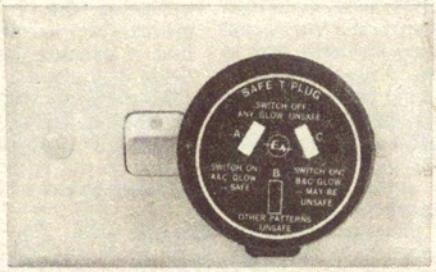
This is a plug for safety...

Elementary Electronics

by ROSS TESTER

"A little knowledge is a dangerous thing." The writer of that proverb might well have been talking about electric power, for there are few things more dangerous than a person with a little knowledge tampering with the power supply. Whereas a person who is aware of his own ignorance will leave well enough alone, someone with a little knowledge — (but not enough) is likely to rush in — and become the angel who fears to tread!



We at Electronics Australia have been disturbed by recent electrocutions — Neville Williams had something to say about them in his Forum in the August issue.

We thought it time we presented an article about the power mains. Not to discourage our readers from using or building mains operated equipment — far from it. Rather to make them safety conscious — able to use the mains with confidence, knowing that what they are doing is correct.

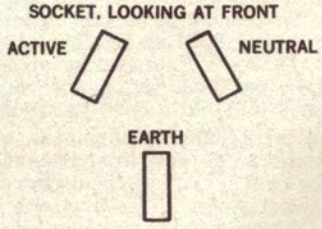
Working on the assumption that our young readers — particularly those who read Elementary Electronics — are the ones most likely to benefit by such an article, we have decided to forgo the usual elementary project this month, and present an article which, we hope, might prevent an accident.

Not that those who like a simple project each month have been neglected. Later in this article, we will show how to make a particularly useful safety device — a simple unit which can be plugged into any outlet and which will indicate immediately whether the outlet has been correctly wired. But more about this later.

Most of our readers would have seen marked on a power point (known as a GPO — general purpose outlet) the words "240V AC only 10A". If you have had the chance to see the reverse side of the outlet there would be, among other things, the letters A, N and E. What do these mean?

The "240V AC" means 240 volts, alternating current. This is the theoretical supply voltage to which household appliances and light machinery are connected. In fact, the voltage can vary, depending on the load placed on the supply network, but most supply authorities try to keep it within plus or minus 5%.

The "10A" means 10 amps, the amp being the unit of current flow. Ten amps is the usual maximum which can be drawn from one outlet. If more than this is drawn the outlet may overheat and eventually destroy itself. If you have ever felt an outlet after it has been supplying a 2400W (watts) room heater (which draws 10A) you will know what we mean.



This is the recommended SAA wiring for a 3 pin mains socket. It is reproduced normal size, as viewed from the front.

The letters A, N and E which we mentioned before stand for the words "active," "neutral" and "earth." These names are given to the three wires in the system.

Two of the wires, the active and the neutral, connect to the wires coming into the house from the street mains. The third wire, the earth wire, is connected to a good earth connection — typically a water pipe — within the boundaries of the property.

Of the two wires which go back to the substation, one is earthed at the substation. This is the neutral wire. Logically, the other wire is called the active.

In terms of safety, it is the active wire which is dangerous. It is at 240 volts with respect to the neutral and, because the neutral is earthed, with respect to any earthed object. If a person completes a circuit between an active line and the neutral or an earthed object, they will receive a shock. Just how severe the shock will be depends on how good a connection they make to the earthed object. It may simply tickle, or it may kill.

Conversely, a person completely insulated from earth could handle the active line (only) with perfect safety. Witness the birds that perch on high voltage lines without even being aware that these lines are "live".

The earth, active and neutral lines connect to the three pins in the outlet.
There should never be an outlet which is not controlled by a switch. The switch must, by regulations, be in the active line.

Unfortunately, there is no strict rule as to which of the two supply pins — as distinct from the earth pin — should be used for active and neutral respectively. However, there is a recommendation that the left hand pin, when facing the socket, should be the active and most modern installations would satisfy this requirement. But there are many older installations, or amateur ones, which do not. While not necessarily dangerous in themselves, they can help create a dangerous situation in conjunction with incorrectly wired appliances or extension leads.

