the end of each round using VR1 helps to iron out this imbalance. as well as making it more difficult to estimate and anticipate the end of the period.

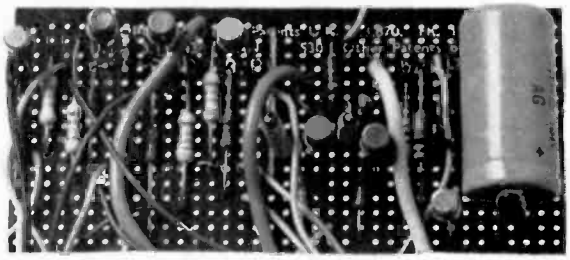
PRECEDENCE CIRCUIT

Two identical bistable circuits form the remainder of the unit. These ensure that only one winning light can come on at one time, and one bistable is used for each row of lights.

In practice, D3 and D4 are mounted at opposite ends of the display (positions 1 and 5 in Fig. 1), and one player has S2 while the other has S3. If S2 is pressed, base current will flow from the positive supply to TR5 via D3, R11, and R10. Transistor TR5 will turn on and D4 will light. If S3 is now depressed, as TR5 collector is at almost the same potential as the negative supply rail, TR4 can receive no significant base current via R13 and D3 will not light. The circuit is extremely fast in operation, and the moment one push button is depressed the other is blocked.



Close-up of the rear of the front panel.



Top view of the circuit board showing component layout.

IN USE

To start the unit it is merely necessary to switch S1 into the *on* position. At the end of the round S1 is put back in the off position, and C1 will then almost instantaneously discharge through S1b and current limiting resistor, R9. After the setting of VR1 has been altered, the unit is then ready to be turned on again and another round played.

A simple method of playing a game using the unit is to have the first player to score 10 points as the winner. One point is scored for each round that is won, and a point is deducted in the event that a player either pushes the wrong button or pushes both at once.

An element of luck can be introduced into the game by having additional points scored by players betting on which light they think will remain on at the end of each round.

The precedence switch part of the circuit could be used as a quiz monitor, and the other part of the circuit a sort of electronic heads or tails, and could possibly have uses in other games. ⌑

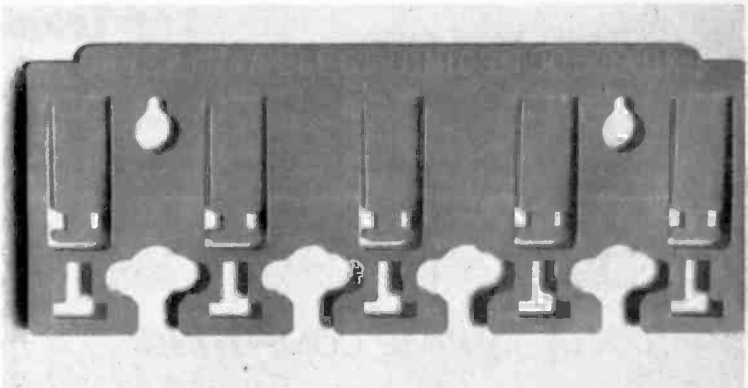
YOUR FREE TOOL RACK

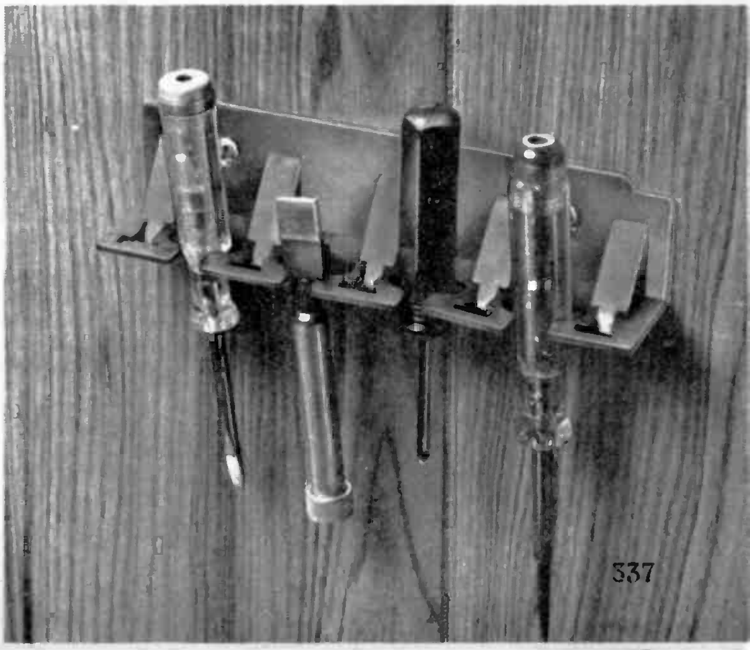
Presented Free with this issue is a very useful item to have in the workshop. How many times after you have finished working on your latest project, put your tools down and walked away, only to discover that when you return the tools have grown legs and vanished. A tool rack solves this problem, by having the tools mounted in an easy to see quick to find position.

As received the EVERYDAY ELECTRONICS Tool Rack is flat, before using therefore it must be folded to the correct shape.

With the Tool Rack on a flat surface and the lettering facing you, bend up at an approximate angle of 45 degrees, the five locating strips. Next bend up the bottom half to meet the strips, at the same time pushing the lugs on the strips into the slots provided and lock them in position by pushing the lugs back. Do this operation with all five strips, and your tool rack is then ready for use. The photographs should make this clear.

It can be mounted in any convenient position using small screws. A half-inch number 8 wood screw would be ideal. Once the tool rack is mounted the tools can be put in, and is then ready for use.





Everyday News

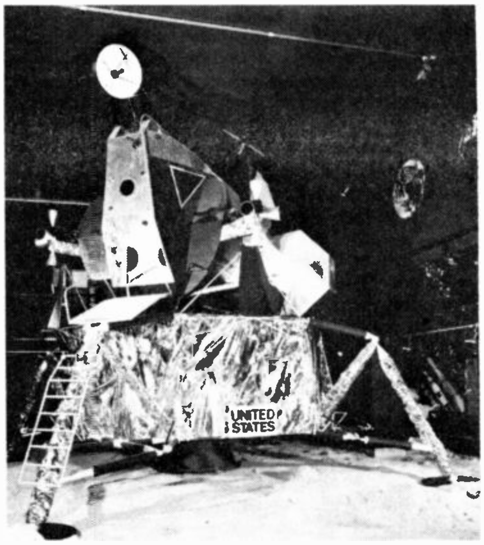
EXPLORE THE WORLD OF SCIENCE

To those familiar with the layout of the Science Museum in London, there have been a few changes just recently. The latest being the conversion of the ground floor Electric Power Gallery into an Exploration exhibition illustrating some of the ways in which scientific and technical skills are being used to explore the world and beyond.

The exhibits include the actual *Apollo 10* spacecraft that completed a moon orbit in 1969, a full size reconstruction of the *Apollo 11* moonbase (with additional "Keep off the MOON" signs so necessary to stop children of all ages from 'stepping boldly'), a lifesize model of a manned submersible and an EMI brain scanner in simulated working operation.

Electronics play such a vital part in the modern world it is good to see this exhibition, which is on for at least three years, depicting so clearly the use to which it can be put, from remote sensing where we can look at familiar objects at wavelengths outside the range of our own eyes and truly see the world in a new light, to earth-based radio telescopes and orbiting observatories.

Each section has its own story to tell, and audio visual aids are everywhere including several video-taped displays. The museum staff are to be congratulated on this exciting and well presented exhibition which is proving so popular.



Full scale model of Apollo Moon Lander, on display in the Exploration Gallery. *(Science Museum Photo.)*

Britain's largest computer company, ICL, is now gaining more than half its revenue from exports. Total turnover is now running at over £400 million a year, a 45 per cent increase over the previous year and pre-tax profit is up 31 per cent. All this despite restriction on output through labour disputes.

Transatlantic Radio Messages

The 240Hz "song" of the early Marconi rotary spark gap transmitter was heard once again on the air waves during a week of commemoration of the first two-way transatlantic radio messages achieved by Marconi and his assistants in 1903.

Amateur stations on the original sites at Poldhu, Cornwall, and Cape Cod, Massachusetts, gave thousands of amateurs throughout the world the opportunity of "working" the historic sites. The control operator at Cape Cod, Robert J. Doherty, received special permission to reproduce by audio means the famous Marconi sound on his c.w. transmissions.

The amateur stations also operated on single sideband R/T, radio teletype and slow-scan t.v., all unknown techniques 75 years ago.

HOME COMPUTING

The popularity and some idea of the tremendous growth of home computing was demonstrated at a recent seminar in London.

The seminar, entitled "Home Computing", was organised by Lynx Electronics Ltd and was a complete sell out. Such was the popularity that they had to expand the accommodation to take 550 people who turned up on the day.

The final line-up of specialist guests who agreed to speak set a standard that would be very hard to better, be it hobbyist or professional. In order of appearance the guests were: Gary Tysoe of Mostek; Jim Ayres of Harrow College of Technology; Phil Pittman of Zilog; Phil Cooke of Sussex University and Tony Rundle of Compeda.

The seminar was given to commemorate the launching of the Nascom 1 Microcomputer Kit. This kit is built around the Mostek Z80 CPU and includes a full keyboard, 1K EPROM which provides eight basic operator commands including single step and a 2K RAM.

The kit has interfaces for connecting to a domestic TV as a monitor, a domestic cassette recorder for data storage and a teletype. The price of the kit is £197·50 (excluding VAT).

Manufacturers of advanced automatic test equipment and a leader in the field, Membrain Ltd, has been acquired by Schlumberger Measurement and Control (UK) Ltd for an undisclosed cash sum. The company will continue to operate as a separate business and with its existing management.

Signing Off

Over 50 million QSL cards (exchanged by radio amateurs to confirm contact) have been handled during the 38 years Arthur Milne, G2MI, and his wife have been running the QSL bureau for the Radio Society of Great Britain (RSGB) which currently has 20,000 members.

Arthur Milne has now retired and the new manager of the QSL Bureau is E. G. Allen, G3DRN, 30 Bodnant Gardens, London SW20 0UD.

Marine Call

Radiotelephone calls through the Post Office v.h.f. maritime radio service have increased more than tenfold in ten years. Annual calls are now 200,000 a year compared with 17,000 ten years ago.

