Practical projects to build at home

# everyday electronics

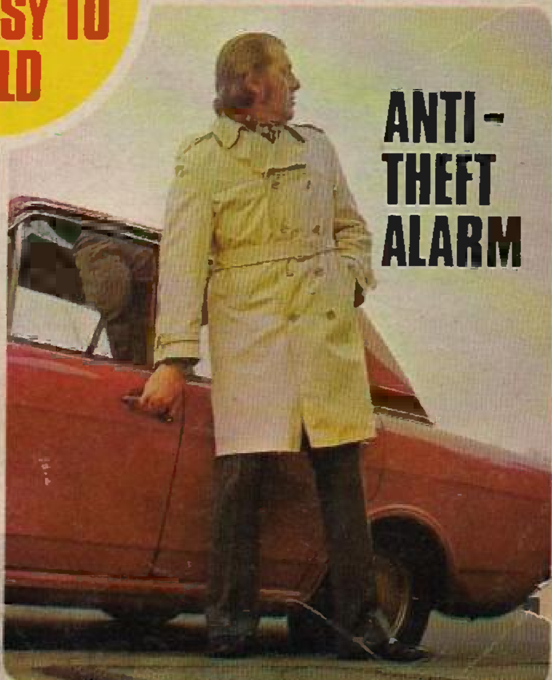
MAY 75
25p

SPECIAL 8 PAGE SUPPLEMENT...
Using Multimeters

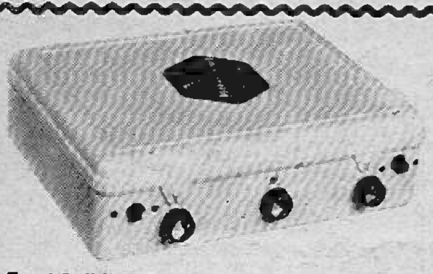

The MINSTREL

ALL INEXPENSIVE AND EASY TO BUILD


WARNING WINKER


ANTI-THEFT ALARM

*Plus*
MW/LW TUNER
*and all the regular features*



# NEW EDU-KIT MAJOR

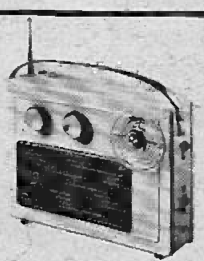
**Completely Solderless Electronic Construction Kit**
**Build these projects without soldering iron or solder**

- ★ 4 Transistor Earpiece Radio.
- ★ Signal Tracer.
- ★ Signal Injector.
- ★ Transistor Tester NPN-PNP.
- ★ 4 Transistor Push Pull Amplifier.
- ★ 5 Transistor Push Pull Amplifier.
- ★ 7 Transistor Loudspeaker Radio MW/LW.
- ★ 5 Transistor Short Wave Radio.
- ★ Electronic Metronome.
- ★ Electronic Noise Generator
- ★ Batteryless Crystal Radio.
- ★ One Transistor Radio.
- ★ 2 Transistor Regenerative Radio.
- ★ 3 Transistor Regenerative Radio.
- ★ Audible Continuity Tester.
- ★ Sensitive Pre-Amplifier.

**Total Building Costs £7·23** P P & Ins. 44p (Overseas Seamail P & P £2·35) (+ 8% VAT 57p)

Components Include: 24 Resistors ● 21 Capacitors ● 10 Transistors ● 3½" Loudspeaker ● Earpiece ● Mica Baseboard ● 3 12-way connectors ● 2 Volume controls ● 2 Slider Switches ● 1 Tuning Condenser ● 3 Knobs ● Ready Wound MW/LW/SW Coils ● Ferrite Rod ● 6½ yards of wire ● 1 Yard of sleeving etc. ● Parts Price List and Plans 55p free with parts.

## NEW ROAMER NINE

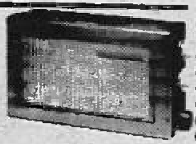


WITH V.H.F. INCLUDING AIRCRAFT

Nine Transistors, 9 Tuneable wavebands as Roamer Ten. Built in ferrite rod aerial for MW/LW. Retractable chrome-plated telescopic aerial for VHF and SW. Push Pull output using 600 mW transistors. 9 Transistors and 3 diodes, tuning condenser with V.H.F. section, separate coil for aircraft, moving coil loudspeaker, volume ON/OFF and wavechange controls. Attractive all white case with red grille and carrying strap. Size 9¼" × 7" × 2¾" approx. Parts Price List and Plans free with parts.

**Total Building Costs £6·95** P P & Ins. 44p (Overseas Seamail P & P £2·35) (+ 8% VAT 55p)

## POCKET FIVE

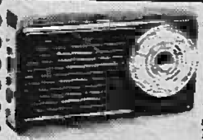


NOW WITH 3" LOUDSPEAKER

3 Tunable wavebands. M.W. L.W. and Trawler Band, 7 stages, 5 transistors and 2 diodes, supersensitive ferrite rod aerial, attractive black and gold case. Size 5½" × 1¼" × 3¼" approx. Plans and Parts Price List free with parts.

**Total Building Costs £2·50** P P & Ins. 36p (+8% VAT 20p) (Overseas Seamail P & P £1·70)

## TRANSONA FIVE

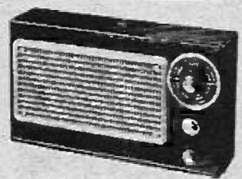


NOW WITH 3" LOUDSPEAKER

Wavebands, transistors and speaker as Pocket Five. Larger Case with Red Speaker Grille and Tuning Dial. Plans and Parts Price List free with parts.

**Total Building Costs £2·75** P P & Ins. 36p (+8% VAT 21p) (Overseas Seamail P & P £1·70)

## NEW Everyday Series



Build this exciting New series of designs

E.V.5. 5 Transistors and 2 diodes. MW/LW. Powered by 4½ volt Battery. Ferrite rod aerial, tuning condenser, volume control, and now with 3" loudspeaker. Attractive case with red speaker grille. Size 9" × 5½" × 2½" approx. Parts Price List and Plans free with parts.

**Total Building costs £2·95** P P & Ins. 36p (Overseas Seamail P & P £1·70) (+ 8% VAT 23p)

E.V.6. Case and looks as above. 6 Transistors and 3 diodes. Powered by 9 volt battery. Ferrite rod aerial, 3" loudspeaker, etc., MW/LW coverage. Push Pull output. Parts Price List and Plans free with parts.

**Total Building Costs £3·60** P P & Ins. 36p (Overseas Seamail P & P £1·70) (+ 8% VAT 29p)

E.V.7. Case and looks as above. 7 Transistors and 3 diodes. Six wavebands. MW/LW, Trawler Band, SW1. SW2. SW2. powered by 9 volt battery. Push Pull output. Telescopic aerial for short waves. 3" Loudspeaker. Parts Price List and Easy Build Plans free with parts.

**Total Building Costs £4·08** P P & Ins. 38p (Overseas Seamail P & P £2·00) (+ 8% VAT 32p)

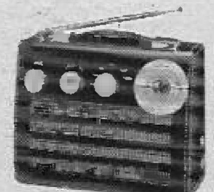
## ROAMER EIGHT Mk I

NOW WITH VARIABLE TONE CONTROL

7 Tunable Wavebands: MW1, MW2, LW, SW1, SW2, SW3 and Trawler Band. Built in Ferrite Rod Aerial for MW and LW. Chrome plated Telescopic aerial can be angled and rotated for peak short wave listening. Push pull output using 600mW transistors. Car aerial and Tape record sockets. Selectivity switch. 8 transistors plus 3 diodes. Latest 4" 2 watt ferrite magnet loudspeaker. Air spaced ganged tuning condenser. Volume/on/off, tuning, wave change and tone controls. Attractive case in rich chestnut shade with gold blocking. Size 9 × 7 × 4in. approx. Easy to follow instructions and diagrams. Parts price list and plans free with parts.

**Total building costs £6·98** P P & Ins. 47p (Overseas Seamail P & P £2·50) (+ 8% VAT 56p)

## ROAMER TEN Mk 2



WITH VHF INCLUDING AIRCRAFT

Now with free earpiece and switched socket.
10 Transistors. Latest 4" 2 watt Ferrite Magnet Loudspeaker.
9 Tunable Wavebands. MW1, MW2, LW, SW1, SW2, SW3, Trawler Band, VHF and Local Stations also Aircraft Band.
Built in Ferrite Rod Aerial for MW/LW. Chrome plated 6 section Telescopic Aerial, can be angled and rotated for peak short wave and VHF listening. Push Pull output using 600mW Transistors. Car Aerial and Tape Record Sockets. 10 Transistors plus 3 Diodes. Ganged Tuning Condenser with VHF section. Separate coil for Aircraft Band. Volume on/off. Wave Change and tone Controls. Attractive Case in black with silver blocking. Size 9" × 7" × 4". Easy to follow instructions and diagrams. Parts price list and plans 50p free with parts.

**Total building costs £9·50** P P & Ins. 52p (Overseas Seamail P & P £2·50) (+ 8% VAT 76p)

## "EDU-KIT"

Build Radios, Amplifiers, etc., from easy stage diagrams.

Five units including master unit to construct.

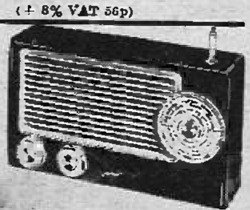
Components include:

Tuning Condenser: 2 Volume Controls: 2 Slider Switches: Fine Tone 3" Moving Coil Speaker: Terminal Strip: Ferrite Rod Aerial: Battery Clips: 4 Tag Boards: 10 Transistors: 4 Diodes: Resistors: Capacitors: Three ½" Knobs. Units once construct[illegible] Master Unit, enabling them to be stored for future use. Ideal for Schools, Educational Authorities and all those interested in radio construction.
Parts price list and plans free with parts.

**Total building costs £5·50** P P & Ins. 35p (Overseas Seamail P & P £2·35) (+ 8% VAT 44p)

## TRANS EIGHT

8 TRANSISTORS and 3 DIODES



6 Tunable Wavebands: MW, LW, SW1, SW2, SW3 and Trawler Band. Sensitive ferrite rod aerial for M.W. and L.W. Telescopic aerial for Short Waves. 3in. Speaker. 8 improved type transistors plus 3 diodes. Attractive case in black with red grille, dial and black knobs with polished metal inserts. Size 9 × 5½ × 2½in. approx. Push pull output. Battery economiser switch for extended battery life. Ample power to drive a larger speaker. Parts price list and plans free with parts.

**Total building costs £4·48** P P & Ins. 40p (+ 8% VAT 36p) (Overseas Seamail P & P £2·00)

## ROAMER SIX

CASE AND LOOKS AS TRANS-EIGHT

6 Tunable Wavebands: MW, LW, SW1, SW2, Trawler band plus an extra Medium waveband for easier tuning of Luxembourg, etc. Sensitive ferrite rod aerial and telescopic aerial for Short Waves. 3in. Speaker 8 stages—6 transistors and 2 diodes. Attractive black case with red grille, dial and black knobs with polished metal inserts. Size 9 × 5½ × 2½in. approx. Plans and parts price list free with parts.

**Total building costs £3·98** P P & Ins. 40p (Overseas Seamail P & P £2·00) (+ 8% VAT 32p)

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SN74160 1·10
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SN74162 1·10
SN74163 1·10
SN74164 2·01
SN74165 2·01
SN74167 4·10
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IN15922 0·08
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AA118 0·08
AA119 0·08
AA129 0·15
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BA115 0·10
BA142 0·17

BA144 0·12
BA145 0·18
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BA154 0·12
BA155 0·12
BA156 0·15
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BAX16 0·10
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4037 1·93
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| 3¾x3¾in | 40 | 39 | — | — |
| 3¾x5in | 45 | 47 | — | 32 |
| 3¾x17in | 1·61 | 1·26 | 1·00 | 1·92 |
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**Components for Scientific Kit**
(illustrated)

1. Coil
2. LSI chip
3. Interface chips
4. Case mouldings, with buttons, windows and light-up display in position
5. Printed circuit board
6. Keyboard panel
7. Electronic components pack (diodes, resistors, capacitors, etc)
8. Battery assembly and on/off switch
9. Soft carrying wallet
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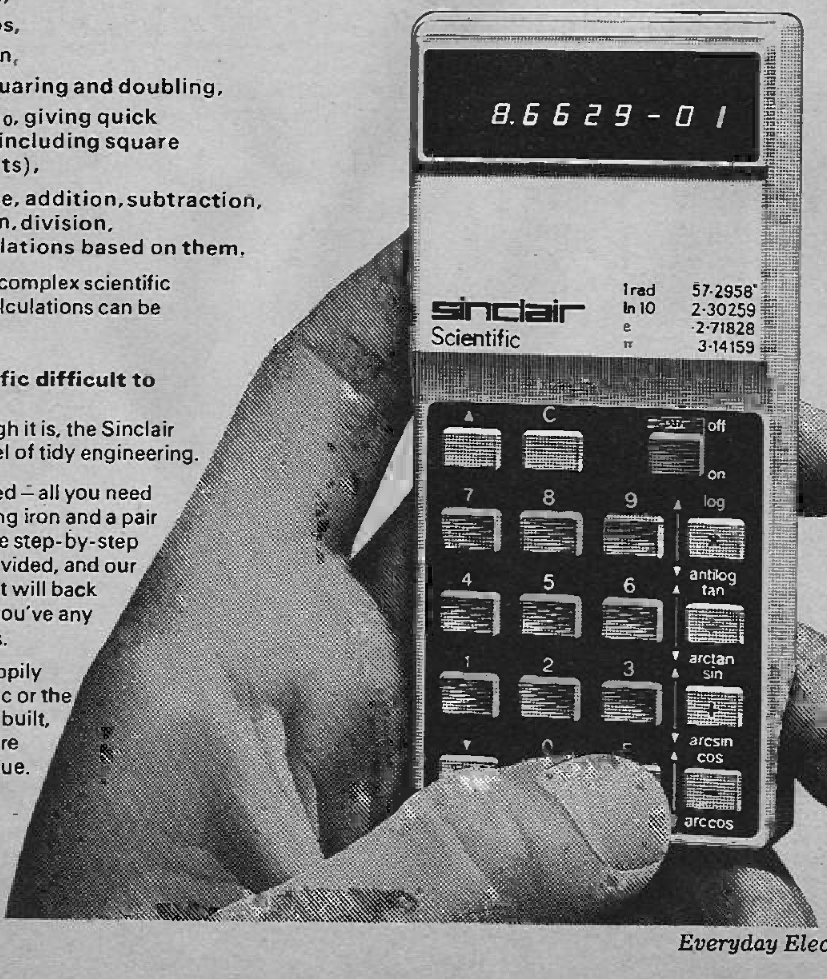
Assembly time is about 3 hours.

## Features of the Sinclair Scientific




- **12 functions on simple keyboard** Basic logs and trig functions (and their inverses), all from a keyboard as simple as a normal arithmetic calculator's. 'Upper and lower case' operation means basic arithmetic keys each have two extra functions.
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3. Interface chip
4. Thick film resistor pack
5. Case mouldings, with buttons, window and light-up display in position
6. Printed circuit board
7. Keyboard panel
8. Electronic components pack (diodes, resistors, capacitors, transistor)
9. Battery clips and on/off switch
10. Soft wallet

Assembly time is about 3 hours.

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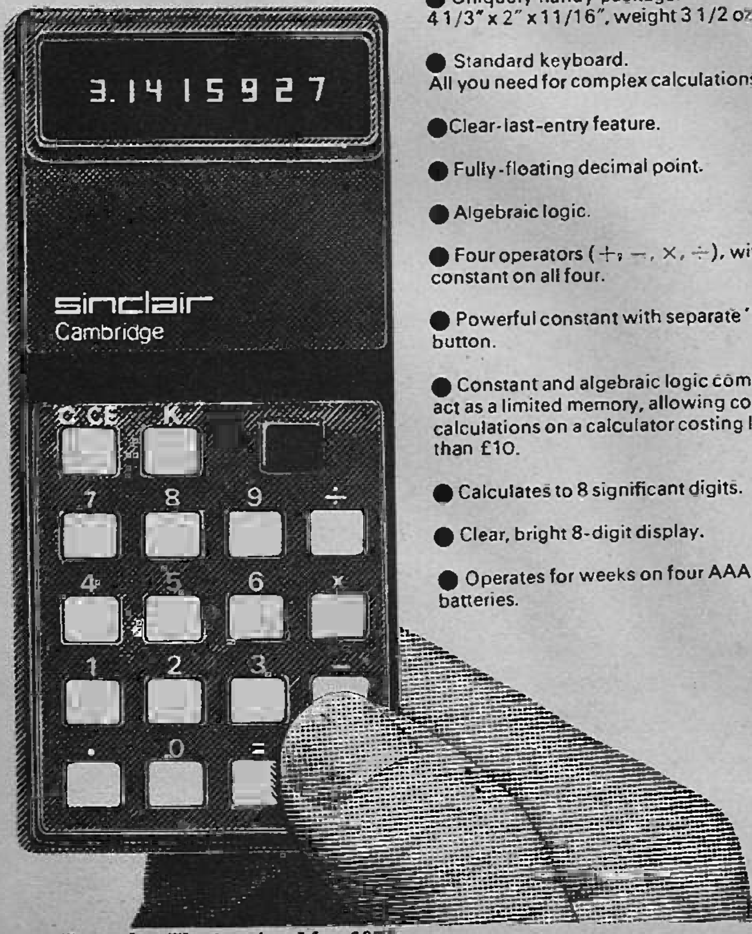
## Features of the Sinclair Cambridge

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# everyday electronics

PROJECTS...
THEORY.....


## WHAT EVERYONE NEEDS

It is small and portable, sometimes pocket size. Indispensable to the likes of readers of EVERYDAY ELECTRONICS, it is available in a great variety of forms, of varying specifications. It may cost anything from a fiver to twenty-five pounds (or more) and its country of origin might be Japan, Italy, Russia or Yugoslavia, or even the U.K. What is it? Well it is not a transistor radio nor is it a miniature calculator. What we have in mind at the moment is a multimeter.

Yes, a multimeter is an essential instrument for anyone who wishes to become involved practically in electronics. It is an initial purchase that should turn out to be a good investment. For if the choice is carefully made the instrument should give service for an indefinite number of years. Provided of course that it is at all times treated with respect, handled with care and used intelligently.

The number and variety of popular and inexpensive multimeters on the market is quite staggering. Selection can therefore be a problem, especially for the inexperienced. The purpose of our special supplement this month is to assist newcomers in this important matter. The information provided concerns not only the factors which should govern the buyers' choice, but also the everyday use of a multimeter. This is every bit as important. Remember the instrument's life will be literally in your hands!

## MUTUAL AID

Rising costs of labour and materials hit the headlines every day. They also hit our pockets, as everyone is all too well aware. In the publishing business as elsewhere it is impossible to escape the consequences of these difficult economic times. The printing of issues of this magazine in excess of actual advance orders from the trade, for example, cannot be justified. Cost apart, paper is after all a valuable commodity which is in short supply throughout the world.

We would like our readers to understand this and see the advisability of giving a firm order to their newsagent. The local supplier will greatly appreciate this, and please do remember that he is is in business to make a living and cannot take chances by buying copies of magazines from his wholesaler just on spec.

To ensure that you get your own copy of EE every month, please advise your newsagent—don't leave it to chance. We hate hearing of disappointed would-be readers. Do as we suggest and everyone involved in the production and distribution of this magazine will be happy. So will you.

Fred Bennett

*Our June issue will be published on Friday, May 16*




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# EASY TO CONSTRUCT
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VOL. 4 NO. 5 MAY 1975

## CONSTRUCTIONAL PROJECTS



## GENERAL FEATURES



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**An INDEX for Vol.3**
**WILL BE INCLUDED WITH**
**NEXT MONTH'S**
**Everyday Electronics**

# Serenade your lady with the Minstrel

## A portable electronic musical instrument

By P. MILLS

Modern electronic organs are sophisticated pieces of equipment, but a lot of fun can be had with the simple one-octave organ described in this article.

The circuit can be split into two distinct parts, first the oscillator which uses a unijunction transistor, for simplicity, and secondly the audio amplifier, consisting of a driver stage and a complementary output stage.

### CIRCUIT DESCRIPTION

The complete circuit diagram of the Minstrel is shown in Fig. 2. Operation of the oscillator is easiest understood with reference to Fig. 1, a basic unijunction relaxation type oscillator.

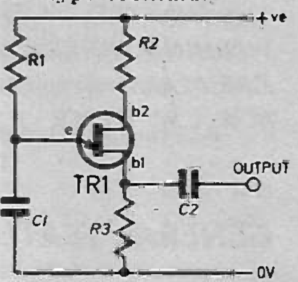
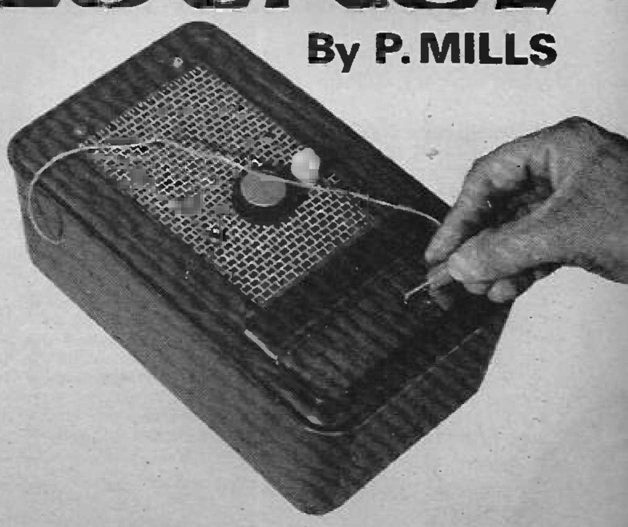



**Fig. 1. A unijunction oscillator, the basis of the Minstrel.**

When the supply is first connected, the capacitor *C1* begins to charge up via *R1* causing the emitter of *TR1* to rise. At a certain voltage level, called the threshold voltage, the capacitor is able to almost instantaneously discharge through the unijunction from emitter to base 1 and via *R3* to ground. This results in a positive pulse at base 1 developed across *R3*.



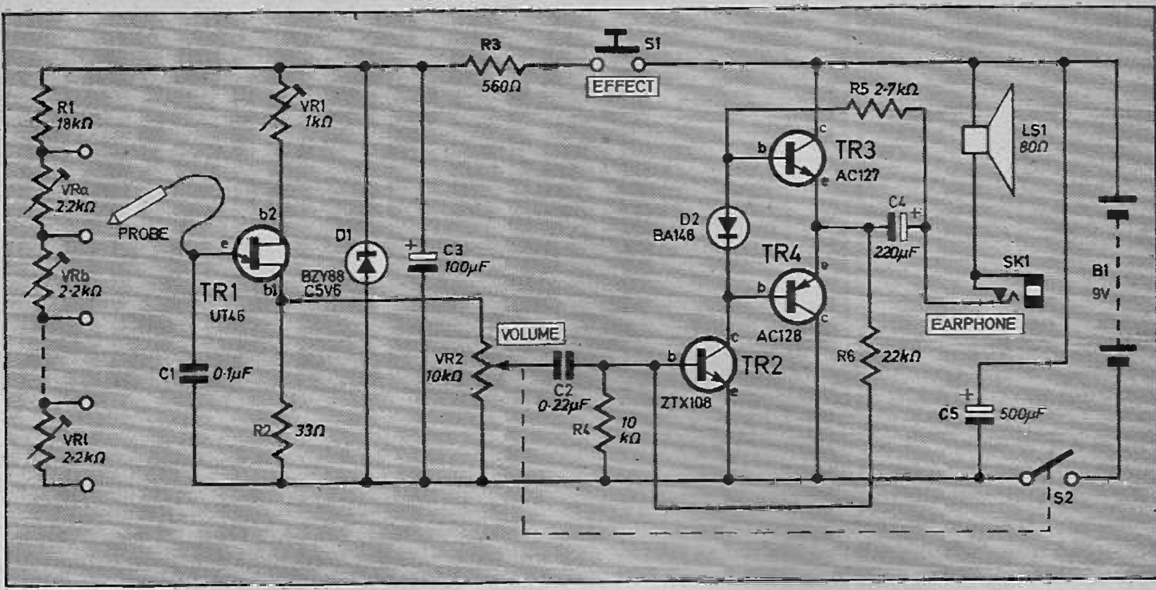



**Fig. 2. The complete circuit diagram for the Minstrel.**

When this has happened the capacitor begins to charge up again and the above process is repeated and continues for as long as the battery is connected, resulting in a train of pulses. The frequency of these pulses is proportional to the values of *C1* and *R1*. Keeping *C1* constant and varying *R1* will change the pitch of the output tone.

In the circuit of Fig. 1 *R1* has been replaced by a string of potentiometers, $VR_a$ to $VR_l$, and by adjusting these values a set of frequencies can be generated (one at a time) to form a musical octave.

The frequency of the oscillator varies with the supply voltage; to help reduce this effect Zener diode D1 has been incorporated in parallel with reservoir capacitor C3. Potentiometer VR2, across b1 load resistor serves as a volume control and the output from the latter is coupled to the amplifier by d.c. blocking capacitor C2.

