May 28, 1957 F. J. KOZACKA 2,794,096

HIGH INTERRUPTING CAPACITY CURRENT-LIMITING FUSES WITH STRIKER PINS

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Fig. 1.

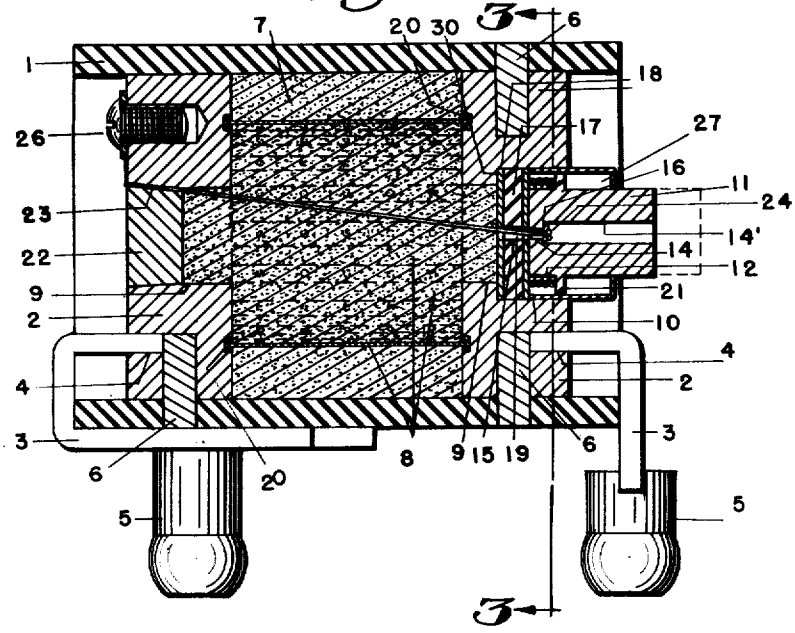


Fig. 2.

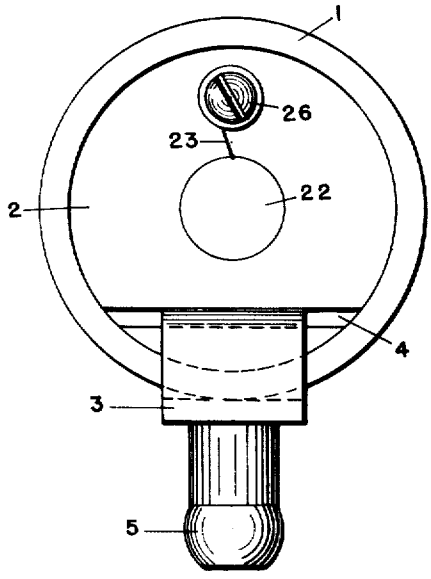
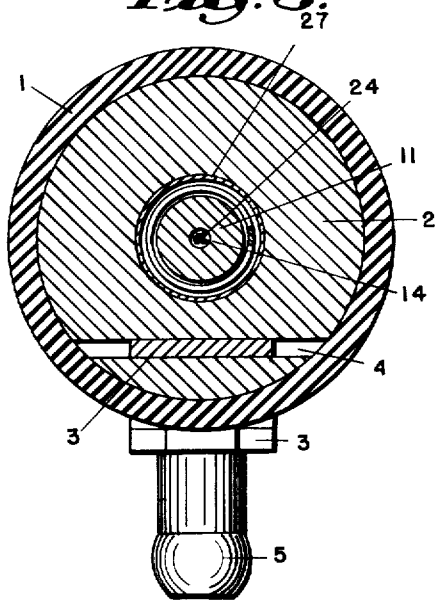


Fig. 3.



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HIGH INTERRUPTING CAPACITY CURRENT-LIMITING FUSES WITH STRIKER PINS

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This invention relates generally to fuses for the protection of electric systems and for the protection of electric apparatus and electric machinery connected into electric systems, and more particularly to high-interrupting-capacity current-limiting striker pin fuses.

