United States Patent [19]

Fister

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[54] **PROTECTOR FOR ELECTRIC CIRCUITS**

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[52] **U.S. Cl.** **337/231**; 337/159; 337/233; 337/291

[51] **Int. Cl.** **H01h 85/16**

[58] **Field of Search** 337/158, 159, 231, 233, 337/290, 291, 295

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[57] **ABSTRACT**

An electric fuse can withstand large centrifugal forces because it has a housing with an elongated small cross-section recess therein, has an elongated support of insulating material secured in face-to-face relation with an elongated fusible element throughout the length of that elongated support of insulating material, and has the inner surface of that elongated recess immediately adjacent the elongated side edges of that elongated support of insulating material to effectively prevent bending of that elongated support of insulating material and thereby also effectively prevent bending of that elongated fusible element. The end of the elongated fusible element which will be subjected to the greatest centrifugal forces is bent around the adjacent end of the elongated support of insulating material to firmly hold that adjacent end, and then is soldered to the adjacent terminal of the electric fuse to connect itself and the adjacent end of the elongated support of insulating material to that terminal in an inelastic and unyielding manner.

13 Claims, 6 Drawing Figures

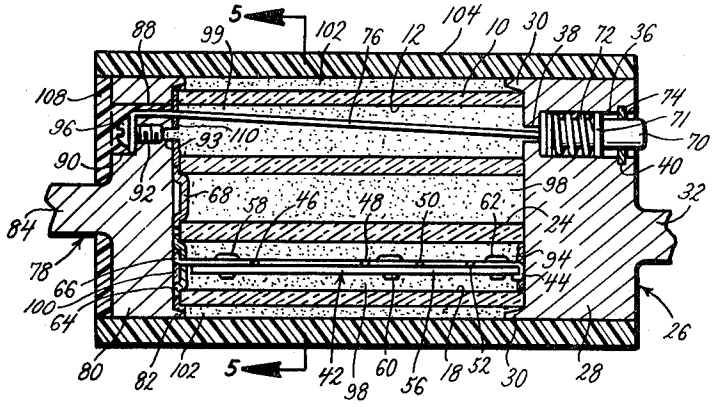


FIG. 1.

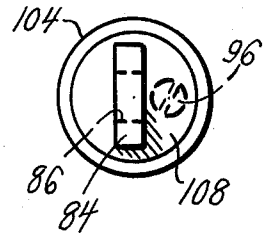


FIG. 2.

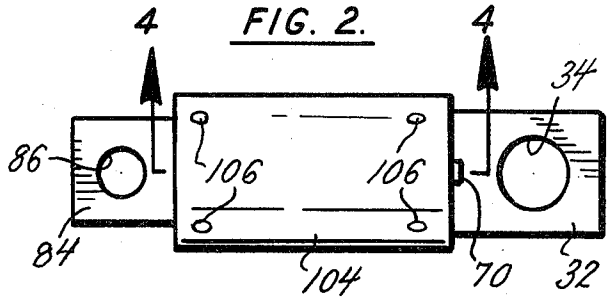
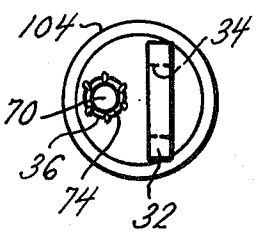


FIG. 3.



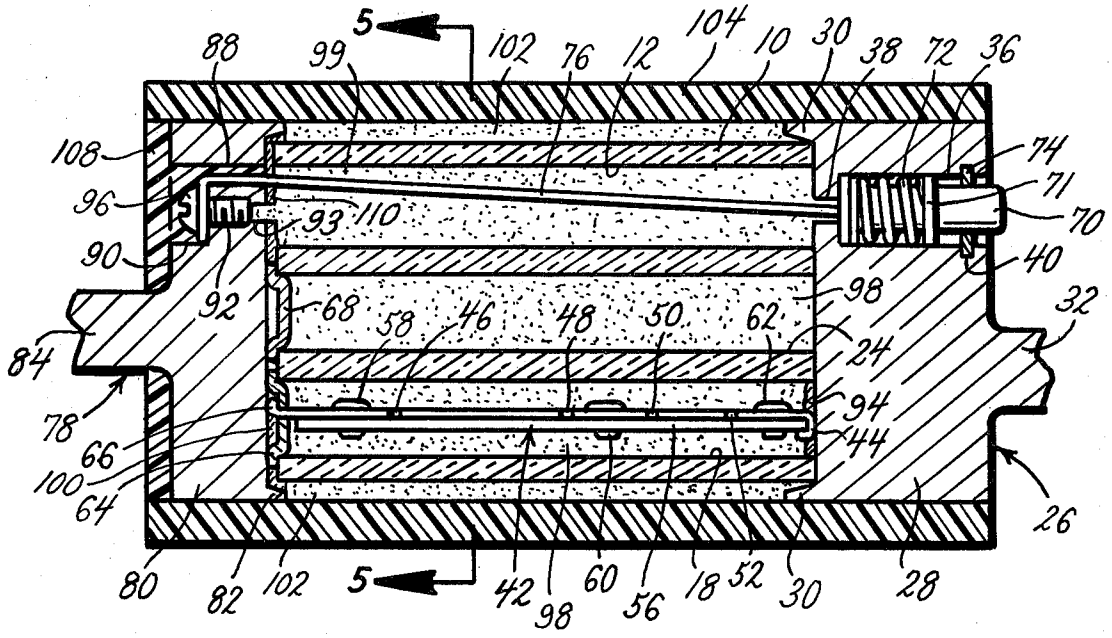


FIG. 4.