### AUDIO AMPLIFIER

The audio amplifier is a conventional complementary output stage, TR3 and TR4 being fed from the driver transistor TR2. Diode D2 provides base bias for the output transistors and R6 provides some negative feedback. The cur-

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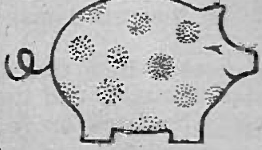
**ESTIMATED COST* OF COMPONENTS including V.A.T.**



**£4.50 excluding case**

*Based on prices prevailing at time of going to press

## Components....

SEE **SHOP TALK**

**Resistors**

| | |
|---|---|
| R1 | 18kΩ |
| R2 | 33Ω |
| R3 | 560Ω |
| R4 | 10kΩ |
| R5 | 2·7kΩ |
| R6 | 22kΩ |

All ¼W ± 10% carbon

**Potentiometers**

| | |
|---|---|
| VR1 | 1kΩ horizontal skeleton preset |
| VR2 | 10kΩ log. with s.p.s.t. switch |
| $VR_a$ . . . $VR_l$ | 2·2kΩ horizontal skeleton presets (12 off) |

**Capacitors**

| | |
|---|---|
| C1 | 0·1μF |
| C2 | 0·22μF |
| C3 | 100μF elect. 10V |
| C4 | 220μF elect. 10V |
| C5 | 500μF elect. 10V |

**Semiconductors**

| | |
|---|---|
| TR1 | TIS43 or UT46 unijunction |
| TR2 | BC108 or ZTX108 silicon *npn* |
| TR3 | AC127 germanium *npn* |
| TR4 | AC128 germanium *pnp* |
| D1 | BZY88C5V6 400mW Zener (5·6V) |
| D2 | BA148 or any similar silicon diode |

**Miscellaneous**

| | |
|---|---|
| LS1 | 80 ohms 75mm diameter |
| SK1 | 3·5mm switched earphone socket |
| S1 | push-to-break switch |
| B1 | 9V PP9 |

Veroboard: 0·1in. matrix 41 strips x 36 holes; printed circuit board size 94 x 45mm; battery clips; wander plug for probe; veropins; plastic case size 22 x 14 x 8cm (approx); multistrand flexible wire.

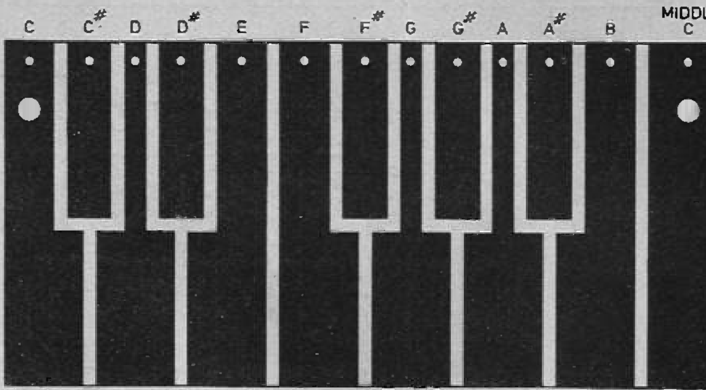



**Fig. 3. The master drawing of the Minstrel Keyboard, shown full size. The black areas indicate the regions of copper to remain after etching.**

rent drain is about 30 milliamps, so a PP9 battery should last for a long time.

An effect button has been incorporated that produces a tremolo-like effect if pressed rapidly whilst the unit is being played. When this is depressed the supply to the oscillator is cut off.

## KEYBOARD

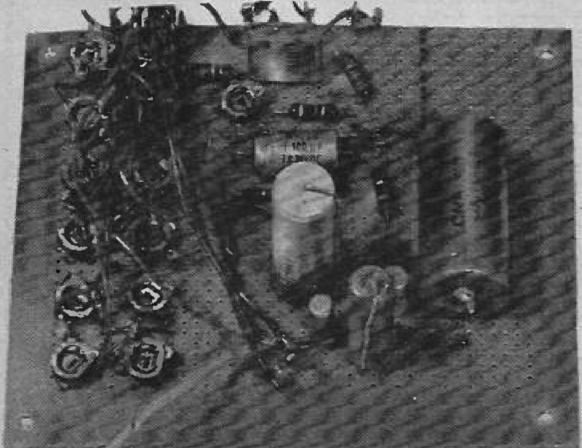
The keyboard was made from a piece of printed circuit board, dimensions 94 x 45mm. Shown in Fig. 3 is a master drawing of the keyboard (shown full size) where the black regions indicate the areas of copper to remain after etching.

With reference to Fig. 3 the black regions should be marked with an etchant resist, such as a Dalo pen, enamel paint or nail varnish, and allowed to dry. The board should then be placed in a dish of ferric chloride solution and left until all the unwanted copper has dissolved.

Etching time will depend on solution strength but can be accelerated by warming the solution and constant agitation.

When etching is complete, the board should be removed with a pair of tweezers and thoroughly washed under a running tap. Care should be taken not to get the ferric chloride solution on the body or clothing as it is a very corrosive chemical and poisonous. Always wash hands immediately after using this chemical.

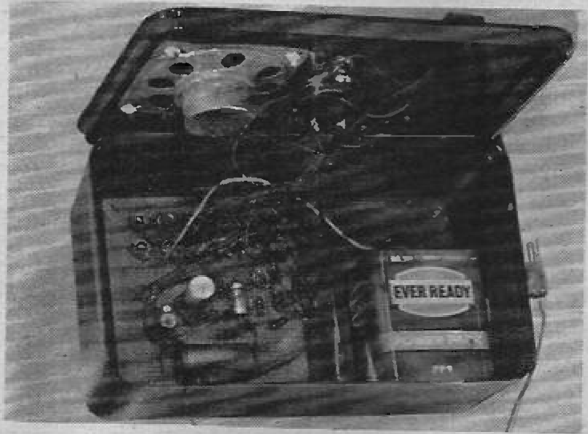
Finally clean off the etchant resist with an abrasive powder and drill the fixing and wiring holes. Suitable lengths of wire should now be soldered to each of the copper areas via the holes; it is recommended that different wire colours be used so as to avoid confusion. If this is not available, each keyboard wire should be labelled by its note i.e. C, C#, D etc.



**Photograph of the completed prototype component board.**

## CONSTRUCTION

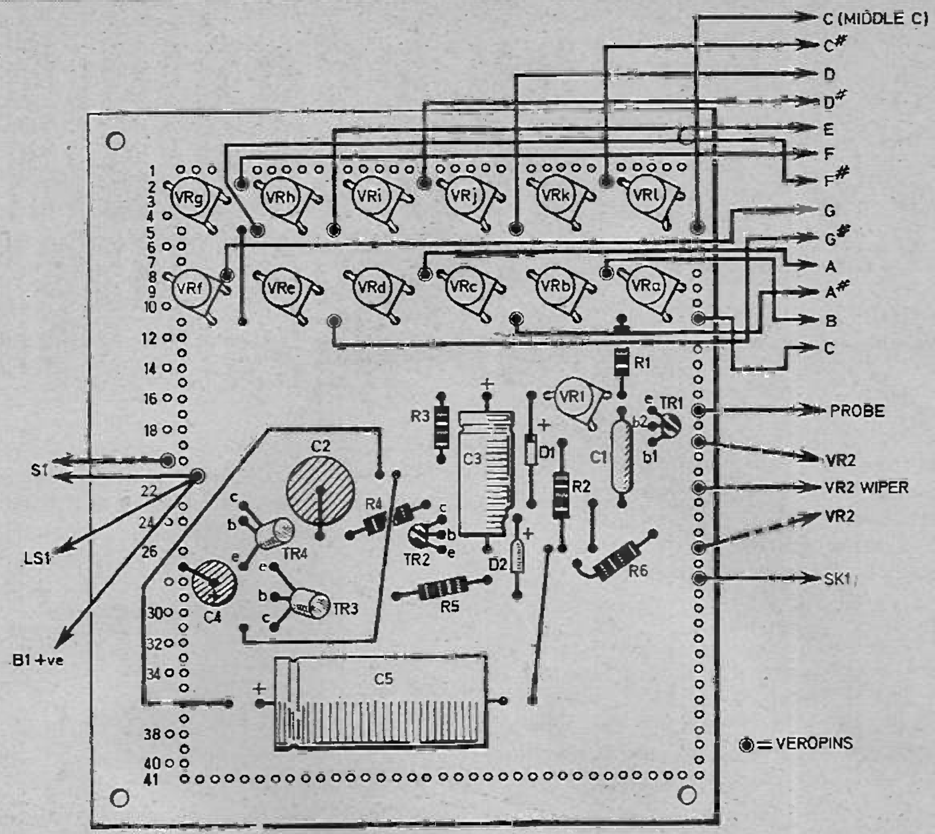
Most of the components are mounted on a piece of 0·1in. matrix Veroboard size 41 strips by 36 holes. Begin by drilling the fixing holes and making the breaks along the copper tracks on the underside as shown.




**Photograph of the Minstrel completed, with lid removed.**

Next insert the Veropins as indicated and position and solder the components as detailed in Fig. 4. The transistors should be soldered in last of all, observing their lead-out connections and a heatshunt used so as to avoid thermal damage by the soldering iron.

The prototype unit was housed in a plastic case size 22 x 14 x 8cm approximately and the remainder of the components mounted on the removable lid, see Fig. 5.



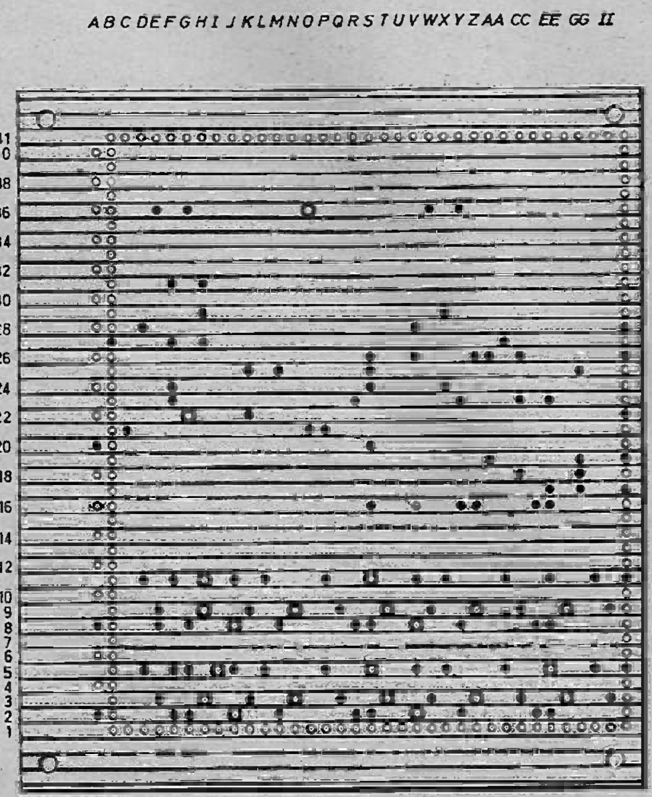




Fig. 4. The layout of the components on the Veroboard and the cut-outs to be made along the copper strips on the underside.

# the minstrel

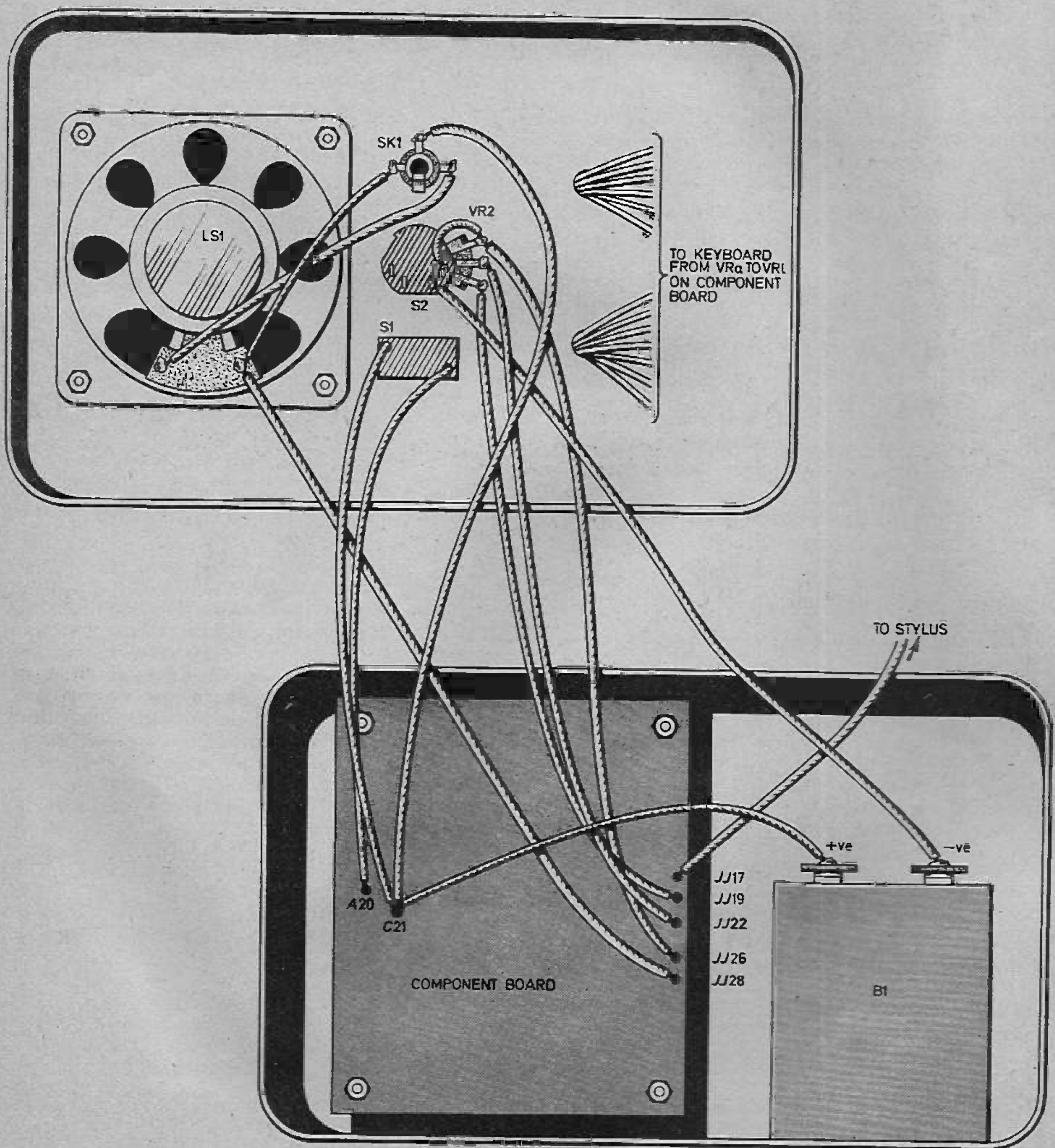



**Fig. 5. Complete wiring up details and layout of the components.**

Prepare the lid to accept components LS1, VR2 and S1. Drill two holes near to where the keyboard is to be cited and pass the keyboard wires through these holes in two convenient groups. Glue the keyboard to the outside lid and cover the wiring with a piece of moulded wood, see photograph below.

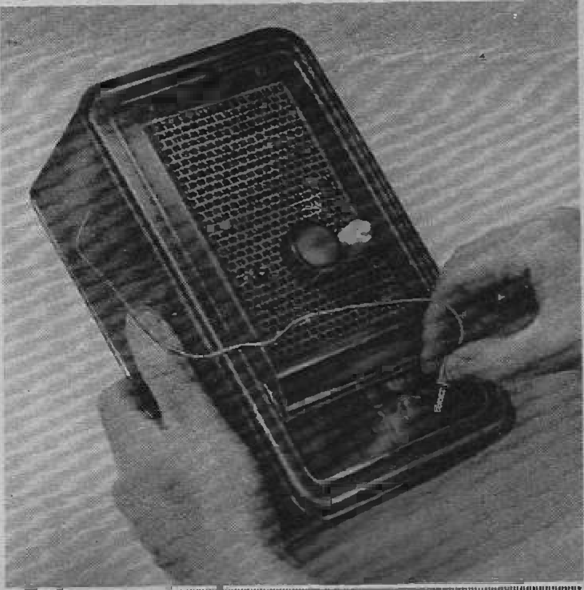
Now secure the lid components in position and wire up to the component board at the Veropin locations. Next connect the battery terminals and secure the board to the base of the case using four self-tapping screws. The flying lead from location *JJ17* should now be passed out through a hole in the side of the case and terminated in a wander plug. This will be the probe or stylus.

Finally glue a piece of speaker covering over the speaker cut-out and the unit is ready for testing and setting up.

### TESTING AND SETTING UP

First turn all the skeleton preset potentiometers $VR_8$ to $VR_1$ (including VR1) so that they give minimum resistance and turn on at VR2. Place the probe in contact with the highest note on the keyboard, and with the aid of a piano, or other instrument set **VR1** to give a middle C note. This will put the other notes, when adjusted, on the right part of the scale. Next place the probe in contact with the next key down, and adjust $VR_8$ to give note B. The rest of the notes are tuned in a similar fashion.

If the unit does not work, check that the components are soldered in the right positions, observing the polarities of electrolytic capacitors and diodes, and check the leadouts of the transistors. Also place a meter in one of the battery leads, this should read around 30mA. The voltage at the emitters of the output transistors to ground should be about 4·5 volts, and the voltage across the Zener diode D1 should be about equal to the nominal Zener voltage. ▣



## Ruminations

By Sensor

### Smaller and Smaller

Larger scale integration, or l.s.i. is quietly creeping into all branches of electronics. Pocket calculators containing just one l.s.i. circuit are now common and the "one chip" radio has been with us for some time. Extremely complex circuits can now be manufactured by semiconductor techniques, all one has to do is to provide the input signal, the power, and the output equipment. By "output equipment" I mean the loudspeaker, cathode ray tube, numerical display or whatever is required to sense the output signals from the device. For without some means of "talking" to the circuit (the input signal) and some means of listening to the circuit (the output signal) there is just no point in having the circuit at all!

Generally speaking, which is always a dangerous thing to do, it seems to me that as the "works" get smaller the output device gets bigger. We demand larger television screens, our search for high fidelity leads us to larger speakers and enclosures, calculators are required to have a bright, easily read display. And, yet the real "business" part continues to shrink. It would seem that we ought to be working to find a better way of receiving information into our minds.

### Taking It In

Since all these circuits merely take in electrical impulses and operate upon them, albeit in complex fashion, and since our brains also function by sensing electrical impulses generated by external stimula, then, it must be possible to bypass our senses, hearing and vision for example and stimulate our minds directly. I have read the neuro-surgeons have been able to do this kind of thing activating certain areas of the brain by tiny impulses applied by probes. The patient has been made for example to experience the sensation of tasting onion by placing the probes in a particular position.

I don't know just how this "direct link" with our brains could be achieved, and I am certaiuly not suggesting that we should undergo major surgery in order to accomplish it, but there would seem to be a great potential field to explore in this direction. The electronics engineer would certainly have a part to play, but the neurologist, bio-chemist, and no doubt others would have a great deal of work to do before results could be expected.

Just think of the benefits, we could each "listen" to our own choice of programmes, "watch" our own television show without disturbing the rest of the family (or the neighbours), the bulky loudspeakers and cathode ray tubes would no longer be required—just one or two l.s.i. circuits!

## be a battery econoMISER with the

# WARNING WINKER...

**By George Hylton**

### A visual indication that battery operated equipment is switched on

Now that light-emitting diodes are obtainable cheaply it is practicable to use them as pilot lights. Being small and of a distinctive colour (usually red) they are made for the job, except for one thing. That is their current consumption, which, though less than an average pilot bulb's, is still great enough to discourage their use in really low-consumption battery equipment.

The usual red l.e.d.s. begin to light up at 10 milliamps and are fairly bright at 20 milliamps. This is often greater than the standby consumption of the battery equipment itself. It is clearly very wasteful to use a l.e.d. just to remind you to switch the equipment off if the penalty is to double or treble the consumption when it is on.

### *CIRCUIT THEORY*

A way out of the difficulty is to make the pilot lamp flash intermittently. Then, even if the *peak* current is high enough to produce a bright flash, the *mean* current can still be kept low.

One way to achieve intermittent flashing is to build the l.e.d. into a relaxation oscillator circuit. One such circuit is shown in Fig. 1 and uses one *npn* and one *pnp* transistor. This "complementary" circuit can be made to have long "off" periods and short "on" periods, and also, it needs only one capacitor.

When the circuit is on, both transistors conduct. The current through D1 is now the emitter current of TR2, and for safety this must be kept below the maximum d.c. current limit as specified by the manufacturer. For the specified Motorola MLED 500 used in this circuit this limit is 100 milliamps.

The emitter current of TR2 is of course the sum of the base current and the collector current. The base current is limited to a small value by R2. (Even if TR1 becomes a short-circuit not more than about 7 milliamps can flow through R2.)

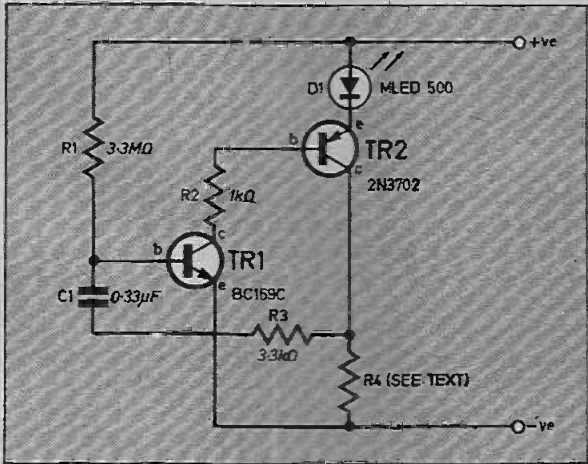



**Fig. 1. The circuit diagram for the Warning Winker.**

The collector current of TR2 depends on the sum of the voltage drops across D1 (about 1·6 volts), across TR2 (emitter to collector) and across R4. The voltage across TR2 is an uncertain quantity but it is not very large. To be on the safe side, R4 should be selected so that even if TR2 becomes a short circuit the current limit for the l.e.d. will still not be reached. Since the l.e.d. drops about 1·6 volts, this leaves, with a 9 volt supply, a maximum of about 7·4 volts across R4. If R4 is 100 ohms, as in Fig. 1, the current cannot exceed 74 milliamps, which

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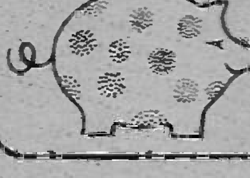


**£0.65**

*Based on prices prevailing at time of going to press

# Components....

**Resistors**

R1 3·3MΩ
R2 1kΩ
R3 3·3kΩ
R4 See text and Table 1
All ¼ watt ± 10% carbon

SEE **SHOP TALK**

**Semiconductors**

TR1 BC169C silicon *npn*
TR2 2N3702 silicon *pnp*
D1 MLED light-emitting diode

**Miscellaneous**

C1 0·33μF
Plain matrix board, 0·15in. matrix 13 x 13 holes; Veropins; connecting wire.

allows a margin of safety for resistor tolerances and other circuit variables. (For other supply voltages, R4 needs to be altered. The appropriate value for the MLED 500 *only* is given in Table 1).

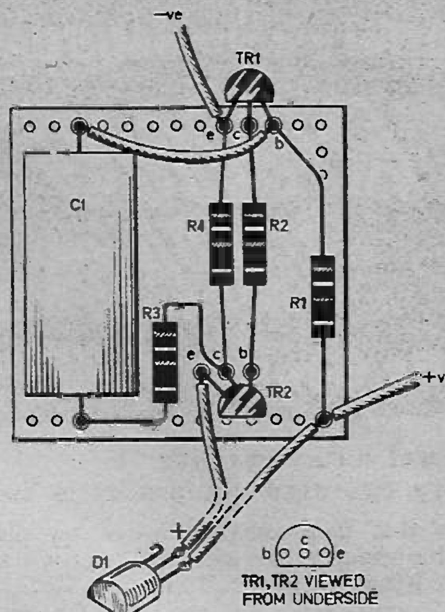



**Fig. 2. The layout of the components on the matrix board and wiring up details.**

## *PULSE LENGTH*

Although the circuit has been designed for safety in terms of the d.c. current limit for the l.e.d., in actual operation the current flows in pulses. It is important that each pulse should last long enough for the eye to see the flash of light clearly. If the flash is too short, it appears faint.

The duration of the on period of the oscillation is what governs the duration of the flash. During the on period, C1 charges up. With the standard form of complementary relaxation oscillator circuit, C1 charges much too rapidly. For this reason the circuit of Fig. 1 is not standard. It has been modified by putting resistor R3 in series with C1, to reduce the rate at which it charges and so prolong the flash.

Even with R3, the flash duration is quite short, so despite the fact that peak currents of up to 70 milliamps may flow, the mean current is only about 0·9 milliamps (see Table 1). In practice the peak amount is often a lot less than 70 milliamps, especially if the supply voltage is low.

The rate of flashing depends on the value of R1 x C1, and the higher this is the *slower* the flashing. A rate of roughly one flash per second is about right, and this is achieved when R1 (in megohms) times C1 (in microfarods) is equal to unity.

Since this calls for a high capacitance for C1, and since it must be a non-electrolytic capacitor, it is economic to keep R1 high in order to reduce the value of C1. This calls for a high-gain transistor for TR1, because a high R1 implies a low base current. The BC169C has a current amplification factor ($h_{fe}$) of 450 to 900.

**Table 1:**
**Circuit details for different supply voltages**

| Supply voltage (V) | R4 (Ω) | Mean current (mA) | Flashes per min. |
|---|---|---|---|
| 6 | 47 | 0·8 | 90 |
| 9 | 100 | 0·85 | 86 |
| 12 | 150 | 0·9 | 83 |

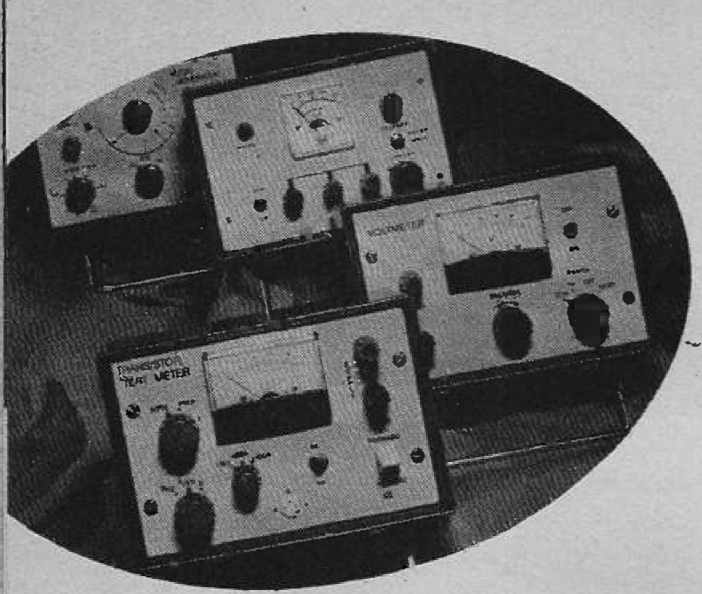
## *CONSTRUCTION*

The prototype unit was constructed on a small piece of 0·15in. plain matrix board size 13 x 13 holes. Veropins are used to anchor the component lead-out wires. The layout is shown in Fig. 2; this is not critical and may be changed to suit individual requirements. Fixing holes should be drilled where required.

