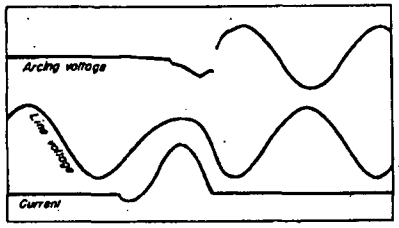
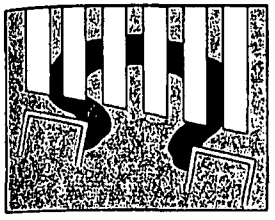
SEVERAL METHODS USED IN CIRCUIT BREAKERS TO INTERRUPT FLOW OF FAULT CURRENT

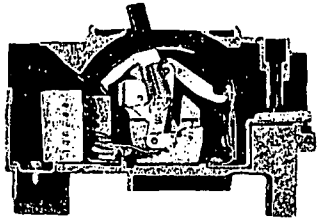


1 Oscillogram shows interruption within ½ cycle of 6450-amp short circuit. Breaker rated 50 amp, 120 v

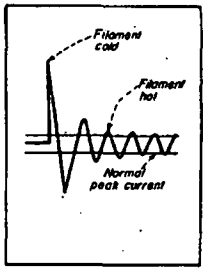
3 Stationary contact coils around insulated iron core that connects steel plates (one shown) to form a U-shaped blowout coil



4 Delon arc quencher has a series of metal plates which break up the arc

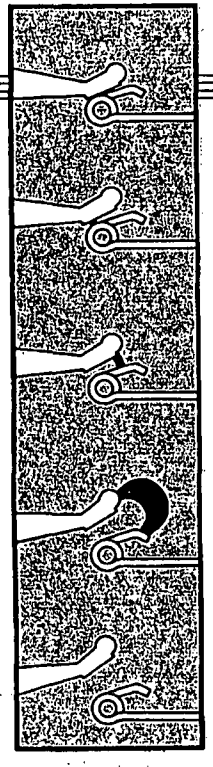


5 Life of breaker contacts is increased through use of the delon arc chamber



6 Incandescent load draws a heavy current momentarily

CIRCUIT BREAKERS



2 Many breakers use plain break shown above to interrupt the current flow. Contacts usually are silver since the silver oxide that forms on the contact surface is a good electrical conductor. Speed in opening breaker reduces contact pitting

The circuit breaker is a device designed to interrupt abnormal current flow in a circuit. It differs from the fuse in that it requires two parts to: (1) detect excessive current and (2) open the main circuit. Here we will discuss principles of circuit interruption as well as types of interrupters.

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Circuit-Breaker Principles. The circuit breaker usually serves a dual function, acting both as switch and overcurrent device. When the breaker trips no replacement of parts is necessary, as it is with a fuse, so time and cost of circuit interruption are reduced.

Formerly circuit breakers were used mainly in high-current circuits (over 600 amp). Of late they have also found wide application in the low-current field. The majority of such breakers have a fault-detecting element that operates on the thermal principle. Many others combine a thermal and magnetic element for more selective operation, Fig. 11. The magnetic principle alone as a fault detector is used in a limited number of circuit breakers in the low-current class, Fig. 3. Construction and characteristics of thermal and magnetic detectors will be described later. When most low-current circuit breakers trip on overload, the operating toggle goes to mid-position. To reset, simply return the toggle to "off" position then snap to "on".

Fig. 10 and 12 show circuit breakers in the high-current class. Their fault-detector usually is magnetic. This type may be operated from a remote point. Where time of circuit interruption must be reduced to a minimum, a reclosing relay allows the breaker to close as soon as the fault is cleared.

Circuit breakers are available with time lag to provide for starting surges, as in Fig. 7. As in motor starting, large surge currents flow when incandescent loads are applied. Fig. 6 shows the momentary current that flows when a cold filament load is applied to a circuit. Note the initial surge current due to the low resistance of the cold lamp filaments. As the lamps heat, resistance of the filaments increases, reducing within a few cycles the current flowing in the circuit. Fig. 7 also shows variation of the circuit breaker tripping characteristic with time, when used with an incandescent load. As current decreases, the tripping point of the circuit breaker is lowered, assuring full circuit protection.