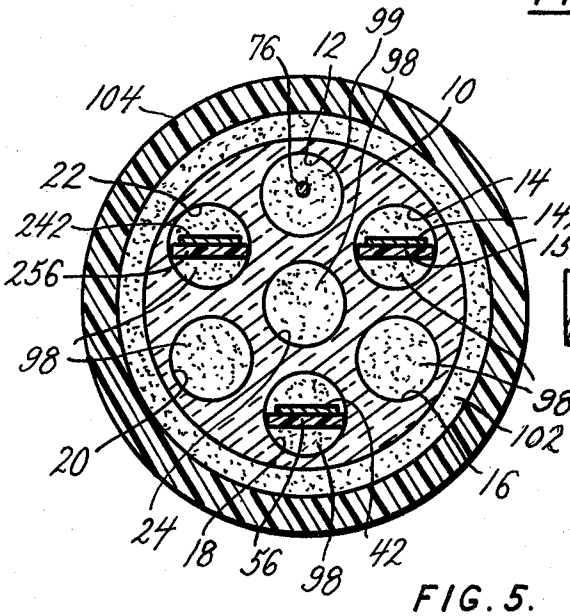


FIG. 5.

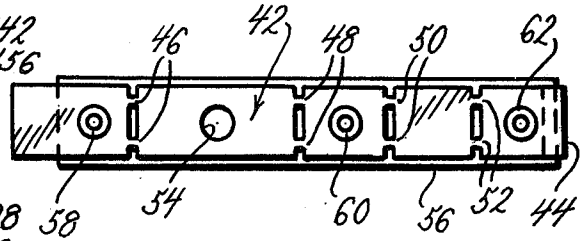


FIG. 6.

PROTECTOR FOR ELECTRIC CIRCUITS

FIELD OF THE INVENTION

Some dynamo electric machines have electric fuses mounted upon rapidly-rotating members thereof; and those electric fuses can be exposed to large centrifugal forces. To be able to rapidly interrupt the currents flowing through such dynamo electric machines, in the event of heavy overloads or short circuits, the fusible elements of those electric fuses must have relatively small cross sections; but electric fuses with relatively small cross sections tend to be fragile.

SUMMARY OF THE INVENTION

The present invention makes it possible to utilize a fusible element of small cross section in an electric fuse that is to be exposed to large centrifugal forces; and it does so by providing an elongated support of insulating material which engages an elongated small cross-section fusible element and by preventing bending of that elongated support of insulating material — and thus of that elongated fusible element. It is, therefore, an object of the present invention to secure an elongated support of insulating material to an elongated small cross-section fusible element and to prevent bending of that elongated support of insulating material — and thus of that elongated fusible element.

Fasteners, such as rivets, secure the elongated fusible element in face-to-face relation with the elongated support of insulating material; and that elongated fusible element has a number of weak spots spaced along the length thereof. One of those fasteners is disposed between one end of that elongated fusible element and that weak spot which is closest to that end of that elongated fusible element, and another of those fasteners is interposed between the opposite end of that elongated fusible element and that weak spot which is closest to that opposite end of that elongated fusible element. As a result, the portions of the elongated fusible element which extend outwardly beyond that one fastener and beyond that other fastener are free of weak spots, and thus are far sturdier and far more rugged than are those portions which have weak spots therein. It is, therefore, an object of the present invention to secure an elongated fusible element, which has weak spots spaced along the length thereof, in face-to-face relation with an elongated support of insulating material by fasteners, at least two of which are disposed axially beyond all of those weak spots.

BRIEF DESCRIPTION OF THE DRAWING

In the drawing,

FIG. 1 is an elevational view of the left-hand end of an electric fuse that is made in accordance with the principles and teachings of the present invention,

FIG. 2 is a side elevational view of the electric fuse of FIG. 1,

FIG. 3 is an elevational view of the right-hand end of the electric fuse of FIG. 1,

FIG. 4 is a sectional view, on a larger scale, through the electric fuse of FIG. 1, and it is taken along the plane indicated by the line 4—4 in FIG. 2,

FIG. 5 is another sectional view, on the scale of FIG. 4, through the electric fuse of FIG. 1, and it is taken along the plane indicated by the line 5—5 in FIG. 4, and

FIG. 6 is a plan view, on the scale of FIG. 4, of one of the elongated fusible elements and one of the elongated supports of insulating material of the electric fuse of FIG. 1.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to the drawing in detail, the numeral 10 denotes a cylinder of ceramic material, such as alumina; and that cylinder has both ends thereof and the portions of the side walls thereof which are adjacent those ends metallized. That cylinder has open-ended elongated recesses 12, 14, 16, 18, 20, 22 and 24 therein; and those open ended elongated recesses have the axes thereof parallel to the axis of that cylinder. Those open-ended elongated recesses are circular in cross section; and the open-ended elongated recess 24 is concentric with the cylinder 10, while the rest of those open-ended elongated recesses are displaced radially outwardly of that open-ended elongated recess and are spaced apart equal distances circumferentially, as shown particularly by FIG. 5. In the said one preferred embodiment of the present invention, the cylinder 10 is one and three-quarters of an inch long and is one and one-eighth of an inch in diameter; and the diameter of each open-ended elongated recess is nine thirty-seconds of an inch.

The numeral 26 generally denotes a terminal which has a cylindrical portion 28 with a rim 30 projecting inwardly from the left-hand face thereof and with a blade-like portion 32 projecting outwardly from the right-hand face thereof; and that blade-like portion has a cylindrical opening 34 of circular cross section through it. The cylindrical portion 28 of the terminal 26 has a cylindrical recess 36 therein, has a small-diameter passage 38 extending inwardly from that recess, and has an annular recess 40 communicating with the recess 36. In the said one preferred embodiment, the cylindrical portion 28 has a diameter of one and three-eighths of an inch, the blade-like portion 32 is one and three-sixteenths of an inch wide and one-quarter of an inch thick, and the cylindrical opening 34 has a diameter of twenty-one thirty-seconds of an inch.