In the same period the number of small coastal craft fitted with R/T has risen from 1,500 to 8,000, much of the increase being attributed to safety-conscious leisure yachtsmen and boatowners.

—ANALYSIS

MICROS AND JOBS

MICROELECTRONICS in general and microprocessors in particular are putting employment at risk. Today's electronics revolution, so technologically sweet, can be socially very sour indeed.

This was one of the messages emerging from the Impact of Electronics conference organised recently by our contemporary, "Electronics Weekly".

The consumer benefits are plain to see. Jack Akerman, managing director of Mullard, reminds us that the domestic radio set of 1936 cost about £13 when a Morris Minor car cost about £100. Today the equivalent radio still costs £13 while the cost of a Mini is about £2,000. Electronics has never been better value.

The Social cost, however, is highlighted by Kenneth Corfield, chairman and managing director of STC. Modern techniques like l.s.i. and p.c.m. have reduced equipment switching size in telephone exchanges by a factor of 15.

This means smaller buildings, less work for the building industry as well as those manufacturing exchange equipment. The present generation of electronic exchanges has reduced direct operatives in manufacture by a factor of 2·6 and the next generation will reduce labour by a further factor of 10:1.

The vice-president of Siemens, W. Germany, Dr. Alfred Prommer, reinforces the argument by pointing out that modern technology has reduced the cost of producing a single component in an integrated circuit by a thousandfold with a corresponding decrease in manpower required for its production.

And Alex d'Agapayeff, chairman of Computer Analysts and Programmers, referring to the broader impact in commerce and industry, suggests that it is inevitable that 2½ million people will endure substantial changes in their jobs and that 1½ million jobs may actually be lost through the application of microelectronics.

Have we, then created a technological monster which threatens to destroy our society? Not at all, provided we all recognise the challenge and abandon complacency.

Electronics has and can enrich our lives. But clearly we shall have to accept and adapt to change in work habits and attitudes if we are to continue to enjoy the riches yet to come.

Brian G. Peck.

The 13th Appleton Lecture delivered in the IEE lecture theatre had the title 'Solid-state devices and the age of indolence'.

Olympics TAMED

The new television centre in Moscow, now under construction for world coverage of the 1980 Olympic Games, will be equipped with Marconi Instruments Television Automatic Monitoring Equipment (TAME).

TAME will monitor all incoming signals from the competition areas and all twenty outgoing programme channels. Picture quality is continuously checked on 24 parameters.

AWARD

The 1977 Royal Television Society Southern Centre Award has been won by Mr. P. A. Crozier-Cole for his contribution to the development of the Independent Broadcasting Authority's Regional Operations Centres. For four years he has been project manager leading the team of engineers whose work is recognised by this award.

The RTS Southern Centre Award is given annually for the most significant contribution to television during the year in the Southern Centre area. It is not confined to the engineering field.

COMPETITION

The "Young Engineer for Britain 1978" competition has now been launched and is organised by PETT (Project-Engineers and Technologists for Tomorrow).

Regional competitions are scheduled for August, followed by the national final. This year's prizes include Concorde flights to the USA and visits to American engineering projects and a spacecraft centre.

One of last year's winners was 14-year-old electronic hobbyist Matthew Tonks with an ingenious integrated circuit test set.

Details of this year's competition can be obtained from the Secretary, PETT, Department of Industry, Room 114, Abell House, John Islip Street, London SW1P 4LN.

The US-based company, Teradyne, has sold $25 million worth of laser-trimming equipment to thick - film microcircuit manufacturers in the past six years.

The recently appointed Assistant Managing Director, Post Office Telecommunications, John Harper, builds radio equipment as a spare time occupation. In his new job he has special responsibilities for business planning and system efficiency.

Farnborough Air Show

The giant Farnborough Air Show, a shop window for avionics, is already fully booked by exhibitors. The exhibition areas have been re-designed for the 1978 show and will be larger and higher, allowing complete aircraft and space vehicles to be displayed under cover.

A quarter of a million visitors are expected to visit Farnborough International '78 which runs from September 3-10. The general public will be admitted only on the three public days September 8-10 when a full flying programme will also be staged.

Deer Wins First Prize

The ninth Scotch Wildlife Sound Recording Contest attracted over three hundred entrants with top prize and Sound Recordist of the Year title (plus equipment worth £500) going to Keith Biggadyke, seen below, for his chance recording of "Muntjac Deer and Nightingale".

He and other winners were recently presented with their prizes by Lord Alec-Douglas Home in the plush surroundings of the Hilton Hotel, London.

The annual competition is open to amateur tape recordists whose task it is to capture on tape cassette or spool, the sounds of British Wildlife. Entry forms for this year's contest, with first prize valued at £1,000 are available from Scotch tape retail outlets.

SQUARE ONE ...FOR BEGINNERS

WE ARE HERE TO HELP YOU - NO MATTER HOW NON-TECHNICAL YOU MAY BE, JUST READ ON!

THE HOUSING SITUATION

Thanks to miniature components and low power requirements, many electronic projects can be accommodated in quite small cases or housings.

Constructors have always been enterprising when it comes to providing a suitable case for some project. Tobacco and mustard tins, even baking tins, have all been pressed into service over the years! More recently, the large variety of cast-off plastic receptacles for all kinds of products have been seized upon by constructors and put to good use.

CUSTOM BUILT

While not decrying these inspired efforts at improvisation, we recommend the use of "custom-made" cases wherever possible. This implies, generally, commercial products, yet does not exclude home-made cases in metal or even wood.

No matter how simple the project, it is possible to finish it off in style. Metal and plastic containers designed expressively to house electronic equipment are available in considerable variety—and even in a choice of colours. So every home-built unit can have a professional look.

Our constructional articles show and specify all the mechanical details, including recommended cabinets or cases, where applicable.

We say "where applicable" because certain projects intended to be used in association with other equipment or apparatus can usually be installed within that equipment without any special housing for the unit itself. For example, the *Electronic Touch Switch* (January '78).

Where projects are designed for incorporation within other equipment, obviously we cannot provide exact details regarding the installation, the interwiring and the drilling of holes for controls and so on. The builder has to think this out for himself.

The greater majority of projects are, however, entirely enclosed within their own box or case. This is generally desirable. It is mandatory for portable or hand-held units—and is necessary also for safety reasons in many instances where the electronic unit is permanently installed in position. Electronic projects for motor cars, for example.

PLASTIC OR METAL

Plastic cases are a boon to the amateur constructor since they can be obtained in a variety of styles, sizes and even colours. They enhance the appearance of the finished project. Plastic cases are generally tough enough for the environmental hazards we normally have to take into account.

For exceptionally hazardous situations a metal housing might be better.

Burglar Alarms and power controllers are examples where the greater security afforded by a sheet aluminium or a die-cast box might be beneficial.

Great ruggedness, rigidity, and resistance to fire are not the only advantages offered by metal housings. There is the important consideration of electro-magnetic screening.

Some electronic circuits *must* be enclosed within a metal container in order to prevent either the radiation or the pick-up of electro-magnetic signals. Such extraneous signals may affect the proper operation of electronic equipment or cause interference on radio, TV, or audio equipment.

HOME-MADE CASES

With the wide selection of plastic and metal cases to choose from, the incentive to build one's own case has largely vanished. But for those who like working with metal or wood, the opportunities are still there.

The construction of metal cases requires certain skills and tools—and will appeal to a specialist minority.

Wood is a more commonly handled material. In fact wood was one time extensively used for home-made cases and cabinets. Modern timber materials with or without some plastic cladding are readily available in variety, and offer a solution for anyone proficient in woodworking.

Examples of projects using wooden cases are not very common nowadays, but as it happens one does appear this month, see the *Audiotest*.

CHOOSE WITH CARE

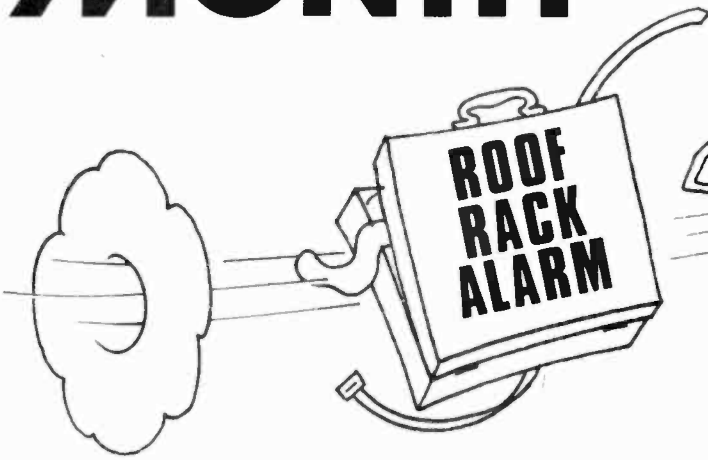
EVERYDAY ELECTRONICS projects are presented in full detail, right through to the housing stage. Suitable cases are specified in the articles, but the individual can use his own initiative and employ something different of course if he wishes.

However, if a metal case is specified there will be a good reason for this, and a plastic (or wooden) case should not be used as a substitute without due regard to the possible consequences.

Conversely, should a metal box be contemplated in place of a specified plastic (or wooden) case, remember that proper electrical isolation of all circuit components and wiring from the metal case is vital.

If in doubt, always stick to the kind of case specified in the articles.

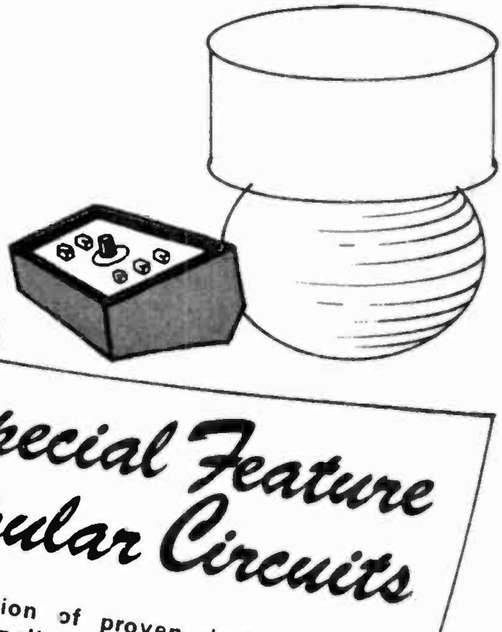
NEXT MONTH



Have you ever been frightened at the state of the load on your car roof rack? If so set your mind at rest with our simple design.