Begin by inserting the Veropins and then soldering in position the capacitor, resistors flying leads and then the transistors and diode in this order. A heatshunt should be used when soldering the semiconductors so as to avoid damage to these devices.

The l.e.d. can be glued to the case of the unit to which it is to be fitted, and the connecting wires passed through a small hole drilled in the case. The l.e.d. should be glued on the flat face, since the light comes out of the curved side. The supply leads should be connected to the equipment on/off switch so that the Warning Winker is switched on with the equipment.

When operated from different voltages, R4 must be selected from Table 1 to suit the voltage. For intermediate voltages use the value for the next highest voltage; e.g. for 7·5 volts use the 9 volt value. ▣



# Workshop Practice

By MIKE HUGHES M.I.E.R.E

PART TWO

A Professional Finish

THIS part is really a follow-on from last month when we made a few suggestions as to how you might go about making cabinets for simple projects. Irrespective of how you go about making the cabinet or how good a craftsman you are, you can make or marr your project with the type of finish you give it. By and large we have to concern ourselves with the appearance of the cabinet and the design and lettering (if any) on the front panel. Let's deal with the cabinet first.

### METAL CABINETS

These are usually made from bent aluminium or wood—plastic cabinets usually do not warrant special finishes as the material itself usually suffices. If you have used the cheaper type of aluminium box as an enclosure you will probably wonder what you can do about the unwelded corners. These always look unsightly and cannot be adequately covered or painted over. A simple solution is to fill the gaps with an epoxy resin glue (e.g. Araldite).

To do this economically and to get a good finish you should first stick a length of Sellotape down the *inside* of the corners in question and then run a thin fillet of the glue down the length of the gap on the outside, see Fig. 1. The fillet should be allowed to stand slightly proud of the gap so that it can be rubbed down when it has set.

If a bit more care is taken you can cover the outside of the fillet (while it is still fluid) with another piece of Sellotape making sure that you do not trap any air bubbles; when the glue is dry this can be stripped off to leave a nice shiney smooth curved surface.

If you have inadvertantly drilled small holes in the wrong places you can use the same technique to fill the holes—provided you will be covering the area later with paint or other material. If you use this suggestion make sure you stick a piece of Sellotape over the hole on the *outside* surface of the metal so that you end up with the epoxy resin exactly flush with the surface—a slight mound on the inside probably will not matter very much.

A cabinet is usually going to have to withstand a fair amount of handling so it is essential that you finish off metal surfaces so that they are resilient enough to stand up to the odd knock or scrape.

Professional metal cases are usually finished off with a stove enamel, a crackle or hammer finish paint, anodising or cladding with a plastic laminate. All of these techniques tend to be outside the scope of the amateur because he does not have the necessary equipment nor the specialised materials.

The two most popular finishes to amateur grade metal cabinets are paint and self-adhesive plastic film. On the face of it there might seem little to advise one to do when using one of these methods but there are one or two little tricks which will help you obtain a good end product.

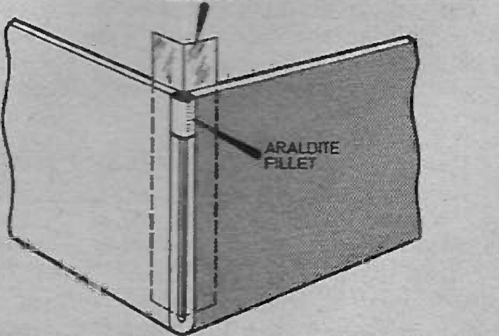



**Fig. 1. Filling the gap along the edge of a bent aluminium case.**

## PAINTING METAL CABINETS

There is no short cut to producing a good painted finish on metal. Never fall for the temptation of using an aerosol spray straight on to the unprepared metal surface—it might look nice initially but it only takes one small tap for the paint to start flaking off. The ideal method described below may sound a long winded process but can be guaranteed to give excellent long lasting results.

First, remove everything from the case, this goes for screws which pass through the sides of the case. You *must* start with a surface that is as free as possible from protrusions. Next make absolutely sure that all the cut edges of the case have been smoothed (and rounded if necessary). Use some very fine emery cloth (that used for rubbing down car cellulose is ideal) and gently abrade the surfaces of the case by rubbing with the emery cloth in small circles. Do not worry about the fine pattern of scratches produced, these are what we need to act as a key to the layers of paint.

When you are satisfied that the surface is evenly abraded and that there are no burrs sticking up at drilling holes, you should thoroughly wash the case in a strong solution of warm water and domestic detergent. This removes the fine particles of metal dust and at the same time removes any remaining grease or oil. Dry the case well, using paper tissues, and try to avoid handling the prepared surface as finger grease can still cause problems. You are now ready to start the painting sequence.

### PRIMER

Always start with a coat of primer paint; the type you choose depends on whether you intend to use cellulose spray later or ordinary oil bound domestic paints. Do not apply too much primer —if you overdo the application you might get runs down the vertical sides of the case and it is almost impossible to remove these later. If you do get runs it is better to wipe the paint off while it is still wet and start again rather than let it dry and hope for the best!

If you have a box shaped cabinet try to avoid placing it so that all four rear edges are on a newspaper as there is always a tendency for the paint to run slightly and this builds up a thickening at the edges in contact with the protective paper. It is best to stand the back edges on four lengths of matchsticks while waiting for the paint to dry as shown in Fig. 2.

Provided you are careful in brushing on the primer and make sure that there are no loose hairs in the paint brush, it should not be necessary to do any rubbing down between coats when working on metal (this, however, is not the case with wood!) and when the primer coat is completely dry you should then apply a layer of undercoat.

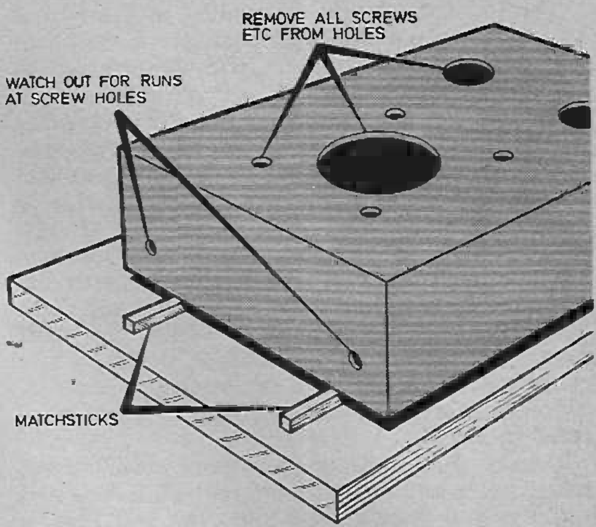



**Fig. 2. When painting, stand the back of the box on match-sticks and try to keep the most important face horizontal.**

Although it is a little old-fashioned, the author prefers normal oil bound household paints without any of the magical "non-drip" additives as they are usually easier to control and generally produce a better finish in the long run. Do not be tempted to use the so called, single coat "super cover" paints, as these crack and flake off easily. Likewise avoid the temptation of putting brush-on enamel paint straight on to the primer—a good oil bound undercoat will provide a better key, give resilience to knocks and produce a smoother finish when the final top coat is applied.

The undercoat, whether brushed on or sprayed on, should look as even and as free from brush marks as you would expect the top coat to be. Sometimes it might be worthwhile rubbing down gently with a *very fine* emery cloth and applying a second coat of undercoat to ensure a really high gloss finish; there is no point in doing this, however, unless you make certain that you keep your work free from dust. It is better to apply several coats of undercoat thinly (making sure that one is dry before applying the next) than a single thick one which might cause runs and is sure to show the brush marks.

### TOP COAT

Provided you have carried out all the preparatory work as recommended, the final, and most important coat (top coat), as far as appearance is concerned, will be the easiest to apply. This can be brushed or sprayed and if you have used oil bound undercoat you can use almost any type of proprietary gloss paint for the top coat but you should not use spray on car cellulose unless you used a cellulose base primer and undercoat.

The top coat should be applied as thinly and as evenly as possible and probably a spray on polyurethane based paint will be easiest to handle.

Finally, before moving on to other finishing methods, a word about spraying. If ever you watch a professional sprayer at work you will see that he works in even sweeps from side to side but he stops the spray at the end of each sweep before starting on the return journey. There is a very good reason for this—it prevents a thicker build up of paint at the left and right hand edges of the job which would happen if he allowed the spray to continue while he was changing the direction of the sweep. It is worth following his example if you wish to avoid runs, refer to Fig. 3.

During the painting operations some of the screw holes and other apertures will have filled slightly; you should wait until the last coat is completely dry and then ease away the excess paint from these areas with a hand-held drilling bit or a knife. It is particularly important that you remove any paint which has dribbled round to the inside of such fixing holes as it might act as an insulator at earthing points.

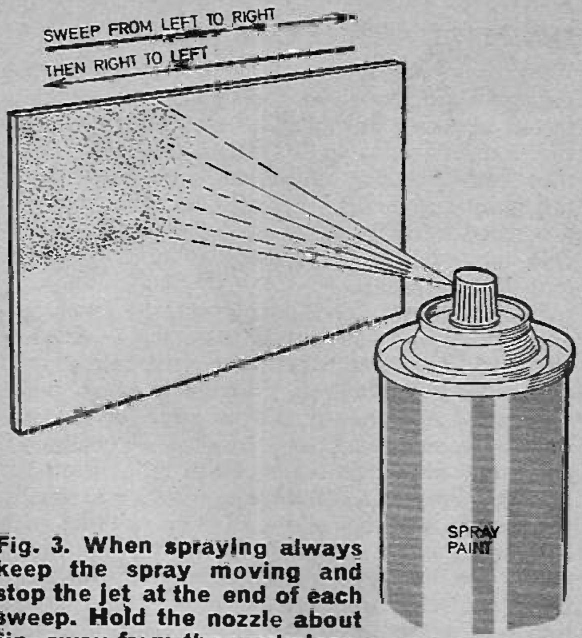



**Fig. 3. When spraying always keep the spray moving and stop the jet at the end of each sweep. Hold the nozzle about 6in. away from the workpiece.**

## SELF-ADHESIVE COVERINGS

Very attractive cabinets can be made by using self-adhesive plastic films to cover the basic metal work. This material is known as Contact or Fablon and can be obtained in most decorating shops and Woolworths. There are some extremely attractive designs available and, in particular, you can get a very smart result by using the simulated wood grain finish.

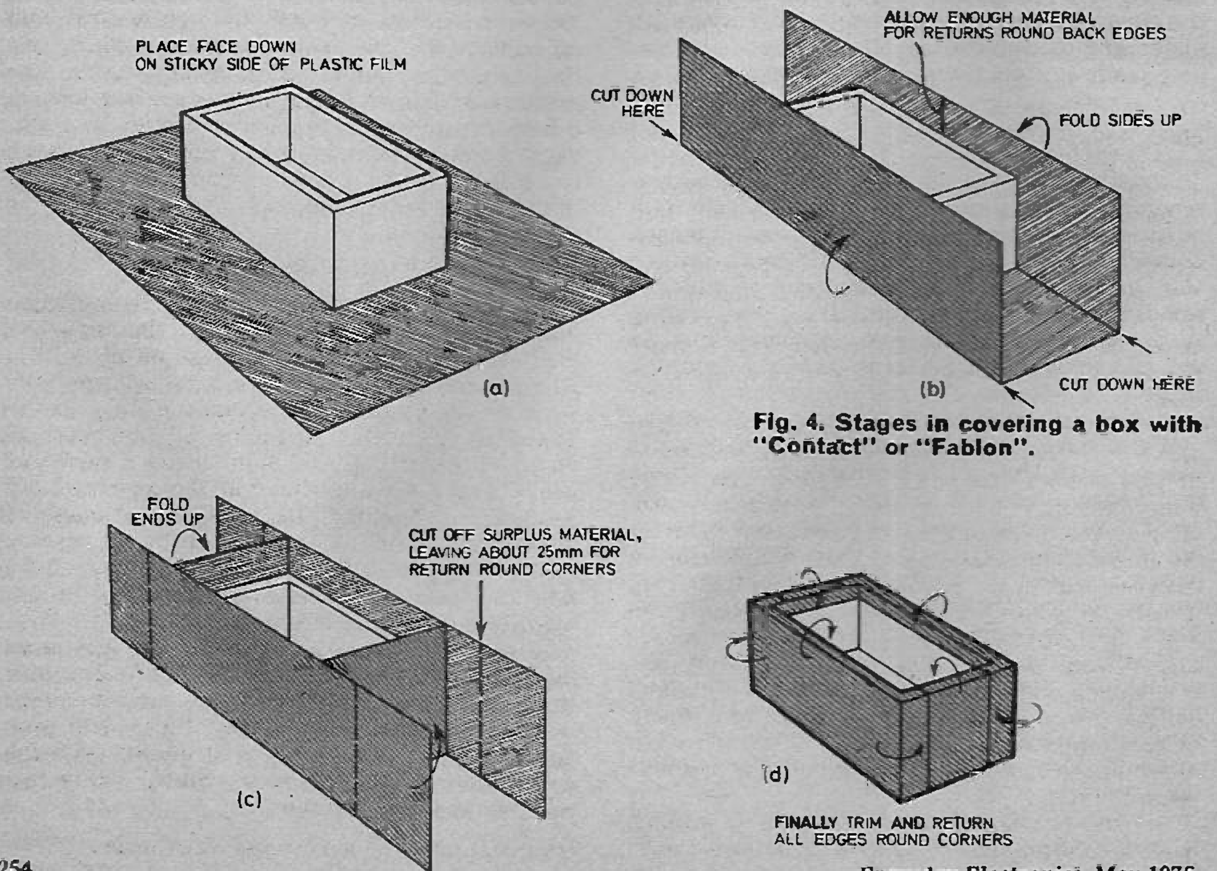



**Fig. 4. Stages in covering a box with "Contact" or "Fablon".**

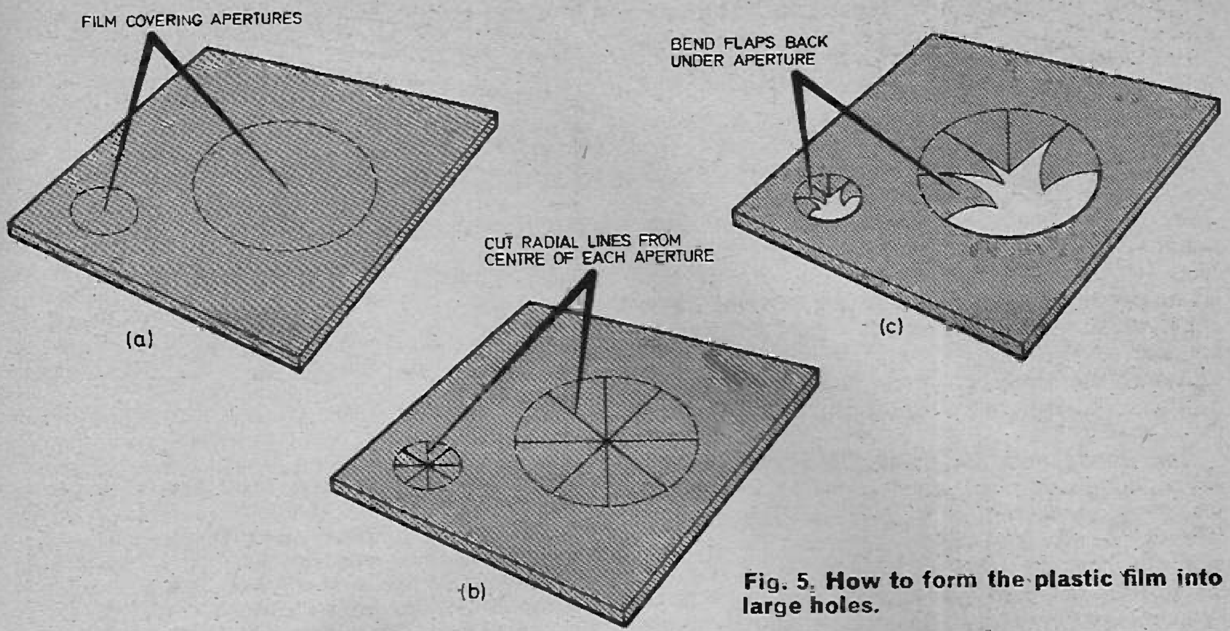



**Fig. 5. How to form the plastic film into large holes.**

Before deciding to use this material you should first ensure that the metal case you wish to clad will not get hot from the circuitry within it; a problem with this material is that the adhesive softens considerably at temperatures in excess of 35 to 40 degrees centigrade and at the same time it tends to shrink in its dimensions. This means that when applying it to a surface you must always return it round any edges to allow for shrinkage.

Where you have difficult corners to manage you may have to use several pieces; if so you must overlap the pieces by at least 5mm and not simply butt the edges together. Butt jointed edges will only pull apart as shrinkage occurs. Where you have such overlaps you will find, over a long period of time, that the adhesive tends to appear at the edge of the joint and this acts as a trap for dust and dirt therefore it is advisable to arrange for any such laps to be at the rear or underneath the box; Fig. 4 shows the stages in covering a box with Contact or Fablon.

As with painting you must ensure that there are no protrusions above the outside surface of the case otherwise you will deform the plastic film in trying to get it to stick. Therefore remove all nuts and bolts and any instruments which are let into the outside surface. Apart from ensuring that the surface of the metal is clean, free from grease or oil and dry, there is no need to do any other prepartory work. Before commencing to cut your material you should carefully plan where you will be returning the free edges and, in the case of wood grained plastic, you should decide whether the grain will follow the right directions when you have folded the material round corners.

At some corners you might have a problem with two butt edges meeting right on the corner; there is very little you can do about this except to put a narrow strip of the same material over the corner so that the two free edges lap over this strip—thus hiding the gap which would otherwise ensue. Do as much of the cutting as you can with the protective backing paper in place and be very generous at the free edges.

When peeling off the backing paper try to avoid stretching the plastic film as this will only aggravate the shrinkage problem and in the worst case you might end up with creases. Having removed the backing it is not a bad idea to leave the pieces of adhesive plastic on a flat surface for a few minutes to allow any stretch to pull back before you start applying the material to the cabinet.

## HOLES AND CUT-OUTS

Where you have screw holes just ignore them and stick the film straight over the top—you can carefully trim the material away with a sharp knife later. Where you have a large hole, such as an aperture for a loudspeaker, do the same but instead of trimming all the material away afterwards you should make a series of radial cuts from the centre of the aperture and push the triangular shaped flaps of material back through the hole to stick on to the reverse side of the box—the smaller the diameter of the hole the more radial cuts you will need to end up with a smooth circle see Fig. 5.

Where you have a hole for a meter it is probably best *not* to do this because you will reduce the internal dimension of the hole and the meter will no longer fit, and anyway, there will probably be no problem with a shrinking edge because the outside edge of the meter will return over the edge of the film.

**Next month we continue on the same theme.**

# *Your Career in* ELECTRONICS

**By Peter Verwig**

**A career in electronics is an exciting prospect! Month by month our contributor Peter Verwig will explain what working in electronics is all about, how to prepare yourself for a rewarding career, and the job opportunities available in the world's fastest growing industry.**

## *THE IMPORTANCE OF QUALIFICATIONS*

LAST month we gave a broad outline of the electronics industry and indicated just a few of the career opportunities open to those keen enough to graduate from just having an interest in electronics to becoming a real professional.

This month we turn our attention to the qualifications you will need to get ahead and which most employers will expect you to have, or to obtain later, before offering you a job. Don't be discouraged by the thought of having to struggle through more exams. If you have a genuine interest in electronics, the battle is more than half won. And unless you are genuinely interested then you would be better off trying something else that does interest you.

Some of your friends may scoff at your ambitions. The temptation to take the job that pays most money and has least demand on your time can be almost overpowering, especially when you are young. And it is by no means impossible to get a job in electronics without having paper qualifications. But what sort of job? And how far do you want to climb the promotional ladder?

## *QUALIFICATIONS*

Qualifications, however modest, are always worth having. Moreover, in a world which tends towards categorisation, it is even conceivable that without adequate qualifications you will not be able to practice. This state of affairs is already with us in the medical profession. It could happen in electronics, but even if it doesn't the man or woman who is on the register as a chartered engineer will clearly be in a far stronger position than one without such a qualification.

We shall be discussing the role of the professional institutions next month and it should be the aim of everyone to reach out for chartered status. This generally means that you will need to continue studying through to a pass degree, and also to demonstrate that you have spent some time in industry.

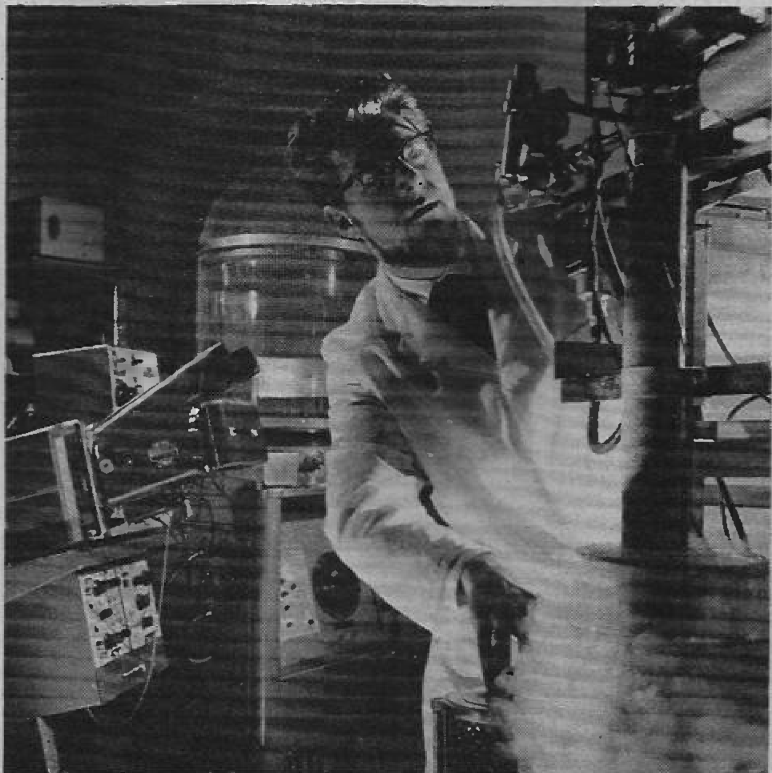
You will need to satisfy the examining bodies that your academic training is to an acceptable standard, that you have received professional engineering training and that you have had a period of responsible experience as an engineer.

Fortunately there are a number of routes which you can take to reach your goal and they can be taken in easy stages and very often with the active assistance of your employer. It is in his interest as well as yours that you should get ahead.

If you are still at school try to do well at your general academic work. The better you do the bigger the range of opportunities that will be available to you. If you haven't done too well it may be that you are a late developer and it is still possible to get into electronics through craft training. If you don't think you can get to degree standard you can still aim at chartered technician engineer status.

Your careers master will give you guidance. Those who have already left school can get advice through the local Further Education Centre.

**An engineer engaged on thick film microcircuit technology research at Standard Telecommunication Laboratories, Harlow, Essex.**



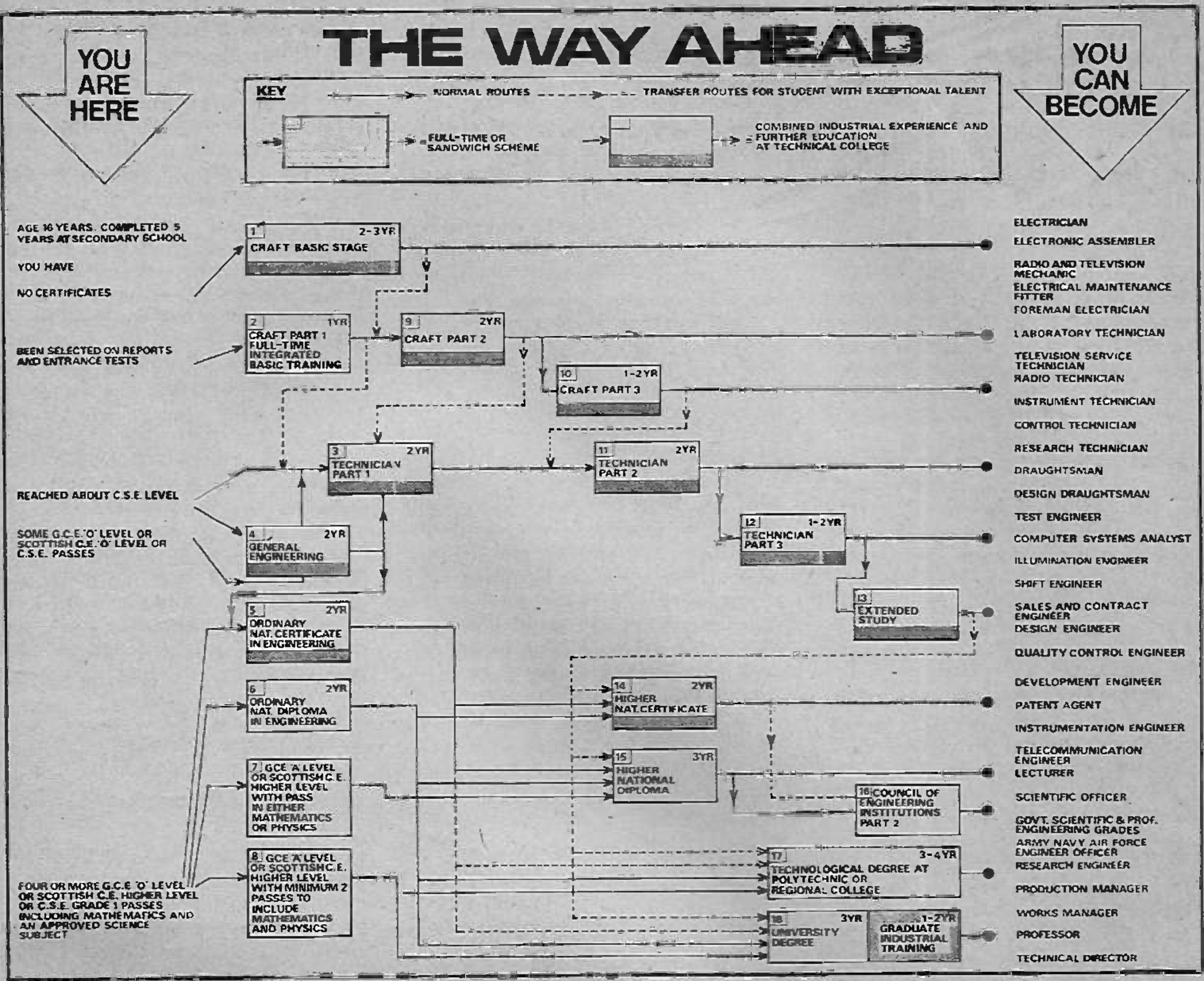



**Fig. 1. The Way Ahead. As you move down the chart on the left hand side the entry qualifications become greater but the job opportunities on the right hand side become greater. But if you follow the dotted lines you will see that a craft apprentice with talent can still climb to the top grades in the industry.** *(Chart by courtesy of the Institution of Electrical Engineers).*

## EDUCATION AND TRAINING

Education and training will generally consist of education in the classroom and laboratory, and training at work. If you enter the profession with the intention of becoming a craftsman or technician then education and training is a combined operation where you do a lot of on-the-job training with part-time release to a technical college.

