Oct. 1, 1940. K. DANNENBERG 2,216,661

HIGH TENSION FUSE

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Fig. 1.

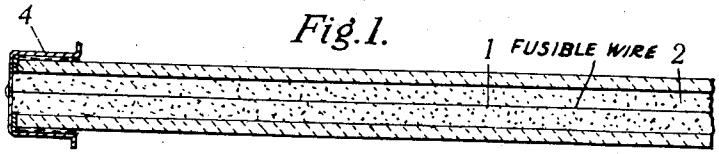


Fig. 2.

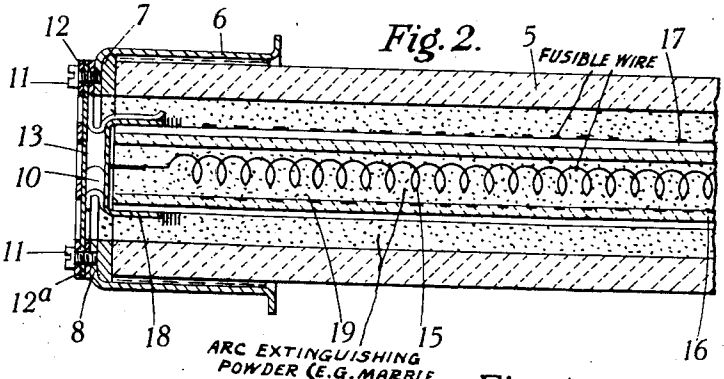


Fig. 3.

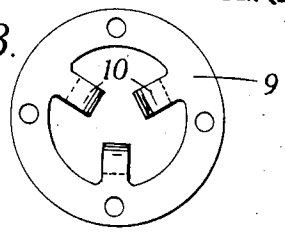


Fig. 4.

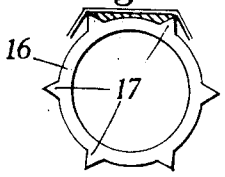


Fig. 7.

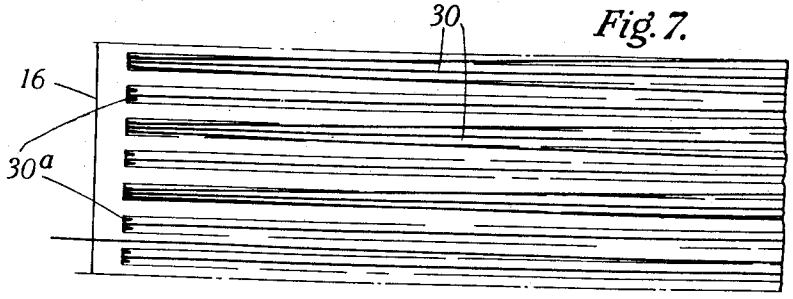


Fig. 8.

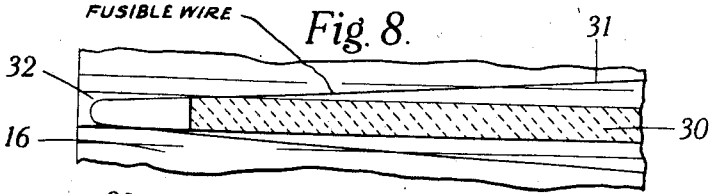
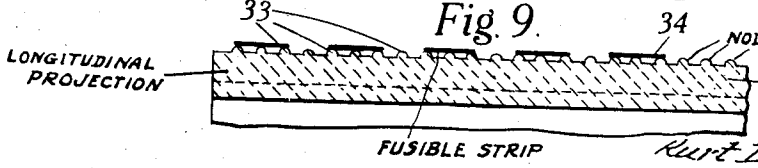


Fig. 9.