Fuses with striker pins are intended to cooperate with automatic switches or circuit breakers. Upon blowing of the fuse the striker pin thereof is caused to trip an automatic switch or circuit breaker associated with the fuse. Tripping of a multipolar automatic switch or circuit breaker causes interruption of all the phases of a multiphase circuit into which the automatic switch or circuit breaker is connected, though but less than all the phases of the circuit might initially have been interrupted by blowing of one or more fuses.

Where striker pin fuses are being combined with automatic switches or circuit breakers to jointly form coordinated and integrated protective devices, serious space limitations are generally imposed as a result of the increase in pieces of equipment. Imposition of such space limitations compels designers of striker pin fuses to cram a maximum of current-carrying capacity and a maximum of interrupting capacity into a minimum of space. Extreme compactness tends to result in very high internal pressures in fuses incident to blowing thereof on severe faults. Occurrence of high internal pressures calls for casings and terminal elements of great mechanical or bursting strength.

There are different methods of pre-storing in a striker pin fuse the energy required to trip an automatic switch or circuit breaker upon blowing of the fuse. One of these methods consists in pre-storing the tripping energy in a compressed striker-pin-biasing spring, the striker pin being normally restrained by a restraining wire attached to it. Upon fusion of the fuse links the restraining wire is caused to carry current and fuses rapidly as a result of heating, thus releasing the striker pin which, impelled by the compressed or otherwise loaded spring, trips the automatic switch or circuit breaker with which the fuse is associated.

The presence of the restraining wire in striker pin fuses has resulted in numerous difficulties and failures, particularly where relatively high-interrupting-capacity and relatively high tripping energy are important requirements.

It is, therefore, one object of this invention to provide high-interrupting-capacity striker pin fuses which are free from the drawbacks and limitations normally resulting from the presence of the restraining wire.

The fuse links of high-interrupting-capacity fuses are generally made of silver, the vapors of which have but a small conductivity at temperatures not substantially higher than the boiling point of silver. Silver cannot be used, however, for restraining wires of the striker pins since silver has a relatively small tensile strength, not sufficient to withstand the relatively high stresses imposed by the relatively strong tripping springs in striker pin fuses. In order to be able to withstand these stresses, restraining wires for striker pins must be made of steel. Steel vapors are highly ionized at relatively low temperatures, and

hence the use of restraining wires of steel tends to contaminate the arcing zone and thus to impose relatively severe interrupting duties upon striker pin fuses. Another factor tending to render the interrupting duty of such fuses particularly severe resides in the fact that the zone surrounding the restraining wire is pre-heated, and to some extent pre-contaminated by products of arcing resulting from the arc, or arcs, formed incident to blowing of the fuse link. In spite of these handicaps inherent in compactly designed high-interrupting-capacity current-limiting striker pin fuses, such fuses can generally be made to operate successfully by imparting utmost mechanical strength to their arcing chamber formed by their casing and their terminal elements. I have observed that however high the mechanical strength of these parts may be, failures may occur occasionally in erratic or random fashion, for which failures no explanation has been given heretofore.

It is, therefore, another object of this invention to provide high-interrupting-capacity current-limiting striker pin fuses which perform consistently and are absolutely free from erratic behavior.

I have found that high-interrupting-capacity fuses without striker pins may consistently interrupt a given circuit, yet the very same fuses may show erratic behavior when a striker pin mechanism including a restraining wire of steel is added to them. From this observation it is safe to conclude that it is the striker pin mechanism which causes the fuses to perform inconsistently, or erratically.

The destruction of a restraining wire by a high fault or impulse current is in the nature of an explosion. Such wire explosions have been investigated by a great number of investigators, and for a more complete understanding of the phenomena involved in fusion and vaporization of wires at high current densities reference may be had to the papers of these investigators. (See, for instance, Anderson, J. A.: Proc. Nat. Acad. Sci., Wash., 6, 42 (1920); 8, 231 (1922), and Anderson, J. A. and S. Smith: Astrophys, J. 64, 295 (1926).) The classic investigations by Anderson and his associates were applied to wires in fuses and broadened by J. Wrana (see Archiv fuer Elektrotechnik 33, 656 (1939)) with whose findings my own findings are substantially consistent.

