CIRCUIT BREAKERS

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WHAT IS A CIRCUIT BREAKER?

- A circuit breaker is an equipment that makes or breaks a circuit either manually or automatically under all conditions at no load, full load or short circuit.

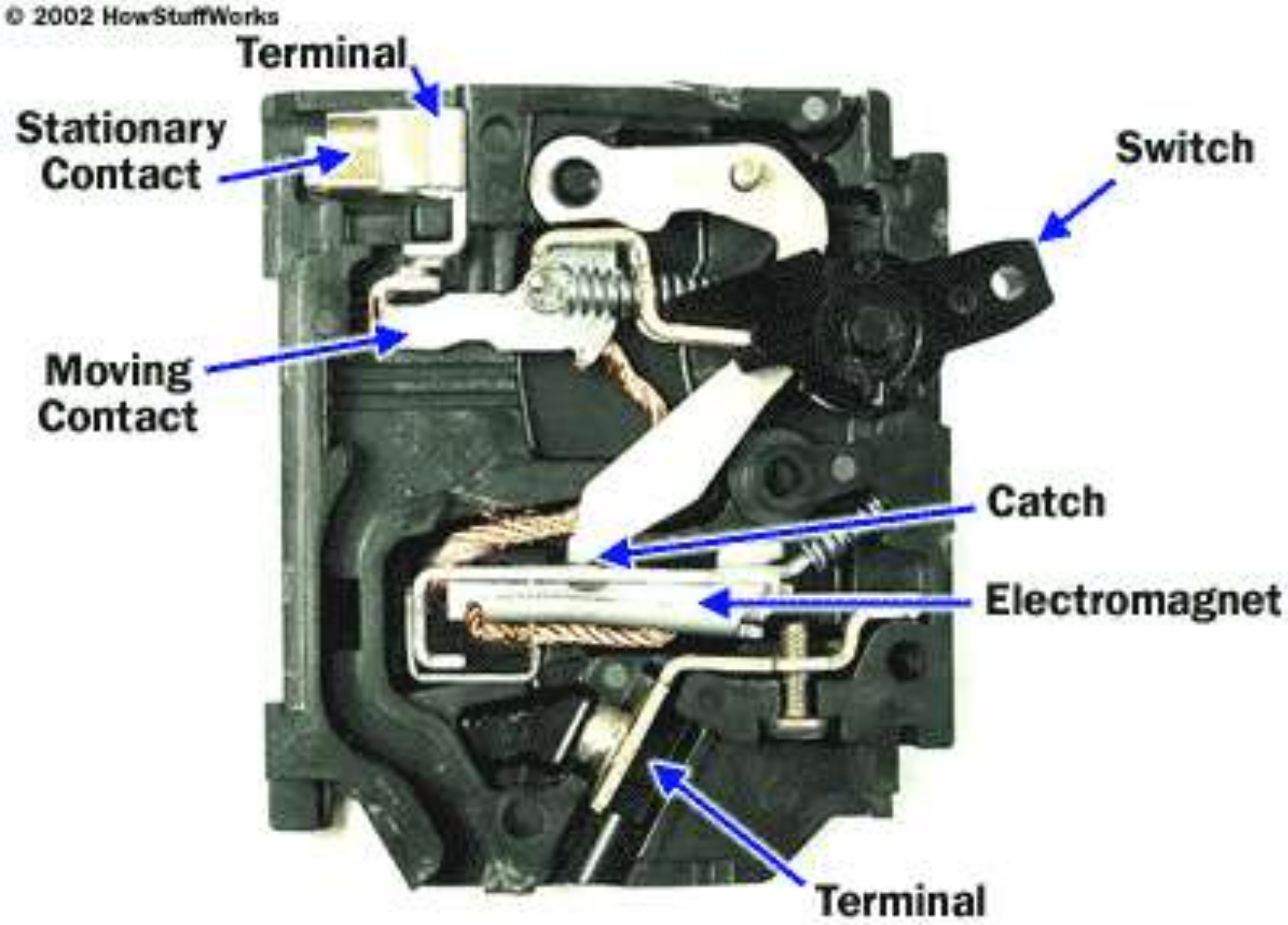
Operating Principle:

Two contacts called electrodes remains closed under normal operating conditions.

When fault occurs on any part of the system, the trip coil of the circuit breaker get energized and contacts are separated.

Basic difference between fuse and circuit breaker ?