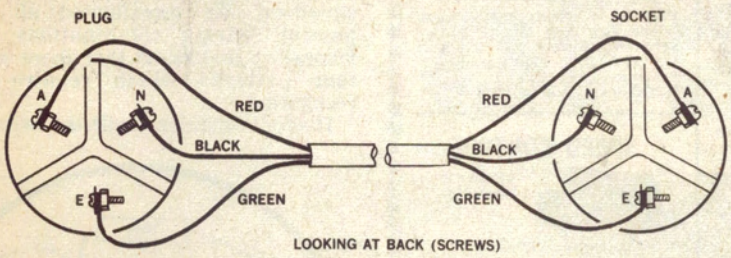
In any plug or flexible cord there should be three wires, each insulated from the other by a coloured PVC sleeve. In Australia, the colours used in the past have been red, black, and green. Other countries have used other combinations. A new colour code is now emerging, recommended by the IEC (International Electrotechnical Commission) and is being accepted by most countries, including Australia. Hopefully it will become a world standard. The new colours are brown, blue, and a green / yellow stripe pattern.

"OXFORD"
RADIO CHASSIS —
INSTRUMENT CASE —
ENGRAVED & PRINTED PANEL
"MINI BOXES"
(Aluminium)
HEATING SYSTEMS
PTY LTD
19-21 The Boulevarde,
Caringbah 2229
Phone 525-5222
4 lines

The red lead (or brown in the IEC code) should be used for the active lead, black (or blue) for the neutral, and green (or green / yellow) for the earth.

However, this code is not always followed correctly. Never, in any circumstances, assume that a lead which is black or comes from the right hand pin is the neutral line. In many cases, particularly on older outlets, it isn't!

We have shown the three pin outlet and the connections which are now regarded as standard.



How to wire an extension cable. Check it by pushing the plug into the socket and noting that the lead colours correspond for all three pins.

The other end of the flexible cord must be correctly connected to the appliance. The active and neutral wires connect to the heating element, motor terminals, transformer etc and, in general, it does not matter which way round these two are connected. However, if there is a switch on the appliance, it should be in the active line.

The earth wire, green or green / yellow, connects to the metal frame of the appliance. It is vitally important that this lead is not confused with either of the other leads. Transposed active and earth leads will result in the active lead being connected to the appliance frame; a very dangerous situation tempered only by the fact that the appliance will not work thus, hopefully, leading to an investigation before anyone is hurt.

A transposed earth and neutral can be just as dangerous, but is more subtle. The appliance will work in a correctly wired power point, and is not particularly dangerous. But in a power point with transposed active and neutral pins it will not work and, again, the active is connected to the appliance frame.

Correctly connected, the earth wire provides a very high order of protection. Without it, an insulation breakdown within the appliance can result in the frame being connected to the active line. If the frame is then handled by someone in an earthed situation he will receive a shock; a shock which could be fatal.

By an earthed situation we mean standing on a concrete floor in leather shoes (usually slightly damp) or worse still, out of doors on bare earth. It can also mean touching an earthed object, such as a tap, water pipe etc.

With an earth wire properly connected, a breakdown to frame will result in a short circuit across that particular supply circuit, causing a blown fuse or tripped circuit breaker, thus disconnecting the supply and drawing attention to the fault.

If you have to replace a fuse (and the chances are that you will sooner or later), make sure that you first turn off the power at the main switch. This switch is always labelled as such. Just because the circuit is dead does not mean that power is disconnected. In fact, one of the fuse contacts will still have 240V applied to it.

The fuse box should have labels on it to tell you which fuse controls which circuit, so there should be only a couple to choose from. Remove suspected fuses one by one, and replace before removing the next one. Different circuits may require different fuses, so do not mix them up.

When the blown fuse is located (you will be able to tell it by the burn marks on the procelain) note which fuse wire is used in it from its label. Replace with a single strand of the same wire. (This is available quite cheaply from hardware and department stores.) Never (except, perhaps, in cases of extreme and genuine emergency) replace the fuse wire with another gauge or ordinary wire — it is too easy to forget.