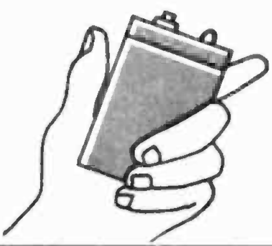
MAINS DELAY SWITCH

This timing circuit can be used with TV's, radios, tape recorders etc. With the option of a remote control the uses are endless.



POCKET TIMER

A portable unit for indicating elapsed time from a few seconds to several hours. Ideal for use in games, the kitchen and as a parking meter reminder.



Special Feature Popular Circuits

A selection of proven designs of varied application. Something for everybody!

Everyday ELECTRONICS

APRIL ISSUE ON SALE FRIDAY, MARCH 17

By Brian Terrell

New products and component buying for constructional projects.

Printed Circuit Boards

In last months issue of EVERYDAY ELECTRONICS you will have noticed that two of our constructional projects, *Chaser Light Display* and *Stereo/Mono Lead Tester* use printed circuit boards as the basis of construction as was the case with the *Automatic Phase Box* in the December issue.

Although details of fabricating home-made p.c.b.s were included in each of these issues it is felt that certain constructors may not wish to get involved in this and may prefer to obtain the p.c.b.s ready etched and drilled. The use of p.c.b.s in constructional projects is known to be in the minority as opposed to stripboard and other general purpose boards, but it is surprising to find no firms advertising such a service to readers. So advertisers (or would-be-advertisers) how about it? We feel sure it will be well received by our readers.

New From Vero

A new addition to the Verobox range of small plastic enclosures has recently become available. Known as the Flip-Top Box, it has a unique flip-over hinged cover to protect panel mounted items.

The cover, hinge and base are moulded in one piece of polypropylene and has a textured matt exterior. An aluminium alloy panel is supplied with the enclosure which clips in and requires no fixing bolts or screws. The inside of the enclosure contains pillars, integrally moulded to facilitate horizontally mounted components boards. Six self-tapping screws are supplied for this purpose.

The boxes are available in two sizes, 130 × 75mm (pocket size) and 196 × 127mm and there is a colour choice in both sizes—black or yellow.

The cases will find many uses and are ideal for keyboard units, field test equipment etc. Across the counter prices are £1·92 and £2·50 excluding VAT and are available from the usual Vero stockists.

Ultrasonic Transducers

As constructors will no doubt have found, there are very few suppliers to the amateur market of ultrasonic transducers. We are pleased to inform readers that Ace Mailtronix, Tootal Street, Wakefield, West Yorkshire can supply a pair of ultrasonic transducers at a cost of £4·00 including VAT and post and packing. This is a very good price and we believe it to be the lowest.

The transducers known as type 7505 are a suitable replacement for the RL400P as used in the *Ultrasonic Remote Control System* featured in the November and December 1977 issues of EVERYDAY ELECTRONICS (all issues sold). Ace Mailtronix tell us that they can supply a set of electronic components to build this project and can supply a priced component list for this project on the receipt of a stamped self-addressed envelope. Also they can supply a photostat copy of the article at a cost of 25p per part.

The company extends this service to all other constructional projects featured in EVERYDAY ELECTRONICS from the October 1977 issue onwards, see their advertisement in this issue. For components they are unable to supply, they will advise constructors of competitive sources of supply. An invaluable service to the constructor—especially the beginner!

Logic I.C. Stickers

Users and designers of circuits embodying TTL integrated circuits will be pleased to hear of an ingenious aid, called STICKIES. These are self-adhesive printed labels—same size as i.c.s—and show pin-outs for 61 of the most popular 74 series of integrated circuits, both 14 and 16 pin.

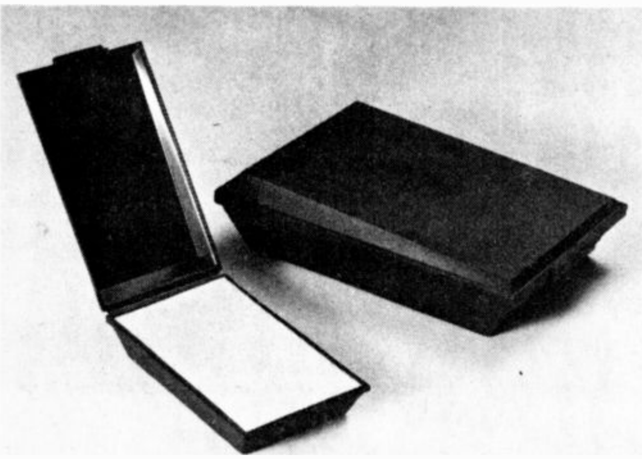
The labels are peeled from a master sheet and then positioned on the upper body of the i.c. thereby giving instant recognition of pin function, see photograph. They can be used for constructing and de-bugging prototypes, and useful in fault location. Another application is evident when designing printed circuit and other component board layouts.

These STICKIES are available in sets of 450 and come complete with comprehensive instructions. The cost is £2·80 for one sheet containing 450 labels with discounts on quantities, and can be obtained from Concept Electronics, (Dept. EE.), 8 Bayham Road, Sevenoaks, Kent, Tel: Sevenoaks 514110.

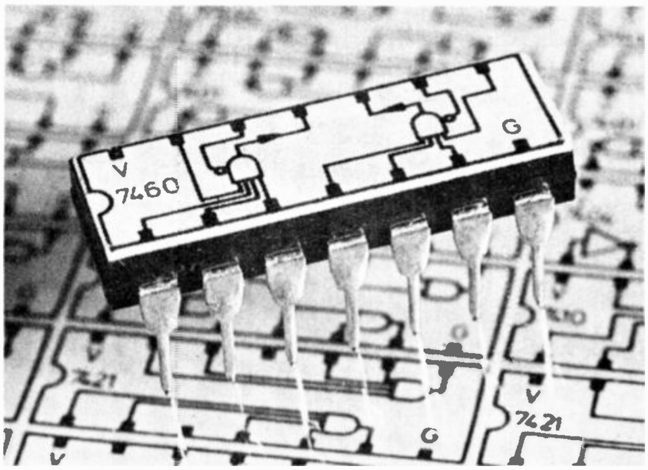
Constructional Projects This Month

No buying problems should be experienced when getting together the components for the *C-R Substitution Box*. The types of capacitors specified are those that appeared in the author's model, but these are not critical and can be of any composition that may be available. Attention should be paid to the working voltages however, since these will limit its application. The

The two sizes of Flip-Top Box from Vero.



A STICKIE in position on an integrated circuit.



voltage ratings should, if necessary, be raised to be compatible with the voltage levels in the equipment likely to be used with the unit.

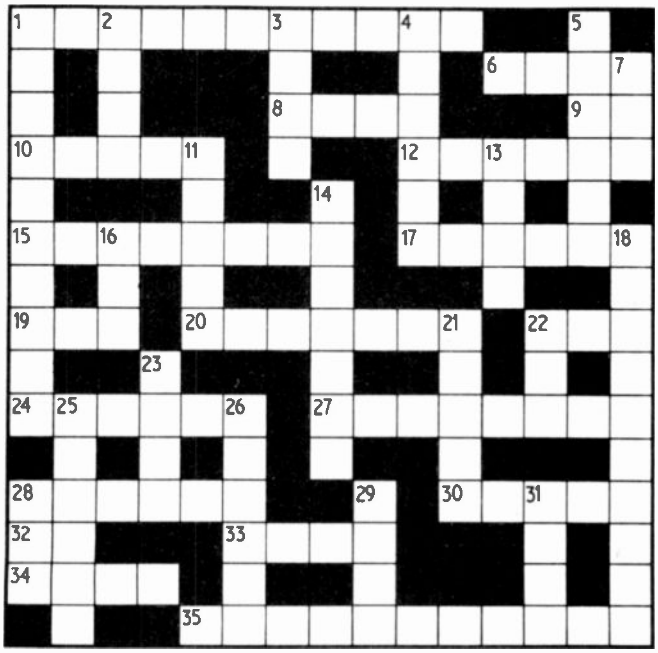
A d.p.d.t. slide switch is specified although only a s.p.d.t. version is called for as the latter type is unavailable.

All the components for the *Weird Sound Effects Generator* are available from a number of sources and should present no problems. The silicon *pnp* transistors specified may be unfamiliar to some readers and were chosen since they are complements to the BC108. However, any silicon *pnp* type may be substituted if more readily available. A suitable replacement is the 2N3702, but remember that this has a different pin configuration to the BC178.

The "heavyweight" project this month is the *Audiotest* and a few components may prove difficult to locate. These are the 10 watt resistors, the 350pF variable capacitor, and the territe beads. All of these components are listed in the Maplin catalogue. Also, the 10 watt resistors are stocked by Marshall's. Both of these suppliers' addresses can be found in the advertisement pages of EVERYDAY ELECTRONICS.

All components required to build the *Catch-A-Light* are available from a number of sources and should present no buying problems.

CROSSWORD No. 1 BY D.P. NEWTON



ACROSS
1 A bet on a battery?
6 Stand open for an old capacitor.
8 Pure and tidy.
9 Frequency modulation.
10 Entrance terminal.
12 Guiding lights.
15 Send across.
17 Musical devices for selection.
19 Useful for fishy work.
20 Grounded.
22 A small item of computer information.
24 Mistakes
27 A device of usefully low conductivity.
28 Pert. to the stars.
30 There's a stoat about for a drink. (Anag.)
32 A small piece of a circuit.
33 Reflect to give a t.v. ghost.
34 A light switch with watery connections.
35 Diminution of a signal.

DOWN
1 Impedance reciprocates to allow entry.
2 A semiconductor found on some shoulders.
3 If this is missing it can cause some trouble.
4 Delivery terminal.
5 Roof beam.
7 Take arms in part to give the equivalent D.C.
11 A sense from a state. (Anag.)
13 A wire along which signals are sent.
14 The fixed plates of a capacitor also found in some motors.
16 With tar about we don't get science. (Anag.)
18 The above and beyond state when nothing extra is to be gained.
21 Electronic wandering.
22 To offer money against a chance of gain.
23 Not a gate.
25 Not quite a blank screen.
26 To choose in a tuned circuit.
28 The dielectric for some capacitors.
29 A cornucopia of a loudspeaker.
31 Against.