The numeral 42 generally denotes an elongated unitary and homogeneous piece of metal, such as silver, which serves as a fusible element. The right-hand end 44 of that elongated fusible element is bent to have a J-shaped configuration, as shown by FIG. 4. Pairs of weak spots 46, 48, 50 and 52 are spaced along the length of the elongated fusible element 42; and each of those pairs is defined by a transversely-located slot in alignment with two inwardly-extending notches. In the two hundred ampere size of the preferred embodiment, the elongated fusible element 42 has a length of one and six hundred and fifteen thousandths to one and six hundred and twenty thousandths of an inch, has a width of two hundred and fourteen thousandths to two hundred and sixteen thousandths of an inch, and has a thickness of forty-two ten-thousandths to forty-six ten-thousandths of an inch. The numeral 54 denote an opening in the elongated fusible element 42; but that opening is not significant in the operation of the electric fuse provided by the present invention and it could be eliminated.

The numeral 56 denotes an elongated support of insulating material, such as silicone-impregnated woven glass fibers. That elongated support of insulating material is rectangular in cross section, as indicated particu-

larly by FIG. 5. In the said one preferred embodiment, that support of insulating material has a length of one and six hundred and fifty thousandths to one and six hundred and sixty thousandths of an inch, has a width of two hundred and forty-five thousandths to two hundred and fifty thousandths of an inch, and has a thickness of one thirty-second of an inch. One surface of the elongated fusible element 42 is disposed in face-to-face engagement with one surface of the elongated support 56 of insulating material, as indicated particularly by FIGS. 4 and 5. That elongated fusible element and that elongated support of insulating material have three aligned openings therein; and fasteners 58, 60 and 62, such as rivets or eyelets, pass through those aligned openings and are suitably cold-formed to intimately and permanently lock the confronting surfaces of that elongated fusible element and of that elongated support of insulating material in face-to-face relation. As indicated by FIG. 5, the width of the elongated support 56 of insulating material is close to the inner diameter of the open-ended elongated recess 18 — there being only about seventeen thousandths of an inch between each elongated side of the elongated support 56 of insulating material and the adjacent portion of the inner surface of the open-ended elongated recess 18.

The numeral 64 denotes a plate-shaped slotted washer which has the offset central portion thereof dimensioned to extend into the left-hand end of the open-ended elongated recess 18 in the cylinder 10. The slot in that plate-shaped slotted washer is dimensioned to accommodate the left-hand end of the elongated fusible element 42 but not to accommodate the left-hand end of the elongated support 56 of insulating material. As a result, the left-hand end of that elongated support of insulating material terminates approximately one-sixteenth of an inch short of the offset central portion of that plate-shaped slotted washer. The left-hand end 66 of the elongated fusible element 42 is bent over after it has been passed through the slot in the plate-shaped slotted washer 64.

The numeral 68 denotes a plate-shaped disk which has the offset central portion thereof dimensioned to extend into the left-hand end of the open-ended elongated recess 24 in the cylinder 10. If desired, a plate-shaped slotted washer, such as the plate-shaped slotted washer 64, which had the slot therein filled with solder, could be used in lieu of the plate-shaped disk 68. All of the open-ended elongated recesses 14, 16, 18, 20, 22 and 24 will have the left-hand ends thereof closed by a plate-shaped slotted washer, similar to the plate-shaped slotted washer 64, or by a plate-shaped disk, similar to the plate-shaped disk 68. The left-hand end of the open-ended elongated recess 12 is initially left open.

The numeral 70 denotes a plunger which has a shoulder 71 intermediate the ends thereof; and that plunger and that shoulder are dimensioned to telescope into, and to be freely movable relative to, the recess 36 in the right-hand surface of the cylindrical portion 28 of the terminal 26. A helical compression spring 72 has one end thereof bearing against the inner end of the recess 36, and has the other end thereof bearing against the shoulder 71 on the plunger 70; and that helical compression spring tends to move that plunger out of the retracted position shown by FIGS. 2 and 4. An annular stop 74 is disposed within the annular recess 40, which communicates with the recess 36; and once that annular stop has been set in position within that annular recess, it is permanently held there by a "staking" operation which cold-forms the walls of the recess 36 into holding engagement with that annular stop. The numeral 76 denotes a strain wire which is permanently connected to the left-hand end of the plunger 70, and which extends through the open-ended elongated recess 12 in the cylinder 10.

The numeral 78 generally denotes a terminal which has a cylindrical portion 80 with a rim 82 projecting inwardly from the right-hand face thereof and with a blade-like portion 84 projecting outwardly from the left-hand face thereof. As indicated particularly by FIG. 2, the blade-like portion 84 has a cylindrical opening 86 of circular cross section through it. In the said preferred embodiment, the cylindrical portion 80 has a diameter of one and three-eighths of an inch, the blade-like portion 84 is one inch wide and one-quarter of an inch thick, and the cylindrical opening 86 has a diameter of fifteen thirty-seconds of an inch.

The numeral 88 denotes a small passage through the cylindrical portion 80 of the terminal 78; and that passage is large enough to accommodate the left-hand end of the strain wire 76. A generally cylindrical recess 90 extends inwardly from the left-hand face of the cylindrical portion 80 of the terminal 78, as indicated particularly by FIG. 4. A threaded socket 92 communicates with the recess 90; and that threaded socket accommodates a screw 96. A passage 93 extends from the inner end of the threaded socket 92 to the right-hand face of the cylindrical portion 80 of the terminal 78.