A fuse may blow for two reasons: the circuit has been overloaded with too many appliances, or one of the appliances is faulty. In the former case the load should be lightened before the power is turned back on. If a faulty appliance or wiring is suspected, the supply authority should be contacted.

In the case of a tripped contact breaker there is no need to turn off the power, but the cause of the failure must still be investigated.

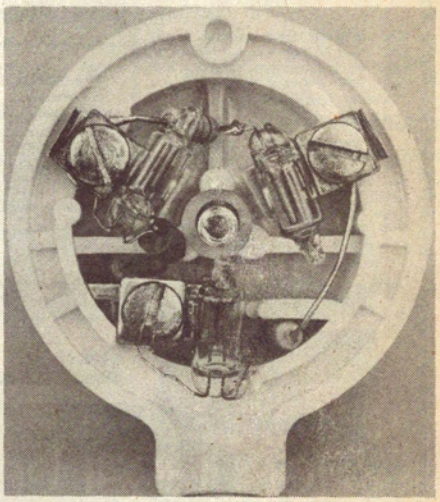
A common cause of the twenty or so electrocutions which occur each year is incorrectly wired plugs and sockets on extension leads, together with a "mirror image" type double adaptor which has now been withdrawn from sale.

These adaptors cause an active / neutral transposition on one outlet. While not usually dangerous in itself, this can contribute to a dangerous situation if used with an appliance or extension lead having an equally innocent looking fault — a neutral earth transposition. Together they make a death trap. If you have one of these adaptors, destroy it.

Similarly, if you have an extension cord, check it very carefully to make sure it is wired correctly.

If you must wire a mains cord or extension lead yourself (they are best left to electricians) take care. We have shown how they should be wired, but there is still the chance that a mistake can be made. With this in mind, we present our SAFE-T-PLUG.

We must admit that the idea is not our own. Apparently, such devices have been available overseas, although we have never seen one. One of our readers, Rev R. W. Fiegert, of Finschafen, New Guinea,



Wiring and assembly of the SAFE-T-PLUG. Compare it with the diagram on page 80.

MULTIMETERS

MODEL C-1000 POCKET MULTIMETER
1000 ohms per volt. AC volts: 0-10, 50, 250, 1000. DC volts: 0-10, 50, 250, 1000. DC current: 0-100 mA. Resistance: 0-150K ohms (3K centre). Two colour scale. Range selector switch. Dimensions: 3½ x 2¼ x 1 inch.
Price $6.95, postage 30c

MODEL 200H MULTIMETER
20,000 ohms per volt. DC volts: 0-5, 25, 50, 250, 500, 2500 (20,000 o.p.v.). AC volts: 0-15, 50, 100, 500, 1000 (10,000 o.p.v.). DC current: 50 uA., 2.5 mA., 250 mA. Resistance: 0-60K / 6M ohm (scale centre 300, 30K ohm). Capacitance: 10 pF. to 0.001 uF. / 0.001 uF. to 0.1 uF. DB. scale: —20dB. to plus 22dB. Size: 4½ x 3¼ x 1⅛ inch.
Price $12.95, postage 30c

MODEL OL-64D MULTIMETER
20,000 ohms per volt. DC volts: 0.025, 1, 10, 50, 250, 500, 1000 (at 20K o.p.v.), 5000 (at 10K o.p.v.). AC volts: 0-10, 50, 250, 1000 (at 8K o.p.v.). DC current: 50 uA., 1 mA., 50 mA., 500 mA., 10 amps. Resistance: 0-4K, 400K, 4M, 40 megohms. DB. scale —20 to plus 36dB. Capacitance: 250 pF. to 0.02 uF. Inductance: 0-5000 H. Size: 5¾ x 4⅛ x 1¾ in.
Price $19.95, postage 30c