Solution to Crossword on page 351

"This computer my wife constructed tends to be a bit garrulous"

AIRPORT RADAR

BY G.A.G. BROOKE

EVERYONE appreciates the need for airport radars that keep Air Traffic Controllers (A.T.C.) "in the picture" as to where all arriving and departing aircraft are at any one moment. But most people would be surprised to know that, at major airports anyway, exact knowledge of aircraft on the ground (on runways and taxiways) is likely to become of even greater importance.

BLIND LANDING

What really makes this ground knowledge so vital are the increasing pressures on A.T.C. staff. These condense to more aircraft leading to tighter schedules (there can be eighty movements an hour), larger airports with 4km runways making visual checks difficult or impossible, and the introduction of blind landings in fog.

Blind landings whatever the cloud height and with runway visibility at only 50m will soon be used by British Airways at Heathrow and any other airport fitted with the necessary equipment. Gatwick and eight other British airports can handle landings with a ceiling of 30 feet and runway visibility of 400m.

It is the Civil Aviation Authority's aim to bring all major airports up to Gatwick standard as soon as possible. So, where previously fog meant a rest for A.T.C. staff it now means even greater pressure and necessity to know where everyone is on the ground.

AIRFIELD SURFACE MOVEMENT INDICATION

How in fact do they do it at all? Well at Heathrow, Paris (Orly) and Rome (Fiumicino) and shortly at Milan and Turin they rely on the ASMI (Airfield Surface Movement Indication) radar. To anyone familiar with ordinary radar the problems would seem immense.

The surface of an airport, not unlike a small town, with its control buildings, hangars, stores, car parks and so on would normally provide a radar picture that was an indiscriminate jumble of echoes at best. ASMI is not, however, a normal radar; it was purpose designed, in collaboration with the Civil Air Authority, for this one airport job.

Radar does not pass through solids like radio, so that a target in front of another will throw a "shadow" on the display in the form of a blank space. So the first requirement was to give the radar

Heading photo via *Flight International*.

a high viewpoint, obviously the top of the control tower.

This has the advantage that it has the same view as the Controller a few feet below, but it also has a disadvantage in that the weight of the aerial (and its turning mechanism) restricts aerial size, with an important result as we shall see. At Heathrow and other places the control tower is suitably central, but at Rome it is not, needing a second ASMI to cover the outlying area, its radar data being transmitted back by microwave link.

PERFORMANCE

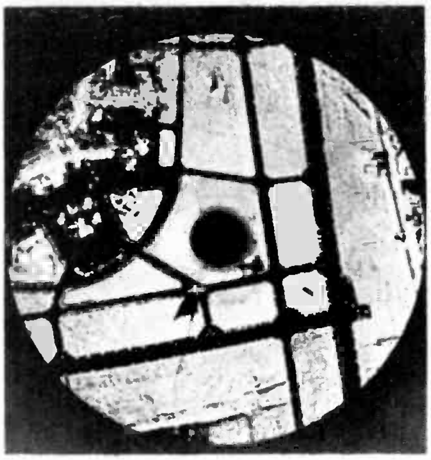
The next question was how to give ASMI an unheard of radar performance in all parameters except range, which needs in most cases to be not more than 4,500m. Arriving at the eventual specification was an interesting exercise in juggling the various characteristics involved so that they "meshed" suitably for the ASMI requirement.

Radar design is no different to that of ships, cars or in fact any complex system in that it is a compromise. In this case tremendous resolution was vital, but range, as we have seen, unimportant. The designers started with two other variables fixed, or at least limited, one of them unusual to the point of it being unique.

AERIAL ROTATION

This was the necessity for a very high aerial rotation rate. Aerials of ordinary radars revolve at from 24 to 60 r.p.m., which means that the synchronised trace in the display crosses the target, renewing echo brightness, every one to two seconds. This is good enough for slow moving targets (or even fast targets) at long range, but if you consider an aircraft only 800m away taking off at 120 knots across the front of the observer, it will travel 60 yards between each passage of the trace and thus appear to be leaping forward in disconnected jerks.

With the unique rotation rate of 750 r.p.m. however, targets are "repainted" 12 times a second and the aircraft will only advance a few yards between renewals; in practice it is seen to proceed smoothly but in a slight blur.



An aircraft on a taxiway at Fiumicino (Rome) airport as seen by the Decca Airfield Surface Movement Indication (ASMI) radar. The aerial is on the control tower, centre circle, hence the "shadow" thrown by the aircraft's echo.

Another advantage of the high rotation rate and only slightly secondary in importance is that the resulting picture is virtually steady and flicker-free, much easier on the eyes of Control Officers who may have to watch it for long periods, than the usual bright trace circling round a dark display.

The other limited variable was size of aerial. Mounted on top of a tower, the weight of the aerial and its turning mechanism limited size to 6ft and it will soon be seen how this influenced other factors. It is actually encased in a radome to reduce wind resistance and so the power and size of turning motor required.

RESOLUTION

With a steady picture providing smooth motion we are already some way towards that "unheard of radar performance." Providing very high resolution takes us the rest of the way.

In broad terms resolution means the ability to see the shape of a target and is therefore divisible into definition (accurate delineation of the extremities of the target) and discrimination (ability to separate adjacent echoes). To do these two things well you have to measure the target in range; front to back, and in azimuth; from side to side.

The keys to these measurements are pulse length and aerial beamwidth (pulse repetition frequency also comes into it, but only to the extent that at the high aerial rotation rate used here, a high p.r.f. is necessary in order to record the target at all). The shorter the pulse length the better for purposes of range discrimination; short pulse represents a shorter distance over the ground so that two close objects are more easily resolved than with a long pulse. ASMI pulse length is 0·03 microseconds, resulting in a range discrimination of 13·8m as observed on the Plan Position Indicator (P.P.I.) at 1,800m.

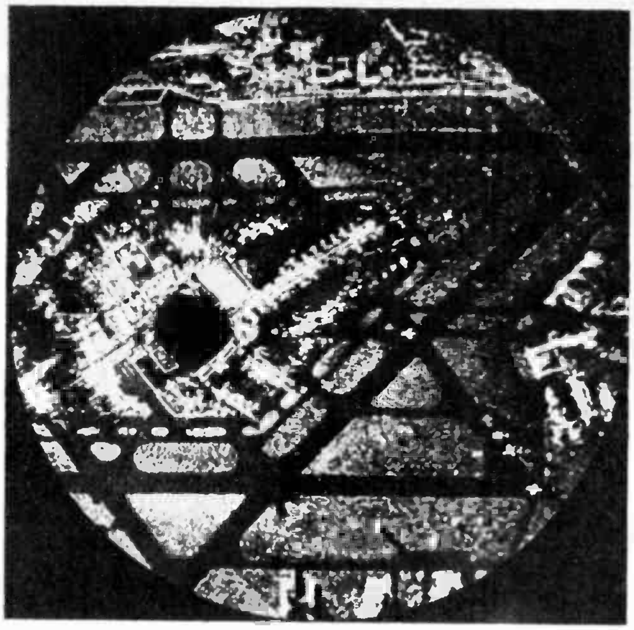
BEAMWIDTH

Good bearing discrimination comes from narrow beamwidth (obviously a broad beam is not so

A view of the Heathrow control tower. Top right is ASMI, encased in a "radome".

accurate). Beamwidth depends on the size of the aerial; the longer the aerial the more concentrated the beam and the narrower the beamwidth.

Using the standard radar X-band frequency (about 9·4MHz) an aerial of about 25ft (as employed in major harbour surveillance systems) would be necessary to provide the beamwidth required by ASMI, i.e. 0·4 degrees. We have seen that a large aerial is ruled out for practical reasons and so recourse has to be had to very high frequency in order to permit the use of a 6ft aerial. The frequency chosen is Q - band (35MHz).



A radar picture of Heathrow airport showing control tower and runways. A Jumbo jet is waiting to take off.

INCANDESCENT MAP

The end result is startling, more like an incandescent map than a radar picture; grass is reproduced as a bright, speckled expanse, flat concrete as jet black, so the runways and taxiways of airports are distinctly drawn. Resolution is such that dead hares, six inch countersunk runway lights and puddles of paint only half an inch thick show up.

With ordinary radars an aircraft shows up as a blob, but ASMI "draws" its shape, faithfully enough for seasoned operators to be able to recognise different types: and of course a Jumbo stands out a mile. Due to an effect already mentioned, aircraft just off the ground throw a "shadow" on the grass and the exact moment of take-off or touch-down can be told by the behaviour of this shadow. Though they can see directly whenever the visibility is good, many A.T.C. officers have come to rely on ASMI all the time.

One of four Decca ASMI Bright Displays in the visual control room at Heathrow. Any particular section of the radar coverage can be displayed, enlarged as required.

BRIGHT DISPLAY

A problem common to all radars but particularly applicable to those in the Visual Control Room of an airport control tower, is that the radar screen is difficult to see in bright light. This has been overcome in recent years by the provision of Bright Display, which employs a television technique.

The Visual Control Room at Heathrow has just been completely redesigned, the opportunity being taken to fit four ASMI Bright Displays; one for the western and one for the eastern facing control consoles, one for the Ground Controller and one for the Lighting Controller. The aerial itself is in a radome conspicuously mounted above and a little to one side, at the top of the Control Tower).

The radar in the form of azimuth, video and trigger signals is fed to a P.P.I. display employing a small (11cm) but high resolution cathode ray tube. The P.P.I. picture is optically coupled to a vidicon camera channel employing a storage vidicon pick-up tube. The camera channel will operate on various scanning standards with 2:1 interlace, and may be internally or externally driven.

The camera channel output can be fed to any desired number of t.v. displays either directly or via a t.v. distribution system or a t.v. link. The P.P.I. and camera channel are specially compensated to ensure a substantially uniform video signal over the total t.v. field area.

The P.P.I. is provided with four range scales and an off-centring facility, both of which can be remotely controlled if necessary, for example at the t.v. viewing position. Thus, by off-centring in the desired direction and switching to the shortest range (to give the largest scale) the whole display can be filled with a fairly small section of the original total coverage. A useful facility when, for instance, there has been an "incident", such as a crashed aircraft.

OTHER TASKS

This leads to the fact that there are, indeed, several subsidiary uses for ASMI itself, in addition to the general surveillance role. It can be used, in conjunction with the runway lighting, to assist pilots to leave the runway at the designated point, more quickly and without fear of collision with other aircraft, thus speeding up operations generally. It can ensure that aircraft and vehicles (both being fitted with v.h.f. communication) do not encroach on the instrument landing system restricted area, as their presence can cause distortion to the glide path and localiser beams.

