

Electrical Resistance

Resistance (R)

Any device in a circuit which converts electrical energy into some other form impedes the current. The device which converts electrical energy to heat energy is termed a resistor and its ability to impede current is termed resistance. So resistance can be defined as the opposition to current caused by a resistor.

The value of resistance of a conductor depends upon four things;

1. The material from which the conductor is made,
- 2 The length of the conductor (in the direction of the current path),
- 3 The thickness (cross-sectional area *of* the conductor),
- 4 The temperature at which it operates (in general, the higher its operating temperature the greater its resistance).

Unit of Resistance - Ohm (Ω)

Resistance is measured in ohms (symbol Ω). All materials at normal room temperature have electrical resistance. If the material is classed as *a* conductor its resistance is probably much less than 1000 ohms. If the material is classed as an insulator its resistance is probably well in excess of 20,000,000 ohms.

The current in a circuit can be changed by changing the value of the supply e.m.f. (voltage) or the value of the resistance

If the supply e.m.f is increased but the resistance remains the same the current will increase.

If the supply e.m.f remains the same *but* the resistance is increased the current will decrease.

NOTE: It is not possible to change the resistance by changing the e.m.f or the current. The only way to change the resistance is by physically altering the resistor (different material, longer wires, or by changing the conductor area).

Energy and Heat

Whenever there is current in a circuit, energy will be converted from electrical energy to some other form. If resistance is present in the circuit the electrical energy will be converted to heat energy. A lamp will get hot when in use because its filament has resistance and besides converting electrical energy to light it will also convert some to heat.

Overload

The amount of current in a circuit increases as the load increases; the term 'load' refers to the total demand made by all of the electrical devices in the circuit.

Adding devices, such as irons, heaters, washing machines, etc to a circuit increases the load and hence the current. Increasing the load so that it is over the specified maximum for the circuit causes excessive current to flow (known as overload current).

Fuses and Circuit Breakers

The amount of heat produced in a mains supply circuit depends on the amount of current drawn by the load.

For example, when a cable is installed for a domestic lighting circuit the electrician must consider, amongst other factors, the maximum current the cable may be required to carry.

If the correct size of cable has been used the heat generated within it will be minimal when the maximum current flows.

However, if the conductors of the cable are too light (thin), serious overheating of the cable may result. As many of the materials in close proximity to conductors, e.g. timber, wallpaper, birds nests, etc, are of a flammable nature, there is the possibility that overheated wires and connections could cause a fire.

To avoid this danger a protective device is needed in the circuit and the most commonly used are fuses or circuit breakers.

Fuse

A fuse is like the weak link in a chain. When greater than normal current is present the fuse "blows" (i.e. fuses or melts) and opens the circuit interrupting the flow of current, thus destroying itself but preventing the circuit from being damaged through overheating.

Practical Fuses

There are many different types of fuse made today. Two examples are shown on the next page.

The fuse is a weak link such as a thin wire. The box holding the fuse is made of a fire resisting electrical insulator.

Common Causes of Excessive Current

- Short-Circuits (*for example live wires touching inside equipment or cable*)
- Overloads (*for example too many Appliances plugged into one socket outlet*).
- Insulation Faults (*for example worn cables to outdoor equipment allow live conductors to touch earth, or metal objects touch overhead power lines and earth at the same time.*

Let's look again at the report early in the programme.

"Afire at a chemist's shop in Wellington was due to a short circuit n a flexible cord".

It is most likely that the short circuit was caused by a breakdown in the insulation between two conductors after prolonged twisting and bending.

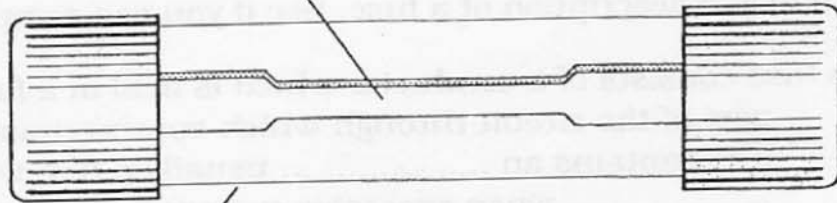
Such a breakdown may occur in many ways - deterioration of insulation with age and deterioration of insulation due to excessive heat.

In such circumstances the fuse protecting the circuit would 'blow' and no significant damage would normally result.