When a wire fuses and vaporizes at high current densities, series breaks are formed along the wire at a very rapid sequence. The location of the particular points at which breaks along a wire are formed, and the sequence in which these breaks are formed, seems to result from uncontrollable inhomogeneities in the microscopic structure of the wire. The arc voltage at the first formed break is generally not sufficient to have an appreciable effect on the current intensity in the wire. As additional series breaks are rapidly formed, the total arc voltage is rapidly increased to the point where it is sufficient to reduce the current rise and to bring the current down to zero. It can be seen in high-speed pictures taken of explosions of wires that one or more breaks may occur at a particular region of a wire, say immediately adjacent of one of its ends, and result in substantial vaporization of the wire at that particular region, whereas the wire is still substantially intact everywhere else along its length, or shows relatively few signs of deintegration except at the particular region where deintegration of the wire has initiated. This phenomenon is of considerable importance as regards the operation of striker pin fuses. If a restraining wire of a high-interrupting-capacity current-limiting striker pin fuse comprises a region where the deionizing action to which it is subjected is but relatively small, and if initial arc formation should happen at this particular region, and if a relatively long time should elapse until series arcs resulting in a substantial rise of the arc voltage are formed at other points of the restraining wire, then

a combination of conditions exists which is conducive to failure of the fuse, however high the mechanical or bursting strength of its structure may be.

It is, therefore, another object of this invention to provide highly pressure-resistant high-interrupting-capacity current-limiting striker pin fuses comprising bodies of pulverulent arc-quenching fillers substantially co-extensive with the restraining wire so as to avoid formation of regions along the wire, however short the length thereof may be, where the wire is subjected to but a relatively small de-ionizing action. In other words, it is another object of this invention to provide highly pressure-resistant high-interrupting-capacity current-limiting striker pin fuses wherein the length of the restraining wire extending beyond the pulverulent arc-quenching filler is practically zero.

A further object of this invention is to provide compact high - interrupting - capacity current - limiting striker pin fuses having improved sealing means for precluding escape of incandescent or hot metal vapors resulting from vaporization of the restraining wire.

These and other objects and advantages of the invention will become apparent upon consideration of the following detailed description of one embodiment thereof when taken in connection with the appended drawing, wherein

Fig. 1 is a longitudinal section of a striker pin fuse embodying my invention,

Fig. 2 is an end view of the structure in Fig. 1 seen from the left side thereof, and

Fig. 3 is a section along 3—3 of Fig. 1.

Referring now to the drawing, numeral 1 has been applied to indicate a casing made of a heat-shock resistant and high pressure-resistant insulating material. In other words, the material of which casing 1 is made is able to withstand high temperatures occurring at a rapid rate of change and has a very high shock bursting strength. Casing 1 consists preferably of a glass-cloth-synthetic-resin laminate. The terminal elements of the fuse comprise a pair of relatively heavy copper plugs 2, a pair of relatively heavy copper straps 3 of which each is inserted into a groove 4 in one of plugs 2, and a pair of pin contacts 5 each supported by one of said copper straps 3. Pin contacts 5 are shaped spherically at the lower ends thereof and are intended to be inserted into a pair of cooperating tulip-contacts (not shown). Each copper plug 2 closes one end of casing 1 and is secured to casing 1 by a plurality of steel pins 6 projecting transversely across casing 1. Casing 1 accommodates a pulverulent arc-quenching filler 7, preferably chemically reasonably pure quartz sand from which such impurities as iron have been carefully removed. Casing 1 further accommodates fuse link means 8 consisting of a plurality of multi-perforated silver ribbons conductively interconnecting the pair of plugs 2. Each of both plugs 2 is provided with an inner coaxial cylindrical recess 9 which is filled with pulverulent arch-quenching medium 7. The right plug 2—as seen in Fig. 1—comprises an outer coaxial cylindrical recess 10 accommodating the striker pin 11 and the helical spring 12. The striker pin 11 has a first relatively short bore 14 of relatively small diameter arranged adjacent to recess 9 in the right hand plug 2. In addition thereto, striker pin 11 is provided with a relatively long bore 14' of relatively large diameter. Bore 14' is arranged on the side of striker pin 11 remote from recess 9. Bores 14 and 14' form a shoulder 16 at the junction thereof. Partition 15 separates the inner recess 9 from the outer recess 10. Partition 15 comprises an inner disc 17 made of a relatively soft elastomer, preferably of highly heat resistant silicone rubber, sandwiched between a pair of outer discs 18 of relatively hard material, e. g. copper. A hole 19 of small diameter is provided in the center of partition 15, i. e. hole 19 is arranged in registry with recess 9 and extends transversely across inner disc 17 and outer discs 18. Partition 15