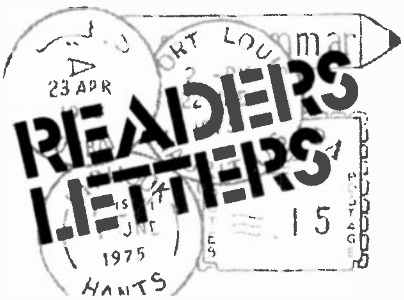
As we have seen, fire engines, ambulances and other emergency vehicles can be directed to the scene of an accident, which might be just outside the airport. This is important in foggy weather; there have been instances of precious time being lost by such vehicles being unable to find the spot.

Lastly, and this was probably not in the manufacturer's mind when an ASMI was first installed at Heathrow ten years ago, is its undoubted value to security. If hares show up, a gentleman with a bazooka will be only too apparent!

What of the famous hare? Bits drop off aircraft, believe it or not, usually inspection plates and so on, and when the ASMI detects one of these, a Land-Rover is sent out to recover the object before it obstructs an aircraft. On one occasion at Heathrow something was indicated on the runway and a Land-Rover despatched, only to find that it was a dead hare! Those with radar experience find such sensitivity hard to believe, but it is true.

A lot of people are already taking a second look at this unusual radar that does a specific job extremely well. ⌑

The ASMI "radome" being lowered into place at Orly airport, France.



Wiper Mods

Having recently obtained my first car, I found it annoying to switch the windscreen wipers on and off during fine drizzle.

With that in mind, I decided to build an electronic slave to do the job for me. The sensor for this device comprised of a piece of stripboard wired in the form of "interlocking fingers", and was held in place on the radiator grille with the help of two elastic bands.

However, this did not prove satisfactory, as a droplet of water between two adjacent tracks on the stripboard, took an appreciable time to disperse.

This is where your colleague's idea, mentioned in *Shop Talk*, which was to paint a pattern of "interlocking fingers" on the windscreen using electrically conductive paint gave me the idea of writing to you.

Although I have not tried the paint, I feel sure it would work. For this reason I've enclosed the circuit diagram for my original idea, which although very simple I hope will be of interest to your readers.

It is at this point I feel I should point out the need for two models, i.e. one for positive and one for negative earth vehicles. Should a negative earth design be fitted to a positive earth car, in heavy rain, a virtual short circuit across the battery would be inevitable. A model of the correct polarity could not let more than a current of 1·2mA (R1=10kΩ) drain to earth.

J. M. Hayes,
Keighley,
Yorks.

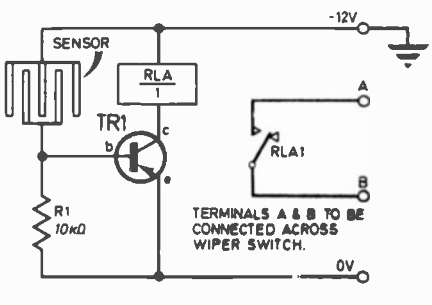


Fig.1. Circuit diagram for a negative earth vehicle wiper delay. The terminals A & B are connected across the car wiper switch. For positive earth vehicles TR1 should be any medium power *npn* switching transistor.

Thyristor

In the February issue of EVERYDAY ELECTRONICS a design for a *Windscreen Wiper* was published.

So far I have been unable to obtain the specified thyristor. I would be grateful if you could list a supplier or an alternative.

G. L. Clifford,
Warwickshire.

A suitable alternative for the thyristor is the C126M available from Maplin Electronics, PO Box 3, Rayleigh, Essex. The latest price we have is £1·42. In fact any thyristor with a rating of 10A at 50V would suffice.

Triac

I am in the process of building the *Enlarger Timer* featured in the October '77 issue of EVERYDAY ELECTRONICS. One component I cannot seem to obtain is the 2N5756 triac.

I wonder if you could possibly advise me where to obtain this part.

B. Appleton
Bucks.

You can obtain the triac from Arrow Electronics, Leader House, Coptfold Road, Brentwood, Essex. The cost is £2·04 including VAT and post/packing.

WEIRD SOUND EFFECTS GENERATOR

By. D. Ewards

INTRODUCTION

This unit came about as a result of experiments in electronic music and musique concrète. While the unit's musical validity may be open to some question, tastefully used it can be put to good effect. For those who indulge in making tape plays, the Weird Sound Effects Generator can provide a whole host of futuristic sounds to rival even those heard in the film *Star Wars*. The circuit, in fact, was designed with the creative tape recording enthusiast in mind and the prototype, in extensive use, has proved its worth.

START HERE FOR CONSTRUCTION

The circuit is built on a piece of 0·15 inch matrix perforated board size 15×9 holes. The layout of the components on the topside of the board and the interwiring on the underside is shown in Fig. 1.

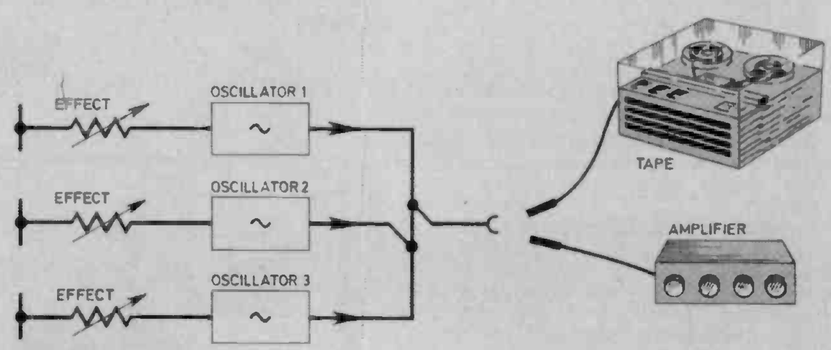
It is advisable to leave the component leads untrimmed as these can form the wiring for the underside connections. Leave the transistors until last. Unless you are an experienced constructor, able to carry out speedy soldering, a heat-shunt is recommended when soldering the transistors in place.

CASE

The next stage of construction concerns the case. In the prototype, a plastic hinged case measuring 90×90×30mm that was designed as a presentation case has been effectively utilised by the author. Make the cut-outs in any suitable case to suit the DIN socket and the three potentiometers, and then fix these in position. The layout of these components within the case is shown in Fig. 1, but this is not critical and may be changed to suit individual requirements. Attach a battery clip as shown and then wire up between board and case mounted components as detailed in Fig. 1.

One important point to be aware of when selecting a suitable case, is the overall depth of VR1/S1 body. The type used in the prototype was a "midget" type which just fitted in the case. If a larger potentiometer/switch assembly is obtained the height of the case will need to be increased.

HOW IT WORKS



Three oscillators running at different frequencies have their outputs connected to form a composite output signal. The output signal of each oscillator when combined with the other two is both affected by and affects the other two outputs. No oscillator however is dominant and a strange mixture of electronic sounds appears at the unit output socket.

COMPONENTS

Resistors
R1 39kΩ
R2 1·5kΩ
R3 39kΩ
R4 1·5kΩ
R5 39kΩ
R6 1·5kΩ
R7 1kΩ
All ¼ watt carbon ± 10%

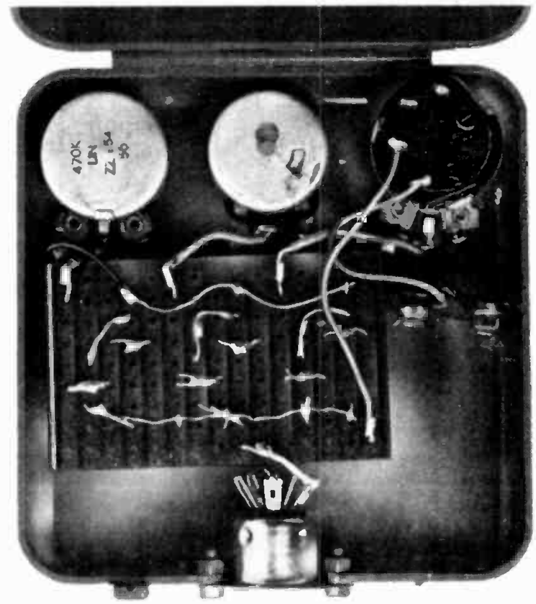
Potentiometers
VR1/S1 470kΩ lin. carbon with ganged on/off switch
VR2 470kΩ lin. carbon
VR3 470kΩ lin. carbon

Capacitors
C1 0·047μF plastic or ceramic
C2 0·1μF plastic or ceramic
C3 0·01μF plastic or ceramic
C4 0·1μF plastic or ceramic

Semiconductors
TR1 BC178 silicon *pnp*
TR2 BC108 silicon *npn*
TR3 BC178 silicon *pnp*
TR4 BC108 silicon *npn*
TR5 BC178 silicon *pnp*
TR6 BC108 silicon *npn*

Miscellaneous
B1 9V type PP3
SK1 5 pin 180° DIN socket
0·15 inch plain matrix board size 15 × 9 holes; battery connector to suit B1; plastic case approximate size 90 × 90 × 30 mm; control knobs (3 off); connecting wire.

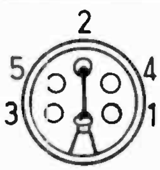
See **Shop Talk** page 342

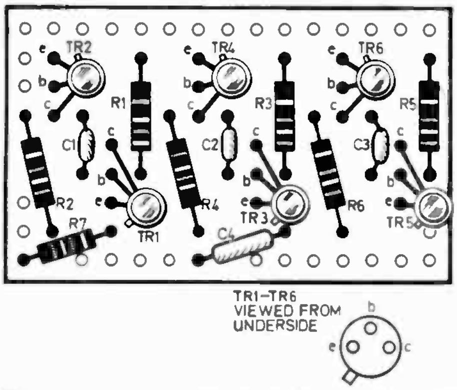


Components and circuit board mounted inside the case.