The numeral 94 denotes bonding material, such as solder, which engages the inner face of the cylindrical portion 28 of the terminal 26, which engages the metallized right-hand end of the cylinder 10, which engages the J-shaped right-hand end 44 of the elongated fusible element 42, and which also engages the J-shaped right-hand ends 44 of similar elongated fusible elements 142 and 242 which are disposed, respectively, within the open-ended elongated recesses 14 and 22 in the cylinder 10. The elongated fusible element 142 is secured in intimate face-to-face engagement with an elongated support 156 of insulating material; and the elongated fusible element 242 is secured in intimate face-to-face engagement with an elongated support 256 of insulating material. Fasteners, not shown, which can be identical to the fasteners 58, 60 and 62 will fixedly secure the elongated fusible elements 142 and 242 to the elongated supports 156 and 256 of insulating material, respectively.

The numeral 98 denotes arc-quenching filler, such as quartz sand, which is introduced into all of the open-ended elongated recesses 14, 16, 18, 20, 22 and 24 before the plate-shaped slotted washers, such as the plate-shaped slotted washer 64, and before the plate-shaped disks, such as the plate-shaped disk 68, are used to close the left-hand ends of those open-ended elongated recesses. The numeral 99 denotes arc-quenching filler such as quartz sand, which is introduced into the open-ended elongated recess 12. Bonding material 100, such as solder, is used to bond the plate-shaped slotted washers and the plate-shaped disks to the metallized left-hand end of the cylinder 10, and also to bond the left-hand ends 66 of the elongated fusible elements 42, 142 and 242 to those plate-shaped slotted washers.

The numeral 102 denotes further arc-quenching filler which surrounds the exposed surface of the cylinder 10

and which is confined by a tubular casing **104** of insulating material. In the said preferred embodiment, that casing has an outer diameter of one and one-half inches, has an inner diameter of one and one-eighth inches, and has a length of two and twenty-five thirty-second inches. That casing has a slip fit with the outer surfaces of the cylindrical portions **28** and **80**, respectively, of the terminals **26** and **78**. Fasteners **106** extend through openings in the casing **104**, adjacent the ends of that casing, and seat in sockets within the cylindrical portions **28** and **80**, respectively, of the terminals **26** and **78**. The numeral **108** denotes a layer of epoxy resin which overlies the left-hand face of the cylindrical portion **80** of the terminal **78**.

In assembling the electric fuse of the present invention, the terminal **26** is disposed so the blade-like portion **32** thereof is vertical and extends downwardly from the cylindrical portion **28**. At such time the rim **30** extends upwardly so it will be able to act as a dam for the solder **94** when that solder is caused to melt. The cylinder **10** is disposed with its axis vertical so the lower metallized end thereof abuts the inner surface of the cylindrical portion **28** of the terminal **26**, and so the open-ended elongated recess **12** is concentric with the passage **38** in that cylindrical portion. Pellets of solder **94** are disposed within the open-ended elongated recesses **14**, **18** and **22** of the cylinder **10**; and the elongated fusible elements **42**, **142** and **242** and the elongated supports **56**, **156** and **256** therefor are then telescoped down into the open-ended elongated recesses **14**, **18** and **22** until the J-shaped bent ends **44** of those elongated fusible elements are immediately adjacent the upper face of the cylindrical portion **28**. Heat will be applied to the terminal **26** to raise the temperature of the cylindrical portion **28** thereof well above the melting temperature of the solder **94**; and, thereupon, that solder will bond together the upper surface of that cylindrical portion, the metallized lower end of the cylinder **10**, and the J-shaped bent ends **44** of the elongated fusible elements **42**, **142** and **242**.

Thereafter, the arc-quenching filler material **98** will be introduced through the upper ends of the elongated recesses **14**, **16**, **18**, **20**, **22** and **24** of the cylinder **10**; and then those upper ends will be suitably closed by plate-shaped slotted washers such as the plate-shaped slotted washer **64**, or by plate-shaped disks, such as the plate-shaped disk **68**. The plate-shaped slotted washers will, of course, have the slots therein telescoped over the upper ends of the elongated fusible elements **42**, **142** and **242**; and thereafter those upper ends will be bent over as indicated by FIG. **4**. The solder **100** will be used to bond the plate-shaped slotted washers and the plate-shaped disks to the metallized upper end of the cylinder **10** and also to the upper ends of the elongated fusible elements **42**, **142**, and **242**.

The terminal **78** will be disposed so the blade-like portion **84** thereof is vertical and extends downwardly from the cylindrical portion **80**. At such time the rim **82** extends upwardly so it will be able to act as a dam for further solder **110** that will be used to help bond the terminal **78** to the cylinder **10**. Thereafter, the cylinder **10** and the terminal **26** will be inverted so the terminal **78** is underneath that cylinder and so the terminal **26** is atop that cylinder. The terminal **78** will be heated to a temperature well above the melting temperature of the solder **100** and of the further solder **110**; and, thereupon, a composite mass of solder will form and will bond together the inner surface of the cylindrical portion **80** of the terminal **78**, the adjacent metallized end of the cylinder **10**, the bent over ends **66** of the fusible elements **42**, **142** and **242**, and the plate-shaped slotted washers and plate-shaped disks.

At this time, the passage **88**, the recess **90**, the threaded socket **92**, and the passage **93** will be formed in the cylindrical portion **80** of the terminal **78**; and those passages will extend through the solder **110**. The free end of the strain wire **76** will be passed successively through recess **36**, passage **38**, elongated recess **12**, and passage **88**; and then the arc-quenching filler **99** will be introduced into the elongated recess **12** through the recess **90**, the threaded socket **92** and the passage **93**. The free end of the strain wire **76** will be pulled taut to move the plunger **72** into the recess **36** and into the retracted position shown by FIGS. **2** and **4**. While that strain wire is held taut, the free end thereof will be bent around beneath the head of the screw **96**, and then that screw will be tightened to hold that strain wire taut. The annular stop **74** will be moved into the annular recess **40**, and then the adjacent areas of the cylindrical portion **28** will be "staked" to permanently lock that annular stop within that annular recess.