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HIGH TENSION FUSE

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Fig. 1a

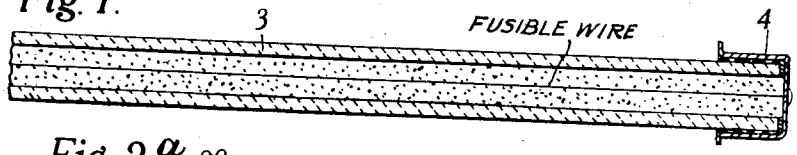


Fig. 2a

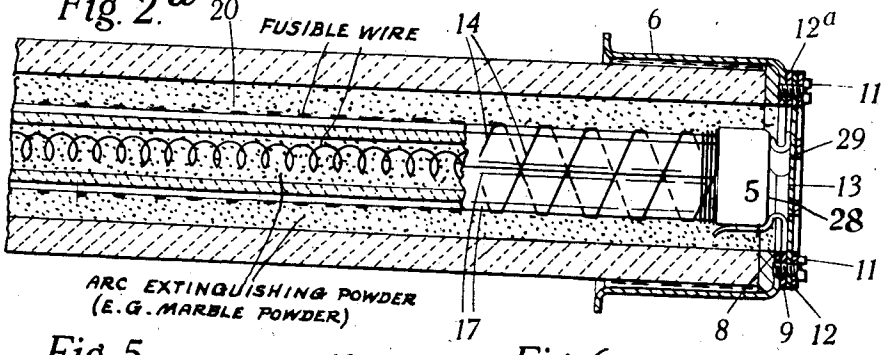


Fig. 5.

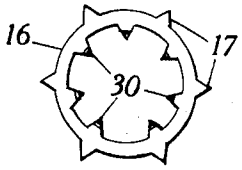


Fig. 6.

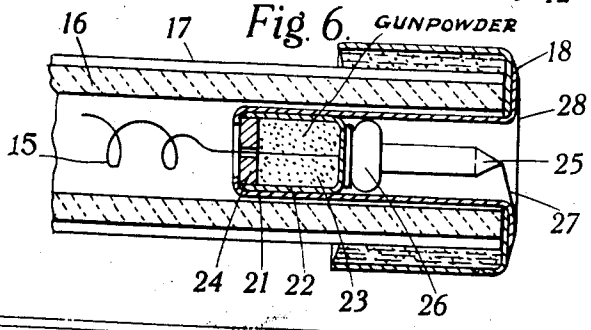
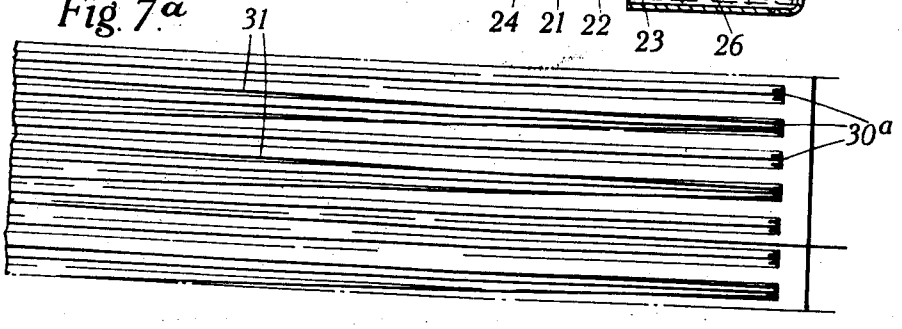


Fig. 7a



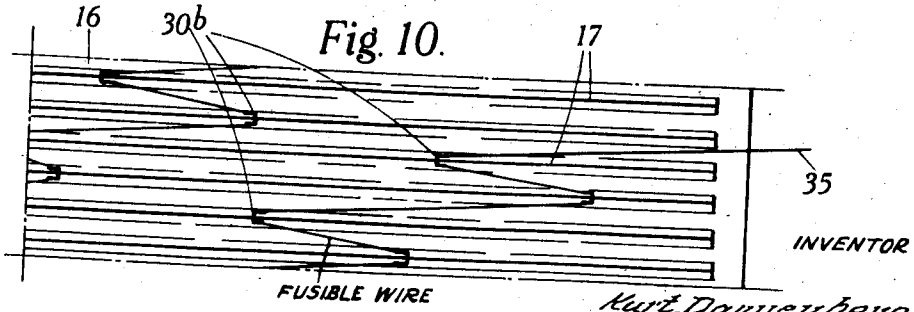


Fig. 10.