Normally you would join a firm straight from school and the part-time release is generally one day a week at college. An alternative is the block release when the firm releases you for several weeks of study at a time. The certificates for which you will be studying are the part-time National Certificates or certain of the City and Guilds full technological certificates or full time National Diplomas.

If you aspire to full chartered engineer status the education and training are separate but they can be interleaved when you spend some of your time with the firm and some in education. This is known as the "Integrated Sandwich Course". But you can, for example, spend a year at work after leaving school, then do a spell at university, followed by a final period of training back at work. This is the "Thick Sandwich Scheme". Yet a third method is to go straight from school to university and leave all your on-the-job training until you have obtained your degree.

## DEGREE

Quite clearly to go on to university you will need to have good general academic qualifications to satisfy the university entry regulations. But the late developer can still climb the ladder. For example you may start in craft training and after a year or so start showing exceptional promise. In this case there is nothing to stop you transferring to a higher level of course with the intention of becoming a technician rather than a craftsman.

You may even climb eventually on to a degree course, depending on your progress. Satisfactory completion of an Ordinary National Certificate course will automatically open the door to the Higher National Certificate course. But a student who does exceptionally well in the ONC may find the door open to a Degree or Higher National Diploma course. A good employer will encourage you in your ambition.

The length of your training will vary. Craft training extends over three years and sometimes longer. Three years or more will also be required for technician grades. A technological degree taken through a Polytechnic or Regional College will take three to four years.

A university degree coupled with sufficient graduate industrial training to satisfy the requirement for on-the-job experience will spread over five years. So whichever route you take, don't expect to become qualified overnight. It's much better to face up to the fact that it may take five years, perhaps even longer, before you are fully trained.

### AFTER TRAINING

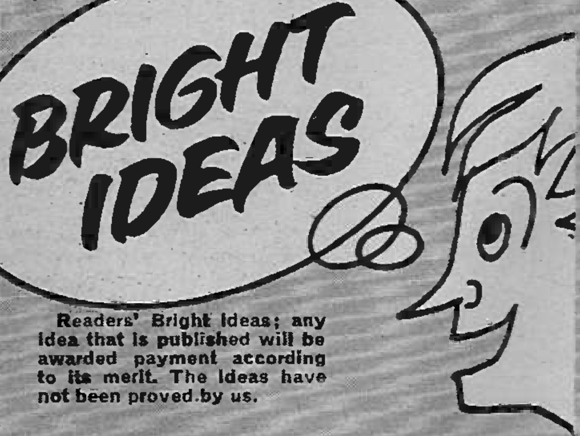
What sort of job can you expect after your training? Craft grades will fit you for radio and TV servicing and for testing assemblies and systems and for installation work. Technician grades can expect to be laboratory assistants, could be engaged on quality control, or as draughtsment, sales engineers or, after suitable laboratory experience, could become development engineers

Those technicians with the capability of expressing themselves could become technical authors. Those with aptitude for computer science could do a useful job as computer systems analysts.

The fully chartered engineer with requisite experience can really get ahead in the area of his choice. He can become a technical director, or works manager, a project leader with a team of development engineers working under his direction, a scientific officer in government research establishements or a technical officer in the armed services. As a fully qualified person he may, after some years in industry, become a lecturer and help train a younger generation of entrants to the profession.

In future articles we shall discuss specific sectors of employment. But first you should think seriously about becoming qualified. The opportunities for doing so have never been greater or less costly. There are some 150 colleges in the UK with approved schemes leading to Higher National Certificates or Diplomas in Electrical and Electronic Engineering. Including the Polytechnics there are some 70 establishments where you can take a degree course.

And most of the larger commercial companies, public corporations and all the armed services run schemes to help you with qualifications. What could be better than to earn while you learn?




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

I find it hard to resist sending in a couple of ideas from this part of the world. I am an electronic hobbist and I have found these ideas very handy and would like to share them with your readers.

Very often a service or instrument technician is faced with the difficulty of inserting a screw into a position inaccessible to a finger. By wrapping a suitable length of 18 s.w.g. solder wire around the shank, the screw can be located in position with the other hand free to screw it in. With a little effort the solder wire can be forced off the shank.

I was faced with the problem of assembling parts of instruments. Having screw locations accessible to only one finger and perpendicular to the force of gravity. I have overcome this problem by inserting a suitable length of 18 s.w.g. solder through the location, ringing the nut round the solder and while withdrawing the solder place a finger on the nut. After the solder is fully withdrawn the nut is in position for the screw to be fitted.

A. Berlie,
Bombay.

When drilling holes in printed circuit boards to mount integrated circuits, the holes frequently show the amazing property of being able to transport themselves miraculously a milimeter or two to either side of the intended position. My method produces holes in perfect line by relying on the ability of 0·1inch matrix Veroboard to take integrated circuits "straight off". The boards are aligned, taped down and the Veroboard holes used as guide holes for the drill. This works for 28, 14, 16 and 8 pin integrated circuits.

J. Savage,
Barnsley.

I have found a simple way of constructing cheap cases for projects.

It is possible to obtain from electrical wiring engineers heavy gauge plastic square section conduit. The sizes I have used are 50 x 50mm outside measurement and 75 x 75mm. The conduit is made in a pleasing grey colour, is extremely rigid and has a sliding panel along one side. This panel is a tight fit when pushed into place.

The advantages of this system are: the case may be any length (it is easily sawn with a wood saw or hacksaw), it is insulating, the walls are heavy enough to support switches and pots without bending and the sliding panel makes an ideal lid.

End caps are needed for the open ends and can easily be made from offcuts. They are extremely firm if glued in with polystyrene cement, but for extra strength, small self tapping screws may be used, as the wall thickness is about 3mm. The cost is between 15p and 30p per metre—a considerable saving over aluminium boxes.

R. M. Henderson, B.Sc.,
Newcastle upon Tyne.

*New products and component buying for constructional projects*

# SHOP TALK

By Mike Kenward

A NEW range of educational "toys" has recently been introduced in this country by Patterson Edwards Ltd. The kits, designed for young people, will appeal to inquisitive minds of all ages and include optics, aeronautics, electrics and electronics, and range in price from approximately £4·95 to £17·95 including V.A.T. Each comes with its own comprehensive illustrated manual giving assembly instructions and details of the experiments which can be carried out.

The most expensive kit, is a miniature computer that can be assembled by a twelve-year-old and programmed to play games and solve simple problems. It comes complete with a 112-page assembly and programming manual. Apart from the fifty programmes illustrated, youngsters can make up their own programmes.

All kits should be available from toy shops, hobby shops or large department stores by the time you read this.

## *The Minstrel*

Parts for *The Minstrel* should all be readily available—that printed circuit kit from Home Radio (mentioned last month) would also be useful for this project. One point to watch when buying components—the skeleton presets should be the very small type, otherwise you may have difficulty in fitting them all on the board. The case for the original unit was a plastic food box—the type sold in most hardware and general stores.

## *Warning Winker*

Once again, no buying problems for the *Warning Winker*, in fact there are very few parts to buy anyway. Different l.e.d.s. can be used—red ones are the cheapest normally. Some types are available with a chrome mounting case and these would enhance the appearance of the unit to which they are fitted—they are, of course, more expensive.

Incidentally, the end of diodes marked with a plus sign is the cathode not the anode as some readers tend to think. The positive sign goes on the "arrow head" of the circuit symbol and this is the cathode.

## *Car Alarm*

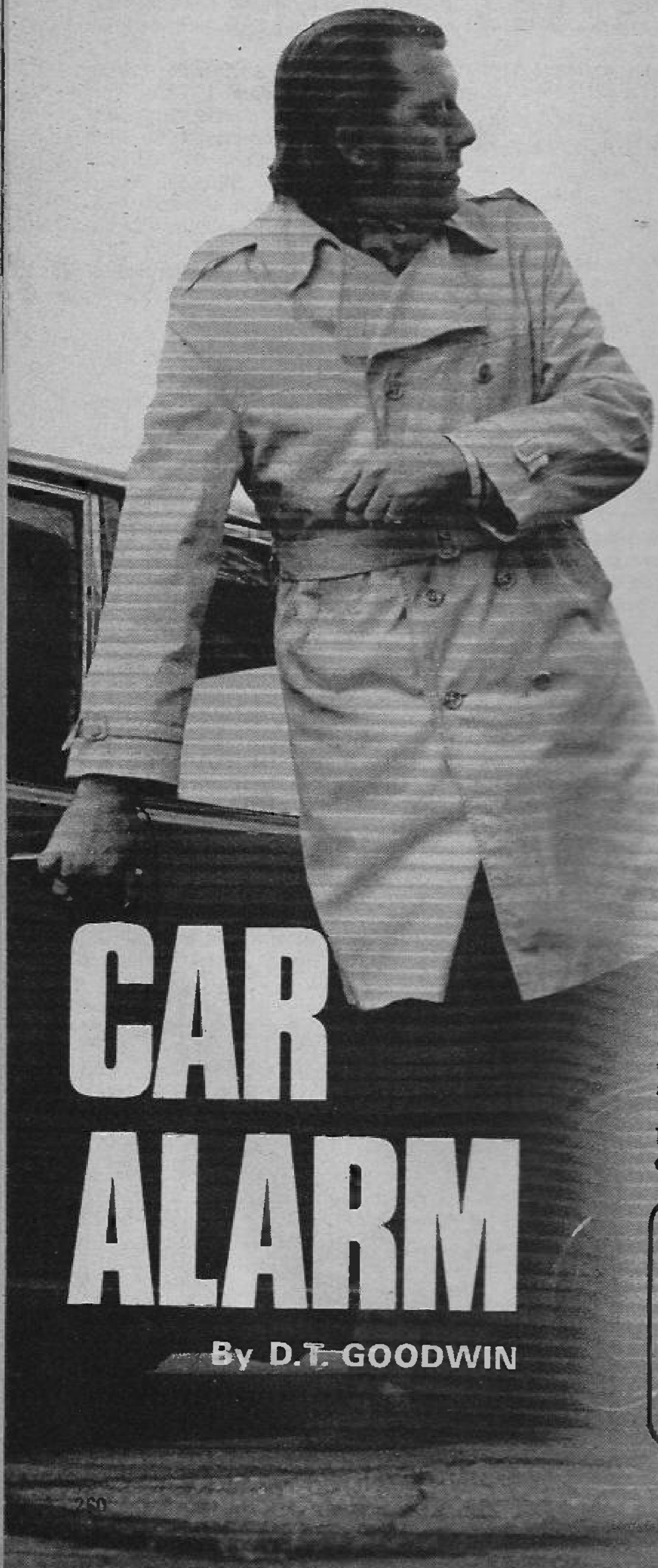
The *Car Alarm* components should not provide any undue difficulty. The prototype unit shown in the photographs used an enclosed preset for one of its controls, but this is not essential and a skeleton type will do just as well.

A suitable heavy duty relay may require some looking for, but most of the larger suppliers should have something to suit with approximately the correct coil resistance. Suitable extra switches for bonnet and boot may be required and either microswitches or normal courtesy light door switches can be employed. The latter should be available from a garage.

## *M. and L.W. Tuner*

The special coils and transformers for the *M. and L.W. Tuner* are all available from Denco. A cheque or P.O. for £3·85 and an order for their parts as listed should bring results. A trimming tool type TT5 is available for an extra 22p if ordered with the other components—prices include V.A.T. and postage. Denco are at 357/9 Old Road, Clacton-on-Sea, Essex.

Incidentally, we should make it clear that it is simply not possible to build a superhet radio for less than the cost of an equivalent Japanese set. Thus we cannot say that you will be saving money by building this design, but we have been asked to publish one by many readers and hope that they will learn from the construction and have the satisfaction of completing a sensitive design that will make an excellent addition to any amplifier.



# CAR ALARM

By D.T. GOODWIN

## A simple circuit for the protection of your car.

WITH the number of car thefts increasing daily a simple and effective car alarm is becoming a necessity for every car owner. This article describes just such an alarm. The circuit is extremely easy to construct and it's time delays are adjustable for personal requirements. It is quite a small device and thus can easily be concealed under the dashboard.

### *CIRCUIT ACTION*

The heart of the alarm circuit is simply a large capacitor C1 which controls the voltage at the base of TR1 (see Fig. 1) and thereby the state of the relay RLA. The alarm is triggered by any one of the door, bonnet or boot switches being made by the would-be thief entering the car. When a switch is made the capacitor begins to charge up through VR2 and D1, the rate of charge being set by VR2.

When the voltage across C1 reaches a certain level (the switching voltage of the relay (8V)) RLA1 switches on, activating the car horn. When the switch is opened again the horn will continue to sound, this is because the holding level (3V) of the relay is much less than the switching level (8V). When the door is closed the capacitor will begin to discharge through VR1, the rate being dependent on the setting of VR1, and when the voltage across C1 drops below the holding voltage the alarm will switch off.

The low resistance of the relay coil is isolated from the capacitor circuit by the super-alpha pair TR1 and TR2, this configuration having a high input impedance and thus drawing only a minute discharge current. Because of this the discharge time is virtually solely dependent on the value of VR1 and is adjustable from zero up to minutes depending on the value chosen. In this circuit the maximum VR1 setting is 10 kilohms and thus the maximum hold-on time is only about a minute, but with no resistor across the capacitor (i.e. only the super-alpha discharge path) the relay will stay latched for about ten minutes.

The purpose of the switch on delay introduced by VR2 is to enable the owner to open the car door and immotivate the alarm on entering

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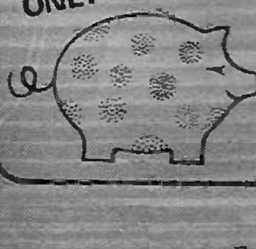
**OF COMPONENTS**
**including V.A.T.**

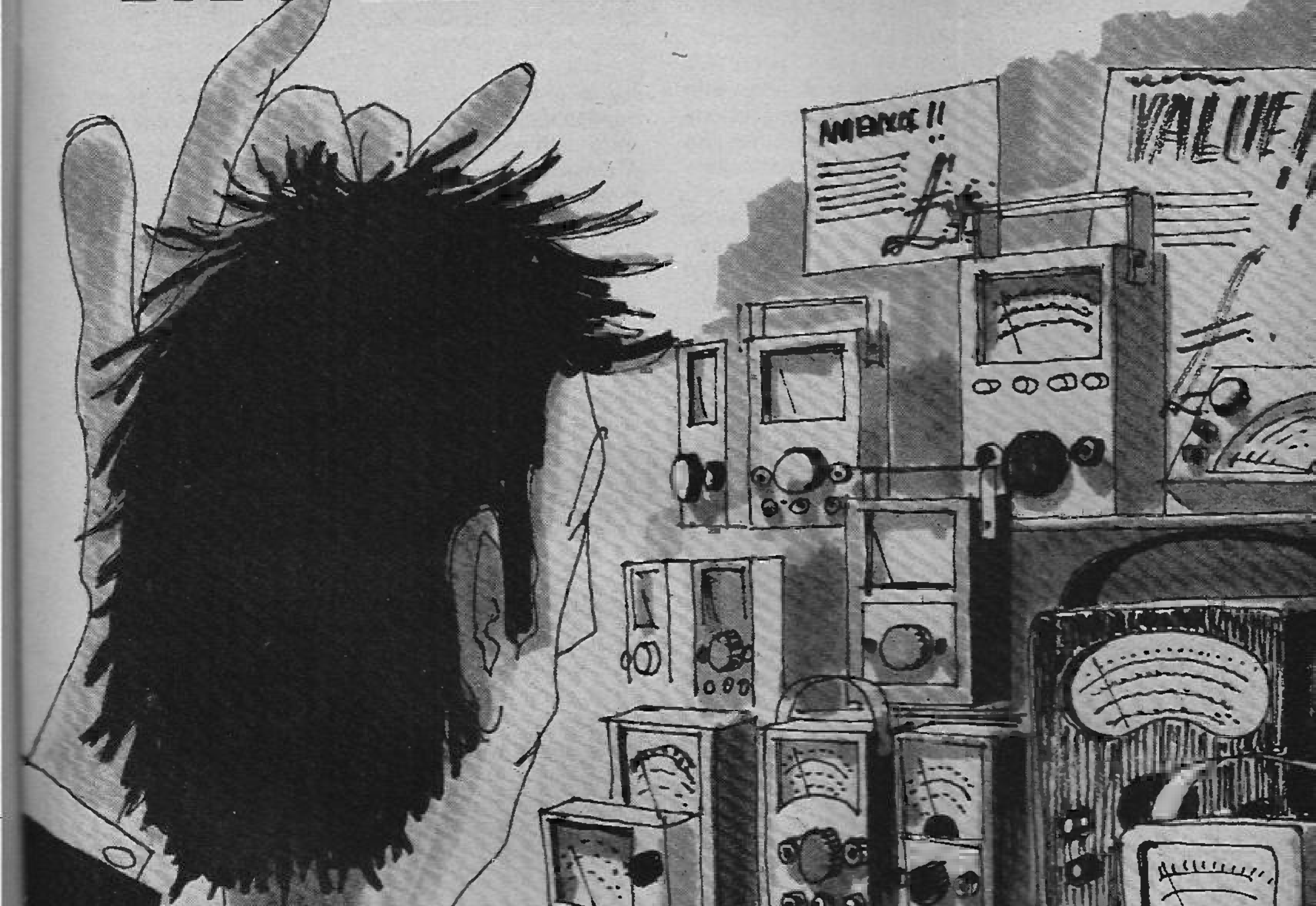


**£2.90**

*Based on prices prevailing at time of going to press

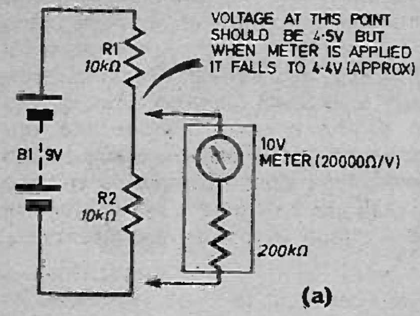
SPECIAL SUPPLEMENT

# Choosing and using MULTIMETERS



WHEN starting into the hobby of electronics there are comparatively few essential items to possess. Of course, a soldering iron, pliers and side cutters are taken for granted and nobody would deny that these are essential. Test instruments, on the other hand, are expensive and as far as possible one has to do without unnecessary luxuries. We, however, feel that there is one instrument that no constructor should be without; it is the multimeter and should be considered as essential a part of the tool box as a pair of pliers.

Very few hobbyists are able to get away with



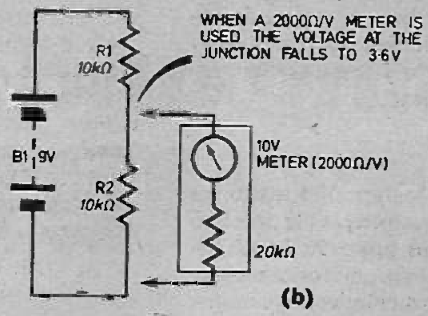




**Fig. 1. The 20,000Ω/V meter would read about 2 per cent low (a). Whereas the error would be over 15 per cent if a 2,000 Ω/V meter was used (b).**

many projects working absolutely correctly first time—there are often dry joints to locate, connections left off, transistors put in the wrong way round and sometimes (we hope not often) some components have values other than their markings suggest.

Whether you are a newcomer to the business or an "old stager" there is only one instrument that can help you sort out problems like these; without the multimeter the only way to carry out "get-it-going" tests is by a process of guesswork, component substitution and luck.

Even with a test meter you need a good supply of the first and last of these commodities but the less unsoldering and re-soldering of alternative value components the better—it spoils the circuit, is time consuming and can be a very frustrating job.

## TYPES

To follow up our statement that a multimeter is as essential as a pair of pliers or a soldering iron, have a brief look through the advertisements in our pages and, if you like, count up the number of different types of meters, pliers and soldering irons that are advertised and we bet you will find that the meters greatly outstrip the others—and they would not be advertised if the suppliers did not feel them to be essential!

The great proliferation of different types of meters presents the newcomer with a problem to decide which one to go for. Some are big, some small, some cheap, some expensive; some claim to have all sorts of fancy adjuncts while others look positively tame in comparison. We hope that the first portion of this supplement will throw a guiding light on what to look for when buying a meter and having invested your money in the ideal instrument the latter portion is designed to help you get the most out of it.

## USER

Firstly we had better specify the type of person to whom we are aiming our recommendations because different meters are sometimes offered with totally different applications in mind. We shall assume he is the average reader who will be embarking on the types of projects we publish; that he is a newcomer but quite likely will progress on to more complicated projects in years to come.

He will probably want to use his meter for other applications—e.g. on the car or house electrics and he is a practical fellow who would rather go for servicability, ruggedness and ease of use rather than ultra high precision accuracy.

One, very safe, way of ensuring one is getting the best instrument is to shop around and go for the highest price but, unfortunately, the sky tends to be the limit for this method. We must assume that the buyer is as much interested in getting value for money as any of the foregoing.

Advertisements for meters have, usually, to be brief specifications and consequently much of what we have to say may not easily be checked against such short details. By far the best method of buying is to go to a shop and have a good look at the product in real life—ask the shop assistant for sight of the full specifications of the instrument; if he is worth his salt he will realise that you need to know quite a bit more than simply the number of ranges available on the switch!

## MOVEMENT

The heart of any meter is its movement. There are two types on the market; the most common one, thank goodness, is now the **moving coil** movement and this is the one to go for. We will mention the other (**moving iron**) to advise you against such an instrument.

Unfortunately moving iron types are seldom stated to be such but there are one or two distinguishing features which can be used to identify them. First and foremost they are very cheap and are usually quite small. Instead of having totally different switched positions for a.c. and d.c. voltage their inputs are often stated as "volts a.c./d.c." and they are equipped with two sets of markings on the scale for a.c. or d.c. measurements.

If you pick one up in a shop and carefully tilt it in different directions you will find that the needle will swing away from its zero position to quite some distance up the scale and stay there for as long as you hold the tilt. The reason why we say "avoid such an instrument" is that they are invariably low in sensitivity; the needle tends to swing around a lot before settling down to a true reading and they should only be operated when placed on a flat surface. They are admirable for some applications—but not ours!

It would be unfair to dismiss a meter as a moving iron type solely on its price because, fortunately for us, the cost of moving coil types has fallen dramatically in recent years. Even so we would suggest that meters costing in the range of two or three pounds are probably not very suitable for our type of work—and certainly would not prove a worthwhile investment to last you for years to come.

## *SENSITIVITY*

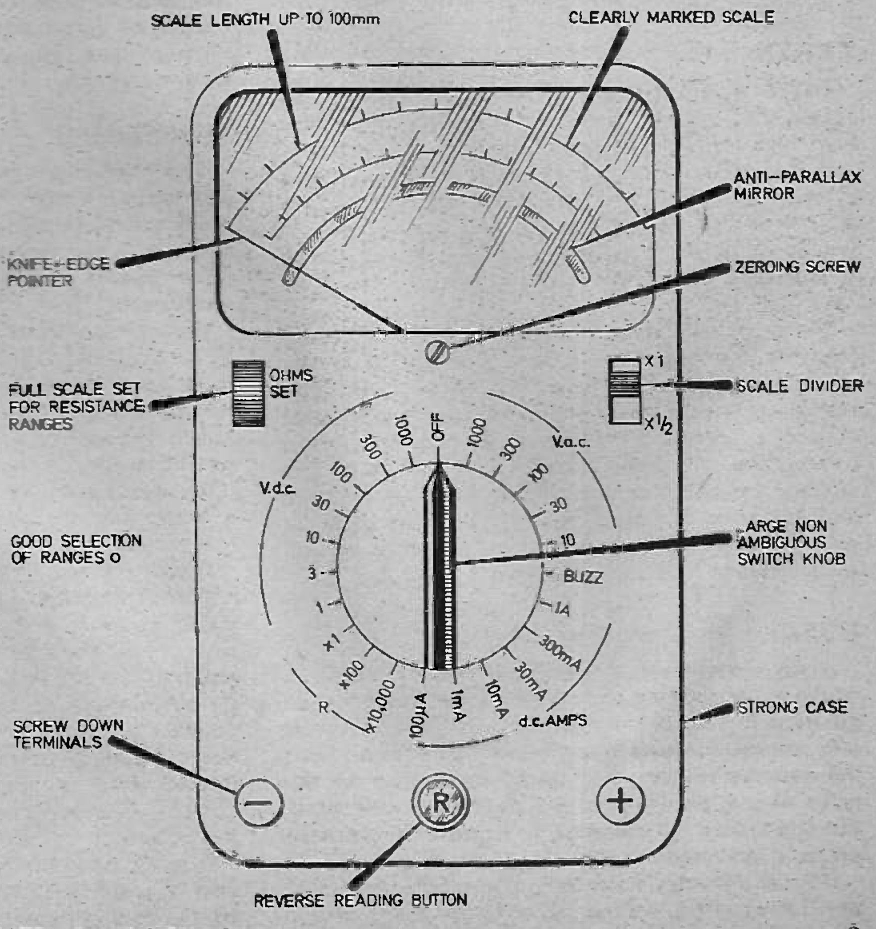
Probably the most important feature of a meter for electronic applications is its sensitivity. This is specified by the unusual units of **ohms per volt**. Ohms per volt (Ω/V) represents the total internal resistance of the meter when switched to a particular voltage range. For example if you have a good meter having a sensitivity of 20,000 ohms per volt and switch it to a 10V full scale range then its internal resistance will be 10 x 20,000 or 200 kilohm.