At this time, the casing **104** will be telescoped successively over the cylindrical portion **28** of terminal **26**, over the exposed surface of cylinder **10**, and over the cylindrical portion **80** of terminal **78**. Just before the left-hand end of that casing engages the cylindrical portion **80** of terminal **78**, the arc-quenching filler **102** will be introduced into the space between the inner surface of that casing and the exposed surface of that cylinder. After the casing **104** has been set in the position indicated by FIG. **4**, the fasteners **106** will be passed inwardly through the radially directed openings in the casing **104** and seated within the radially directed sockets, not shown, within the cylindrical portions **28** and **80**, respectively, of terminals **26** and **78**.

Finally, the electric fuse will be set with the axis of the cylinder **10** vertical, and with the terminal **26** at the bottom and with the terminal **78** at the top. At such time, the epoxy resin **108** will be poured into the shallow recess which is defined by the outer surface of the cylindrical portion **80** of terminal **78** and the adjacent projecting end of the casing **104**. That layer of epoxy will fill the passage **88**, and also will insulate the outer face of the cylindrical portion **80**.

It will be noted that the blade-like portion **32** of terminal **26** is located wholly below the axis of the cylinder **10** in FIG. **4**, but that the said axis passes through the blade-like portion **84** of terminal **78**. The resulting radial displacement of the blade-like portions **32** and **84** will coact with the different diameters of the cylindrical openings **34** and **86** in those blade-like portions to facilitate proper orientation of the electric fuse relative to a rotatable member. Specifically, the fuse-holding elements on a rotatable member, such as the rotor of a dynamo electric machine, will be axially displaced relative to each other a distance corresponding to the radial displacement of the blade-like portions **32** and **84**; and the radially outermost of those fuse-holding elements will have a stud or bolt which will fit into the cylindrical opening **34** while the radially innermost of those fuse-holding elements will have a stud or bolt which will fit into the cylindrical opening **86**. As a result, whenever the electric fuse of the present invention is assembled with those fuse-holding elements, the

bent ends **44** of the fusible elements **42, 142** and **242** will be remote from the axis of the rotatable member, whereas the bent ends **66** of those fusible elements will be close to that axis.

As the rotatable member is accelerated from a condition of rest to a condition of full speed, forces will develop within the elongated fusible element **42** and within the elongated support **56** of insulating material which will be transverse of the axes of that elongated fusible element and of that elongated support of insulating material. Those forces will tend to cause that elongated fusible element and that elongated support of insulating material to bend intermediate the ends thereof; but the inner surface of the elongated recess **18** will be close enough to the elongated side edges of that elongated support to effectively prevent bending of the elongated support **56** of insulating material or of the elongated fusible element **42.** Similarly, when the rotatable member decelerates from a condition of full speed to a condition of rest, forces will develop within the elongated fusible element **42** and within the elongated support **56** of insulating material which will be transverse of the axes of that elongated fusible element and of that elongated support of insulating material. Those forces will tend to cause that elongated fusible element and that elongated support of insulating material to bend intermediate the ends thereof; but the inner surface of the elongated recess **18** will be close enough to the elongated side edges of that elongated support to effectively prevent bending of the elongated support **56** of insulating material or of the elongated fusible element **42.** In this way, the electric fuse of the present invention effectively keeps acceleration forces and deceleration forces from bending the elongated fusible element **42.**

As the rotatable member accelerates from a condition of rest to a condition of full speed, and as it operates at full speed, centrifugal forces will develop within the elongated fusible element **42** and within the elongated support **56** of insulating material. Those forces will urge every part of that elongated fusible element and every part of that elongated support of insulating material to move radially outwardly relative to the axis of that rotatable member; but the other ends of that elongated fusible element and of that elongated support of insulating material have an inelastic and unyielding connection with the terminal **26.** Consequently, regardless of the magnitude of the centrifugal forces which develop within the elongated fusible element **42** and within the elongated support **56** of insulating material, the outer end of that elongated fusible element and the outer end of that elongated support of insulating material will be wholly incapable of moving radially outwardly.

The centrifugal forces that are developed within the elongated fusible element **42** and within the elongated support **56** of insulating material also will tend to make that elongated fusible element and that elongated support of insulating material bow in the manner in which an axially compressed column tends to bow. However, in the event centrifugal forces within the fusible element **42** and within the elongated support **56** of insulating material ever increased to the point where they could cause that elongated fusible element and that elongated support of insulating material to bow, the immediately adjacent inner surface of the elongated recess **18** would promptly intercept the elongated side edges of that elongated support of insulating material and halt such bowing. In this way, the present invention effectively limits the forces, to which the elongated fusible element **42** and the elongated support **56** of insulating material are subject, to axially directed compressive forces rather than to a composite of such forces plus bowing forces.

It will be noted that the fastener **58** is interposed between the pair of weak spots **46** and the left-hand end of the elongated support **56** of insulating material. This is important, because it means that said pair of weak spots is wholly isolated from twisting and bending forces during the assembly and use of the electric fuse. The portion of the elongated fusible element **42** which is located between the fastener **58** and the terminal **78** is far more rugged and far sturdier than the pair of weak spots **46;** and thus is well able to withstand all twisting and bending forces to which it may be subjected during the assembly and use of the electric fuse. Similarly, it will be noted that the fastener **62** is interposed between the pair of weak spots **52** and the right-hand end of the elongated support **56** of insulating material. This means that the pair of weak spots **52** is wholly isolated from twisting and bending forces during the assembly and use of the electric fuse.

