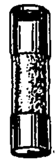
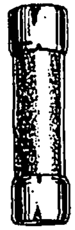
CONSTRUCTION FEATURES OF NONRENEWABLE FUSES

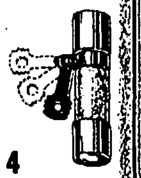
1 Plug fuses are used for branch-circuit protection. Maximum rating is 30 amp at 125 v. Time-lag type, shown at right, does not open on short-time overload



2 Indicator shows if fuse opens, making blown fuses easy to find. Not used on renewable type

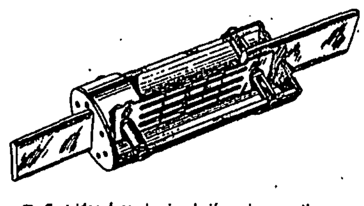


3 Ferrule-end cartridge: 35-60 amp



4 Fuses are replaced safely by use of insulated grip. Conventional fuse puller is not needed

OPERATING TIME ON SHORT CIRCUIT AND OVERLOAD



5 Cartridge fuses having knife-end connections are rated 70-600 amp at 250 v. Similar construction is used in 600-v fuses but over-all length is greater

6 Oscillogram at A shows a successful circuit interruption under short circuit. Reignition of the arc is clearly indicated in B, delaying the circuit opening. Note voltage during period of short circuit

FUSES

A fuse serves as a safety valve in an electrical circuit, opening it when too much current flows. Unlike most other electrical protective devices, the same element detects flow of excessive current and interrupts the primary circuit. Simplicity, low first cost and application flexibility make fuses particularly suitable to protect low-voltage low-capacity circuits.

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General Characteristics. Fuses consist essentially of two parts: (1) fusible element that carries current and melts when the current exceeds a definite value for a certain length of time (2) casing that encloses and supports the fusible element, or *link*, and makes contact with the external electrical circuit.

The original fuse was a thin piece of copper wire. This proved unsatisfactory since the element had to reach an extremely high temperature before it would blow. Copper soon gave way to alloyed wire with a lead base. As zinc has less tendency to hold an arc, it soon replaced lead.

All ordinary fuses have links of zinc alloy, with one or more reduced sections near the center. If an excessive current flows long enough, the link overheats and the thin portion melts. At first, the gap is not big enough to open the circuit and an arc forms. Further melting increases the gap to a length over which the arc cannot be maintained, and the circuit is then interrupted.

The two oscillograph traces, shown at *A* in Fig. 6, are of voltage and current taken at the point of short circuit. When the short was applied voltage dropped to a near-zero value while current increased to over 3000 amp. The fuse opened the circuit in 1/60 of a second. Oscillogram, *B* in Fig. 6, shows reignition of the arc, delaying circuit interruption. Here, increased capacity allowed short-circuit current to build up to 7580 amp. Time required to clear the circuit was twice that of *A*.

All fuses possess an *inverse time characteristic.* This means the amount of current flow that will blow the fuse decreases as the length of time over which it is applied increases. Fig. 7 shows a typical characteristic curve, illustrating the inverse-time principle. This curve represents the average blowing time of different makes and sizes of enclosed fuses of both the renewable and the nonrenewable types.

National Board of Fire Underwriters specifies that all fuses shall carry 110% of rated current indefinitely, and shall blow on 150% of rated current in a specified time. Fig. 8 shows time limits within which fuses of a given rating blow when carrying 150% rated current. For example, a 200-amp fuse opens in 6-12 min when carrying 300 amp. Since the ability of a fuse to dissipate heat increases with its size, because of increase in the conducting area, blowing time is greater for the larger fuse. Standard enclosed fuses must be capable of interrupting short-circuit currents of at least 10,000 amp at rated voltage. This test uses direct current. We may consider the maximum short-circuit current as that which would flow if the circuit were shorted at the point where fuses are to be installed.

Fuses are plainly marked to show current rating and voltage. Cartridge fuses in the 0- to 15-amp 250-v class have a blue label pasted on the fiber tube. If they are rated at more than 15 amp they carry a green label. All 600-v fuses have their current and voltage rating printed on a red label.