If you then were to measure the voltage across the bottom resistor of a potential divider as shown in Fig. 1—the meter is, in effect, connected in parallel with the lower of the 10 kilohm resistors and thus modifies the resistance in the lower leg of the divider. As the meter's resistance is 200 kilohm there will be very little change to the effective resistance of the potential divider—the bottom leg becomes 9,525 ohms instead of its original value of 10 kilohm.

The voltage drop that you are measuring across the bottom resistor will therefore be slightly less than the 4·5V you would expect; nevertheless the difference is so small that it is negligible. If, however, you had used a meter having a lower value of ohms per volt (say 2,000) then its internal resistance, when switched to a 10V range, would be 20 kilohm and this would have a very significant shunting effect on the bottom portion of the potential divider and you would obtain a much lower voltage reading than expected. Obviously the higher the ohms per volt of a meter the less likely the instrument will modify the parameters of the circuit which you are measuring.

We used the word "sensitivity" to describe this parameter and at first sight this does not seem to accurately describe the effect. If you remember that a moving coil meter measures voltage by having a resistor in series with the basic movement then all should become clearer. The internal resistance is governed by the value of this series resistor—plus the relatively insignificant resistance of the movement's coil.

Obviously the higher the series resistor the better—as we have just seen—but with a very high value of resistance the amount of current flowing through the coil will be very small and this calls for an extremely sensitive basic meter movement (possibly responding to a small fraction of a milliamp). For a 20,000 ohm per volt meter the series resistance on the 10V range will be 200,000 ohms so to get a full scale deflection when measuring 10V the meter




**The type of meter to aim for when buying. The availability of all the facilities shown may not be possible in low priced meters.**

movement must have a full scale deflection of 50µA.

Always buy a meter having at least 20,000 ohms per volt sensitivity (some go as high as 50,000 ohms per volt!). Most advertisements state this parameter but if it has been omitted you can check very quickly by looking for its highest sensitivity range on current. Many multimeters allow you access direct to the terminals of the movement when you switch to the most sensitive current range and if this is marked as 50µA then you have a high sensitivity instrument.

If the most sensitive current range is only 1mA it does not necessarily mean the meter has poor sensitivity but unless a high ohms per volt value is quoted you should be very suspicious.

## *ELECTRONIC TYPES*

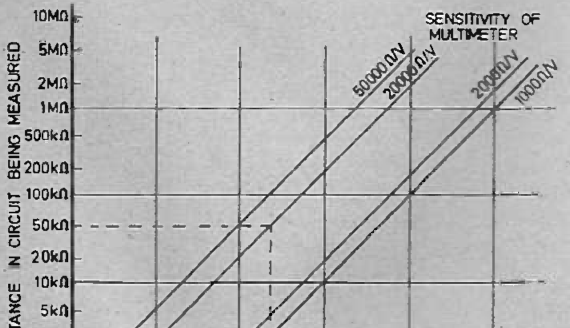
Some multimeters are quoted as having exceptionally high input resistance values—sometimes several megohms per volt. These are most likely electronic meters—comparable to the older valve voltmeters. The high input resistance is obtained by having an internal voltage amplifier.

While such instruments are very good indeed they are at the higher end of the cost spectrum and generally speaking offer more than the normal amateur wants—unless he intends to go very deeply into the subject.

## *ACCURACY*

Some people wrongly expect a meter to be accurate to the ultimate degree. While it may be nice to think that the reading you get is accurate to a fraction of a per cent, what are you prepared to pay for it?

Normally we are only interested in using a meter to check approximate values of voltage in a circuit and seldom would one raise one's eyebrows if a correctly indicated voltage was off that specified by up to 10 per cent. We hasten to add that we are **not** advocating 10 per cent accuracy meters but are trying to illustrate a point.




**Graph showing maximum advisable resistor value across which you should measure. Example shown dotted—for a 20,000 Ω/V meter on 30V range maximum value is 50kΩ**

Further than this you must remember that with normal sized scales it is almost impossible to read a meter to better than plus or minus 2 per cent. A small pocket meter might have a scale length of 50mm—to read this to an accuracy of 2 per cent is equivalent to using a ruler and measuring a length to 1mm.

Obviously the longer the scale length the more accurate your reading will be. It is unusual for amateur grade meters to have their calibration accuracy quoted and you are in the hands of the manufacturers but generally speaking if you pay in excess of £7 you can expect better than 2 per cent and if the scale length is in the order of 50-100mm you can be assured that your reading accuracy approximately matches the latent accuracy of the meter.

There is no point in going to a larger scale length meter—at a much higher price—unless a calibration accuracy of better than 1 per cent is quoted.

## *RANGES*

When looking at different types of meters one can easily be confused by the large proliferation of different switchable ranges but when you actually come to look at the differences you will probably not see much to choose from. Certainly you must have a reasonably good selection of ranges.

The meter should provide you with means of measuring with some confidence from about 1V full scale to about 1,000V full scale for d.c. voltages. This means ranges similar to: 1, 3, 10, 30, 100, 300, and 1,000V d.c. For alternating voltage you need not be quite so fussy because, on the whole, you will only want to be checking the outputs from transformers or mains voltages; 10V, 30V, 100V, 300V and 1,000V a.c. would suffice (in most cases the 1,000V ranges could be dispensed with for the sake of cost).

You do not often need to measure current but it is useful to have a few d.c. ranges available. You should have no difficulty finding a meter to give you ranges similar to: 3mA, 100mA and 300mA. Sometimes a range going up to 1A can be useful but this is not so common on lower priced instruments.

Three good resistance measuring scales are most valuable. These are usually calibrated to give you mid scale readings of about 100 ohms, 10,000 ohms, and 1,000,000 ohms. Because the ranges are cramped towards the left hand end of the scale it is always convenient to switch to a higher range to bring the needle more central on the scale.

Resistance ranges are a little misleading because they are quoted for what the manufacturer regards as the highest readable resistance value on each scale. It is better to look at the centre of the ohms scale, see what figure is quoted at that position and then see that when multiplied by the factor on the switch (usually x1, x100 and x10,000) you get something near the three figures mentioned above.

If the meter has only two resistance ranges you should go for the lower two values of the above.

## *EXTRAS*

Although not essential we would suggest you give preference to a meter which has an "off" position on its range changing switch. By turning the knob to this position you will help protect the movement from mechanical damage because the switch applies a short circuit across the coil and thus damps down the needle's tendency to swing about when carried.

A "buzz test" facility is a useful little extra on some meters but is not really essential and certainly should not rate very highly on your selection list. On the other hand you should always try to buy a meter with some form of overload protection—most medium priced instruments have this embodied.

Some meters have a range "divide by two" switch which simply changes the scaling by a factor of two on all ranges. This is a useful feature and effectively doubles the number of ranges available—thus making it easier to get accurate readings around the centre of the meter's scale. This facility is worth while looking for but it is not worth paying more than a pound extra for it if a cheaper instrument has all the rest of the functions you desire.

The same can be said of a scale reversing switch—which enables you to reverse the connections to the meter without having to disconnect the leads.

## *SWITCHES OR SOCKETS*

The tendency is for low priced meters to use sockets to connect the probe leads to the instrument. These certainly help keep the prices down but after a period of use can suffer from loose and dirty contacts which give rise to erratic indications. It is, perhaps, expecting a lot but we would ideally recommend screw down terminals for connecting leads to meters. These are found on the more expensive of the middle price range instruments.

There is, however, a point in favour of the socket input variety; they enable the manufacturer to give you a few extra facilities at virtually no extra cost e.g. a capacitively coupled input to measure low frequency a.c. signals superimposed on d.c. levels (useful for checking r.m.s. signal levels of audio at loudspeaker)

They also allow extra high voltage inputs—up to several thousand volts. It is doubtful that you would wish to use these options very frequently so you ought to weigh up the pros and cons yourself.

If you get a chance to study the instrument in real life before you buy it make sure that it is mechanically robust. Lightweight plastic cases are very liable to break so if you feel that its enclosure it is a bit flimsy check to see if there are any leather cases designed to go with it—a carrying case is very useful because it enables you to keep the leads and any other accessories with the meter.

Have a close look at the calibration of the scale; it should be clear and legible and preferably different ranges should be printed in different colours to prevent ambiguities in reading. If you are interested in accuracy of reading make sure that the pointer is really thin like a knife edge and that there is an anti-parallax mirror running round the scale.

In conclusion we suggest you go for a straight-forward meter that is robust and easy to use. Unless you are wealthy it is best to avoid too many gimmicks like transistor testing sockets, internal signal generators, buzz tests etc. To help a little, here is a check list with *our* opinion of the order of priorities you should put on the selection:

1) Must be moving coil movement
2) Sensitivity of 20,000 ohms per volt or greater
3) Should have good length scale (about 100mm)
4) Should be robust mechanically
5) Overload protection should be present
6) Should have switched ranges which overlap
7) D.C. voltage from 1V to 1,000V
8) Resistance measurement should be split over two or three ranges
9) A.C. voltage from about 10V to 1,000V
10) D.C. current from a milliamp to about 1A
11) An off position on the range switch is useful
12) A leather case should be available
13) Screw terminals are preferable to sockets
14) Extras like buzz testers, scale reversal switches and scale range dividers are useful

# USING

WE'LL assume you have bought your "ideal" multimeter; the following paragraphs will give a few hints about how to get the best use from it.

Your meter is a delicate instrument and has probably cost a lot of money. It is probably your only way of checking what is going on inside an electronic circuit and should be regarded as an extension of one of your own senses so take very great care of it.

## *GENERAL CARE*

Avoid subjecting the meter to knocks; if you do accidentally drop it always check that it is functioning correctly by measuring a known voltage or a known value of resistance—the chances are that the only damage sustained by a drop is to the movement and provided it gives a correct reading on one range you can be fairly sure that all other ranges are working correctly. When carrying out this check make sure that the needle moves up the scale smoothly without any jerks and that the tip of the pointer has not been bent by the impact.

Keep the meter away from magnetic fields as these will tend to de-magnetise the movement's magnet and cause the calibration to change (the meter will start to read low). Avoid keeping it in dusty or damp conditions—if you do not have a leather case for it, keep it in a shoe box together with all its leads and probes and, in particular, keep it out of the hands of small children.

You should keep all the connecting terminals clean and free from grease and dirt — this is particularly important if access to the meter is via sockets.

When putting your meter away after use always check that you have not left it switched to a resistance measuring range (otherwise you might run down the internal batteries if the leads were to short together). Preferably switch the meter to the off position if one is available. Failing that switch to the highest current measuring range (the internal shunt will provide a short across the movement). Do not transport the meter if it is switched to a sensitive current range.

Every month check the condition of the internal batteries and at the slightest indication of deterioration remove them. If you do not intend to use the meter for some length of time it is a wise move to take the batteries out. Leaking batteries can totally ruin a multimeter by corroding the switch contacts and leaking into the movement itself.

## ZERO AND PARALLAX

Before and after each reading (whether on d.c. or any other range) always check that the needle comes to rest exactly on zero. If it does not, give the meter a gentle tap with the finger—some plastic meters can pick up a static charge and this sometimes causes the needle to be deflected slightly from its true position

If a gentle tap does not correct the zero reading you should carefully adjust the zero setting screw on the front of the movement. When doing this make sure you are looking vertically down over the needle to avoid parallax errors. **Always** carry out zeroing when the meter is in its correct operating position (i.e. on its back or standing up vertically).

Parallax errors are caused by the slight gap between the needle and the scale and you can experience this by positioning your head so that your nose is vertically above the needle; shut one eye and then the other while keeping your head still and you will notice that the needle appears to show slightly different readings.

Better quality meters have an anti-parallax mirror which helps prevent the errors that arise from this problem. If you have such a mirror on your meter you should close one eye and then move your head until the needle and its reflection in the mirror are exactly coincident. When this happens you know that your eye is in an exactly vertical position over the needle and the reading obtained in this position is the correct one.

## POLARITY

As well as making an estimate of the voltage range you select you should likewise try to ensure that you apply the probes with correct polarity. This is usually not a very difficult thing to do but you should not be casual with the leads. Always keep the red probe on the red lead and the black on the black lead. Keep the black lead connected to the negative or common terminal of the meter and only use the red lead in the alternative input sockets. Provided you do this the meter will always read "upscale" if the red lead is connected to the more positive voltage.

If you have a scale reversing switch this should, likewise, be kept in the "normal" position and only switched to "reverse" when needed. If you do not have a reversing switch but have made a mistake in your estimate of polarity it is better to reverse your connections at the probe ends of your leads rather than at the meter because you will only have to change the meter connections back afterwards.

**Never** try switching the meter to a current measuring range while your probes are connected to a piece of equipment because it is quite possible to overload the circuit with the internal meter shunt. For a similar reason **never** switch through the resistance measuring range while connected to a circuit—not only might you damage the circuit but you could damage the meter movement.

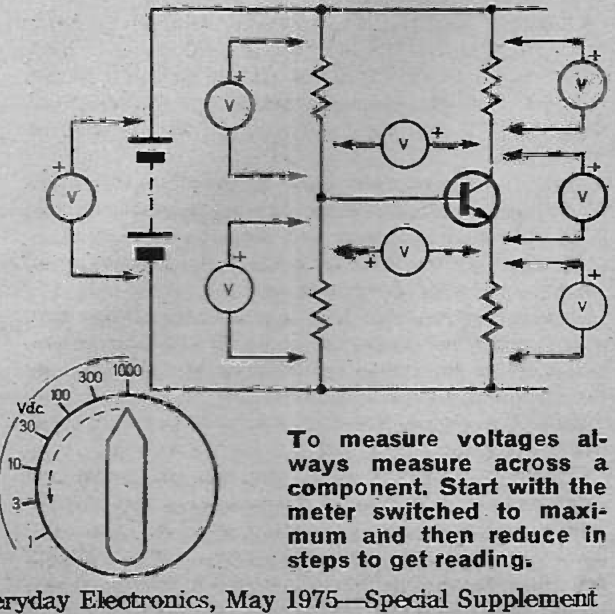
## D.C. VOLTAGES

We shall go through the principles of using each of the main ranges one finds on general purpose multimeters — much is obvious but there are a few important points that are often overlooked and these can cause errors or damage to the instrument. D.C. voltages are probably the measurements most frequently required.

It may seem obvious to say that you should switch the meter to a d.c. range but many people have found that they get readings of d.c. voltages when their meter is switched to a.c. This is to be expected if you remember that all you are doing is applying the d.c. through a rectifier.

You will not, however, get a correct reading because the meter is calibrated to give an r.m.s. value of a.c. with a duty cycle that may be half wave or full wave. The rule is never use the a.c. range when measuring d.c. and always check that you have the selector switch set correctly.

When measuring voltage you are invariably measuring the **voltage drop** across a component and the




**To measure voltages always measure across a component. Start with the meter switched to maximum and then reduce in steps to get reading.**

internal resistance of the meter can shunt the component and give a lower than true reading. Before connecting the meter across a resistor check that the value of the resistor is—at most—a tenth of the resistance of the meter when switched to the range you desire.

For example if you are measuring with the 10V range of a 20,000 ohms per volt meter the meter's resistance is 200 kilohm so you should not expect accurate indications if you measure across resistors having values greater than 20 kilohms.

If it is essential to get some sort of reading across, say, 100 kilohms you should switch the meter to the 100V range and by doing this you will increase its internal resistance to 2 megohms but your reading will, of course, be very much down the scale to the left hand side! Your reading accuracy will therefore be impaired even though the meter is indicating a more correct value.

Always make a mental estimate of the voltage you expect to see and select a range that should put your expected reading in about the middle of the scale. If you are totally in the dark about the voltage you might expect it is wise to set the meter to its highest d.c. range and then switch down through the ranges until you get a measurable reading.

**Never** start with the meter set to a high sensitivity range and switch up or you will quite likely cause the needle to hit the end stop. If the meter has overload protection you will not burn the meter out but you might cause the needle to bend when it hits against the end of the scale at high speed!

## *A.C. VOLTAGES*

The same rules apply to measuring a.c. voltages. You are most likely to be concerned with signals having frequencies of 50Hz—for example mains voltages and those from transformers. Polarity of lead connections is not important because, by definition the polarity of the signal you are measuring is changing continuously.

We must qualify this, however, because true a.c. alternates equally about zero and your meter is only calibrated with that type of signal in mind. If the voltage oscillates unevenly about zero (i.e there is a d.c. shift to the a.c.) then your reading will be inaccurate.

You can check that such a condition exists by first trying to measure the a.c. signal on a suitably high d.c. range. A true a.c. signal will show zero volts when connected thus because the meter cannot respond to the high frequency.

When carrying out this test **do not under any circumstances** drop the range of the d.c. meter selection to get a reading because you will damage the overload protection circuitry. If you have a d.c. biased a.c. signal the d.c. bias will show up quite readily without doing this.

If such a condition exists you can still get a true value reading for the a.c. by switching back to the correct a.c. range and inserting a 0·22μF capacitor (with a working voltage higher than that which you are measuring) in series with one of the meter leads. This capacitor will block the d.c. level but will pass the a.c. signal.

Some meters have this capacitive input option built in and if so you should simply transfer the red lead to the socket thus marked. Also some meters have this socket marked "output"—not because anything comes out of the socket but because the facility is usually required for making measurements across loudspeaker output terminals where a.c. audio signals are often superimposed on d.c. levels. This special capacitative input will only operate when the meter is switched to an a.c. range.

## *INSULATION*

If ever you use your meter to measure mains voltage you must check that there is no possibility of you personally coming into contact with any of the terminals. This goes for the probes as well as the sockets or terminals on the meter. The probes **must** be fully insulated and tested to withstand voltages in excess of 1,000V. Unless your meter states this fact in its book of instructions do not attempt to use the probes across a mains socket!

For safety reasons **never** leave one probe of your meter connected to a source of high voltage and the other probe lying on the bench; if you accidently touch the metal contact of the loose probe you could get a shock. If you, or a child, inadvertently switched the meter to a current measuring range while this state of affairs existed there would be virtually no limiting resistor in the meter to protect you from a **lethal** shock.

For convenience and, again, safety you should—as far as possible—always use long insulated probes with spring loaded hooks. Because they are insulated right down to the small hook there is very little chance of them shorting across parts of a circuit you do not wish to touch and at the same time they are very easy to apply to the ends of small components.

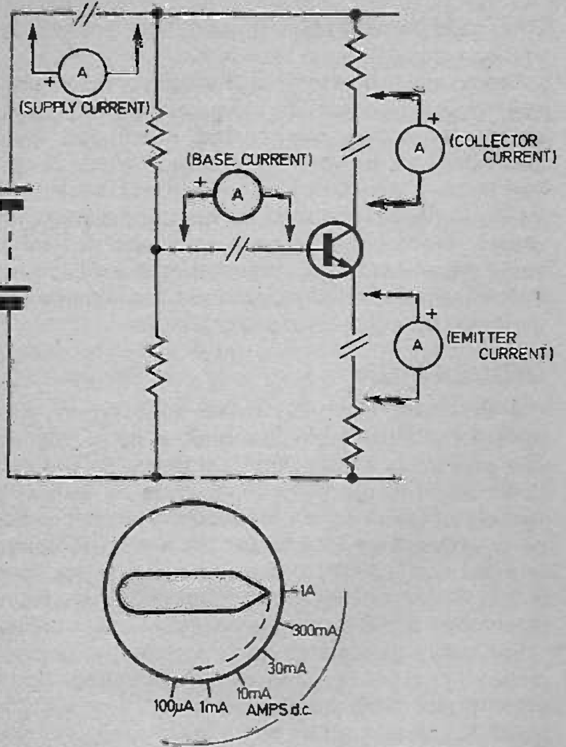
Crocodile clips ought to be avoided. Better quality meters are provided with probes such as the type we describe but if not they can be obtained from most electronic suppliers.

## *AUDIO MEASUREMENTS*

Although most a.c. measurements are likely to be carried out on 50Hz signals you can usually get useful readings on the a.c. range of most meters up to a few kilohertz, hence they can be used to measure the a.c. audio signals feeding loudspeakers as we have just explained.

Do not expect precision readings and remember that you cannot hope to measure signal levels of less than about 0·25V on normal meters when operating in this mode. There is, of course, the same limitation on the maximum impedance of the voltage source—as for the maximum resistance in d.c. measurements.

Most meters have a lower "ohms per volt" when measuring on a.c. and this should be taken into account. Even though some crystal cartridges give outputs of up to 500mV you cannot expect to measure this on a multimeter because the source impedance




**To measure current you must break the circuit and insert the meter across the break. Start with the highest range and reduce in steps to get a reading.**

is far too high—you would need a valve voltmeter or a transistorised multimeter for this purpose.

## *CURRENT RANGES*

When measuring d.c. current you have to break the circuit and insert the multimeter in series with the wire down which the current you wish to measure is flowing. The red lead of the meter should be connected to the **positive** source of the current and initially you should always set the meter to its maximum current range. While viewing the scale reading you should then increase the sensitivity of the meter in steps with the range switch until you get as near a mid scale reading as possible.

Remember that by putting a current measuring meter in series with the power supply rail of an amplifier you are, in effect, introducing a series resistor into the circuit you are measuring—in the case of amplifiers this can sometimes degrade the performance of the circuit and in the worst of cases can cause oscillations to start. To prevent this happening you must keep the meter set to the highest current range possible (commensurate with getting a useful reading) because that way you are operating with the lowest value shunt resistance in the series circuit.

Some of the more expensive meters are equipped with a.c. current ranges. These are not often required in electronics work (they are more suitable for electrical engineers) but they should be used in exactly the same way as the d.c. ranges but the polarity of lead connection is unimportant.

## *RESISTANCE*

Using the resistance measuring ranges is fairly straightforward. The main point to remember is that you must—**before every measurement**—short the probes together and adjust the resistance range control so that the needle points to zero ohms on the top end of the scale.

If you change ranges you must remember to re-adjust this control because its setting will vary from one range to another. Select a range that will keep your readings as near the top end of the scale as possible—this way you will obtain the highest accuracy.

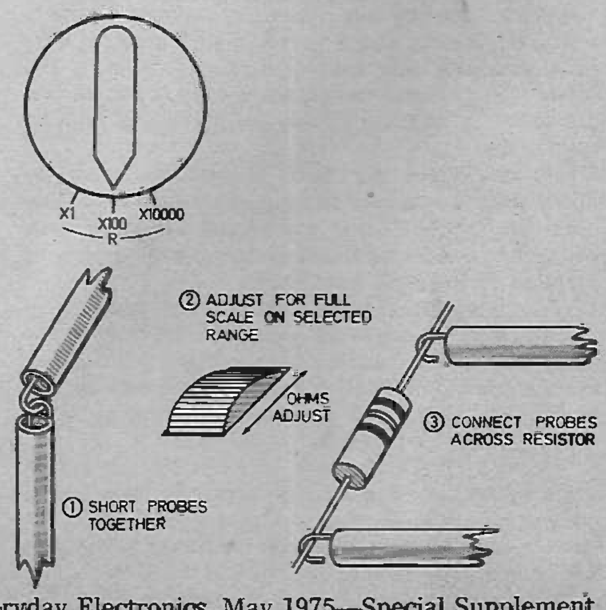
When using the resistance range for continuity testing you should make sure that you select the **lowest** resistance setting of the switch—you are then more likely to see the resistance caused by dry joints and dirty contacts—which may only be a few ohms.

Apart from resistance and continuity tests you can use these ranges for a quick check on transistors, capacitors and diodes. (An article concerning checking of these devices will be published in a future issue of EVERYDAY ELECTRONICS).

You must remember that there is a battery inside your meter which comes into play when you switch to the resistance ranges. The polarity of this battery is such that its positive terminal is effectively applied to the black lead which comes out of the meter.

The simple rule is that "positive comes *out of* the black lead"!

**When measuring resistance, lead polarity is not important. Select a range between the middle and top of the scale and multiply the reading by the factor on the switch.**



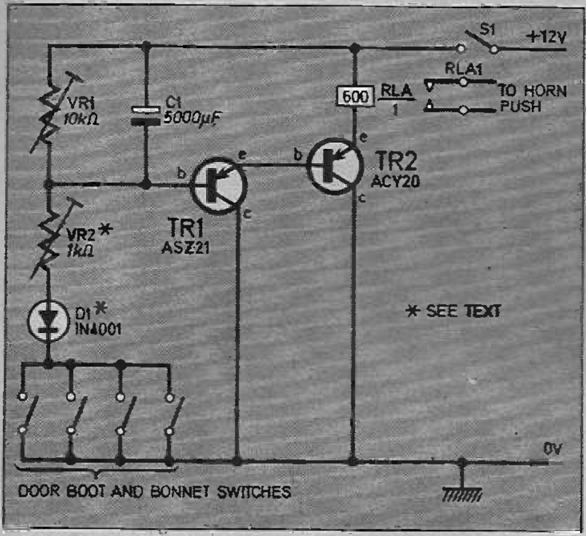



**Fig. 1. The circuit diagram for the Car Alarm.**

the car. This is made possible due to the fact that there is a considerable difference in the time taken to open the door and switch the alarm off and the time taken to open the door and get in; VR2 is set about mid-way between the two times.