Because the width of the elongated support **56** of insulating material must closely approach the inner diameter of the elongated recess **18,** for the reasons set forth hereinbefore, the slot in the plate-shaped slotted washer **64** would have to be made unduly large enough to accommodate the combined cross sections of that elongated support of insulating material and of the elongated fusible element **42.** Also, because bonding material does not readily bond to silicone-impregnated woven glass fibers, it would be difficult to seal the slot of the elongated support **56** of insulating material extended through the slot in that plate-shaped slotted washer. In addition, because plus or minus variations of a thirty-second of an inch in the lengths of commercially-obtainable cylinders **10** must be expected, it would be difficult to provide a precisely-fixed length for the elongated support **56** of insulating material if the left-hand end of that elongated support extended to or through the plate-like slotted washer **64.** As a result, the elongated support **56** of insulating material is dimensioned so the left-hand end thereof terminates approximately one sixteenth of an inch short of, and does not pass through, the slot in the plate-shaped slotted washer **64.**

The elongated fusible elements **142** and **242** and the elongated supports **156** and **256** are preferably identical to the elongated fusible element **42** and to the elongated support **56** of insulating material, respectively. Where that is the case, those elongated fusible elements and those elongated supports of insulating material will perform in the same manner in which the elongated fusible element **42** and the elongated support **56** of insulating material perform. In addition, the elongated recesses **14** and **22** will effectively limit bending of those elongated supports of insulating material, and hence of those elongated fusible elements. Because each of the fusible elements **42, 142** and **242** is a unitary and homogeneous piece of metal, it has a desirably low resistance and a desirably high resistance to shock and fatigue.

Where the ratio of the electric fuse of FIG. **1** is less than two hundred amperes, fewer than three elongated

fusible elements will be used. Where the ratio of that electric fuse is greater than 200 amperes, more than three elongated fusible elements will be used.

The elongated fusible elements **42, 142** and **242** will remain un-fused as long as the current flowing through the electric fuse of FIG. **1** does not exceed the rated current of that electric fuse. Although those elongated fusible elements will be subjected to acceleration forces as the rotatable member accelerates from a condition of rest to a condition of full speed, those elongated fusible elements will be held against bending or breaking by the elongated supports **56, 156** and **256** of insulating material and by the interaction between those elongated supports of insulating material and the closely adjacent inner surfaces of the elongated recesses **18, 14** and **22,** respectively. Similarly, although the elongated fusible elements **42, 142** and **242** will be subjected to deceleration forces and to centrifugal forces during the operation of the rotatable member, those elongated fusible elements will be held against bending or breaking by the elongated supports **56, 156** and **256** of insulating material and by the interaction between those elongated supports of insulating material and the closely adjacent inner surfaces of the elongated recesses **18, 14** and **22,** respectively.

In the event a short circuit or a heavy overload occurs, the elongated fusible elements **42, 142** and **242** will immediately fuse at one or all of the pairs of weak spots therein. As those pairs of weak spots fuse to open the circuit, the metal of the elongated fusible elements **42, 142** and **242** will volatilize and will tend to become products of combustion; and the resulting vaporized metal and products of combustion will momentarily but very substantially increase the pressures within those halves of the elongated recesses **18, 14** and **22** which contain those elongated fusible elements. This is due to the fact that the elongated supports **56, 156** and **256** substantially subdivide those elongated recesses into two halves, and also act to retard the escape of volatilized metal and products of combustion from those halves in which the elongated fusible elements **42, 142** and **242** are located. As a result, the pressures within the halves of the elongated recesses **18, 14** and **22** in which the elongated fusible elements **42, 142** and **242** are located will momentarily increase to levels which are substantially higher than the levels which those pressures could reach if the elongated supports **56, 156** and **256** were not used. The momentary, substantially higher pressures in those halves of the elongated recesses **18, 14** and **22** in which the elongated fusible elements **42, 142** and **242** are located help the arc-quenching filler **98** to provide rapid and safe opening of the circuit.

After the elongated fusible elements **42, 142** and **242** have opened the circuit, the heavy overload or short circuit current will attempt to flow through the strain wire **76.** However, that strain wire will immediately fuse; and, thereupon, no further current will be able to flow through the electric fuse of FIG. **1.** As the strain wire **76** fuses, the helical compression spring **72** will force the plunger **70** out of the retracted position of FIGS. **2** and **4** to its extended position. At such time, that plunger will indicate that the electric fuse has opened the circuit.

The present invention makes it possible to provide electric fuses in the range of 50 amperes and greater which are fast-acting in operation, and yet are sturdy and rugged. Moreover, that invention makes it possible for those electric fuses to successfully withstand all forces which could conceivably be applied thereto during acceleration, deceleration and full-speed conditions of operation of the rotatable members on which they are mounted.

Whereas the drawing and accompanying description have shown and described a preferred embodiment of the present invention, it should be apparent to those skilled in the art that various changes may be made in the form of the invention without affecting the scope thereof.

What I claim is:

1. A protector for electric circuits which can be mounted on a rotatable member and which comprises a housing of insulating material that has an elongated recess therein and that has the axis of said elongated recess disposable substantially parallel to a radius of said rotatable member, a terminal at one end of said housing of insulating material, a second terminal at the opposite end of said housing of insulating material, an elongated fusible element which is a unitary and homogeneous piece of metal and which is disposed within said elongated recess with its axis substantially parallel to said axis of said elongated recess, an elongated support of insulating material disposed within said elongated recess with its axis substantially parallel to said axis of said elongated recess, means holding said elongated fusible element in face-to-face engagement with said elongated support of insulating material to enable said elongated support insulating material to reinforce and support said elongated fusible element, said elongated support of insulating material being disposed immediately adjacent said axis of said elongated recess, said elongated support of insulating material having the elongated side edges thereof immediately adjacent the inner surface of said elongated recess so said inner surface of said elongated recess can limit bending of said elongated support of insulating material away from said axis of said elongated recess in either direction and can thereby prevent appreciable rotation-induced bending of said elongated support of insulating material, whereby said elongated fusible element is effectively relieved from all rotation-induced bending forces, said elongated support of insulating material having a predetermined length, said elongated fusible element having a length which is substantially the same as said length of said elongated support of insulating material, the width of said elongated support of insulating material being greater than the width of said elongated fusible element, and said elongated support of insulating material having both elongated edges thereof extending laterally outwardly beyond both elongated edges of said elongated fusible element, whereby said elongated edges of said elongated fusible element are spaced inwardly from, and out of engagement with, said inner surface of said elongated recess.