FOR GUIDANCE ONLY
ESTIMATED COST OF COMPONENTS
£3·00
excluding case

WEIRD SOUND EFFECTS GENERATOR





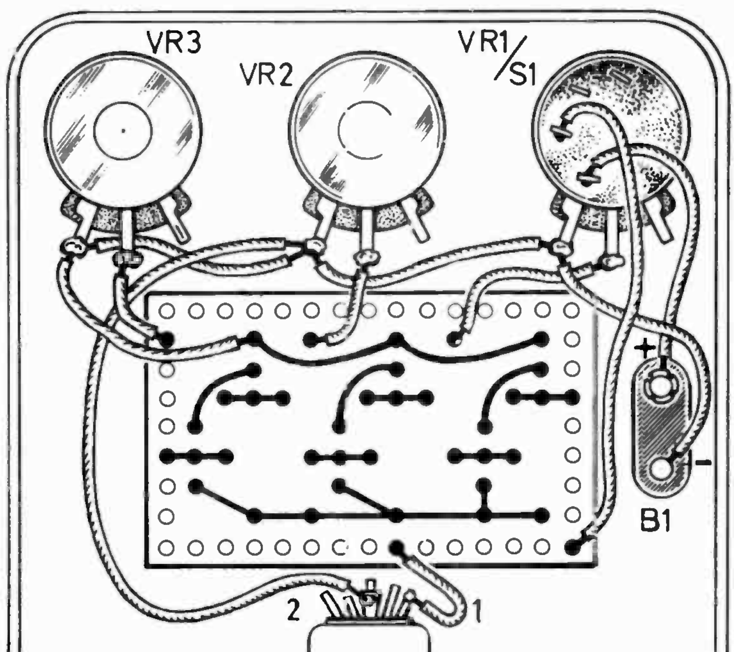


Fig.1. Component layout for the circuit board and interwiring to the controls and underside of board.

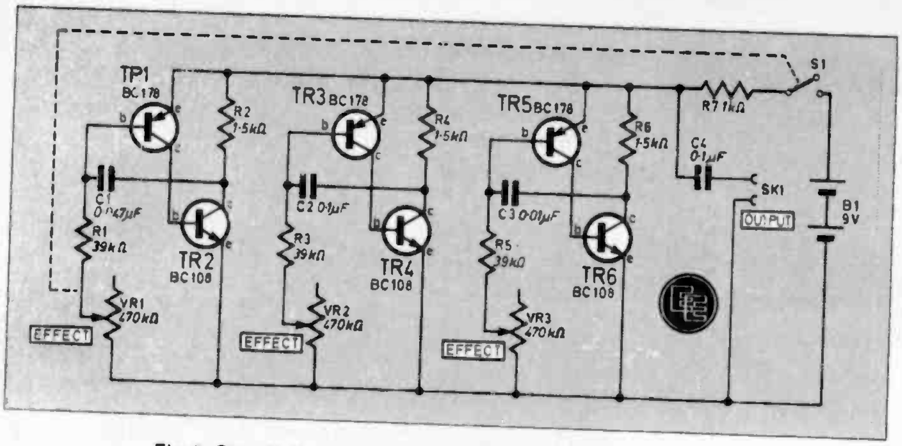


Fig.2. Circuit diagram of the Weird Sound Effects Generator

CIRCUIT DESCRIPTION

The complete circuit diagram of the Weird Sound Effects Generator is shown in Fig. 2 and can be seen to consist of three distinct, similar sections, each being an oscillator of different frequency from the complementary astable multivibrator family.

The operation of each of these oscillators is identical, so only the circuit action of that comprising TR1 and TR2 and associated components will be described.

When power is applied to the circuit, capacitor C1 initially uncharged begins to charge up via R7, R2, R1 and VR1 with TR1 and TR2 off (non-conducting). The capacitor continues to charge up until the voltage on the base of TR1 becomes negative with respect to its emitter. This causes TR1 to turn on (conduct) and at the same time the potential on TR2 collector, coupled to TR1 base rises and causes TR2 to be biased on (conducting).

Under these conditions the capacitor is presented with a discharge path through TR1 and continues to discharge until the voltage on the base of TR1 becomes positive with respect to its emitter and turns off. The base bias of TR2 is thus removed and so TR2 turns off. The capacitor then starts to charge up again and the above cycle of events repeats, and continues for as long as power is applied to the circuit.

During each cycle, the voltage level on TR2 collector rises and falls and this is coupled to the output socket via d.c. blocking capacitor C4 from a split collector load R2, R7.

The frequency of oscillation, being the inverse of the charging time of C1, is therefore governed chiefly by the setting of VR1 with R1 (since their values are much greater than the combination R2, R7 which completes the charging route).

Since all the oscillators share a common load resistor R7, the output is a complex signal that is substantially changed by the operation of a single effect potentiometer.

Although a DIN socket was used in the prototype, there is no reason why any other socket cannot be substituted to be compatible with the tape-recorder or other equipment that will be used with the Weird Sound Effects Generator. Finally connect the battery, fix three control knobs and the unit is ready for testing.

TESTING

Connect the unit via a suitably terminated lead to an amplifier or tape recorder set to record and switch on the unit. Rotating each control knob in turn should alter the sound heard. This condition will indicate that the unit is functioning satisfactorily and is ready for use.

IN USE

The Weird Sound Effects Generator consists of three separate oscillators but there is no reason why the number of oscillators cannot be increased to provide an even greater range of sounds.

Different values of tuning capacitors would, of course, be required for each of the additional oscillators.

Alternatively by using only two oscillators coupled together and giving the timing capacitors values of a few microfarads, the unit can be used as a simple rhythm generator. In this mode, of course, the remaining oscillator could be used as a metronome. There is no need to rigorously adhere to the values of the timing capacitors suggested, try any values from 0·001 microfarads to 10 microfarads (with electrolytics, the positive plate should be connected to the collector of the *npn* transistor at each oscillator). The higher the value, the lower the frequency of the oscillator.

Also, switches ganged with VR2 and VR3 to switch these oscillators in or out of circuit as desired could be incorporated for extending the number of effects.

The author has used the prototype generator to create electronic compositions in conjunction with a mixer, tape recorder, organ, fuzz box and waa-waa unit to produce "out of this world" sounds and effects.

The output level and the wiring of the output socket makes the generator compatible with most automatic recording level tape recorders (eg. Philips, as used by the author) although it should work equally well with other machines.

However, in the case of an amplifier or similar high input level equipment, a small booster amplifier should be added and the output for this could be wired to pin 3 of the DIN socket SK1. A separate lead should then be made up to allow this output to be fed to the high input level equipment, ie. DIN plug with connections at pin 3 and earth.

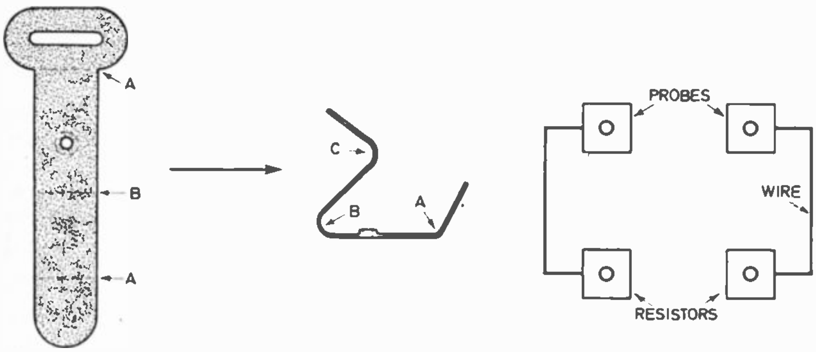
Readers' Bright Ideas; any idea that is published will be awarded payment according to its merit. The ideas have not been proved by us.

RESISTOR CLIPS

It is sometimes found when measuring resistors with a multimeter that body resistance across the probes cause misleading readings. I therefore designed the following.

A small piece of plastic is drilled with two sets of holes one above the other; four cable buckles are then bent as shown and fixed over the holes. It is then a simple matter to connect the probes to one set, and the resistors to the other set. The buckles can easily be bent over to hold the resistor in place when taking measurements.

C. Ashcroft, Dorset.



METER CASE

I have just discovered an economical case for the *Exposure Meter* featured in the August issue of Everyday Electronics.

An empty plastic sticking plaster reel is used. The l.d.r. is mounted in the centre of the tube and held in by Araldite. The meter and switch are mounted in the base of the reel so that the detachable base can be used as a cover. Finally the case may be painted to hide any printing on the surface.

S. D. H. Saunders, Surrey.

TIME DELAY

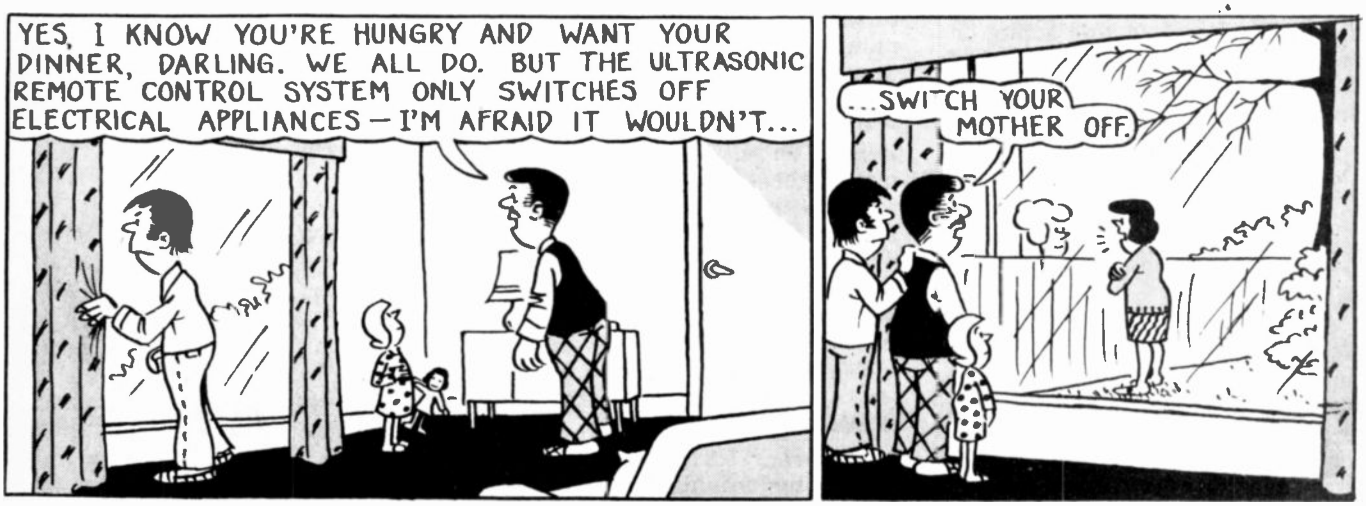
Having read the *Flasher Bleeper* article in the September issue of Everyday Electronics, I thought that a sensible improvement would be to incorporate a time delay. In normal circumstances the unit would not operate, but if the car indicators were left on longer than normal, the time delay would come into operation.