An alternative to this is to use a locking switch mounted on the car exterior as the main on/off switch and replace VR2 with a low value resistor, say 100 ohms (necessary to protect the capacitor). The key-operated switches should be readily obtainable from most car spares dealers.

## SWITCH WIRING

If the courtesy light switches are to be utilised for SW1 the wiring is extremely simple. However, the bulb presents a low resistance path across the capacitor which rapidly discharges it; to avoid this a diode (D1) is wired in series with VR2 as shown.

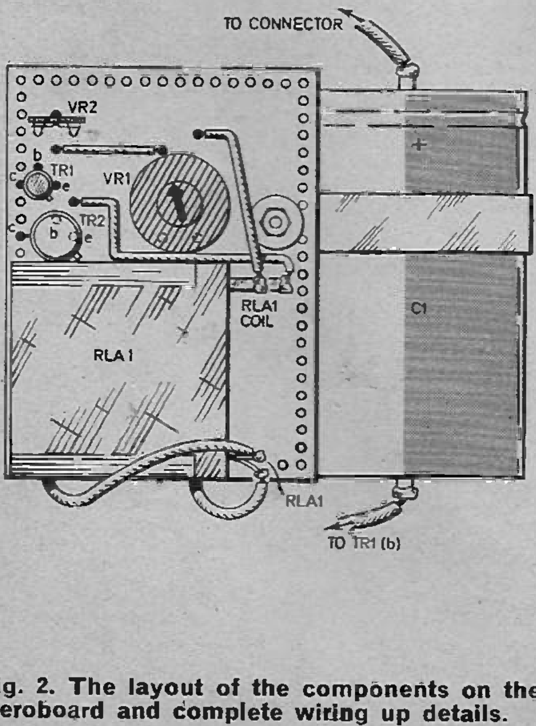
To connect the unit, a wire is run from the switch side of the bulb holder to the circuit board. The switch side can be found by looking at the switch in the light unit which will be in parallel with the door switches.

If however the existing switches are not going to be used or if the system is extended to cover the boot, and bonnet, etc., then simple push-to-break switches can be used. These can be mounted on a metal bracket screwed to the door frame such that when the door is closed it pushes the switch and opens the contacts. The switches are all wired in parallel, one side being taken to the car earth and the other being taken to the circuit board input. The mounting plates should be positioned so they do not obstruct normal use of the door.

## CIRCUIT CONSTRUCTION

The whole circuit is constructed on a piece of 0·15 inch matrix Veroboard, 22 holes by 17 strips, and the layout is shown in Fig. 2. A connection block is glued to the board to make wiring the circuit in much simpler, all external wiring is then taken to this block. The circuit is held in the car with a circlip mounted around the capacitor.

Commence construction by cutting the board



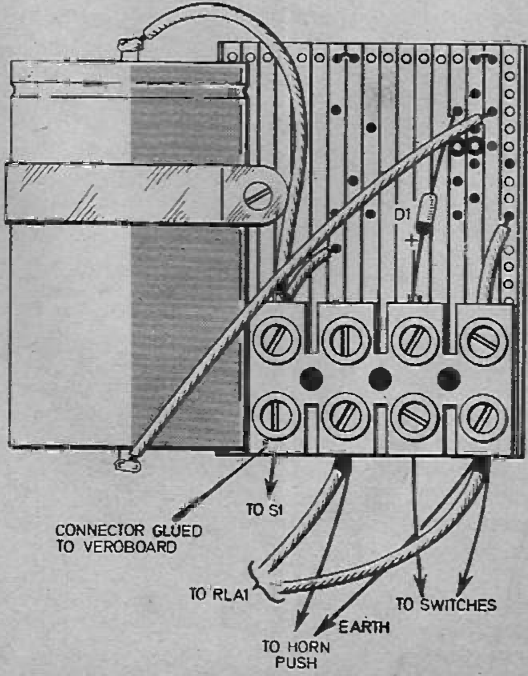




**Fig. 2. The layout of the components on the Veroboard and complete wiring up details.**

to size and making the necessary breaks in the copper strips, as shown in Fig. 2. Next mount C1 and the connection block and finally the remaining components and connection wires. Take care not to overheat the transistors when soldering.

If RLA1 is much larger than that in the prototype a bracket may be needed for its fixing. The circuit diagram (Fig. 1) is for negative earth systems. For positive earth cars simply change TR1 and TR2 to 2N2483 and 2N1306 respectively (*npn* types) and reverse the connections to C1 and D1, i.e., change positive to negative in Fig. 2 by placing the components the other way round.

### EXTRA SECURITY

The positioning of the on/off switch is obviously most important, it can be either hidden or camouflaged. Personally I prefer camouflage; if the master switch is placed in a row of other switches and mounted such that when it is up it is on, and when it is down it is off, then it will be fairly well concealed once activated.

For extra security two more switches can be incorporated. One of these should be wired in parallel with the door switches so that anyone trying to fiddle with the switches will prolong the alarm or, if the timer has timed out, restart the alarm. The other is used to short out the contact breaker points and is wired the same way round as the on/off switch such that up is on. This is used as a last line of defence should the would-be thief get past the alarm.

### SETTING UP

When setting up the timing periods it is advisable not to have the horn connected. The switch-on time should be just enough for the driver to get to the master switch and turn it off before the alarm is triggered. The switch off time is up to the driver but it should not be too long or it may drain the battery.

A cautionary note about the values chosen for the preset potentiometers. As should be clear from the circuit diagram VR1 and VR2 form a potential divider thus limiting the voltage to which the capacitor is allowed to charge, therefore care must be taken to ensure that the VR1: VR2 relationship is greater than 3:1 otherwise the capacitor will never charge up to the switch on voltage of the relay.

The horn connection can be taken to the horn push button for ease of wiring.

Wiring from RLA1 to the horn should be of heavy duty wire e.g. 14 strand insulated. ■

## Components....

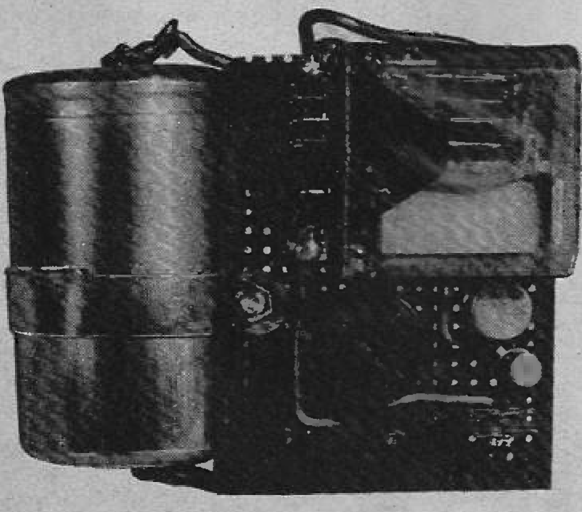
**Potentiometers**
VR1 10kΩ miniature or skeleton preset
VR2 1kΩ miniature or skeleton preset

SEE SHOP TALK

**Capacitor**
C1 5,000 μF elect. 24V

**Semiconductors**
D1 1N4001 silicon diode
TR1 ASZ21 silicon *pnp* (negative earth)
2N2483 silicon *npn* (positive earth)
TR2 ACY20 silicon *pnp* (negative earth)
2N1306 silicon *npn* (positive earth)

**Miscellaneous**
RLA1 12V relay 600Ω (approximately) coil with at least one set of normally open heavy duty contacts.
S1 s.p.s.t. toggle switch—dash type if required (see text).
Veroboard 22 holes by 17 strips by 0·15 inch matrix, 5A 4-way connection block, circlip for C1 and board mounting, connecting wire.



**Photograph of the completed prototype Car Alarm.**

## PLEASE TAKE NOTE

**The battery specified for the *Quiz master* (April '75 issue) should be a 6V type, not 9V as stated. This can be four U7 batteries (1·5V each) in a plastic holder connected by the PP3 clip.**

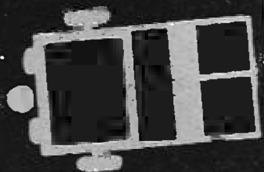
**Some recent issues of EE have been slightly oversize and may not fit in the binder, to overcome this, slightly trim the top of each issue near the spine.**

**In Part Two of the *Modula 3* (EE March '75) Fig. 9 shows two C9's. The one on the right should be C10. In the text under Preamplifier Wiring, page 120, the tape input pins are incorrectly numbered 6 and 7, this should be 6 and 17.**

# *All in* NEXT MONTH'S *issue!*

## WHITE LINE FOLLOWER

Not only an interesting and unusual exercise in electronic construction, but also an introduction to simple control systems.



## MULTIMETER SENSITISER

A simple add-on unit that can increase meter sensitivity from 20,000 ohms volt up to 10,000,000 ohms/volt. Provides three d.c. voltage ranges each with increased sensitivity.

*It's not my fault!*

## FAULT FINDING FEATURE

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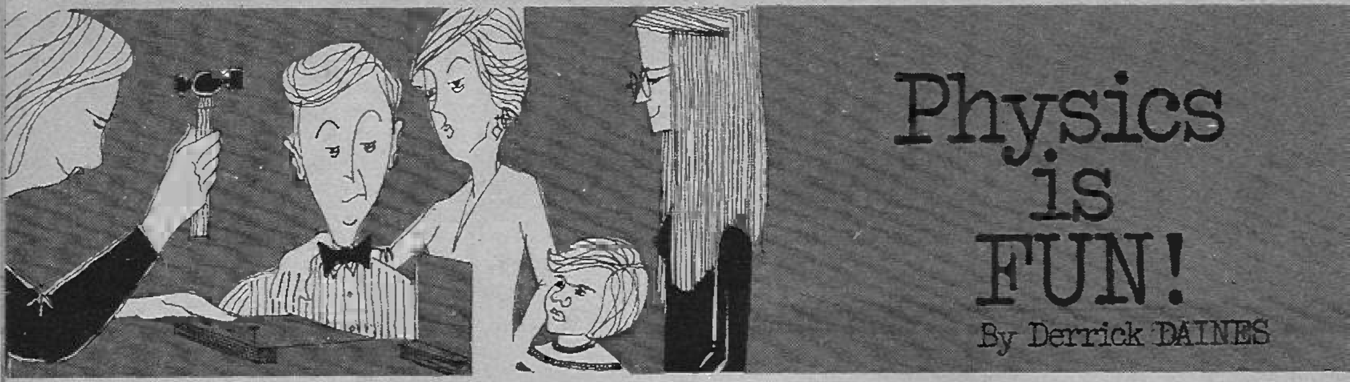


# Physics is FUN!

By Derrick DAINES

## MORE ON THE HOME-MADE CAPACITATOR

Cut each of the two plates so as to make four equal-sized plates. We now have two complete, but smaller, capacitors. Now consider the following question—if we link the capacitors with wire as in Fig. 1, will the total charge that we can put on the combination be greater or less than on one capacitor alone?

The answer is obviously greater—twice as great, in fact. A few minutes experiment will convince you of this, if you cannot see it immediately.

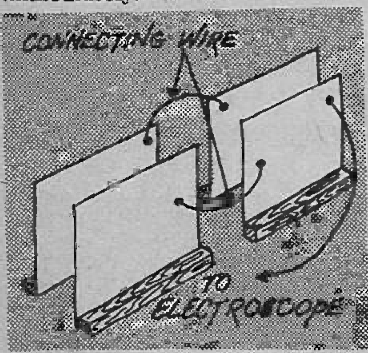



**Fig. 1. Linking two home-made capacitors so they are in parallel.**

If you now consider Fig. 2, you will see the similarity between this and Fig. 1; Fig. 2 uses the symbol that we use for a capacitor. You will see that there are two and that they are in parallel. From this we deduce the simple fact that:

**Capacitators in parallel are added together**

In formal terms, we may write $C_1 + C_2 = C_{total}$ and the same holds no matter how many capacitors we put in parallel. Therefore if we have a 100 microfarad capacitor and a 50 microfarad capacitor in parallel, the resultant value is 150 microfarads.

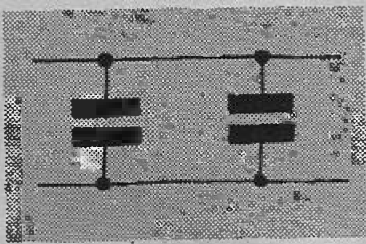


**Fig. 2. How two capacitors in parallel are represented by circuit symbols. Compare this with Fig. 1.**

Now consider Figure 3. Here the capacitors are no longer in parallel, but in series; what could their value be? If you duplicate the set-up with your four plates of the home-made capacitor, you will find to your surprise that the whole thing is more easily charged than with one pair of plates alone.

Conduct the experiment this way: have one plate connected to your electroscope and another to earth. Between them put another pair back-to-back but electrically connected. Now charge a film by rubbing it with wool and bring it up to the electroscope needle. Repeat as often as necessary until the leaves of the electroscope fly apart and remain apart when the film is removed. The pair of capacitors are now charged.

Use an insulated rod to push the two centre plates out of the way and the earthed one near to

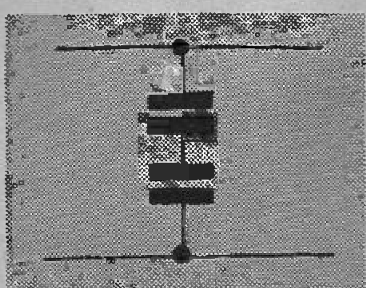


**Fig. 3. Circuit symbol representation of two capacitors in series.**

the one connected to the electroscope. The leaves of the electroscope will have collapsed and will remain collapsed.

It may be argued that we have removed some of the charge with the centre plates, so as an alternative, try counting the number of times a charge must be brought up to the electroscope, both with the centre plates in and without.

With our limited means we cannot accurately determine the value of capacitors in series. Finer methods have, however, determined that the value is:

$$\frac{1}{\frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \cdots}$$

So for 100 microfarad and a 50 microfarad capacitors in series, the result is 33·3 microfarads, which is smaller than either.

One interesting point arises when we stop to ask ourselves what exactly the electroscope is showing. It cannot be the quantity of electricity because in many of our experiments the quantity held in charge remained constant but the electroscope changed its indication. Clearly, what it shows is the *pressure* or potential charge. This is known as the voltage (after Volta) and can reach many hundreds of volts even with our simple equipment.

When we consider that the sometimes lethal household supply is normally 240 volts, the prospect of many hundreds of volts can be frightening. However, we have not had any more than a faint tingle from our equipment, so obviously the *quantity* of electricity is the vital factor.

We apologise for an error last month where it was said that all capacitors are electrolytic. It should have said all capacitors have a dielectric. An electrolytic capacitor is one in which "electrolysis" takes place when charge is stored.

# for your Entertainment...

By Adrian Hope

Out of a combined sense of duty and pleasure I went along and saw the film *Earthquake* at the Empire Cinema, Leicester Square. Probably "subjected" myself to the film would be a better description.

By now everyone will know that this film is a feature film starring Iron Jaw Heston and the work of just about every special effects man in Hollywood. In remarkably convincing detail it pre-constructs what will happen to San Francisco when the inevitable earthquake finally comes.

Readers will also doubtless know that the events on screen are accompanied by off-screen noises as have never before been heard in the cinema. Three American inventors (W. O. Watson, Robert Leonard and Richard Stump) have devised for Universal Pictures a sound effects system that simulates the sound of an earthquake. Having, fortunately, never been in an earthquake, I have no idea whether the sound is authentic but it certainly is dramatic.

I took along a sound level meter and deliberately sat fairly near the front of the cinema, in between the two massive black boxes that stand one each side of the screen. Two more similar boxes lurk at the rear of the cinema, rather like the four speakers of a mammoth quadraphonic set-up.

## SOUND LEVELS

During the earthquake sequences the *Sensurround* equipment (for that is what the system has been christened) generates low frequency rumbles which not only assault the audience's ears but also physically shake their bodies and their seats. In fact when the Sensurround gear is running full blast the noise level in the cinema is quite staggering. The level of speech on the screen is automatically boosted by 6dB to make it audible over the earthquake rumble and all the ashtrays in the cinema rattle in high-pitched unison.

My sound level meter reads only up to 110dBA and the pointer wrapped itself round the dial stops, suggesting that the sound level towards the front of the cinema is probably around 120dBA or even more. As the A scale favours high frequencies a true reading would be even higher!

If you need some kind of guidance as to what this means in practice, the average dBA level in the cinema is somewhere in the dBA 70s, and only the very noisiest tube train blasting into a station notches up over 90dBA. Some pop groups produce sounds at the level of 100dBA, 110dBA or even 120dBA, but in Leeds the local authority has made it illegal to make musical sounds above 96dBA.

## DANGER LEVEL

The Leeds legislation is intended to protect pop fans who regularly attend loud concerts from the hearing damage which could result from prolonged exposure to high level musical sounds. Although the Sensurround levels are very, very high it is unlikely that anyone will suffer any hearing damage because the exposure time is short. But I checked with the inventors in the USA on the frequencies used, because both very high frequencies and very low frequencies can be a special danger to the human body.

For instance, high frequencies, as used in some intruder detection alarms, can cause fatigue and irritability, even though their high-pitched whistle cannot actually be heard by the human ear. Likewise low frequencies, as may be generated in trains and cars, can cause fatigue and possibly even symptoms resembling drunkenness.

## INFRASOUND

Infrasound, as the low frequency noise is called, is in the audio range of 1 to 20 hertz. Few people are able to hear below around 20 hertz and above around 16 kilohertz.

I would like to think it is through good judgement rather than luck that the Sensurround inventors have produced a system which generates rumbles in the region of between 20 hertz and 125 hertz; in other words, outside the region of infra-sound.

Because most cinema sound systems cannot possibly cope with most of the low frequencies involved or with the high sound levels required, simple pulses are recorded on the sound tracks which trigger independent sound effects generators and amplifiers powering the speakers at the four corners of the cinema.

## PATENTS

Because patents are pending on the system, the inventors will not say exactly how they work, but I would guess that fairly straightforward, positive feedback circuits and band-pass filters are used to produce low frequency oscillations. These oscillations are amplified by equipment rated at around 750 watts and reproduced by massive, low-frequency loudspeaker horns specially made by the audio firm Cerwin-Vega.

The system was first tried out in the States with a 1,000 watt amplifier powering a 32-foot spread of horns in front of the screen at the Chinese Theatre in Hollywood. But, not surprisingly, bearing in mind the way my meter reacted to the Empire Cinema presentation, this layout was found just too violent and the horns were relegated to the corners of the cinema instead.

Everyone concerned seems quite confident that no physical damage to the audience or building can result and I hope they are right. In fact they will *need* to be right because there are plans to use the Sensurround system for future films, using the gear to reproduce other extra-high-level sounds. Like volcanos erupting, aircraft crashing or cinemas falling down under the effects of low-frequency sound waves, perhaps?

Finally, still on the subject of safety, anyone receiving a suspicious package through the post should not be lulled into a false sense of security simply because it appears too flat to contain a bomb and battery.

Explosive can, of course, be flat sheets and the half-a-billion dollars invested by the Polaroid Company in the new SX70 instant picture system currently being advertised by Peter Ustinov in the UK and Sir Laurence Olivier in the USA, have answered the bombers' prayer for a flat battery.

The SX70 camera body contains complicated electronics but not power source. Each film pack contains its own battery. These were developed by E.S.B. Inc. of Philadelphia, the company which makes Ray-O-Vac batteries. Nineteen cell-layers are compressed into a battery flat enough to fit unobtrusively into a film pack—or a flat letter.

This is obviously well known, now both to the terrorists and to the police. Thus to publicise the fact can only safeguard the public, by dispelling the illusion that only thick packages can contain letter bombs.

# ...Counter Intelligence

**BY PAUL YOUNG**

*A retailer discusses component supply matters.*

I SUPPOSE everybody must have have heard the old joke about the difference between a salesman and an engineer.

The salesman must have a very wide knowledge, so he learns less and less about more and more until he knows nothing about everything! An engineer on the other hand must specialise and therefore he learns more and more about less and less until in the end he knows everything about nothing! Exactly how the poor old component retailer (who is both) fits into all this I have not yet fathomed out, but it set me thinking about two big problems he has to wrestle with. Knowledge and stock.

## RUNNING A BUSINESS

The average small retailer will most likely have only one technical person on the premises and that is himself. Unfortunately, he is the one who is least able to put his knowledge at the customers' disposal, because he is tied up with a hundred and one other things, that running a business entails, buying, banking, wages, V.A.T., income tax and the reams of paper work. I am fortunate in having two or three technically minded friends who help me out (or more accurately, help the customers out) on Saturdays. The rest of the week, we have to leave it to the customers, to find what they want in our catalogue, list it out, with quantities and catalogue numbers, and then one of our good ladies will produce it for them.

Most of our customers are understanding and appreciate the problem, but occasionally I have the indignant one who says, "You really should have a technical assistant serving behind the counter". In extreme cases I explain that such a person's wages (even if I could find a suitable candidate) in the long run are paid by the customer, and I do not think our customers would stand for the increase in prices it would necessitate.

## STOCKING

Another problem the retailer has, is trying to keep up with all the new devices that are arriving on the market. The poor man is usually so hard pressed that the best he can do is to skim through the magazines each month, and he probably only does that to see his advert has not been left out. In an ideal world he would have time to read of new inventions, and even time to experiment with a few of them himself, perhaps even time to wish his customers "Good day". Alas, that world does not exist.

But enough of dreaming, to come back to reality let us consider the question of stock. The small retailer, and even the large one, has only a certain amount of money he can invest in stock, and with electronic components proliferating at such a fast rate, he has to make the invidious choice of stocking in width or depth. In other words if he decides to stock everything that comes along, he will have less and less of (quantity) more and more (variety) if he decides to keep narrowing his ranges he will have less and less (variety) of more and more (quantity).

I am fairly certain most of us steer a middle course; some veering slightly more one way, some the other.

## SUMMING UP

What does all this add up to for you, the consumer? Simply this. You must reconcile yourself to the fact, that you are unlikely to be able to obtain all your requirements from one source of supply, and any firm that advertises that they can supply you with everything should be regarded as suspect! In my opinion you will need to deal with at least three or four and my suggestion would be this.

Select six or seven from the magazines and send each of them small trial orders (not too small). From the results, you will be able to judge their performance both as to prices and delivery.

Do of course make allowances for the fact that any of them might be unlucky with the post. If this does happen give them a second chance. Finally, I think you will be able to narrow your choice down to one main supplier for the "run of mill" components (resistors, capacitors, transformers) and two or three for specials such as for transistors, modules and i.c.s, etc.

Well, here's wishing you successful buying.

# MW/LW TUNER

By R. A. PENFOLD

## A superhet. circuit to feed most amplifiers

THIS is a good quality tuner covering the m.w. and l.w. bands, and which will feed virtually any amplifier or tape recorder. The unit can also be used as a high quality personal receiver by plugging a crystal earpiece into the output socket.

A standard three transistor plus one diode superhetrodyne circuit is used, providing a very sensitive receiver. It is quite compact, measuring approximately 170 x 135 x 70mm, and is self-contained, using an internal ferrite aerial, and 9 volt battery supply. It is very economical to run, having a battery consumption of only about 2mA.

### SUPERHETRODYNE CIRCUIT

In a superhet. circuit, the received signal is converted to an intermediate frequency (i.f.), where it is greatly amplified, and then passed to the detector, which produces the a.f. output from the i.f. signal. The stages of a basic superhet. circuit are shown in block form in Fig. 1.

The input tuned circuit is tuned to the frequency of the received signal, and in this design is the tuned circuit on the ferrite aerial. The signal is passed from here to a mixer, where it is combined with the output from an oscillator. Here the hetrodyne principal is used to convert the signal to the i.f., which is 470kHz in this circuit. The frequencies at the output of the mixer are equal to the two input frequencies, plus their sum and difference frequencies.

For instance, if the tuner is tuned to Radio 1 on 1214kHz, the oscillator will be on 1684kHz, producing frequencies of 470kHz (1684−1214=470) and 2898kHz (1684+1214=2898), plus the two input frequencies at the output. The i.f. amplifier will reject all but the 470kHz signal, which it will amplify. It is worth noting that the oscillating frequency could have been 744kHz (1214−744=470), but it is more convenient to have the oscillating frequency above the signal frequency in this instance. The oscillator is adjusted so that it is always 470kHz above the frequency of the input tuned circuit, so as to always produce an i.f. of 470kHz.

Automatic gain control is incorporated in the circuit, and is described in more detail later.

To a beginner the superhet. may seem unnecessarily complicated, but this system is used in all good quality sets. By having the main amplification at a fixed frequency, it is possible to have the stages concerned adjusted for optimum performance, and a high degree of sensitivity and selectivity is obtained.

It would not be possible to obtain such a high performance if these amplifiers were at the signal frequency, having to operate over a wide range of frequencies. Also, although the circuit would be more simple, the physical layout and construction would be very critical. Thus most t.r.f. sets (ones which have the r.f. amplification at the signal frequency) usually have only one r.f. amp., and subsequently an inferior performance.

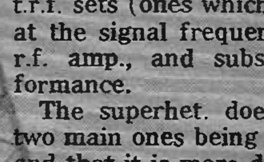
The superhet. does have disadvantages, the two main ones being its comparitively high cost, and that it is more difficult to adjust once built, as the oscillator and aerial circuits must be properly aligned over each band.