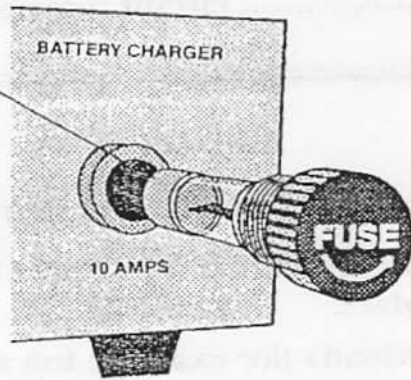
Sometimes, however, there is only a partial breakdown in the insulation separating two conductors and some resistance remains in the circuit

A Cartridge Fuse

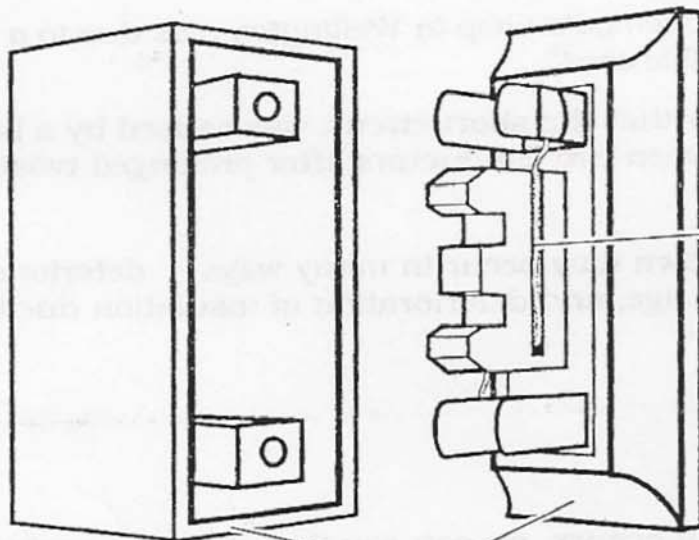
Element: wire or metal strip



A Cartridge Fuse



A Rewirable Fuse



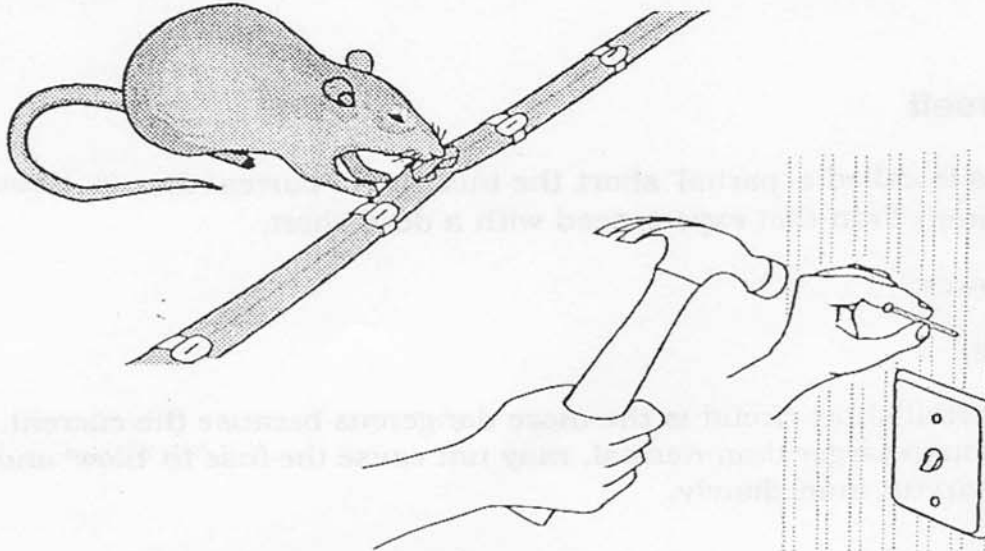
Fuse Wire

A Porcelain Fire-Retardant Base

Insulation

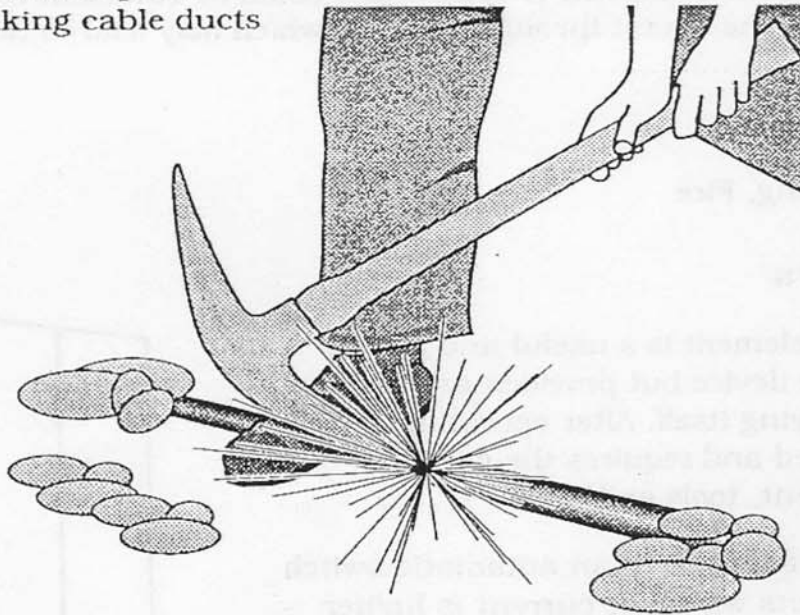
Insulation can be destroyed by:

- Rodents



- Nails driven into walls and penetrating wiring

- Workmens picks striking cable ducts



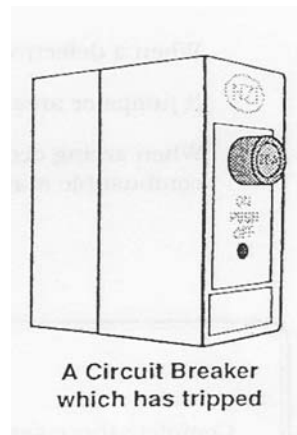
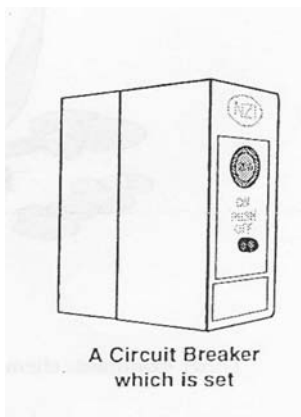
Other examples: chemical attack, movement of building, age, sunlight.

Circuit Breakers

The fuse element is a useful and simple protective device but provides protection by destroying itself. After operation it must be replaced and requires the correct replacement, tools and time.

The circuit breaker is an automatic switch which opens when the current is higher than the maximum rated value of the circuit (overcurrent). The overcurrent heats up the tripping mechanism, which opens the circuit. The circuit breaker is set to the maximum safe current. The setting is more accurate than a fuse, the operation is more rapid and it is possible to reset it easily and without tools.

If a circuit is adequately protected by a fuse or circuit breaker excessive current and dangerous overheating should not occur as a result of an overload, short circuit, or earth fault.



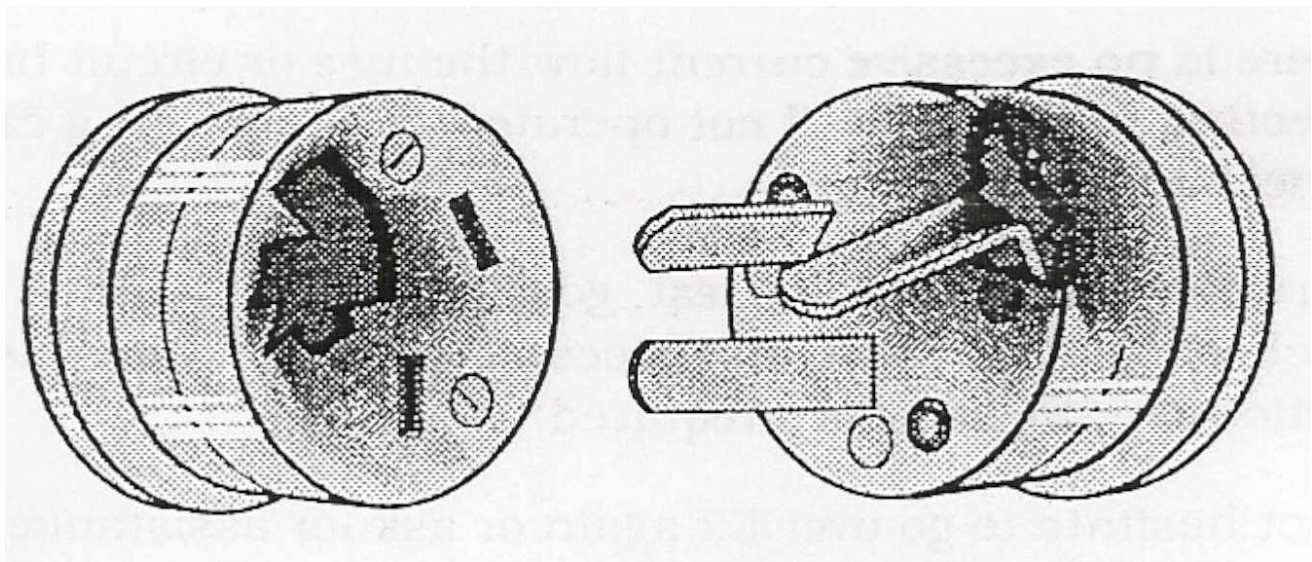
Detective Contact

Sometimes heating occurs in an electric circuit without excessive current flow.

On investigation a defective contact is often found somewhere in the circuit.

Whenever conductors are brought together to complete a circuit, such as in a switch or in a plug and socket, it is essential that good contact is made. Dirt and oxidised metal make a very high resistance path, which reduces the current and may even be of sufficiently high resistance that it acts as an insulator and prevents current flow.

Due to its high resistance a dirty contact will also heat up and could damage the plastic insulation of the plug or socket which could be a fire hazard.



When a defective contact exists the flow of current may continue.

It jumps or arcs across the contact.

When arcing occurs heat is produced and may set fire to any combustible material nearby.

The important thing to realise about a defective contact is that it might not cause excessive current flow.

If there is no excessive current flow the fuse or circuit breaker protecting the circuit will not operate and overheating can continue unchecked.