R. L. Johnson, Leicester.

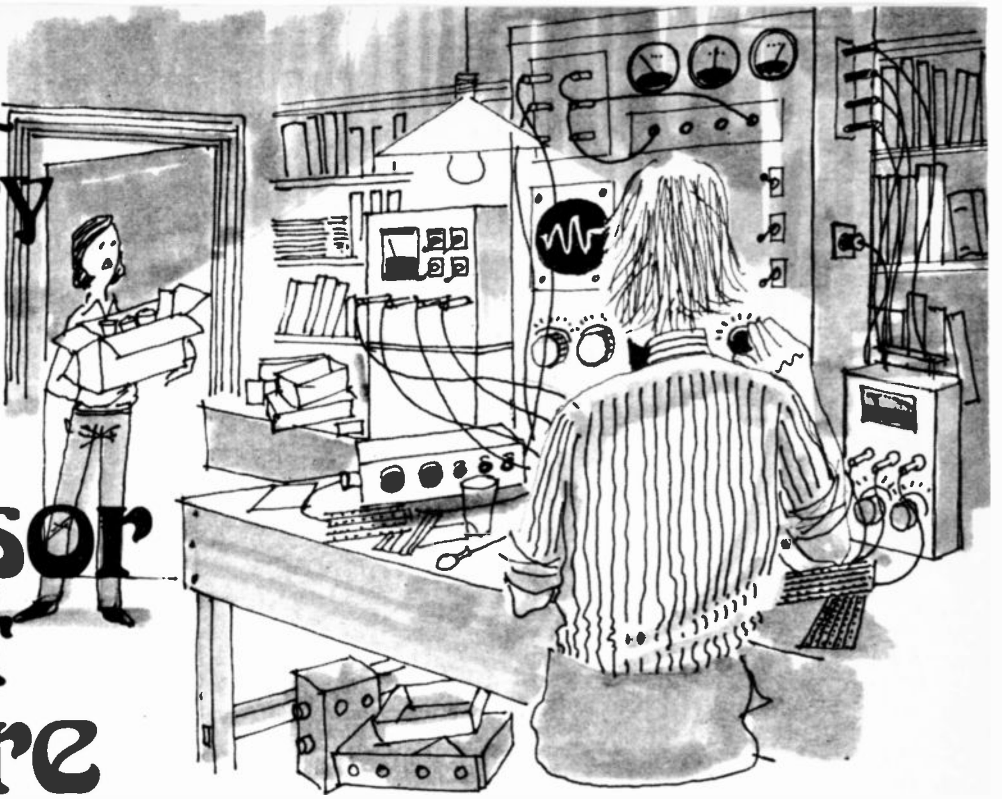
Crossword No. 1—Solution

JACK PLUG & FAMILY...

BY DOUG BAKER



The Extraordinary Experiments of Professor Ernest Eversure



by Anthony John Bassett

Bob has been assisting Miss Lilian Whiteley, in some "Extraordinary Experiments in Dowsing" in the presence of the Prof. and Dr. Angus R. Paterson, who is highly sceptical of the procedures of dowsing. Lily has been using a Radiesthetic Preamplifier to assist her in the identification of concealed substances, and Bob has queried the function of this pre-amplifier.

DISTURBING INFLUENCE

The Prof's experimental Robot soldered a small copper plate to each end of a length of copper wire of just over 1 metre, and acting on the Prof's instruction, has arranged this wire in place of the Radiesthetic Preamplifier with its copper input plate and output plate.

This is to test Bob's surmise that the influence which Lily picks up by dowsing will travel along a plain piece of wire without the assistance of the Radiesthetic Preamplifier.

Following the same procedure as before, Bob secretly placed a sample of one of the five substances onto the copper plate at one end of the wire, concealed from Lily by means of an opaque screen. The wire led past the screen to the plate at the other end, over which Lily now swung her pendulum.

"It's no good, Bob", she announced, "I'm not getting any response at this end".

Bob was astounded. "I felt sure that it would work!" he said in puzzled disappointment.

"I thought that, if this influence would travel along a conducting wire with the assistance of the preamplifier, it should equally do so without one!"

"Actually I think you're right", Lily told him, "But there is a factor which you have not allowed for. It is the disturbing influence of the nearby samples in their containers. If you move the containers away to a distance of several metres I'll try again."

Bob placed the five sample containers on a small tray and removed them from the vicinity. A few moments later Lily was able to correctly identify the sample which was concealed from her by the opaque screen, but connected by a wire to the copper plate over which she swung her small perspex pendulum.

NEW ARRIVALS

However, this had been witnessed by an increased audience as the Prof. had meanwhile admitted two more visitors to the laboratory; Tom and Maurice, who enthusiastically devoted most of their spare time to the running of events for their favourite charity organization.

Lily explained to the small assembly: "The influence of the sample on the plate at one end of the wire travels along the conductor to the plate at the other end and by dowsing at this end I am able to identify the sample at the other end. But this process is subject to a number of disturbing influences, such as the presence of a nearby sample of the same substance in a container. One of the functions of the Radiesthetic Preamplifier is to enable me to overcome disturbing influences such as these—and it helps me to obtain more accurate results."

DOWSING COMPETITION

Tom and Maurice were very interested. "We are running yet another Charity Fair", said Maurice, "Bob I wonder, Miss Whiteley, whether you might very kindly give a dowsing demonstration as one of the events there."

"That's a really good idea, Maurice", Tom chipped in enthusiastically, "Maybe you could also help us to run a Dowsing Competition so that members of the Public could try their hand. We could easily fix up one or two tables with small opaque screens, and a wire leading to two copper plates just like you have here!"

"Maybe!" Angus thought out aloud, "Maybe the Prof. could construct a Dowsing Robot."

"Angus!" warned Lily, "For this Charity Fair, we're going to dress you up in a Robot suit made of sheets of cardboard covered in shiny aluminium foil, with flashing lights, electronic bleepers and an electronic Cyberman voice projector". She turned to Tom and Maurice, "I'd be delighted to help at the Charity Fair, boys, maybe we could arrange details later as Angus and I must leave now. Thanks, Prof., and Bob for mending my preamplifier."

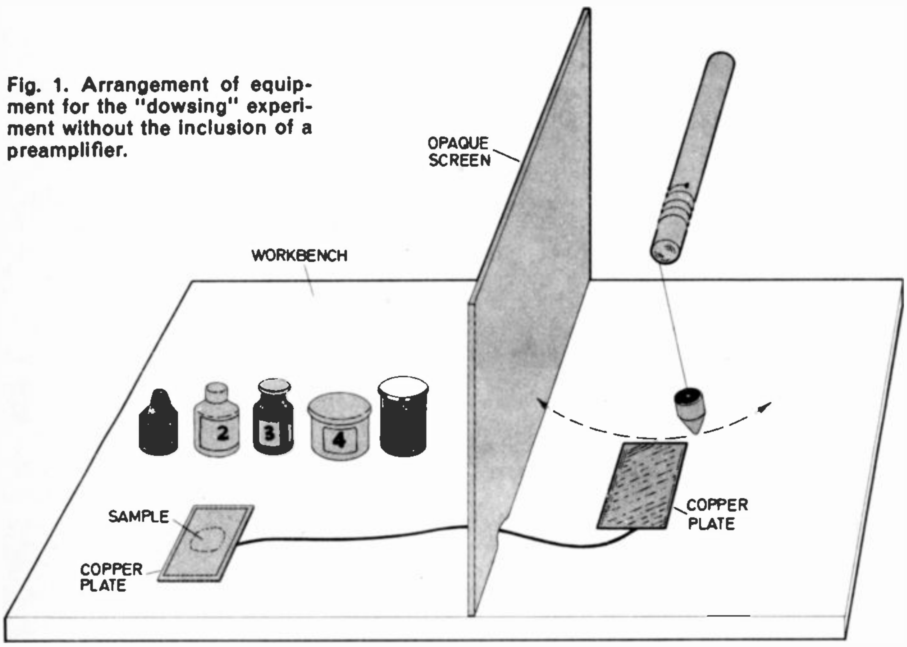


Fig. 1. Arrangement of equipment for the "dowsing" experiment without the inclusion of a preamplifier.

"It has been a most interesting visit", said Angus, then suddenly, "Hey! Whatever is that?" His eyes had fallen on a brightly coloured small box which Maurice had placed on one of the laboratory workbenches.

It was garishly labelled "The Thing—from the Crypt!" Maurice opened the packet and brought out a small box with a slot in the top. "This is what I have come to consult the Prof. about," he told Angus, "We are thinking of using several of these as coin collector mechanisms at the Charity Fair and I have the idea that the Prof. might be able to advise on how to connect them up electrically to operate various amusing gadgets or competitions".

Angus placed a coin in the slot, and, to his surprise the box began to rock and move, with a mysterious grinding noise. A flap opened and out slunk a green plastic hand which slowly approached the coin, grabbed it and suddenly slammed back into the box with a bang! "I think I'll be leaving now!" remarked Angus with mock horror, then, "Cherrio, everyone, Au Revoir". Angus and Lily left the Laboratory.

DRACULA'S BANK

The Prof. now picked up the small black plastic box. "So this is Dracula's Bank!!" he remarked, examining the writing on one side, "What a good idea of yours to convert it for the benefit of Charity.

From my initial observations it would seem that the mechanism in this box could be used for two chief functions when activated by the donation of a coin. One would be to initiate or enable an action or the start of a small game, display or competition sideshow.

The other function would be to act as a timing mechanism dependent upon the time taken from first placing the coin in the slot, until the coin is snatched away by "The Thing". Of course timing accuracy may not be very good, but is probably adequate for amusement purposes".

"Prof., we tried to look inside the box in order to see whether we could work anything out for ourselves, but the box is sealed with blobs of molten plastic which we could not cut away as the blade in our craft knife has been broken."

"Yes, Maurice, I can see them". The Prof. had removed the batteries and also unscrewed the bottom of the box. After tipping out a small heap of coins he could see that further access to the mechanism was sealed with a few small blobs of molten plastic.

"I will be able to remove those seals quite quickly, Prof." he offered. "Okay, Tom, and you can use some of my tools if you like, as some of the plastic which you must cut away is rather awkward to remove. Meanwhile I think Bob has something he wishes to ask me".