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UNITED STATES PATENT OFFICE

2,216,661

HIGH TENSION FUSE

Kurt Dannenberg, Islington, London, England

Application September 7, 1937, Serial No. 162,789
In Great Britain September 29, 1936

18 Claims. (Cl. 200—120)

This invention relates to electric high tension fuses of high rupturing capacity wherein the fusible element or elements are embedded in an insulating, arc-extinguishing powder filling in a sheath.

In high tension fuses it has been found that corona discharge caused deterioration of the elements along their length or at one or more points along their length with the result that the fuses broke down or otherwise interrupted their circuits at or below the loads at which the fuses were rated.

It may be mentioned that 6,000 volts is considered in the art to be the base at which protection from or prevention of corona is necessary; and it is known that many variables, for example temperature and humidity, cause or allow a corona discharge, sometimes an invisible discharge, to take place on the fusible element at potentials as low as 3,000 volts.

My researches show that an insulating and arc-extinguishing powder can be used to prevent deterioration of the fusible elements owing to corona discharge if the sheath be hermetically sealed and the density of the filling which the powder forms and the way in which filling is effected be such that the oxygen in the interior of the sheath is eliminated to an extent sufficient to prevent oxidation of the fusible element or elements and the grains of powder are sufficiently close to the fusible element or elements to enable ions discharged from the element or elements to cancel the electric field between the element and the grains without impairing the arc-extinguishing property of the powder.

Grains of marble powder having a maximum diameter of 0.1 millimetre and filled or packed into the sheaths by mounting the sheaths in a shaking jig vibrating at least 150 times per minute have been found to prevent corona discharge, the necessary duration of the shaking process being in direct proportion to the length of the sheath; and the marble powder, which is an endothermically reacting powder, has the further property of ensuring that the embedded element or elements on operation are instantaneously dissipated along their whole length.

In the accompanying drawings:

Figure 1 and Figure 1*a* together constitute a sectional view of a single element cartridge fuse;

Figure 2 and Figure 2*a* together constitute a sectional view of a cartridge fuse with replaceable support and elements;

Fig. 3 is an end view of a replaceable ring carrying contact fingers;

Fig. 4 is an end elevation, on an enlarged scale, of the element support illustrated in Fig. 2;

Fig. 5 is an end view of an element support provided internally with longitudinal ribs adapted to retain a fusible element in zig-zag formation within the support whilst another element or elements are wound around the ribs on the outer surface of the support;

Fig. 6 is a sectional elevation, on an enlarged scale, of one end of the element support provided with an indicator;

Figure 7 and Figure 7*a* together constitute a development of a support bearing a fusible wire in zig-zag formation;

Fig. 8 is a plan view, partly in section and on an enlarged scale, of an end of a rib illustrated in Fig. 7 and has been given to show, more particularly, the manner in which the peaks of the zig-zag stand out of contact with the ribs;

Fig. 9 is a sectional elevation of a rib provided with nodules for use in conjunction with a strip element; and

Fig. 10 is a development of part of a ribbed support bearing a fusible wire in the form of a zig-zag the axis of which is helical.

In Fig. 1 the fuse wire 1 lies within the bore 2 of a hollow cylindrical, refractory support 3 and is connected at its ends to metal caps 4 cemented by means of litharge, plaster of Paris or the like to the support 3. This hermetically closes the inside of the support or sheath to atmosphere but before the closing is effected the bore is filled with powder in the vibrating jig, the degree of fineness of the powder being as previously stated.