rests against a shoulder 30 formed in plug 2 at the junction of recesses 9 and 10. Helical spring 12 rests with one end thereof against partition 15 and with the other end thereof against a collar 21 projecting radially outwardly from the main body of striker pin 11. Normally striker pin 11 is maintained in position against the action of striker-pin-biasing spring 12 by a strong restraining wire 23 of steel of which one end is firmly anchored in the left recess 9 by means of a plug 22, driven into that recess and wedging restraining wire 23 therein. Restraining wire 23 extends through the pulverulent arc-quenching filler 7 in both recesses 9 and is threaded through hole 19 in partition 15 into bore 14. To secure restraining wire 23 to striker pin 11 the former is provided with a knot 24 abutting against shoulder 16 at the junction of bores 14 and 14' of striker pin 11.

It is desirable to establish highly conductive joints between the fuse link means 8 whose shape is subtantially tubular or cylindrical and the copper plugs 2. This may be achieved by pressure type contacts, as more fully disclosed in my copending patent application Ser. No. 436,398 filed June 14, 1954, for Power Fuses With Tubular Links and Pressure Type Link Connections, now United States Patent 2,777,033, issued January 8, 1957. It is also possible to join fuse link means 8 and copper plugs 2 by solder. To this end each of the axially inner surfaces of plugs 2 is provided with a coaxial circular groove 20 receiving the ends of link means 8, which groove 20 can readily be filled with solder on account of the capillary action thereof.

The part of hole 19 extending through the inner silicone rubber disc 17 is sufficiently narrow to exert radially inward pressure against the periphery of restraining wire 23. The pressure of spring 12 against the outer copper disc 18 upon which it rests tends to compress the inner disc 17 made of silicon rubber or another rubber-like material. Consequently, inner disc 17 is compressed axially and tends to expand radially inwardly and radially outwardly, providing a highly effective seal between inner recess 9 and outer recess 10.

It will be apparent from the foregoing that the body of pulverulent arc-quenching medium 7 is substantially coextensive with the active length of the restraining wire 23, this being mainly achieved by the provision of the recesses or filler pockets 9. The length of the portion of the restraining wire 23 which extends beyond the body of pulverulent arc-quenching medium 7 is virtually zero. This length is equal to the distance between the point 16 where restraining wire 23 is anchored to striker pin 11 and the point where it leaves hole 19 in partition 15 and enters the recess or filler pocket 9. Because of the shortness of this length, the danger that arc-initiation will occur along said length is minimized. In case that the initial break in wire 23 should form a some point outside of filler 7, inner disc 17 has a limited deionizing or arc-quenching action tending to delay failure for a short but sufficiently long interval of time to permit formation of multi-breaks along that portion of restraining wire 23 submersed in pulverulent arc-quenching filler 7.