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Interrupting the Arc. A circuit breaker must break the primary circuit and also extinguish the arc that forms between the contact surfaces when the breaker opens. Below we outline the fundamentals of circuit interruption using an air breaker, in addition to a few common methods of breaking the arc.

Direct Current. To interrupt dc successfully, the circuit breaker must open to a point where voltage required to maintain an arc is greater than that existing between the open contacts. Consider the load's nature when selecting circuit breakers for dc systems. Incandescent and resistive loads may be interrupted with relative ease. Heavy arcing occurs when a series motor circuit is opened because of the magnetic effect of the series field. The collapsing magnetic field induces a voltage within the series field windings, which in turn tries to maintain current in the circuit during the period of circuit-breaker opening.

Alternating Current. Let's consider the ideal case if an ac circuit breaker interrupts a unity power factor or resistor load. Since current and voltage are in phase, the arc is interrupted when the voltage reaches its zero value. A sufficient gap must exist between the contacts at that time to prevent re-establishment of the arc when voltage increases in the next cycle.

Interrupting a reactive or motor load presents a greater problem since voltage and current are out of phase. Current continues to flow during the time voltage passes through its zero value. When current decreases to zero, a voltage exists between the open contacts, resulting in re-establishing the arc. The time necessary to interrupt a reactive load depends mainly on the speed at which the contacts separate the necessary distance to prevent restarting the arc.

Short Circuit. A short circuit at any point in a system causes an abnormal current to flow. The value of this fault current in an ac circuit depends upon the sub-transient reactance of the rotating machines connected to the system at the time, and the impedance of the circuit between the source and point where short circuit occurs.

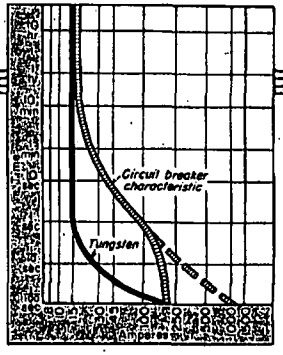
All synchronous generators, synchronous motors and induction motors are sources of short-circuit current. They contribute an initial heavy current surge that diminishes rapidly, Fig. 9. This is a typical curve of a short-circuit current in one phase of a low-voltage 3-phase system. The curve *AB* represents the dc component that displaces the total current wave from the horizontal zero axis. After a few cycles this dc component of current dies down and leaves only the ac component, which is symmetrical to the zero axis.

Since the maximum interrupting duty of low voltage air circuit breakers is assumed to occur one-half cycle (60-cycle basis) after the fault occurs, effect of the dc component on the short-circuit current is considered in design of circuit breakers for high-current applications.

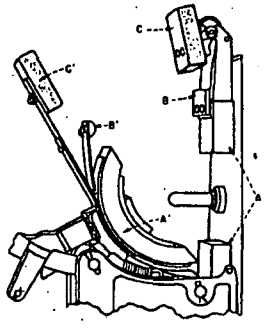
Plain Break. The smaller circuit breaker, often uses a simple break arrangement to interrupt the primary circuit. Successive steps in interrupting current flow are illustrated in Fig. 2.

When circuit breaker contacts open in air, an oxide of the contact metal is formed on the contact surfaces, after an electrical arc is established. Silver contacts are generally used since silver oxide is a good electrical conductor.

Delon Principle. For an arc to exist, the gas between open contacts must be in a conducting state. When the electric-current flow is interrupted between two surfaces, air between the contacts becomes ionized, making it an electrical



7 Circuit breakers with initial time lag will not trip on incandescent surge



8 When breaker trips the main contacts shift load to contacts B'B. These in turn should open before arc is broken by carbon tips C'C. Carbon was used to break arc because of its non-pitting characteristic. Most manufacturers now use a silver alloy in place of carbon