In Fig. 2 a hollow, refractory cylinder 5 forming the sheath of the fuse or cartridge has caps 6 cemented to it at its ends, asbestos rings 7 lying between the ends of the sheath and the inwardly turned flange 8 of the caps. A ring 9 (see also Fig. 3) with spring contact fingers 10 is secured to each flange 8, the fingers 10 projecting into the hollow of the sheath, by means of screws 11 passing through clamping rings 12, gaskets 12ª and discs 13 of foil.

The support for the fusible elements or wires 14 and 15 consists of a hollow cylinder 16 of uniform, refractory material along the outer surface of which are ribs 17 (see also Fig. 4) giving point-support to the wires 14 tightly wound around the support, whilst the hollow of the support accommodates the helically coiled wire 15. The wires 14 and 15 are connected at their ends to caps 18 sealed to the ends of the support.

The hollow of the support is filled with arc-quenching powder 19 and the space between the

support and the interior of the sheath, which sheath is of larger diameter than the said support, is filled with arc-quenching powder 20.

An assembly comprising the support and wires 14 and 15 is inserted through one end of the sheath 5 until one of the caps 18 is properly gripped by a set of fingers 10. The powder 20 is then packed into the space between the support and the sheath and the remaining set of fingers secured to their cap 6. The fuse is thus complete.

It will be seen from Fig. 6 that one of the end caps 18 has a re-entrant portion 21 lying within the end of the cylinder 16. Within the portion 21 is a capsule 22 containing gunpowder 23. One end of the wire 15 is straight and passes through the inner end of the portion 22, through an insulating washer 24 which ensures that the said wire does not make electrical contact with the portion 21, and through the centre of the capsule to a point where it is electrically connected to the capsule. The outer end of the said capsule has a bolt 25 fixed to it whilst a buffer 26 surrounds the inner end of the said bolt. A short wire 27 electrically connects the bolt to the cap 18 so that an electrical circuit is complete from the wire 15 to the cap, said circuit consisting of parts 22, 21, 25 and 27. A disc 28 of aluminum or tin foil closes the re-entrant portion 21 and, therefore, seals the interior of the cylinder or support 16, the other end of the support being sealed by the other cap.

When the fuse operates the wire 15 in the capsule 22 ignites the gunpowder with the result that the bolt 25 is caused to pierce the disc 28 and the adjacent disc 13, thus indicating the said operation. The buffer 26 contacts with the bent parts of the fingers 10 or with a bridge piece 29 in a clamping ring 12 to ensure that the bolt is not completely ejected from the fuse.

A linesman wishing to recondition the fuse replaces the support 16 by a similar support with intact wires, the linesman withdrawing the dead support and inserting the new through that end of the fuse where the foil is punctured after the linesman has removed a ring 12, the punctured foil and a ring 9 from the sheath, it being understood that the powder 19 is emptied out of the sheath before the inner support is inserted and replaced or replenished by fresh powder. Both sets of contact fingers can be examined at the time of reconditioning the fuse and, if necessary, either or both can be replaced by undamaged ones carried by rings as 9.

The present invention also comprises a fuse having one or more fusible elements helically wound around the outside of a ribbed or point-support and embedded in the arc-quenching powder and thermally balanced with respect to a helically coiled fusible element embedded in the filling within a longitudinal bore in the support. The thermal balancing, i. e. causing substantially the same cooling effect to be produced on both fusible elements, is obtained by arranging that a quantity of powder equal to that tightly filled into the recesses between the supporting points of the body and lying underneath the element or elements wrapped around the support and chosen in amount to suit the number of elements and their dimension is filled into the hollow of the coil of the inner fusible element, said inner element being arranged to take part in the process of interruption or acts as a main element of good conductivity leaving the final interruption to an element of higher resistance on the outside point-support surface. This fuse has a rupturing capacity considerably greater than that of known fuses of substantially like dimensions.