The clamping screw 26 provided on one of plugs 2 is needed when assembling the fuse but has no functional object as far as the operation of the assembled fuse is concerned. In the process of assembling the fuse a subassembly is formed including striker pin 11, spring 12, partition 15, restraining wire 23 and metal cap 27 forming a housing for striker pin 11 and spring 12 and having a hole in the front surface thereof for the passage of the striker pin. Subassembly 11, 12, 15, 23, 27 is inserted into recess 10, whereupon the opposite end of restraining wire 23 is passed through left recess 9—as seen in Fig. 1—and tautly held in position by means of clamping screw 26. Then casing 1 is filled with quartz sand, or another equivalent pulverulent arc-quenching medium through the recess or passage 9 adjacent clamp-

ing screw 26. When casing 1 is substantially entirely filled, plug 22 is driven into recess or passage 9 adjacent screw 26, whereby casing 1 is firmly closed and whereby restraining wire 23 is firmly maintained in taut position without reliance on the effectiveness of clamping screw 26 which, in time, may loosen.

Upon occurrence of a major fault fuse link means 8 fuse and vaporize. Up to that time restraining wire 23, being effectively shunted out by fuse link means 8, does not carry any appreciable current. Upon removal of that shunt the current density in restraining wire 23 rises rapidly, resulting in an explosion-like disintegration thereof in a pre-heated and pre-contaminated surrounding. Casing 1 and plugs 2 firmly held in position by transverse steel pins 6 have sufficient bursting strength to withstand the resulting shock or pressure wave. Escape of products of arcing is positively precluded by the sealing means formed by partition or barrier 15. While partition or barrier 15 may bodily be moved by high internal pressures from left to right (as seen in Fig. 1), the inner disc 17 thereof operates in the fashion of a piston ring, precluding hot gases from moving from one side to the other side of recess 10. The higher the internal pressure, the higher the force with which sealing disc 17 tends to radially expand, and the higher the sealing action thereof.

While, in accordance with the patent statutes, I have disclosed the specific details of one embodiment of my invention, it is to be understood that these details are merely illustrative and that variations in their precise form will not only be desirable but necessary in certain instances. It is my desire, therefore, that the language of the accompanying claims shall be accorded the broadest reasonable construction and shall be limited only by what is expressly stated therein and by the prior art.

I claim the following as my invention:

1. A high-interrupting-capacity current-limiting striker pin fuse comprising a tubular casing of insulating material, a pulverulent arc-quenching filler filled directly into said casing, and fuse link means immersed in said filler, a pair of terminal elements including a pair of metal plugs conductively interconnected by said fuse link means, each of said pair of plugs being inserted into and closing one end of said casing and each having an internal recess on the side thereof situated inside of said casing, a portion of said filler being accommodated in said internal recess in each of said pair of plugs, a spring biased striker pin accommodated in an external recess provided in one of said pair of plugs in juxtaposition to said internal recess in said one of said pair of plugs, and a restraining wire for said striker pin conductively interconnecting said pair of plugs and extending through said internal recess in each of said pair of plugs.

2. A high-interrupting-capacity current-limiting striker pin fuse comprising a tubular casing of insulating material, a pulverulent arc-quenching filler filled directly into said casing, and ribbon-type fuse links immersed in said filler, a pair of terminal elements comprising a pair of metal plugs conductively interconnected by said fuse links, each of said pair of plugs being inserted into and closing one end of said casing and attached to said casing by transverse pins and each of said pair of plugs having an internal cylindrically shaped recess in the center of the side thereof situated inside said casing, a portion of said filler being accommodated in said recess in each of said pair of plugs, an external cylindrically shaped recess formed in the center of one of said pair of plugs at the side thereof outside said casing, a striker pin and a helical spring biasing said striker pin both arranged in said external recess, and a restraining wire for said striker pin conductively interconnecting said pair of plugs and extending through said internal recess in each of said pair of plugs, the axially outer ends of said restraining wire being but narrowly spaced from said internal recess in each of said pair of plugs.