NEW MODEL US-100
Overload protection. Shockproof movement. Polarity switch. DC volts: 0-025, 1, 25, 10, 50, 250, 1000 (20K o.p.v.). AC volts: 0-2.5, 10, 50, 250, 1000 (5K o.p.v.). DC current: 1 mA., 25 mA., 500 mA. and 10 amp. AC current: 10 amp. Resistance: 0-50 Megohm (centre scale 50), R x 1, 10, 100, 1K, 10K. DB. scale: —20 to plus 10, plus 22, plus 35, plus 50 dB.
Price $34.50, postage 40c

MODEL AS100 / DP HIGH SENSITIVITY MIRROR SCALE
100,000 ohms per volt DC. Mirror scale, protected movement. DC volts: 3, 12, 60, 120, 300, 600, 1200 (100K o.p.v.). AC volts: 6, 20, 120, 300. 600, 1200 (10K o.p.v.). DC current: 12 uA., 6 mA., 60 mA., 300 mA., 12 amps. Resistance: 2K, 200K, 20M, 200 megohm. Decibels: —20 to plus 63 dB. Audio output: 6, 30, 120, 300, 600, 1200 volts AC. Size: 7½ x 5½ x 2¾ inch.
Price $34.50, postage 75c

HAM RADIO SUPPLIERS
MAIL ORDER SPECIALISTS

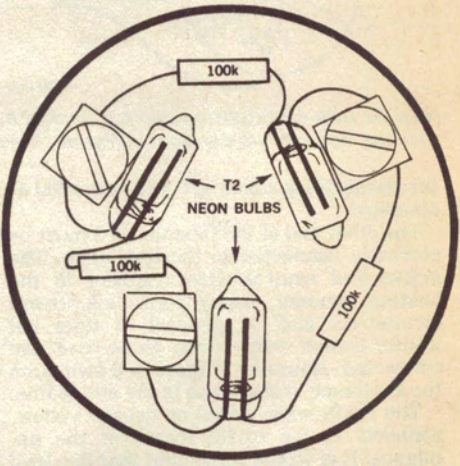
323 Elizabeth St. (2 doors from Little Lonsdale St.)
Melbourne, Vic. 3000. 'Phones: 67 7329, 67 4286.

mentioned the idea to us some time ago, and we elaborated on it until we had a design we liked.

We took an ordinary three pin "piggy back" plug, removed some of the interior wire guides which normally keep the three wires separate, and placed between each pin a neon globe and a series resistor. The diagrams and photos may give a better idea of this. We then made an instruction label to fit over the back of the plug.

These instructions list four different situations. We investigated all of the possible wiring combinations in our laboratory and found that there are only four patterns which require to be recognised.

The first condition is with the switch off. If



How the plug is wired. Follow this carefully to ensure correct operations.

any lights glow the outlet is wrongly wired. The switch should be in the active line, but presence of a glow means that this requirement has not been satisfied. The situation should be treated as dangerous.

The remaining conditions are with the switch on. If lamps A & C glow, the outlet may be be regarded as a safe one into which an appliance may be plugged

If lamps A & B glow, the outlet or lead has an active / neutral transposition. As we said before, this in itself is not normally dangerous, but another fault may make it so.

It should be treated as potentially dangerous.

If any other patterns appear the outlet must be regarded as unsafe. If all three lamps glow, either the neutral or earth lead is open circuit. An open neutral lead is not likely, because no correctly wired appliances would work from the outlet if it was. However, the possiblity that the earth is open circuit is very much greater. It would not be noticed until such times as a fault occured, and then there would be no earth wire to protect the user. It is most important to have the earth wire intact.

While investigating this unit we were made aware of two shortcomings which appear to be inevitable with such a simple device. Provided these are appreciated, their importance will be minimised.

The first concerns the unit's inability to detect transposed earth and neutral wires. Thus, the condition "A & C glow" could be obtained with a neutral / earth transposition. As we stated earlier, this situation,

Elementary Electronics Ideas Worth Trying

Spacer Substitute

Projects published in "Electronics Australia" often call for "1in x ¼in insulated pillars, tapped ⅛ Whit." While these are ideal for the purpose, they are relatively expensive, about 20c, considering the material involved.