- Unlike a fuse, which operates once and then has to be replaced, a circuit breaker can be reset (either manually or automatically) to resume normal operation.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Terminal
Stationary Contact
Switch
Moving Contact
Catch
Electromagnet
Terminal

Parts of Circuit breaker

Parts:

1. Actuator lever - used to manually trip and reset the circuit breaker. Also indicates the status of the circuit breaker (On or Off/tripped). Most breakers are designed so they can still trip even if the lever is held or locked in the "on" position. This is sometimes referred to as "free trip" or "positive trip" operation.
2. Actuator mechanism - forces the contacts together or apart.
3. Contacts - Allow current when touching and break the current when moved apart.
4. Terminals
5. Bimetallic strip
6. Calibration screw - allows the manufacturer to precisely adjust the trip current of the device after assembly.
7. Solenoid
8. Arc divider/extinguisher

Operation

- The circuit breaker must detect a fault condition; in low-voltage circuit breakers this is usually done within the breaker enclosure. Circuit breakers for large currents or high voltages are usually arranged with pilot devices to sense fault conditions.
- Once a fault is detected, contacts within the circuit breaker must open to interrupt the circuit; some mechanically-stored energy contained within the breaker is used to separate the contacts, although some of the energy required may be obtained from the fault current itself. Small circuit breakers may be manually operated; larger units have solenoids to trip the mechanism, and electric motors to restore energy to the springs.
- Contacts are made of copper or copper alloys, silver alloys, and other materials.

Arc Phenomenon

- An arc is struck when contacts are separated. The current is thus able to continue. Thus the main duty of a circuit breaker is to extinguish the arc within the shortest possible time.
- The arc provides the low resistance path to the current and the current in the circuit remains uninterrupted.

Arc Phenomenon

During arcing period, the current flowing between the contacts depends upon the resistance. The greater the resistance, smaller the current that flows between the contacts.

The arc resistance depends upon:

i) Degree of ionization: Arc resistance increases with the decrease in number of ionised particles b/w the contact

ii) Length of Arc: Arc resistance increases with the length of arc

iii) Cross section of Arc: Arc resistance increases with the decrease in X- section of the arc.

The factors that are responsible for maintenance of arc between the contacts are:

i) Potential Difference between the contacts.

ii) ionised particles between the contacts.

Arc Extinction

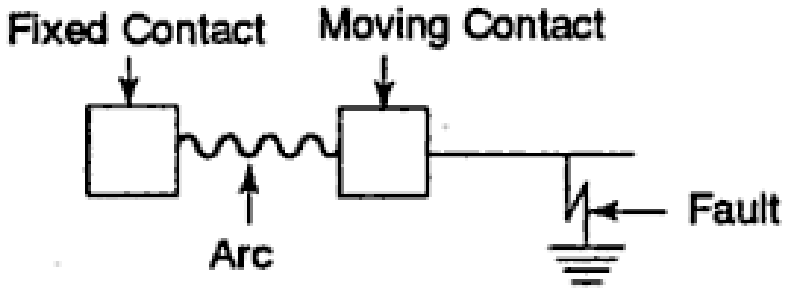

FIGURE 9.1 Separation of the contacts of circuit breaker

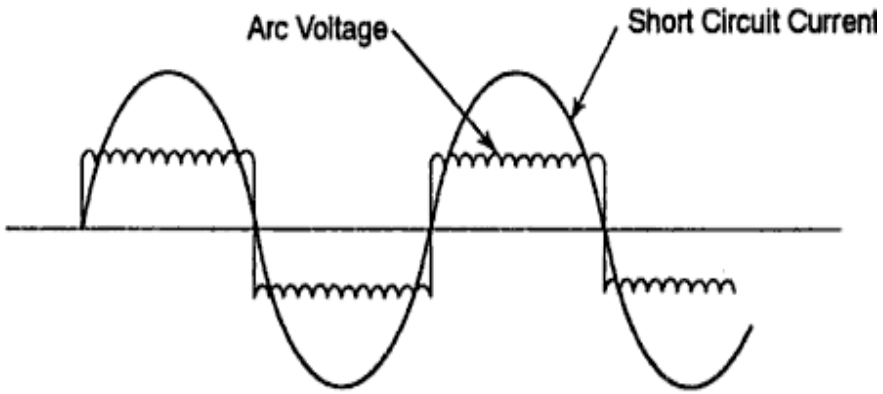

FIGURE 9.2 Short circuit current and arc voltage

Arc Voltage:

The Voltage drop across the arc is called Arc Voltage.

Arc Quenching: (C.B)

- The Arc Produced not only delays the current interruption process but it also generates enormous heat which may cause damage to the system or to the circuit breaker itself.
- Therefore main problem in a C.B is to extinguish the arc within the shortest possible time so the heat generated by it may not reach a dangerous value.

Methods of Arc Interruption

- There are two methods of Arc Interruption or Extinction are

  i) High resistance interruption

  ii) Current zero interruption

High resistance interruption

The arc resistance can be increased by cooling, lengthening, reducing x- section and splitting the arc.

It is employed for low power AC and DC circuit breakers.

Current zero interruption

There are two theories to explain the zero current interruption of the arc.

i) Recovery rate theory (Slepain's Theory)

ii) Energy balance theory (Cassie's Theory)

Techniques used to extinguish the Arc.

- When a current is interrupted, an arc is generated. This arc must be contained, cooled, and extinguished in a controlled way, so that the gap between the contacts can again withstand the voltage in the circuit. Different circuit breakers use vacuum, air, insulating gas, or oil as the medium in which the arc forms. Different techniques are used to extinguish the arc including:
- Lengthening of the arc
- Intensive cooling (in jet chambers)
- Division into partial arcs
- Zero point quenching
- Connecting capacitors in parallel with contacts in DC circuits