### CIRCUIT

A circuit diagram of the tuner is shown in Fig. 2; TR1 performs the functions of both mixer and oscillator. Coils L1, L2, and L3 are wound on the ferrite aerial, L1 being the m.w. winding,

FOR GUIDANCE ONLY

**ESTIMATED COST* OF COMPONENTS** including V.A.T.



**£8.50 excluding case**

*Based on prices prevailing at time of going to press

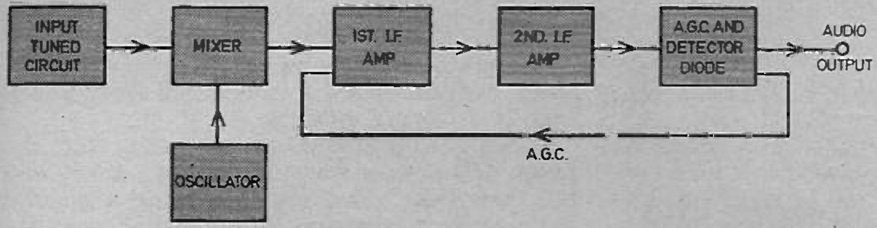



**Fig. 1. Block diagram of a superhet. circuit.**

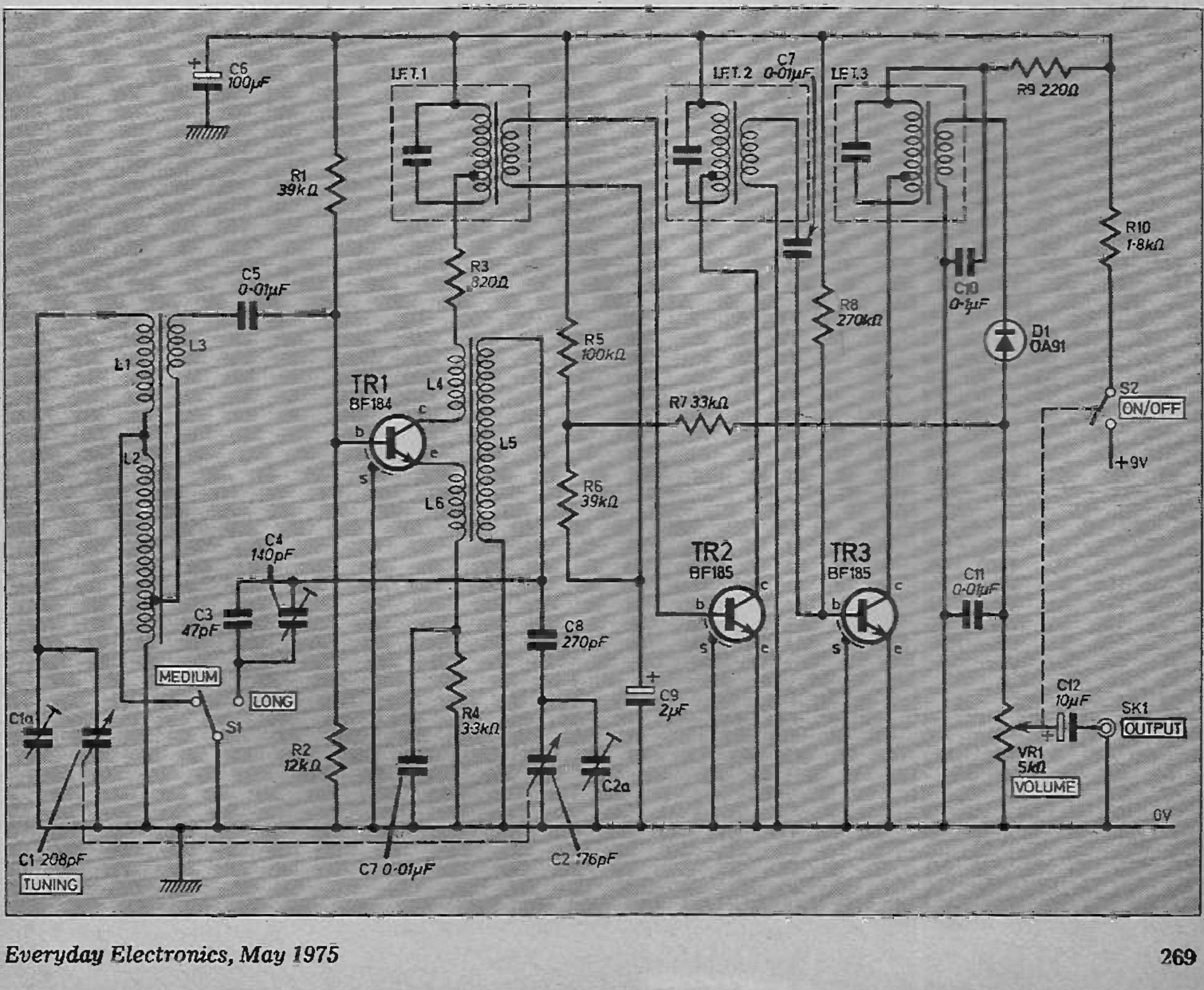
and L1 and L2 in series forming the l.w. winding. Switch S1 is the wavechange switch, and this shorts out L2 in the m.w. position. These coils are coupled to the base of TR1 via the coupling coil, L3, on the m.w. band, and the tap on L2 plus L3 on the l.w. band.

The transformer formed by L4/5/6 is the oscillator transformer, and provides positive feedback between the collector and emitter of TR1, at a frequency determined by the tuned winding, L5. Capacitor C1 tunes the aerial tuned circuit, and C2 tunes L5 (C1 and C2 are ganged on a common shaft), C1a and C2a are alignment trimmers. With S1 in the l.w. position, C3 and C4 are shunted across L5, so as to reduce the oscillator frequency range to one which is suitable for l.w. coverage.

The output of TR1 is developed across the primary of IFT1, which is tuned to 470kHz. This couples the signal to the first i.f. amplifier, TR2. This has a similar transformer in its collector circuit, which couples the output of this stage to the second i.f. amplifier, TR3. From here the signal is coupled by a third transformer to the diode detector, D1. The volume control VR1 forms the load across which the audio frequency is developed. This is connected via C12 to the output socket.

The selectivity of tuner is largely determined by the three tuned circuits in the i.f. stages, and not by the selectivity of the ferrite aerial, as it would be in a simple t.r.f. design. This gives greatly superior selectivity.

**Fig. 2. Complete circuit diagram of the MW/LW tuner.**



## AUTOMATIC GAIN

Capacitor C11 smooths the r.f. half cycles that pass D1 to negative d.c. bias. This bias is fed via R7 to the biasing resistors of TR2, which are R5 and R6. On weak signals the bias voltage is small, and will have no significant effect on the circuit. On strong signals it will be large enough to cause the biasing voltage at TR1 base to fall noticeably, causing TR2 collector current to be reduced, this in consequence causing TR2 gain to be reduced.

The stronger the signal, the larger the a.g.c. bias voltage, and the resultant reduction in gain. This prevents the detector from being overloaded by strong signals, and also gives a fairly constant audio output level, even though the strength of received signals will vary considerably. It also minimises the effect of fading on stations prone to this form of interference.

## Components....

**Resistors**

| | | | |
|---|---|---|---|
| R1 | 39kΩ | R6 | 39kΩ |
| R2 | 12kΩ | R7 | 33kΩ |
| R3 | 820Ω | R8 | 270kΩ |
| R4 | 3·3kΩ | R9 | 220Ω |
| R5 | 100kΩ | R10 | 1·8kΩ |

All ¼W ±10% carbon

**Capacitors**

| | |
|---|---|
| C1/C1a, C2/C2a | 208 + 176pF air spaced variable (Jackson 00 with trimmers) |
| C3 | 47pF silver mica |
| C4 | 40 to 140pF mica compression trimmer |
| C5 | 0·01μF disc ceramic |
| C6 | 100μF elect. 10V |
| C7 | 0·01μF disc ceramic |
| C8 | 270pF |
| C9 | 2μF elect. 10V |
| C10 | 0·1μF disc ceramic |
| C11 | 0·01μF disc ceramic |
| C12 | 10μF elect. 10V |

SEE SHOP TALK

**Inductors**

| | |
|---|---|
| L1/2/3 | Denco MW/LW/5FR ferrite rod aerial (1 off) |
| L4/5/6 | Denco TOC1 oscillator coil |
| IFT1/2 | Denco IFT13 transformers (2 off) |
| IFT3 | Denco IFT14 transformer |

**Semiconductors**

| | |
|---|---|
| TR1 | BF184 silicon *npn* |
| TR2/3 | BF185 silicon *npn* (2 off) |
| D1 | OA91 |

**Miscellaneous**

VR1 5kΩ log. potentiometer with switch (S2).
S1 s.p.d.t. rotary switch.
SK1 phono socket.
Materials for case—see Fig. 3, control knobs (3 off), plain perforated board 33 by 24 holes 0·15 inch matrix, PP3 battery and connecting clip, 6BA and 4BA fixings, connecting wire.

## CASE

The prototype case was made from 6mm plywood, with an 18 s.w.g. aluminium front panel. Details of this are shown in Fig. 3.

Commence construction by cutting out the parts to the sizes shown. The base, sides, and back are then glued together using a general purpose clear adhesive. Four corner pieces are used to strengthen the structure, and when these have been glued in position, the lid is glued in position also.

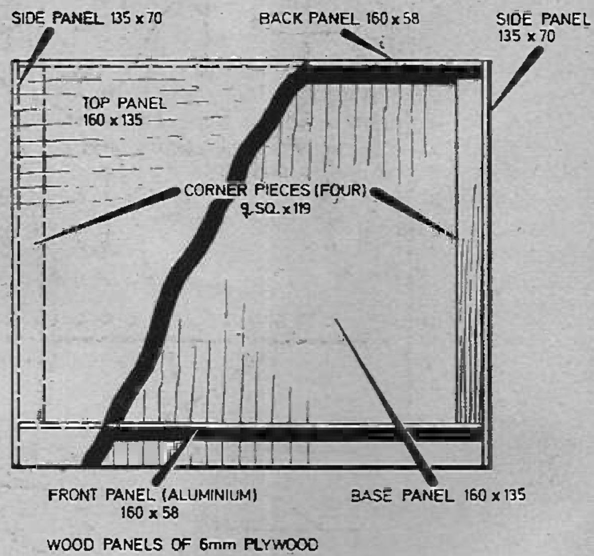



**Fig. 3. Construction and dimensions of the prototype case for the tuner.**

The front panel is drilled as shown in Fig. 4. A paper template can be made with the aid of C1/2 to enable the positions of the three small mounting holes for this component to be located.

Details of the mounting bracket for the component panel are also shown in Fig. 4. This is also made from 18 s.w.g. aluminium, drilled as shown in the diagram, and then bent at 90 degrees along the line indicated. The two 6BA clearance holes on the lower edge of the bracket are used to mount the component panel using two 6BA screws. The component panel is not mounted until it has been drilled, and then it is used as the template to locate the positions of the two mounting holes on the mounting bracket.

The bracket fits in place behind the front panel; C1/2, S1, VR1 and SK1 are mounted on the panel, so as to fasten the bracket to the front panel. Capacitor C1/2 is mounted by three 4BA 6mm countersunk screws. If the case is made accurately, the front panel assembly will be a snug push fit into the outer casing. The outer casing can be finished with a veneer of fablon, etc., or it can be painted or varnished, as preferred by the constructor.

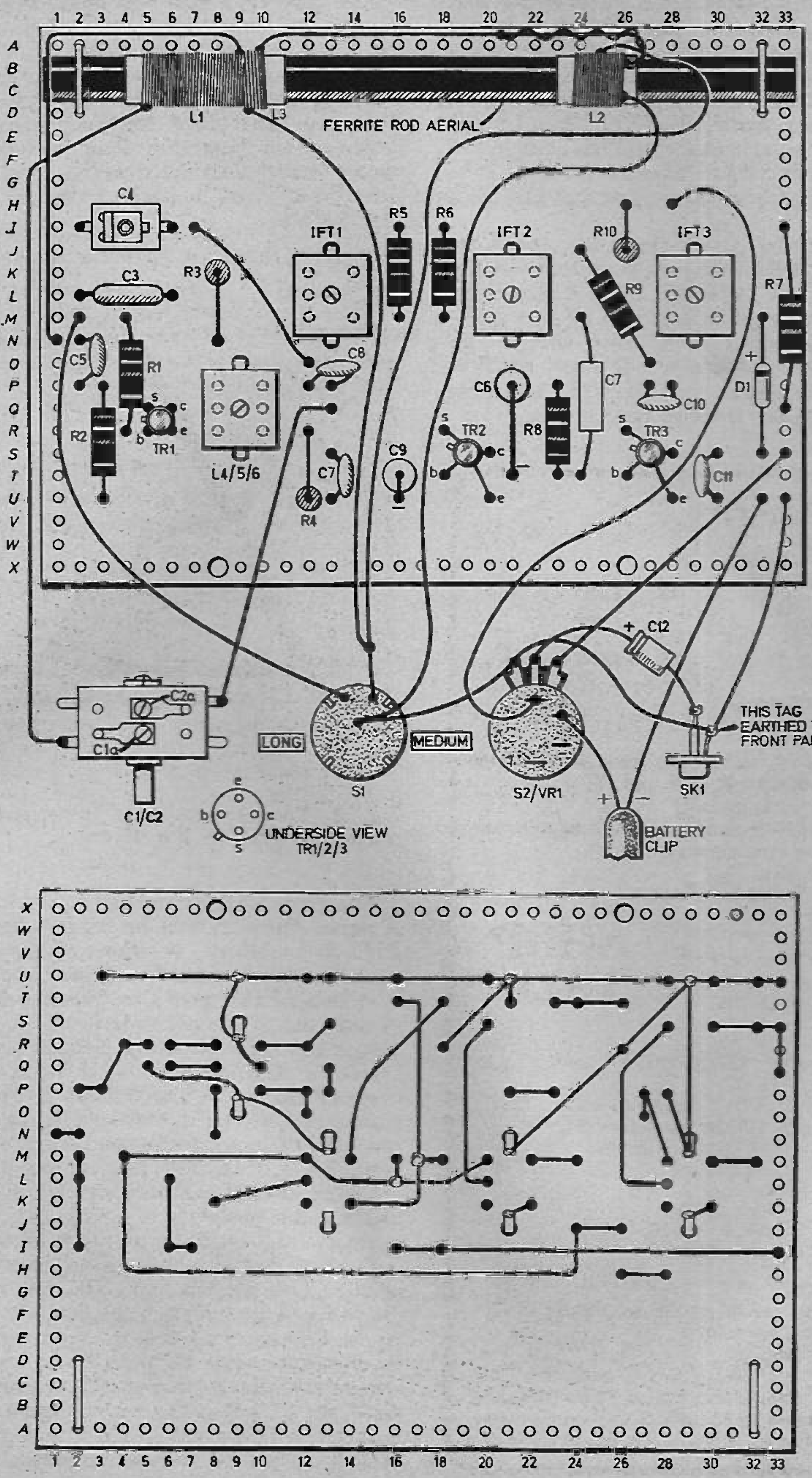



**Fig. 5. Construction and wiring of the complete tuner.**

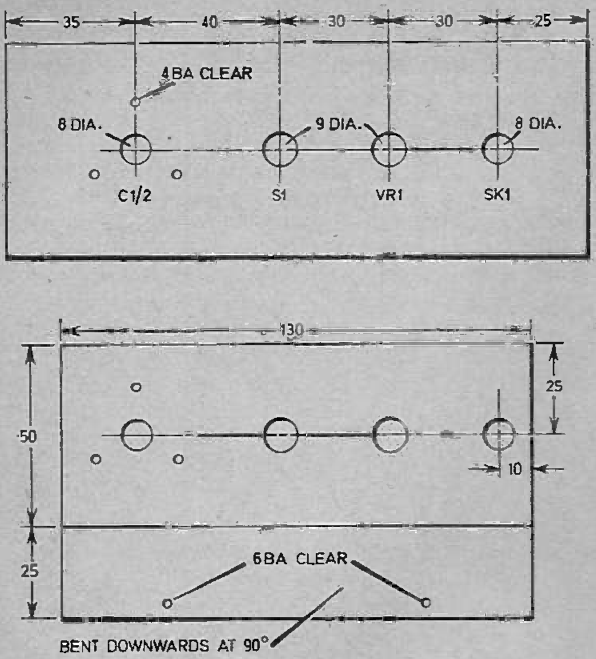



**Fig. 4. Front panel and mounting bracket for component panel.**

## COMPONENT PANEL

Constructional details of the component panel are shown in Fig. 5, this diagram also shows all the other wiring of the tuner. The perforated board is a standard size.

Before the oscillator coil, C4, and the IFTs can be mounted, it is necessary to enlarge the holes for their pins and mounting lugs, using a No.31 twist drill. The ferrite rod is tied to the panel using two loops of thin p.v.c. sleeving, knotted on the underside of the panel.

Start the wiring by inserting all the components in the positions shown. The board is then turned over, and the negative supply lead is connected up, followed by all other wiring, until the board looks like Fig. 5. Wherever possible, use the component leads to do this wiring. Where these are too short, link wires made from about 18 to 22 s.w.g. tinned copper wire can be used. Where leads cross, or pass close to one another, they should be insulated using p.v.c. sleeving.

Note that connections are made to the mounting lugs of the IFTs and oscillator coil, as the screening cans are earthed.

The ends of the lead outs of the ferrite rod aerial coils have been prepared ready for soldering, and so should not be shortened. All other leads are kept short and direct, and are insulated.

## ALIGNMENT

Before the tuner is ready for use, it is necessary to adjust the various tuned circuits for maximum performance. With the unit connected to an amplifier or an earphone, it should be turned on, and switched to the m.w. band. Adjusting C1/2 should enable a few stations to be received. Tune accurately to one of these, choosing a weak one which will not operate the a.g.c.

Using a proper trimming tool (Denco TT5 or similar), give the core of IFT3 a slight adjustment in each direction, and leave it with the setting which gives the greatest volume. Repeat this with the core of IFT2, and then that of IFT1.

Note that the IFTs are prealigned, and any adjustment required will only be very small. **Do not use a screwdriver to adjust the IFTs, as this could damage their cores.**

## R.F. ALIGNMENT

After dark the m.w. band is crowded from end to end. It will probably be found that the tuner covers slightly more than the m.w. band, and that there is an area at each end of the band where there are no stations. If the unit lacks sensitivity, this may be difficult to detect, but sliding L1/3 up and down the rod will permit sensitivity to be optimised at any setting of the tuning control.

Trimmer C2a is screwed down until the gap at the high frequency end of the band (C1/2 vanes unmeshed) disappears. Tune to the other end of the band and by slightly unscrewing the core of the oscillator coil, the gap should disappear here also, but will reappear at the h.f. end again. Repeat this process a few times, until, gradually, the correct coverage is obtained. Note that again, any adjustment required will not be large, especially that to the core of the oscillator coil.

Now tune to a weak station at the h.f. end of the band, and adjust C1a for maximum volume. Then tune to a weak station at the other end of the band, and slide L1/3 along the ferrite rod to find the setting which gives the best volume. Go back to the h.f. end of the band, and repeat this process a few times until no further improvement in sensitivity can be made. Carefully tape L1/3 to the ferrite rod, being careful not to alter their position (use insulation tape not Sellotape).

Turn to the l.w. band, and set C1/2 at about the central position. Then adjust the screw of C4 until Radio 2 is received. Slide L2 along the rod to obtain the best signal, and then tape it in this position. The chassis can then be placed in the outer casing, and the unit is ready for use. The battery fits between the two corner pieces on the right hand side of the case.

The lead connecting the tuner to the amplifier or tape recorder should be screened (the outer braiding going to the barrel of the jack plug). ■

# The Extraordinary Experiments of Professor Ernest Eversure

## by Anthony John Bassett

**Professor Ernest Eversure, or the Prof. as his friends call him, has been experimenting in electronics for more years than anyone can remember and we thought that you might like to hear of, and perhaps repeat, some of his extraordinary experiments. Anthony J. Bassett recounts some of these experiments every month so why not follow the Prof's work and learn along with young Bob, his friend.**

PAUL rushed across the laboratory and switched off the helmet. He removed it from the head of his sister Suzy, despite her protests.

"How did you manage to get this helmet?" he asked, "I only built one of them and that has been destroyed!"

"I found your plans in the workshop," Suzy replied, "and built a copy for myself. It's really fabulous!"

"We've had quite enough trouble with the one I built." Commented Paul. He handed the helmet to the Prof., who locked it safely away in a cupboard.

With the electronic kazoo and banjo in one hand, and his sister's hand in the other, Paul and Suzy bade farewell to Bob and the Prof.

Bob and the Prof. had both had enough, for the time being, of the mysterious helmets and their seemingly unpredictable properties, and began to discuss various theories of operation of transistors.

### *TRANSISTOR THEORY*

"There are so many different explanations of how a transistor works," complained Bob, "That I wish someone would come up with one that is sufficiently simple for me to understand and use in a practical way, without need of huge mathematical formulae or complicated concepts."

"To find a simple but workable theory," replied the Prof., "We only need to go back to the history of the invention of the transistor, to find that a transistor can be regarded, for many purposes, simply as a variable resistor, whose resistance is controlled by base current. This can be seen by a simple experiment."

He sketched the circuits shown in Figs. 1a and b. As the variable resistor in Fig. 1a is altered in value, the apparent resistance of the transistor varies, and the meter needle moves across the scale.

If the transistor is a silicon *npn* type such as a BC109 (almost any *npn* silicon transistor will do), the apparent resistance will vary from a very high value, usually over one megohm, down to a very low level (usually below one ohm). If an *npn* germanium transistor (such as type AC176) is used, the resistance shown is usually considerably lower than for silicon. This is due to differences between the properties of the silicon and germanium materials of which the transistors are constructed.

As indicated by the multimeter, the transistor appears like the variable resistor of Fig. 1b.

Bob quickly built the circuit of Fig. 1a. He soon found that, although the circuit behaved in the manner described by the Prof., the resistance values were different according to which way round the meter probes were connected!

The correct method of connecting the meter is such that the test voltage will bias the collector of an *npn* transistor positive with respect to the emitter. This can be confusing as on most meters, the positive wire is black and the negative wire is red! A simple test to find out which is which is to connect the meter leads to the base and collector of an *npn* transistor. When the lowest reading is obtained, the positive lead is on the base.

With the meter Bob was using, the black lead was positive with respect to the red lead. As he

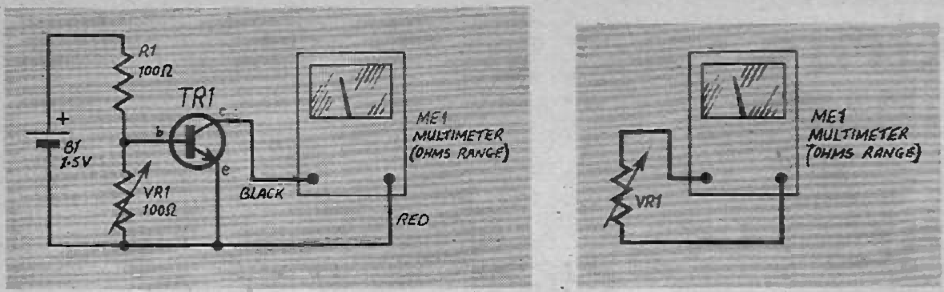



**Fig. (1a left) Transistor action as a variable resistor. The transistor appears like the variable resistor of Fig. 1b (right).**

adjusted the variable resistor VR1, Bob found that a variation of only a few ohms caused the apparent resistance of the transistor to alter by hundreds, or even thousands, of ohms.

"This is one way in which amplification can be demonstrated," remarked the Prof., "Isn't it marvellous how a small variation in one part of the circuit can produce such a large change in another; and if VR1 is replaced by a transistor as in Fig. 2., the variation in resistance seen by the meter will be even greater."

Bob built up the circuit of Fig. 2 and tested it. He found that only a small alteration of the variable resistor caused the meter needle to swing right across the scale! However, the direction of movement had reversed.

"You will notice that in Fig. 1b, as the resistor is varied and increased, the meter reads a higher value, and as the resistor is decreased the meter reads a lower value.

In Fig. 1a, however, the meter reading increases as the resistor is decreased and vice versa. Addition of another transistor inverts the action once again, so that in Fig. 2, an increase in the value of the variable resistor results in an increase in resistance reading on the meter."

Now Bob drew a diagram (Fig. 3).

## SWITCHING ACTION

"It seems to me that almost any number of transistors could be connected in this way, Prof." he suggested. "And each one would act as a variable resistor to control the resistance of the following transistor."

The Prof. agreed. "But you will find, that if you build that circuit and measure the voltage at the collector of each transistor whilst gradually varying VR1, there will be a big difference between the speeds at which the voltages vary. The voltage on the collector of TR1 will change much more slowly than the voltage on the collector of the next transistor, and so on.

After the first two or three transistor stages, the subsequent stages switch rapidly from high to low resistance even if VR1 is varied very slowly! This is called "transistor switching action" and the transistor which is acting like a switch goes quite rapidly from a high resistance state which "blocks" current flow, to a low resistance state like a closed switch."

"When the transistor is not acting as a switch, either fully conducting, or 'blocking' current, it may be in an intermediate condition where it is conducting but there is an appreciable resistance to the flow of current. This condition is the basis of operation of a 'class A' amplifier."

"I would like to experiment with class A amplifiers," remarked Bob, "and build some inexpensive and basic designs for general purpose use and for music. A small portable audio amplifier which I could take from one workbench to another, or carry about as I please could be very useful. Tell me, Prof., how were amplifiers built before the invention of the transistor?"