3. A high-interrupting-capacity current-limiting striker pin fuse as specified in claim 2 comprising sealing means accommodated in said external recess, said sealing means including at least one disc made of an elastomer and having a bore for the passage of said restraining wire sufficiently narrow to exert radially inward pressure against the periphery thereof.

4. A high-interrupting-capacity current-limiting striker pin fuse comprising a tubular casing of insulating material accommodating a pulverulent arc-quenching filler and fuse link means immersed in said filler, a pair of terminal elements comprising a pair of metal plugs conductively interconnected by said fuse link means, each of said pair of plugs being inserted into and closing one end of said casing and being attached to said casing by pins projecting transversely across said casing, one of said pair of plugs having an inner recess filled with pulverulent arc-quenching filler and an outer recess of different diameter accommodating a spring-biased striker pin, a shoulder formed between said inner recess and said outer recess supporting sealing means for sealing said inner recess from said outer recess, and a restraining wire for said striker pin conductively interconnecting said pair of plugs and extending through said filler in said inner recess and across said sealing means to said striker pin.

5. A high-interrupting-capacity current-limiting striker pin fuse comprising a tubular casing of insulating material accommodating a pulverulent arc-quenching filler and fuse link means immersed in said filler, a pair of terminal elements comprising a pair of metal plugs conductively interconnected by said fuse link means, each of said pair of plugs being inserted into and closing one end of said casing and being secured to said casing by pins projecting transversely across said casing, one of said pair of plugs having an inner recess of relatively small diameter filled with pulverulent arc-quenching filler and an outer recess of relatively large diameter accommodating a striker pin, a shoulder formed between said inner recess and said outer recess supporting an inner disc made of a relatively soft elastomer sandwiched between a pair of outer discs of relatively hard material, a narrow hole in registry with said inner recess and said outer recess extending transversely across said inner disc and said pair of outer discs, a helical spring arranged between said striker pin and one of said pair of outer discs tending to compress said inner disc, and a restraining wire for said striker pin conductively interconnecting said pair of plugs, and extending through said filler in said inner recess and threaded through said narrow hole.

6. A high-interrupting-capacity current-limiting striker pin fuse comprising a tubular casing of insulating material, a pulverulent arc-quenching filler filled directly into said casing, fuse link means immersed in said filler, a spring-biased striker pin having a first relatively short bore of relatively small diameter and a second coaxial relatively long bore of relatively large diameter, said first bore and said second bore forming a shoulder at the junction thereof, a partition separating said filler from said first bore, a hole of small diameter in said partition, and a restraining wire for said striker pin conductively interconnecting said pair of plugs and extending through said filler and threaded through said hole in said partition into said first bore, said restraining wire having a knot abutting against said shoulder formed in said striker pin.

7. A high-interrupting-capacity current-limiting striker pin fuse comprising a tubular casing of insulating material accommodating a pulverulent arc-quenching filler and fuse link means immersed in said filler, a pair of terminal elements including a pair of metal plugs conductively interconnected by said fuse link means, each of said pair of plugs being inserted into and closing one end of said casing and being secured to said casing by pins projecting transversely across said casing, one of said

pair of plugs having an inner recess filled with pulverulent arc-quenching filler and an outer recess accommodating a striker pin, said striker pin having a first relatively short bore of relatively small diameter arranged adjacent said inner recess and a second relatively long bore of relatively large diameter arranged remotely from said inner recess, said first bore and said second bore forming a shoulder at the junction thereof, a partition separating said inner recess from said outer recess, said partition having a narrow hole in registry with said inner recess and said outer recess and being made up of an inner disc of a relatively soft elastomer sandwiched between a pair of outer discs of hard material, a spring arranged between said striker pin and one of said pair of outer discs, and a restraining wire for said striker pin conductively interconnecting said pair of plugs and extending through said filler in said inner recess and threaded through said hole in said partition into said first bore in said striker pin, said restraining wire having a knot abutting against said shoulder formed in said striker pin.

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