The wires 14 are thermally balanced with respect to the wire 15. This controls the heating-up of both the inner and the outer elements along their length and ensures an equal cooling effect on both wires along their whole length with the result that the rupturing capacity of the fuse is considerably increased with respect to that of a fuse of like dimension but without the thermal balancing.

The wire 15 is preferably the main element and consists of silver whilst the wires 14 are the auxiliary element and consist of tungsten. The auxiliary element may, however, be arranged on the inside of the support and the main element on the outside thereof. When the wires (e. g., the auxiliary element) consist of like tungsten, tantalum or molybdenum metals there is no need to take special steps to apply the corona protection to them.

Instead of employing a helically wound wire 15 the bore of the support 16 may contain longitudinal ribs 30 in the ends of which are notches 30^a so that a wire 31 can be made to take the zig-zag formation shown in Fig. 7. It will be seen that each length of wire between the bends of the zig-zag extends from one end of one rib to the opposite end of the next rib, the notches being located at the ends of the said ribs. In this manner the said lengths of wire lie in recesses provided by the ribs. The hollow of the bore is, of course, filled with arc-quenching powder.

If desired, the wire or wires on the outside of the support may be wound zig-zag fashion and in this case the development of the outside of the support will be as shown in Fig. 7, an odd number of longitudinal ribs being provided.

The peaks 32 of the zig-zag preferably stand well away from the inner ends of the notches, as illustrated in Fig. 8. When the wire 31 melts the parts adjacent to the peaks thereof thus provide a number of horn gaps in series. It is found that when tungsten wire is used there is no difficulty in arranging the peaks in this way, the toughness of the tungsten permitting this.

In Fig. 9 the rib 17 is provided along its length with a number of nodules 33 and the fusible element instead of being of wire consists of strip material 34 which is wound in helical form around a support along which the ribs with nodules are provided.

Fig. 10 illustrates another form of zig-zag winding suitable, more particularly, for application to the outside of a support. The longitudinal ribs 17 are provided along their length with notches 30^b and the wire 35 is caught in the notches as shown to cause the wire to take the form of a zig-zag surrounding a cylinder in helical manner. The peaks of the zig-zag may be arranged as described with reference to Fig. 8.

If preferred the auxiliary element (of high specific resistance acting as the main interruption element) may be arranged internally of the support and the main element (of good conductivity working as auxiliary interruption element) externally thereof.

It will be seen that in the forms of the invention illustrated the surfaces of the fusible elements are except for a very negligible proportion surrounded by the powder, the ribs forming recesses enabling the powder to get between the wires and the supports. This surrounding is essential to ensure that corona discharge is pre-

vented and to ensure the dissipation of the elements along the whole of their length under short circuit conditions.

It is believed that the following electrical action takes place in the present fuse when corona discharge is prevented. When the field strength at the surface of a fusible element, usually of silver wire, becomes sufficiently great new ions are formed, negative ions are driven off the element and strike powder grains adjacent thereto. This causes the powder grains to be negatively charged whereby the field between the element and the powder is cancelled and the corona discharge is suppressed. The necessary quantity of ions is very small. The smaller the air distance between the element and the grains the better is the effect, which is dependent upon the fine graining of the powder and the density of the powder filling.

It is important to note that the powder employed has a maximum grain diameter limit of 0.1 mm., and that this is one of the controlling factors of the present invention. It is well known that with the fuse wire surrounded with powder, there would be an improvement with respect to the corona discharge over the use of a bare fuse wire alone. Experience has proven that even under these circumstances, and particularly where the powder was of usual course grain, the improvement obtained was comparatively slight and insufficient to cover the high working voltages which are now used. It was developed by the applicant that in a powder having a grain size less than that usually employed, he provides complete corona suppression at higher voltages than heretofore possible. The grain-size of the powder employed in the present application is, therefore, critical and must be regarded as a distinctive fundamental fact of the present improvement. It has been previously known that powder filled cartridge fuses improved the rupturing capacity of the fuse. It was necessary, however, to compromise in the design of such fuses insofar as one could not incorporate adequate corona protection whenever very high rupturing capacities were desired. This was because the Faraday metal cage then employed for corona protection interfered with the insulation of the fuse when clearing very heavy faults.