2. A protector for electric circuits which can be mounted on a rotatable member and which comprises a housing of insulating material that has an elongated recess therein and that has the axis of said elongated recess disposable substantially parallel to a radius of said rotatable member, a terminal at one end of said housing of insulating material, a second terminal at the opposite end of said housing of insulating material, an elongated fusible element which is a unitary and homogeneous piece of metal and which is disposed within

said elongated recess with its axis substantially parallel to said axis of said elongated recess, an elongated support of insulting material disposed within said elongated recess with its axis substantially parallel to said axis of said elongated recess, means holding said elongated fusible element in face-to-face engagement with said elongated support of insulating material to enable said elongated support of insulating material to reinforce and support said elongated fusible element, said elongated support of insulating material being straight throughout the length thereof, and said elongated support of insulating material intimately engaging said elongated fusible element througout the entire length of said elongated support of insulating material, whereby all portions of said elongated fusible element which are in register with any portions of said elongated support of insulating material engage and receive support from said portions of said elongated support of insulating material.

3. A protector for electric circuits which can be mounted on a rotatable member and which comprises a housing of insulating material that has an elongated recess therein and that has the axis of said elongated recess disposable substantially parallel to a radius of said rotatable member, a terminal at one end of said housing of insulating material, a second terminal at the opposite end of said housing of insulating material, an elongated fusible element which is a unitary and homogeneous piece of metal and which is disposed within said elongated recess with its axis substantially parallel to said axis of said elongated recess, an elongated support of insulating material disposed within said elongated recess with its axis substantially parallel to said axis of said elongated recess, means holding said elongated fusible element in face-to-face engagement with said elongated support of insulating material to enable said elongated support of insulating material to reinforce and support said elongated fusible element, one end of said elongated fusible element being immediately adjacent the first said terminal, the other end of said elongated fusible element being immediately adjacent said second terminal, one end of said elongated support of insulating material being immediately adjacent said first said terminal, the other end of said elongated support of insulating material being spaced away from said second terminal, whereby said other end of said elongated fusible element projects beyond said other end of said elongated support of insulating material, and said fusible element having all portions thereof which are in register with any portions of said elongated support of insulating material engaging and receiving support from said portions of said elongated support of insulating material.

4. A protector for electric ciruits which can be mounted on a rotatable member and which comprises a housing of insulating material that has an elongated recess therein and that has the axis of said elongated recess disposable substantially parallel to a radius of said rotatable member, a terminal at one end of said housing of insulating material, a second terminal at the opposite end of said housing of insulating material, an elongated fusible element which is a unitary and homogeneous piece of metal and which is disposed within said elongated recess with its axis substantially parallel to said axis of said elongated recess, an elongated support of insulating material disposed within said elongated recess with its axis substantially parallel to said axis of said elongated recess, means holding said elongated fusible element in face-to-face engagement with said elongated support of insulating material to enable said elongated support of insulating material to reinforce and support said elongated fusible element, said elongated fusible element having weak spots therein, one of said holding means being interposed between one end of said elongated fusible element and that weak spot which is closest to said one end of said elongated fusible element, whereby that portion of said elongated fusible element which extends beyong said one holding means is free of weak spots, and another of said holding means being interposed between the other end of said elongated fusible element and that weak spot which is closest to the said other end of said elongated fusible element, whereby that portion of said elongated fusible element which extends beyond said other holding means is free of weak spots.

5. A protector for electric circuits which can be mounted on a rotatable member and which comprises a housing of insulating material that has an elongated recess therein and that has the axis of said elongated recess disposable substantially parallel to a radius of said rotatable member, a terminal at one end of said housing of insulating material, a second terminal at the opposite end of said housing of insulating material, an elongated fusible element disposed within said elongated recess with its axis substantially parallel to said axis of said elongated recess, an elongated support of insulating material disposed within said elongated recess with its axis substantially parallel to said axis of said elongated recess, means securing said elongated fusible element to said elongated support of insulating material to enable said elongated support of insulating material to reinforce and support said elongated fusible element, said elongated fusible element having one end thereof bent around one end of said elongated support of insulating material and being immediately adjacent the first said terminal, the opposite end of said elongated fusible element extending axially beyond the opposite end of said elongated support of insulating material to be immediately adjacent said second terminal, and bonding material bonding said one end of said fusible element to said first said terminal and bonding said opposite end of said fusible element to said second terminal, said one end of said fusible element and said bonding material providing an inelastic and unyielding connection between said elongated support of insulating material and said first said terminal.

6. A protector for electric circuits which can be mounted on a rotatable member and which comprises a housing of insulating material that has an elongated recess therein and that has the axis of said elongated recess disposable substantially parallel to a radius of said rotatable member, a terminal at one end of said housing of insulating material, a second terminal at the opposite end of said housing of insulating material, an elongated fusible element disposed within said elongated recess with its axis substantially parallel to said axis of said elongated recess, an elongated support of insulating material disposed within said elongated recess with its axis substantially parallel to said axis of said elongated recess, means securing said elongated fusible element to said elongated support of insulating material to enable said elongated support of insulating material to reinforce and support said elongated fusible element, said elongated fusible element having one end

thereof bent around one end of said elongated support of insulating material and being immediately adjacent the first said terminal, the opposite end of said elongated fusible element extending axially beyond the opposite end of said elongated support of insulating material to be immediately adjacent said second terminal, bonding material bonding said one end of said fusible element to said first said terminal and bonding said opposite end of said fusible element to said second terminal, said one end of said fusible element and said bonding material providing an inelastic and unyielding connection between said elongated support of insulating material and said first said terminal, a washer which closes that end of said elongated recess which is adjacent said second terminal, and said opposite end of said elongated fusible element extending through a slot in said washer but said opposite end of said elongated support of insulating material stopping short of said washer.