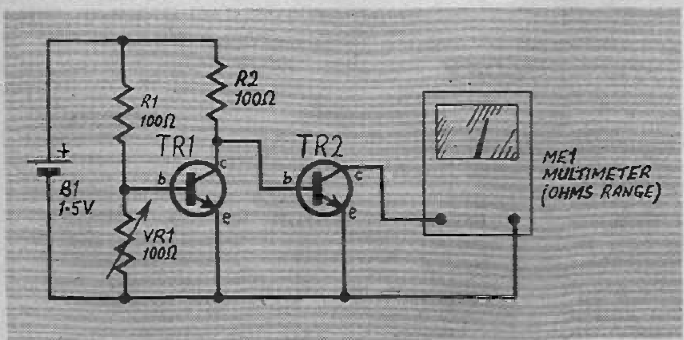
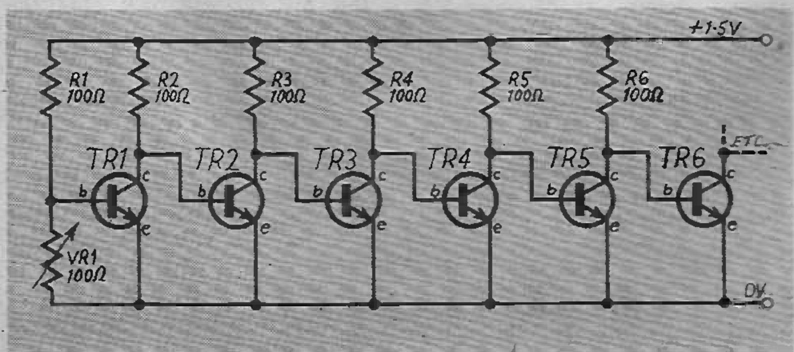



**Fig. 2. One transistor is seen by the meter as a resistor whose resistance is varied by the other (TR1).**

**Fig. 3. Each transistor is controlled by the previous one.**




## CARBON AMPLIFIER

"Before transistors came into extensive use, thermionic valves were relied upon for most amplifiers. But solid state audio amplifiers were in use even before the invention of the thermionic triode valve, and

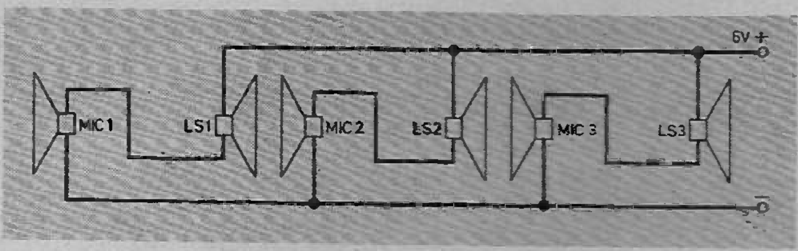



**Fig. 4. The carbon granule amplifier.**

these took advantage of the electrical properties of graphite in the form of carbon granules. Here is a diagram to illustrate the operation of this type of amplifier." (Fig. 4).

"Sound is picked up by a carbon granule microphone MIC1 which acts as a variable resistor modulating the current flow through a small loudspeaker or earpiece LS1. The sound output from LS1 brings about a sound level higher than the original signal, and this is picked up by MIC2. An even louder signal is produced at LS2. A further stage, MIC3, LS3 can be used to amplify the signal even further. But the greater the number of stages used, the greater the risk of acoustic feedback, high noise level, and extensive deterioration in signal quality."

"It would be very interesting to build one of these," remarked Bob, "and compare it with an amplifier built using transistors!"

From an obscure section of his enormous store of components the Prof. produced a number of carbon granule microphones, and also some high impedance moving reed headphone inserts.

"Fortunately I happen to have some suitable microphones and loudspeaker units here. These are ex-government and can be obtained from some government surplus stores."

"Why use moving-reed loudspeakers?" enquired Bob.

"These are small, inexpensive units with high-efficiency in conversion of electrical energy into sound waves. This high efficiency contributes to the gain of the amplifier. Ordinary loudspeakers or high efficiency dynamic inserts may be used, but a matching transformer may be necessary if the impedance is low."

Bob wired the units in accordance with the Prof's diagram (Fig. 4), connected a 6 volt battery and switched on. He found that sounds received by the microphone MIC1 were reproduced, somewhat tinnily, by LS1, which fed them into MIC2. At frequencies within the operating range of the system, which peaks at about 1kHz, the sounds were then picked up by MIC2 and fed to LS2 at increased amplitude. They were then further picked up by MIC3 and fed to LS3.

However, by that stage the tone had become quite "tinny", and although speech, and certain mechanical sounds such as the ticking of a clock, could be heard quite clearly, the quality of reproduction was obviously unsuitable for music.

"This type of amplifier was used to boost the signal along telephone lines many years ago." the Prof. told Bob. "When the signal was required to traverse a great distance, it would become weakened by the resistance of the wire and by other factors. A carbon granule amplifier inserted part way along the line would cause the speech to be more intelligible at the other end."

"In amplifiers built especially for this purpose, the carbon granules were in direct contact with the speaker diaphragm, and this improved quality and efficiency very considerably in comparison with use of a seperate microphone!"

"It is interesting to experiment with methods of amplification which differ somewhat from the conventional valves and transistors, yet we may consider both the carbon granule amplifier, and the circuit of Fig. 3 to be a series of variable resistors each of which has an amplifying effect, and an effect upon the following stage. Compare this diagram (Fig. 5) with both of the other two (Figs. 3 and 4). The variable resistors represent transistors, carbon microphones or any other device whose resistance can be controlled by another similar device. You can easily see how a number of class A stages can be linked together so that each stage is controlled by the previous one."

Bob had been listening to the Prof. through the carbon granule amplifier. As the Prof stopped speaking, Bob suddenly listened more closely to the earpiece. Then he handed it to the Prof. "Do you hear what I hear Prof?" he asked, "A strange bubbling noise!"

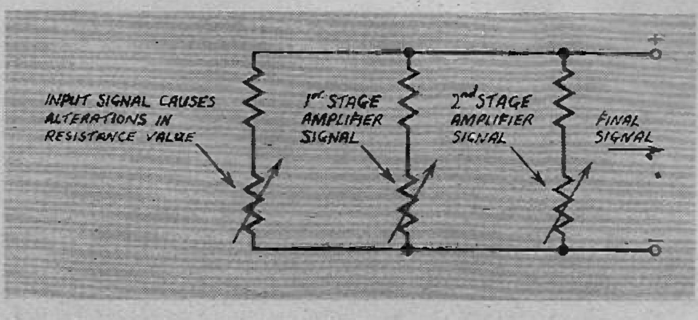
The Prof. could hear it too, and it rapidly grew louder so that it could be heard easily without the aid of the amplifier.

The Prof's experimental robot appeared, covered in bubbles.

A foaming mass appeared to be pursuing the robot towards Bob and the Prof., and from this mass came uncanny squeaking, clicking, popping, bubbling and oozing sounds.

Continued next month.

**Fig. 5. A multiple stage class "A" amplifier can be regarded as a series of variable resistors each controlled by the signal from the previous stage.**




# DOWN TO EARTH

By GEORGE HYLTON

"What is the meaning of *loop* in expressions like *loop gain* which are found in literature concerning amplifiers?"

There are loops and loops. In electrical circuits, a loop is just any part of the circuit in which you can trace a path from a starting point through connecting leads and circuit elements and get back to where you started from without passing the same way twice. There are loops in all electrical and electronic circuits—often dozens of them.

In the present case "loop" has to do with feedback, probably negative feedback. In a negative feedback amplifier the significant loop is the one which connects the feedback from output to input. It ought to be called a feedback loop, of course, but electronic engineers, in their slipshod way, just refer to it as "the loop", in much the same way that astronomers talk of "the galaxy", meaning our own galaxy, and disregarding the fact that the universe is full of the damn things.

## OPERATIONAL AMPLIFIER

The bare bones of a common type of negative feedback amplifier (most "operational amps" are like it) are shown in Fig. 1. Here *A* is an amplifier of unspecified type whose action is to increase the input voltage $V_i$ by *A* times, *A* being the amplification, of course. This gives an output voltage $V_o$ which of course is A times $V_i$. The polarity of $V_o$ can be the same as that of $V_i$ or it can be inverted, depending on the design.

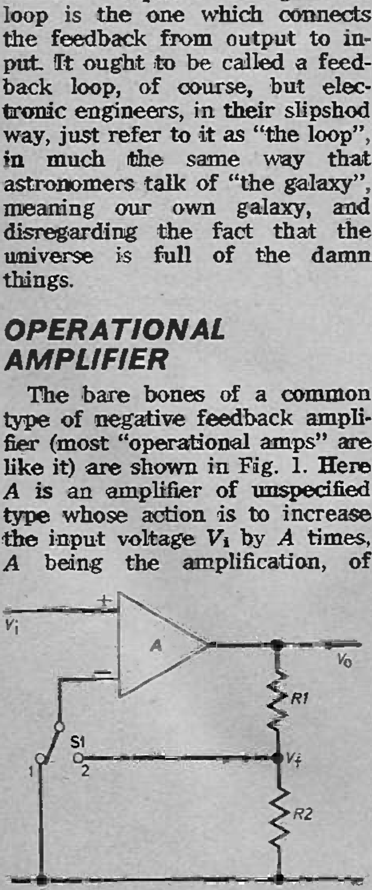



**Fig.1. An operational amplifier with negative feedback.**

The present amplifier has alternative input terminals. If the input voltage is applied to the one marked with a positive sign it gives rise to an amplified output which is in phase with the input. If $V_i$ goes to the other terminal, marked with a negative sign, the output is in the opposite phase. The two inputs are called the non-inverting and the inverting input terminals respectively, at any rate in operational amplifier parlance.

The plus and minus signs have nothing to do with d.c. voltages, they are just a bit of designers' shorthand.

In the present case the input goes to the non-inverting terminal, so the output $V_o$ is in phase with $V_i$. Being highly observant, you'll have noticed that a third voltage, $V_f$, is marked on the diagram. It's just a portion of $V_o$ tapped off by the voltage divider (or potential divider—if you like) formed by *R1* and *R2*.

At the moment, $V_f$ isn't doing anything. But move S1 to position 2 and $V_f$ is now connected to the inverting input. This means that a new output is produced, which is in opposite phase to the original $V_o$ and so tends to cancel $V_o$. It can't cancel $V_o$ completely, because if there's no $V_o$ there can't be any $V_f$ to do the cancelling. This is a long-winded way of saying that with S1 in position 2, $V_f$ becomes a negative feedback signal.

## EFFECT OF NEGATIVE FEEDBACK

How does the negative feedback affect the gain and frequency response? This is shown on the graph (Fig. 2). Naturally, it depends on how much of $V_o$ is tapped off by the voltage divider and fed back. The graph shows the effect of tapping off various proportions, from none at all (curve A), which is the case with S1 at position 1, through B and C which correspond to S1 at position 2 and different values of *R1* and *R2*. Curve B is for a moderate amount of feedback, curve C for rather a lot.

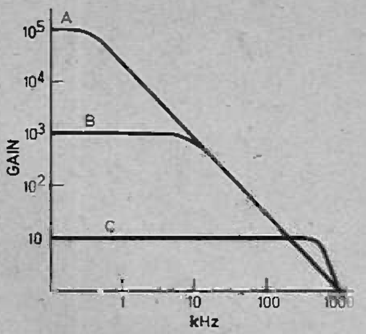



**Fig.2. The effect of negative feedback on gain and frequency response.**

As you can see, when feedback—negative feedback, that is—is applied, gain is sacrificed but the frequency response is improved. That's not all. Distortion is reduced, too, and the effect on the gain, of changing the supply voltage, is reduced.

So where does "loop" come in? Well, with S1 at position 2, there is a negative feedback loop from the amplifier output back to the input and of course through the amplifier itself back to the output again. Putting S1 to position 1 breaks this feedback loop. For this reason the gain without feedback (curve A) is often called the "open-loop gain", that is the real gain of the amplifier inside the triangular "box".

Moving S1 so as to connect the feedback signal closes the feedback loop and we now have the "closed-loop gain", often called just the loop gain. It approximates to $V_o/V_f$, especially if a lot of feedback is applied. This means that the gain can be set by choosing the right values for *R1* and *R2*. If $R1 = 9 \times R2$ the voltage is divided by 10, so $V_o = 10V_f$ and the gain is 10, or very nearly so. To be able to set the gain to an accurate value by selecting *R1* and *R2* you should use an amplifier with a very high open-loop gain then apply a lot of feedback.

# Sinclair Project 80

## For elegant, versatile, stereo hi-fi systems designed and built by you!

Until recently, if you wanted a first-class hi-fi system you had two ways to get it.

You could buy the individual electronic components and build a system from scratch. If you were an electronics genius – fine.

Or you had to buy ready-made units. Expensive – and dull. About the only creative pleasure you'd get would be matching your amp and your speakers, or making your speaker enclosures.

So what's new?

A comprehensive hi-fi system, combining the enjoyment and satisfaction of build-it-yourself (without too much struggle) ... a real value-for-money feeling ... and results of the highest quality.

It's the new Sinclair Project 80.

### How does Sinclair Project 80 work?

Project 80 is a comprehensive set of hi-fi modules, or sub-assemblies. Amps ... pre-amps ... FM tuner ... stereo decoder ... control units ... everything you need to assemble hi-fi units. They're all designed to look alike and they're all completely compatible with each other. Simply decide on the specifications of the unit you want to build ... buy the necessary modules ... connect them ... and house them.

No need to buy everything at once for your eventual set-up. All the modules are designed so that you can add to them as your system grows – whether or not it's based on Project 80.

This applies to refinements, like filters ... to up-grading, adding a second set of amps, say, for greater output ... or to real innovation, like quad. (Add a Project 80 quad decoder, a power supply, a pair of amps, and a pair of speakers – and your stereo's gone quad.)

### Is it difficult to build?

Not at all. The modules are complete in themselves. All you do is connect them to your turntable ... your speakers ... or to each other. It's absorbing, but if you can solder wires to a 5-pin DIN plug, you can build a complete system with Project 80.

And if you're not so hot with a soldering iron? Use Project 805. Project 805 uses Project 80 modules, but provides special clip-on tagged wire connections – absolutely *no* soldering required.

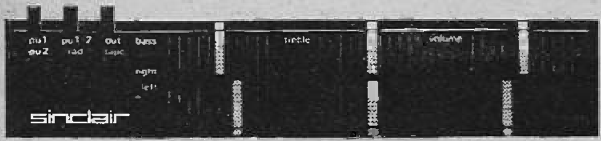
And, of course, both Project 80 and Project 805 come complete with instructions for easy, step-by-step assembly. But if you do run into problems, just call our Consumer Advisory Service who are always happy to help.

### OK: Where do I go from here?

Over the page! There you'll see for yourself the exacting specifications to which Sinclair Project 80 modules are made, and you'll see some suggested systems.

As you skim the suggestions, remember all Project 80 modules are backed by the remarkable no-quibble Sinclair guarantee. Should any defect arise from normal use within a year, we'll service the modules free of charge. What could be fairer than that?

# Choose the Project 80 modules that are right for you.

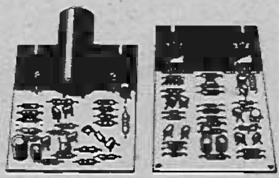



**Project 80 pre-amp/control unit**

The control centre of Project 80. With its distinctive white-on-matt-black styling and plastic control sliders, it's a pleasure to look at, as well as to use.

*Specification*
(9½ in x 2 in x ¾ in.) Separate slider controls on each channel for treble, bass and volume. **Inputs:** *PU* magnetic – 3 mV (RIAA corrected), ceramic – 350 mV; *Radio* 100 mV; *Tape* 30 mV. **S/N ratio:** 60 dB. **Frequency range:** 20 Hz to 15 kHz ± 1 dB. **Outputs:** 100 mV and tape plus AB monitoring. **Press buttons** for PU, radio and tape. **Operating voltage:** 20 V – 35 V.

*Price:* £13.95 + VAT



**Project 80 power amplifiers**

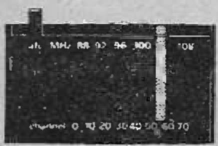
Two different amplifiers, designed to be used separately or combined, with Project 80 modules or as add-ons to existing equipment. Protected against short circuits and damage from mis-use.

*Z40 Specification*
(2¼ in x 3 in x ¾ in.) 8 transistors. **Input sensitivity:** 100 mV. **Output:** 12 W RMS continuous into 8 Ω (35 V). **Frequency response:** 30 Hz – 100 kHz ± 3 dB. **S/N ratio:** 64 dB. **Distortion:** 0.1% at 10 W into 8 Ω at 1 kHz. **Voltage requirements:** 12 V – 35 V. **Load imp:** 4 Ω – 15 Ω; safe on open circuit. Protected against short circuit.

*Price:* £5.95 + VAT

*Z60 Specification*
(2¼ in x 3¾ in x ¾ in.) 12 transistors. **Input sensitivity:** 100 mV – 250 mV. **Output:** 25 W RMS continuous into 8 Ω (50 V). **Frequency response:** 10 Hz to more than 200 kHz ± 3 dB. **S/N ratio:** better than 70 dB. **Distortion:** less than 0.1% at 12 W into 4 Ω at 1 kHz. **Voltage requirements:** 12 V – 50 V. **Load imp:** 4 Ω min; max safe on open circuit. Protected against short circuit.

*Price:* £7.45 + VAT

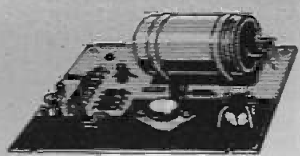


**Project 80 FM tuner**

Excellent reception from a tuner only 3½ in long x ¾ in deep! Styled to match Project 80 control unit.

*Specification*
(3½ in x 2 in x ¾ in.) Tunes 87.5 MHz to 108 MHz. **Detector:** IC balanced coincidence (IC equivalent to 26 transistors). **Distortion:** 0.3% at 1 kHz for 30% modulation. **Sensitivity:** 5 µV for 30 dB signal to noise. **Output:** 100 mV for 30% modulation. **Aerial imp:** 75 Ω or 240-300 Ω. **Features:** dual Varicap tuning, 4-pole ceramic filter, switchable AFC. **Operating voltage:** 23 V – 30 V.

*Price:* £13.95 + VAT



**Power supply units**

Range of power supply units to match desired specification of final system.

*PZ5 Specification*
Unstabilised. 30 V output. Including mains transformer.

*Price:* £5.95 + VAT

*PZ6 Specification*
Stabilised. 35 V output. Including mains transformer.

*Price:* £8.95 + VAT

*PZ8 Specification*
Stabilised. Output adjustable from 20 V to 60 V approx. Re-entrant current limiting makes damage from overload or even shorting virtually impossible. Without mains transformer.

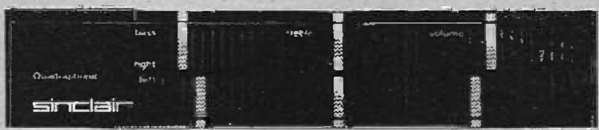
*Price:* £8.45 + VAT


**Project 80 stereo decoder**

Designed for use with Project 80 FM tuner. Sold separately to keep down the price of a mono FM system, but also to make the stereo decoder available for use with existing mono FM tuners.

*Specification*
(1¾ in x 2 in x ¾ in.) 1 IC equivalent to 19 transistors. LED stereo indicator glows red.

*Price:* £8.95 + VAT

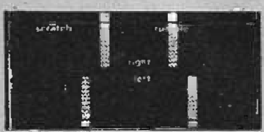



**Project 80 SQ quadraphonic decoder**

Combines with and exactly matches Project 80 control unit for true quadraphonics. This unit is based on the CBS SQ system and is a complete quadraphonic decoder, rear channel pre-amp and control unit.

*Specification*
(9½ in x 2 in x ¾ in.) Connects with tape socket on Project 80 control unit or similar facility on any stereo amplifier. Separate slider controls on each channel for treble, bass and volume. **Frequency response:** 15 Hz to 25 kHz ± 3 dB. **Distortion:** 0.1%. **S/N ratio:** 58 dB. **Rated output:** 100 mV. **Phase shift network:** 90 ± 10 100 Hz to 10 kHz. **Operating voltage:** 22 V – 35 V.

*Price:* £18.95 + VAT




**Project 80 active filter unit**

Eliminates scratch and rumble (high and low-frequency noise).

*Specification*
(4¼ in x 2 in x ¾ in.) **Voltage gain:** –0.2 dB. **Frequency response:** filter at zero: 36 Hz – 22 kHz; HF (scratch) out: variable 22 kHz to 5.5 kHz, 12 dB/octave slope; LF (rumble) out: –28 dB at 28 Hz, 9 dB/octave slope.

*Price:* £7.45 + VAT

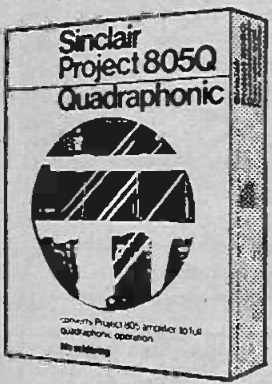
# Some system suggestions from Sinclair


**Project 805 amplifier kit**

Contains following Project 80 units:

Project 80 control unit
2 x Z40 power amplifier modules
1 x PZ5 power supply unit
Masterlink unit
On/off switch
plus pre-cut wiring loom with clip-on tagged wire connections, nuts and bolts, instruction manual.

*Price:* £39.95 + VAT



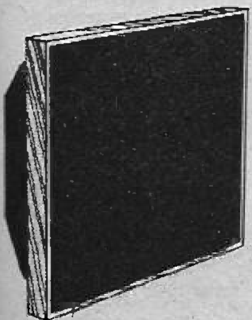

**Project 805Q quadraphonic add-on kit**

Converts your existing stereo hi-fi system to quad using solderless connections.

Contains following Project 80 units:

Project 80 SQ quad decoder/rear channel pre-amp and control unit
2 x Z40 power amps
PZ5 power supply unit
Masterlink unit
On/off switch
plus pre-cut wiring loom with clip-on tagged wire connections, nuts and bolts, instruction manual.

*Price:* £44.95 + VAT



**Sinclair Q16 speaker**

Original and uniquely designed speaker of outstanding quality.

*Specification*
(10⅜ in square x 4¾ in deep.) Pedestal base. All-over black front. Teak surround. Balanced sealed sound chamber. Special driver assembly. Frequency response: 60 Hz to 16 kHz. Power handling: up to 14 W RMS. Impedance: 8 Ω.

*Price:* £8.95 + VAT

1. Quadraphonic system: 25 W per channel RMS
Pre-amp/control unit + quadraphonic decoder + 4 x Z60 amps + 2 x PZ8 mains power supplies + (2 x mains transformers) + (4 x equivalent speakers) + (turntable). Total Project 80 cost: £79.60 + VAT.

2. Stereo amplifier: 12 W per channel RMS
Pre-amp/control unit + 2 x Z40 amps + PZ6 power supply + 2 x Q16 speakers. Total Project 80 cost: £52.70 + VAT.

3. Stereo tuner/amplifier: 12 W per channel RMS
Pre-amp/control unit + FM tuner + stereo decoder + 2 x Z40 amps + PZ6 power supply + 2 x Q16 speakers. Total Project 80 cost: £75.60 + VAT.

**Other applications**

4. PA system
(Mic) + pre-amp/control unit + Z40 amp + PZ6 power supply + 2 x Q16 speakers. Total Project 80 cost: £46.75 + VAT.

5. Convert existing mono record-player to stereo
Pre-amp/control unit + Z40 amp + Q16 speaker. Total Project 80 cost: £28.25 + VAT.

**What more can we tell you?**
The basic facts are covered on these two pages. And you'll find Project 80 at stores like Laskys and Henry's.

But before you look, why not get really detailed information? Clip the FREEPOST coupon for the fully-illustrated Project 80 folder – today!

Sinclair Radionics Ltd,
London Road, St Ives, Huntingdon, Cambs., PE17 4HJ.
Telephone: St Ives (0480) 64646.

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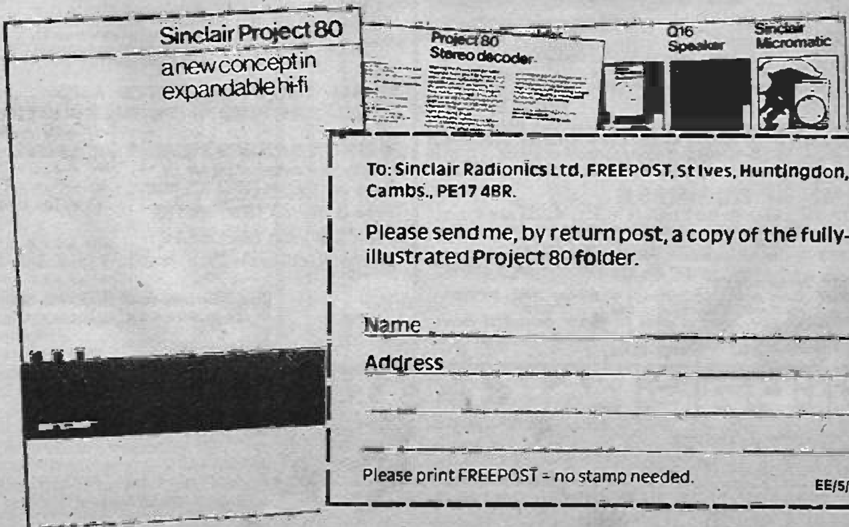


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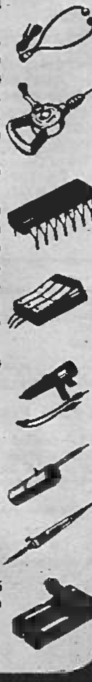

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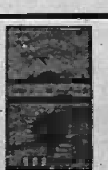

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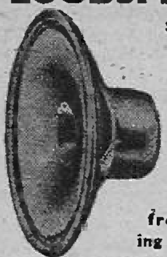

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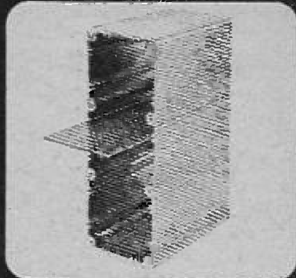

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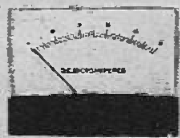

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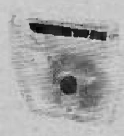

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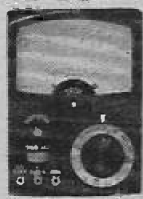

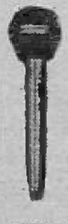

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