The high tension fuse of the present invention succeeds for the first time in solving the problem of producing a high voltage fuse of extra high rupturing capacity and still providing the necessary corona protection, thereby preserving the life of the fuse under normal service conditions.

What I claim is:

1. A high tension fuse of high rupturing capacity comprising a refractory insulating sheath, a dry insulating arc-extinguishing powder such as marble dust filling in said sheath the powder grains having a maximum diameter of 0.1 mm., a fusible element embedded in said powder filling, and hermetic closures at the ends of the sheath, the herein specified diameter of the powder grains insuring that the physical and electrical relationship of the powder grains to the fusible element is such that the grains will completely suppress corona discharge from the element.

2. A high tension fuse as defined in claim 1, wherein the element is of uniform cross section and the powder is endothermically reacting, whereby the fusible element is instantaneously dissipated along the whole of its length under short circuit conditions.

3. A high tension fuse as defined in claim 1, including a ceramic support within the sheath of hollow form with longitudinal ribs on its outer surface, there being provided two fusible elements which are respectively wound one on the outside of the support transverse the ribs and one disposed within the hollow formation of said support, one of such elements being embedded in the powder having the characteristics recited in claim 1, the element on the outside of the support having contact with the ribs.

4. A high tension fuse as defined in claim 1, including a ceramic support within the sheath of hollow formation and with longitudinal ribs on the outer surface, with the provision of two fusible elements of relatively different specific resistances, the element of higher specific resistance being arranged within the hollow of the support and embedded in the powder, the element of lower specific resistance being arranged on the outside of the support in contact with and transverse said ribs, the element of higher specific resistance taking part in the process of interruption.

5. A high tension fuse as defined in claim 1, including a ceramic support within said sheath of hollow form with longitudinal ribs on the outer surface, there being provided two fusible elements of relatively different specific resistances, the element of lower resistance being arranged within the hollow of the support and the element of higher resistance being arranged on the outside of the support in contact with and transverse the ribs and embedded in the powder, the element of lower resistance acting as a main element of good conductivity leaving the final interruption to the element of higher resistance.

6. A high tension fuse as defined in claim 1, including a ceramic support within the sheath and of hollow form with longitudinal ribs on the outer surface, there being provided two fusible elements of relatively different specific resistances, both of which are embedded in the powder, the element of higher resistance being within the hollow of the support and the element of lower resistance being arranged in contact with and transverse the ribs of said support, the element of higher resistance taking part in the process of interruption.

7. A high tension fuse as defined in claim 1, including a ceramic support within the sheath of hollow form with longitudinal ribs on the outer surface, there being provided two fusible elements of relatively different specific resistances both embedded in the powder, the element of lower specific resistance being within the hollow of the support and the element of higher specific resistance being on the outside of the support in contact with and transverse the ribs, the element of lower specific resistance acting as a main element of good conductivity with the final interruption provided in the element of higher specific resistance.

8. A high tension fuse as defined in claim 1, including a ceramic support within the sheath, said support being of hollow form with longitudinal ribs on the outer and inner surfaces, there being two fusible elements of different specific resistances, one element being wound around the outside of the support in contact with and transverse the ribs and the other element being arranged in point-supported zig-zag manner in the hollow of the support, the element of higher specific resistance being embedded in the powder.

9. A high tension fuse as defined in claim 1, including electrical contact members at the end of the sheath, electrical contact members at the

ends of the support and electrically connected to the fusible elements, the electrical contact members at the ends of the support being adapted releasably to cooperate with the contact members carried by the ends of the sheath, and a hermetic closure device at each end of the sheath, one of such closure devices being readily replaceable.