7. A protector for electric circuits which can be mounted on a rotatable member and which comprises a housing of insulating material that has an elongated recess therein and that has the axis of said elongated recess disposable substantially parallel to a radius of said rotatable member, a terminal at one end of said housing of insulating material, a second terminal at the opposite end of said housing of insulating material, an elongated fusible element disposed within said elongated recess with its axis substantially parallel to said axis of said elongated recess, an elongated support of insulating material disposed within said elongated recess with its axis substantially parallel to said axis of said elongated recess, means holding said elongated fusible element in face-to-face engagement with said elongated support of insulating material to enable said elongated support of insulating material to reinforce and support said elongated fusible element, said elongated fusible element being straight throughout the entire effective length thereof, said elongated support of insulating material engaging said elongated fusible element throughout the full length of said elongated support of insulating material, whereby all portions of said elongated fusible element which are in register with any portions of said elongated support of insulating material engage and receive support from said portions of said elongated support of insulating material.

8. A protector for electric circuits which can be mounted on a rotatable member and which comprises a housing that has an elongated recess therein and that has the axis of said elongated recess disposable parallel to a radius of said rotatable member, a terminal at one end of said housing, a second terminal at the opposite end of said housing, an elongated fusible element disposed within said elongated recess with its axis parallel to said axis of said elongated recess, an elongated support of insulating material disposed within said elongated recess with its axis parallel to said axis of said elongated recess, means securing said elongated fusible element to said elongated support of insulating material to enable said elongated support of insulating material to reinforce and support said elongated fusible element, said elongated support of insulating material being wider than said elongated fusible element, and a washer which is disposed adjacent and which effectively closes one end of said elongated recess, said washer having a slot therein large enough to accommodate one end of said elongated fusible element but small enough to prevent the insertion thereinto of the adjacent end of said elongated support of insulating material.

9. A protector for electric circuits which can be mounted on a rotatable member and which comprises a housing of insulating material that has an elongated recess therein and that has the axis of said elongated recess disposable substantially parallel to a radius of said rotatable member, a terminal at one end of said housing of insulating material, a second terminal at the opposite end of said housing of insulating material, an elongated fusible element which is a unitary and homogeneous piece of metal and which is disposed within said elongated recess with its axis substantially parallel to said axis of said elongated recess, an elongated support of insulating material disposed within said elongated recess with its axis substantially parallel to said axis of said elongated recess, means holding said elongated fusible element in face-to-face engagement witht said elongated support of insulating material to enable said elongated support of insulating material to reinforce and support said elongated fusible element, at least one of said terminals having a configuration which coacts with the configuration of a mounting on said rotatable member to hold said one terminal further from the axis of said rotatable member than said other terminal is held from said axis.

10. A protector for electric circuits which can be mounted on a rotatable member and which comprises a housing of insulating material that has an elongated recess therein and that has the axis of said elongated recess disposable substantially parallel to a radius of said rotatable member, a terminal at one end of said housing of insulating material, a second terminal at the opposite end of said housing of insulating material, an elongated fusible element which is a unitary and homogeneous piece of metal and which is disposed within said elongated recess with its axis substantially parallel to said axis of said elongated recess, an elongated support of insulating material disposed within said elongated recess with its axis substantially parallel to said axis of said elongated recess, means holding said elongated fusible element in face-to-face engagement with said elongated support of insulating material to enable said elongated support of insulating material to reinforce and support said elongated fusible element, said elongated support of insulating material being disposed immediately adjacent said axis of said elongated recess said elongated support of insulating material having the elongated side edges thereof adjacent the inner surface of said elongated recess to said inner surface of said elongated recess can limit bending of said elongated support of insulating material away from said axis of said elongated recess in either direction and can thereby prevent appreciable rotation-induced bending of said elongated support of insulating material, whereby said elongated fusible element is effectively relieved from all rotation-induced bending forces, at least one of said terminals having a configuration which coacts with the configuration of a mounting on said rotatable member to hold said one terminal further from the axis of said rotatable member than said other terminal is held from said axis, and said one terminal being the first said terminal.

11. A protector for electric circuits as claimed in claim **5** wherein said opposite end of said elongated support of insulating material is immediately adjacent

said washer, whereby the portion of said elongated fusible element which is between said washer and said opposite end of said elongated support of insulating material is very short.

12. A protector for electric circuits as claimed in claim **5** wherein at least one of said terminals has a configuration which coacts with the configuration of a mounting on said rotatable member to hold said one terminal further from the axis of said rotatable member than said other terminal is held from said axis.

13. A protector for electric circuits which comprises a housing of ceramic material that has an elongated recess therein with the axis of said elongated recess parallel to the axis of said housing, said elongated recess having a diameter which is substantially smaller than the diameter of said housing of ceramic material, an elongated fusible element disposed within said elongated recess with its axis parallel to said axis of said elongated recess, an elongated support of insulating material disposed within said elongated recess with its axis parallel to said axis of said elongatd recess, said elongated support of insulating material being disposed immediately adjacent said axis of said elongated recess, means holding said elongated fusible element in face-to-face engagement with said elongated support of insulating material to enable said elongated support of insulating material to reinforce and support said elongated fusible element, said elongated support of insulating material having a width at least as great as the width of said elongated fusible element, said elongated support of insulating material having the elongated side edges thereof immediately adjacent the inner surface of said elongated recess and acting, at the instant said elongated fusible elements fuses, to retard the movement of vaporized metal and products of combination from that half of said elongated recess in which said elongated fusible element is located to the other half of said elongated recess.

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