After looking for a substitute I found that plastic "Rawlplugs", as used in the building industry, are very suitable. They are rigid, strong, and come in a variety of lengths and diameters. The minimum length appears to be 1in, but they maybe cut with a sharp knife or razor blade. The diameters are designated by colour and the smallest (red) appears to be the most suitable.

Small self tapping screws are used to hold the insulator to the circuit board or panel, etc. Use around number 4 screws — anything larger may split the Rawlplug.

Perhaps the best feature of these is the price. They retail for a little over 1 cent each, against the twenty or more for the conventional units, and are available at most hardware stores. (T.R. Enfield NSW)

Cheap Connector

How many times have you needed a connector for a nine volt battery — and not had one. In many cases, I, for one, have had to resort to wrapping wire around the terminals — not the best at any time.

Instead of discarding a dead battery, cut the top off with a hacksaw. Cut about ⅛in down from the top, taking care not to spill the contents of the battery. The terminal plate of the battery will come out intact — and this is a perfect connector for another nine volt battery. The contacts take solder quite well. The larger (star shaped) terminal becomes the positive, so solder a red wire to it, and a black to the smaller terminal.

The result — a very cheap battery connector! (From T. R., Enfield, NSW.)

---

while undesirable, does not constitute a serious hazard in itself.

Thus, there should be little hazard in plugging an appliance into a socket which gives such an indication. However, it is most important that the socket tested should be the last one in any chain of extension leads or double adaptors — in short, the socket into which the actual appliance will be plugged.

The second concerns the earth connection. The tester should indicate an open circuit earth wire (B glows) and such an indication is quite unambiguous. However, due to the high sensitivity of the lamps, it cannot distinguish between a good earth connection and one which may have developed significant resistance. Such a situation is most likely to occur at the actual earth connection in the installation proper, rather than in extension leads, adaptors, or other auxiliary devices.

To construct the SAFE-T-PLUG, you will need the following parts: 1 piggy back 240V plug, 3 miniature neon bulbs (T2), 3 100k resistors (1/2W), 1 SAFE-T-PLUG LABEL.

The label is an important part of the unit. Some of our advertisers may decide to make these available in thin metal but, in the meantime, we will make photographic copies available, black or white, for $0.50.

Start by removing the back of the plug. Then, with a pair of side-cutters, remove most of the wire guides in the back. Take very small "bites" otherwise the plastic may crack through. Remove only enough of the guides and separators to enable the neons to fit beneath the slots. The resistors fit deep inside the plug.

Then place a neon on each of the clasps which would normally accept the second plug points. Using our diagrams as a guide, screw one of the neon leads under the screws. Place the three resistors where they do not foul any plastic or metal and, after cutting the leads to suit, solder them to the neons. Screw the other end under the opposite screws.

It is important to place the neons where we have shown them on the diagram, with their resistors going to the correct pins. Otherwise, the patterns which appear will not be the same as ours. Equally important, the leads from the neons or the resistors must not foul any of the other wiring or pins. If there is any danger of a short occurring, use insulation tape or spaghetti. Remember that when the back is replaced the pressure might move the neons slightly.

Note that the tip of the neon on the earth pin must clear the centre shaft of the back when it is placed in position, otherwise the neon may be broken or cracked. The neons should not be stressed too much, neither should their leads.

When the internal components are assembled, screw the back on slowly, making sure that none of the neons is stressed. Before plugging in, check with a multimeter set on a high ohms range. There should be no reading between any two pins. If there is, something is wrong. If all is well, plug into an outlet, and turn on. The two top lights should glow (unless you have an incorrect outlet).

The only way to check the bottom neon (B) is to plug it into an outlet with no earth connection. One way is to use an extension lead and, temporarily, remove the earth wire. If all is well, all three neons should glow. Do not forget to re-connect the earth lead.

Once satisfied that the indicator is working properly, the label can be fitted. Cut out the slots for the neons before sticking on, using a razor blade or sharp modeller's knife. Cut around the outside edge of the circle with a pair of scissors.

We finished off the plug with a liberal spray of clear enamel, to protect the label surface. Take care not to spray the pins, which would leave an insulating layer on them. Allow the plug to dry, and you have a piece of test equipment, which will come in handy many times.