10. A high tension fuse as defined in claim 1, including a longitudinal ceramic support within the sheath, said support being of hollow form with longitudinal ribs on the outer surface, the fusible factor including a fusible element wound around said support in contact with and transverse the ribs and thereby free of contact with the surface of the support, a fusible element of coil form within the hollow length of said support, the arc-quenching powder being disposed in the sheath and in the hollow formation of the support to embed said fusible elements, the quantity of the powder accommodated in the total of the spaces bounded by the fusible element wound around the support, the ribs on the support and the surface of the support between the ribs being at least equal to the quantity of powder filling the hollow portion of the coil of the fusible element in the hollow length of the support, the amount of powder being selected in more or less definite relation to the number of turns of the fusible element and the dimension thereof.

11. A high tension fuse of high rupturing capacity comprising a refractory insulating sheath, electrical contact members at the ends thereof, a support for fusible elements with said support of hollow uniform refractory insulating material having longitudinal ribs on its outer surface, a fusible element wound tightly around said support to make contact therewith, a second fusible element arranged within the hollow of the support, said fusible elements being of relatively different specific resistances with the second fusible element taking part in the interruption process, arc-quenching powder such as marble dust within the sheath and within the hollow support and embedding said fusible elements, the arc-quenching powder grains having a maximum diameter of approximately 0.1 mm., said support rigidly fixing the fusible element wound thereon to prevent the sagging or movement of said element otherwise incident to the fineness of the element necessitated by the high rupturing capacity of the fuse, the ribs on the support spacing the outer fusible element from the surface of the support to permit the element to continuously carry a higher current than normal incident to the comparatively large area of the wire of the fusible element in contact with the powder between the supporting points of the ribs, contact members at the ends of the support electrically connected to said fusible elements and adapted releasably to cooperate with contact members carried by the ends of the sheath, and hermetic closure devices at the ends of the sheath, one of said closure devices being easily replaceable.

12. A high tension fuse as defined in claim 11, including fixing means adapted to hold both a contact member to the sheath and to secure said easily replaceable closure device to the sheath.

13. A high tension fuse as defined in claim 11, wherein end caps are provided on the sheath and means removably securing the contacts carried by the sheath to the said end caps whereby to permit the contacts to be readily replaced without removing the caps.

14. A high tension fuse as defined in claim 11, including material having highly refractory properties supplied to said support in the form of a coating.

15. A high tension fuse as defined in claim 11, including nodules on the projections of the support with the fusible element cooperating with said projections in the form of a strip wound around the support to make point contact with said nodules.

16. A high tension fuse according to claim 11, including longitudinal ribs forming the projections on the support, said ribs being notched, the fusible element to be wound on said projections being seated in the notches to take a zig-zag form.

17. A high tension fuse as defined in claim 11, wherein the projections are in the form of longitudinal ribs having notches and wherein the fusible element wound on the projections is seated in said notches to take a zig-zag form, the fusible element being arranged at the peaks of the zig-zag formation to stand away from the bottom of the notches, whereby to provide a number of horn gaps in series when the fusible element melts.

18. A high tension fuse of high rupturing capacity comprising a longitudinal, refractory, insulating sheath, a fusible element support located within said sheath, said support being hollow and of longitudinal form, longitudinal ribs along the external surface of said support, a fusible element wound around said support and making transverse contact with the said ribs so as to be spaced from the surface of said support, a fusible element of coil form located within the hollow of said support, and arc-quenching powder such as marble dust in said sheath and in said support embedding said fusible elements, the arc-quenching powder grains having a maximum diameter approximating 0.1 mm., the quantity of powder held by the hollow of said coiled element being at least equal to the quantity of powder tightly filled into the spaces bounded by the turns of the outer fusible element, the ribs and the support, said powder being chosen in amount to suit the number of turns of the outer element and their dimension.

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