MORE INFO'

The Prof. had noticed that whilst he was discussing the mechanical money-box with Tom and Maurice, Bob had become increasingly agitated, and now looked about ready to burst! "Prof!" he said, "I must know more about the Radiesthetic Preamplifier! What circuit does it use? When I mended it I could see that it did not look very complicated, but I am really keen to know more about the circuit!"

To be continued

TEACH-IN 78 REPRINTS

Owing to great demand the October and November issues of EVERYDAY ELECTRONICS have completely sold out. To help those readers who wish to follow the *Teach-In 78* series but have missed parts 1 and 2 that appeared in these issues, reprints of *Teach-In Part 1* and *Part 2* are available at a cost of 35p each, inclusive of postage. Orders (specifying Part required) with remittances should be sent to: Post Sales Department, IPC Magazines Ltd., Lavington House, 25 Lavington Street, London SE1 0PF.

GEORGE HYLTON brings it down to earth

Measuring Low Resistance

A reader sent us a circuit for using an ordinary 1mA meter to measure low resistances. He has doubts about whether it's right.

First, the problem. The circuit (Fig. 1) is first set up without the unknown resistance R_x. The variable (potentiometer) R_s is adjusted so that the meter (whose resistance is R_m) reads some convenient value, such as exactly full scale.

When R_x is connected (by closing the switch), some of the current is diverted from the meter. The resistance R_x can then (according to our reader's source) be calculated by a formula which includes the two meter readings and R_m but not V or R_s.

When R_x is connected the resistance of the circuit as a whole must fall. So the current must increase. Doesn't this change of current affect the measurement?

Ohm's Law

When confronted with this sort of problem there are two ways of attack. One is to do a lot of algebra and get a thorough understanding.

The other method is to put some plausible circuit values on the diagram and see what happens using nothing more complicated than Ohm's Law. I've done this (bracketed values). If V is 1V, then to set the meter to 1mA (R_x out) it's necessary to have a total resistance of 1000 ohms (1V/1mA = 1kΩ). The meter is 100Ω so R_s must supply 900Ω.

When R_x is connected across the meter there are two 100Ω in parallel, making 50Ω. With R_s the total is now 950Ω and the current is 1V/950Ω = 1·052mA. Half this goes through the meter, which then reads 0·526mA. The question is, do these figures, inserted into the formula, provide the correct value for R_x? The formula is:

$$R_x = \frac{\text{(meter resist.)} \times \text{(2nd meter reading)}}{\text{(1st meter reading)} - \text{(2nd reading)}}$$

Without doing an exact calculation you can see that this gives the wrong answer. The right answer, we know, is 100Ω. But the formula says it is 100Ω times 0·526/0·474. Since 0·526/0·474 is greater than 1, the answer is greater than 100Ω (actually about 111Ω), so the system "reads high".

To produce the right answer, the currents at the top and bottom of the fraction must be equal. One can't avoid the suspicion that the formula "wants" them both to be 0·5mA To obtain this value the total current must not change when R_x is connected. This is impossible, but you can get as close to it as you like by making V and R_s large.

In this case, R_s "swamps" the effect. If V = 10V, then for 1mA, the total resistance must be 10k, of which R_s supplies 9900Ω and R_m 100Ω. Connecting R_x reduces the total resistance to 9900 + 50 = 9950Ω, which is low by only 0·5 per cent. The error is roughly twice this, or about 1 per cent, which is acceptable for most practical purposes.

Linear Scale

The circuit has one distinct advantage. It does not rely on the accuracy of the meter. So long as the meter is *linear*, the system works. Even if the meter calibration is "out" by quite a substantial amount it still works.

But there is also a *disadvantage*. If R_x is small compared with R_m, then on connecting R_x the reading falls to a very small value. This makes it hard to get an accurate reading.

For example, if R_x is 1/100 of R_m then the reading falls from full-scale to less than 1 per cent of full scale. This is less than one small scale division on most meters, and cannot be read accurately. In fact the system is most accurate when R_x is about equal to R_m.

Many of the cheaper multimeters have only a few current ranges, for the higher currents, together with a good selection of voltage ranges. In this case, a different approach to the problem of measuring low resistance is preferable.

Current/Voltage

If a known current is passed through a resistance (Fig.2) then the resulting voltage drop tells you what the resistance is. If, for instance, you pass 100mA through 1Ω, the voltage drop is 100mV (0·1V).

So, a multimeter can be used first to set the current then to measure the voltage drop. A meter which reads 100mA full scale is likely to have a low resistance, perhaps about 1Ω. If R_s is around 100Ω the meter resistance has little effect on the current. If V is 9V, R_s must be 90Ω for 100mA, enough for most purposes.

When the meter is switched to a *voltage* range and connected across R_x to measure the voltage drop, it will not seriously effect the accuracy so long as it takes only a small amount of the current. Most multimeters take 1mA or less for full-scale deflection. So if 90mA is flowing through R_x the accuracy of measurement won't be seriously impaired by the 1mA bled off by the meter.

To measure R_x, then, you use a current range to set a suitable current and a voltage range to measure the voltage drop. For a current of 100mA and voltage range of 100mV (0·1V) a resistance (R_x) of 1Ω gives full-scale deflection (f.s.d.).

Smaller resistances give proportionally less deflection: 50Ω gives a reading of 50mV (0·05V) for example.

This scheme has the disadvantage that any inaccuracy in meter calibration affects the result.

Fig. 1

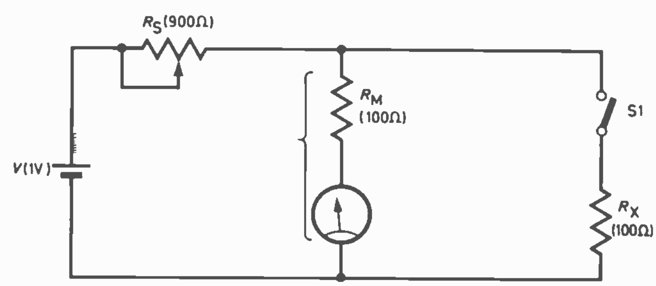
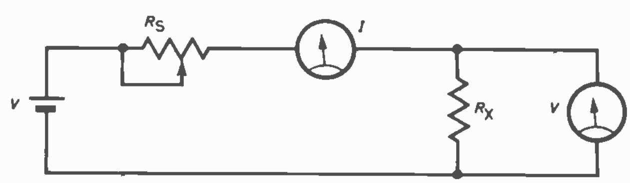


Fig. 2



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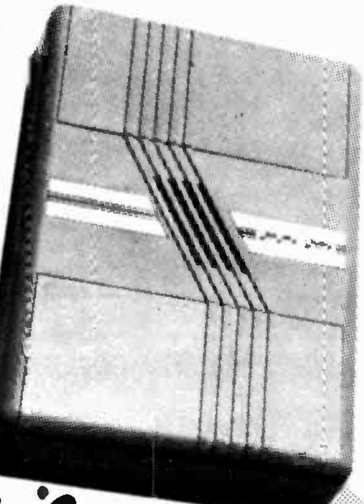

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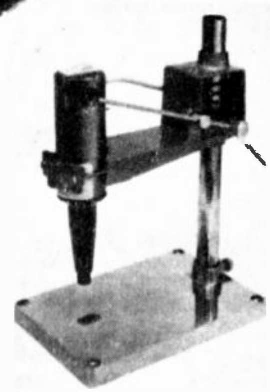

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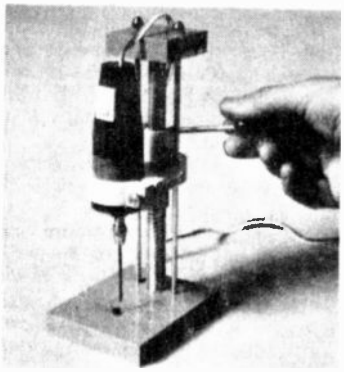

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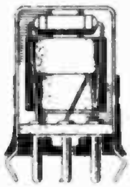

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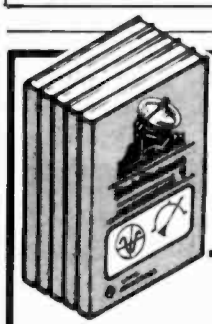

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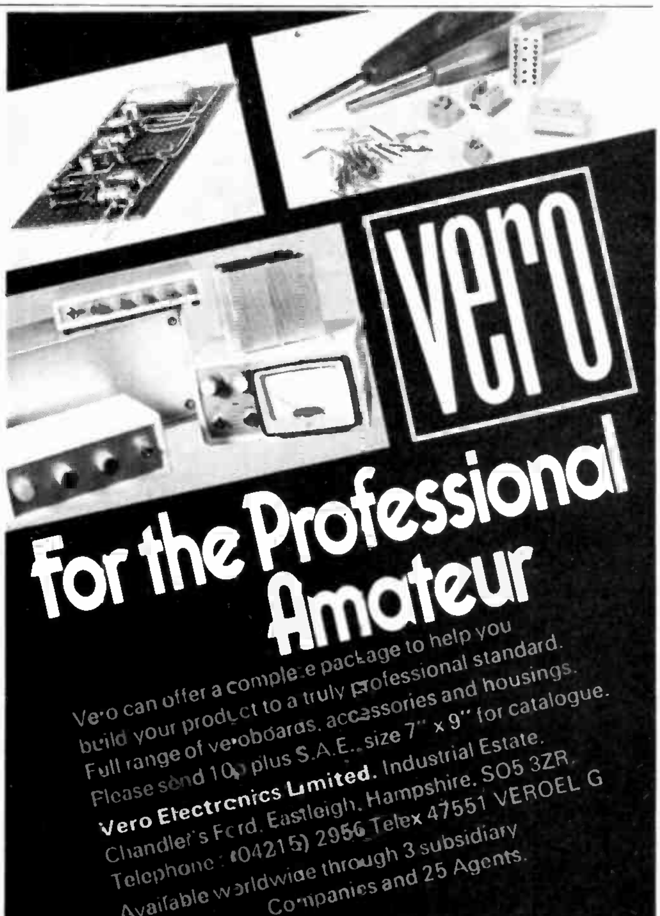

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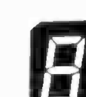

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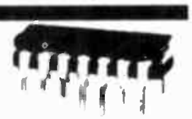

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