Fuses differ mainly in the form of casing. There are three basic types, each usually serving a definite voltage and current range: (1) plug fuses handle up to and including 30 amp at 125 v. (2) Cartridge fuses with ferrule ends are rated up to and including 60 amp at 125, 250 and 600 v. (3) Knife-end cartridge fuses handle currents from 70 to 600 amp, at 125, 250 and 600 v. Over-all length of the 600-v cartridge fuses is greater than of those designed for 250-v circuits.

Plug Fuses. Plug fuses, Fig. 1, are limited to 125-v applications. They are commonly used on lighting circuits and for protection of small motors. A screw-shell base serves for both electrical contact and mechanical support. Fusible element is visible through a window of mica, glass or other transparent material in the cap.

National Electrical Code requires that 0- to 15-amp plug fuses be distinguished from others of larger rating by a hexagonal window in the cap or some other prominent hexagonal feature. Plug fuses are available with a symbol on the transparent top indicating the link's condition. When it opens the symbol is destroyed, making it easy to pick out the blown fuse.

Both industry and the home make wide use of plug fuses. Misuse of units of this class is common. To prevent overfusing, bridging and other abuses, the Type S nontamperable fuse has been developed. It can be installed in its own special fuse holder or any Edison-base fused-cutout by use of an adapter. Type S comes in two sizes: 0-15 and 16-30 amp.

Because of difference in base sizes, Type S fuses of one rating are not interchangeable with those of the other. The adaptors are so made that once they are screwed into a standard-base fuse holder they cannot be removed. At the present time, use of Type S fuses is not mandatory although the National Board of Fire Underwriters has the matter under consideration.

Cartridge Fuses. In cartridge types, the link is enclosed in a hard-fiber tube. The element of nonrenewable fuses is surrounded with heat-resistant powder, which aids in quenching the arc by mechanically displacing it and cooling the metallic vapor. This vapor, produced by the fusible element under short circuit, generates considerable pressure on the cartridge. This is relieved and the gas cooled by vents in the cartridge ends. Typical links and cartridge constructions are shown.

When a fuse blows, only the link is destroyed. Fiber tube and copper ends remain intact. Development of the renewable fuse came as a natural outgrowth of the desire to retain these undamaged parts. Several renewable-link designs are shown in Fig. 13. Fig. 12 illustrates a renewable element that is encased in arc-quenching powder.

Nonrenewable fuses cost less and hence are widely used to protect circuits where faults are unlikely. Many of these fuses may be returned to the maker to refill at small cost. The renewable type represents a larger initial investment, but usually pays over an extended period since only the link is replaced each time the fuse blows.

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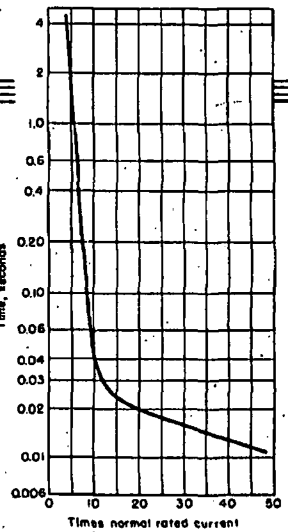
Time Lag. The time-lag fuse was developed to eliminate blowing on momentary overloads. On short circuit, it opens with the same speed as a regular fuse. Such a unit is well suited to protect motor circuits where the large starting currents would blow a regular fuse. This type is available in both the plug and cartridge designs for the standard voltage ranges. Fig. 13 illustrates the regular and time-lag renewable links.

In addition to those shown, another style time-lag fuse consists of a regular link in series with a thermal cutout. Fuse link opens on short circuit but will not blow on short-time overloads. Overloads that persist cause the thermal cutout to operate. This cutout is designed to trip under prolonged loads that are within 500% of the fuse rating. Copper link blows on overloads and short circuits drawing over 500% rated current. A helical spring is connected to the junction of fuse link and thermal cutout. On dangerous overloads solder in the cutout melts, allowing the spring to pull the fuse link and open circuit.

Panelboard overheating may often be traced to accumulated heat developed by fuses. It is reduced with time-lag fuses, which have lower resistance than ordinary units. Reduced resistance comes through the use of copper as the blowing element.



7-8 Typical blowing characteristic for various fuses is shown above. Opening time on 50% overload is shown below