Aug. 26, 1941. G. F. McMAHON 2,253,719

CIRCUIT INTERRUPTING MEANS

Filed April 10, 1939 3 Sheets-Sheet 1

Fig. 1.

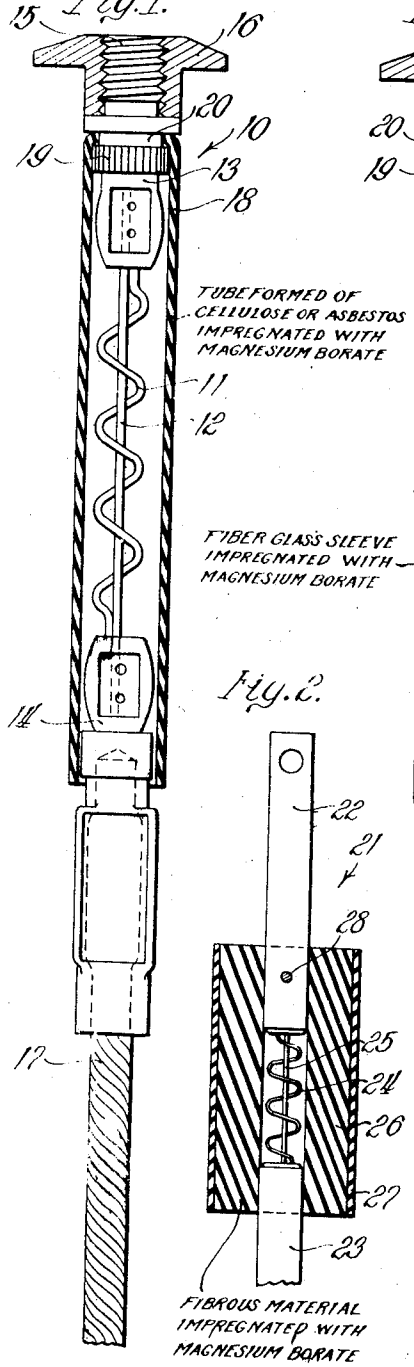


Fig. 3.

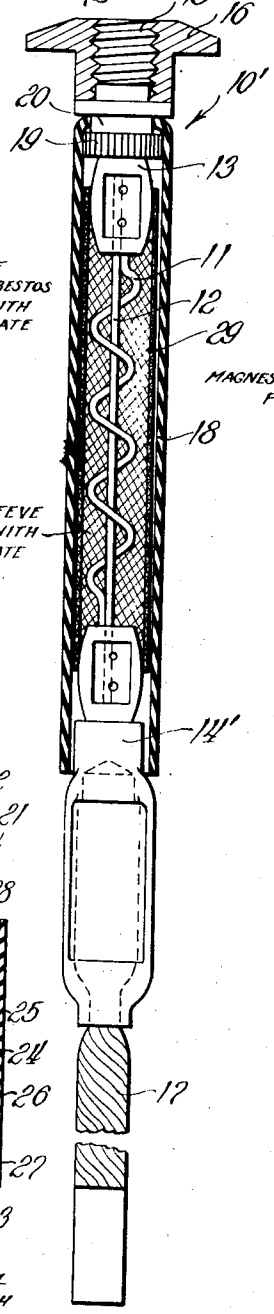


Fig. 4.

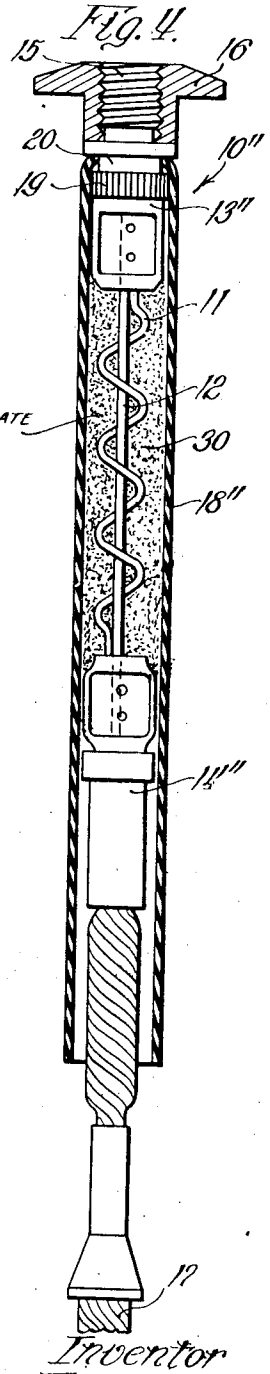


Fig. 2.

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CIRCUIT INTERRUPTING MEANS

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Fig. 7.

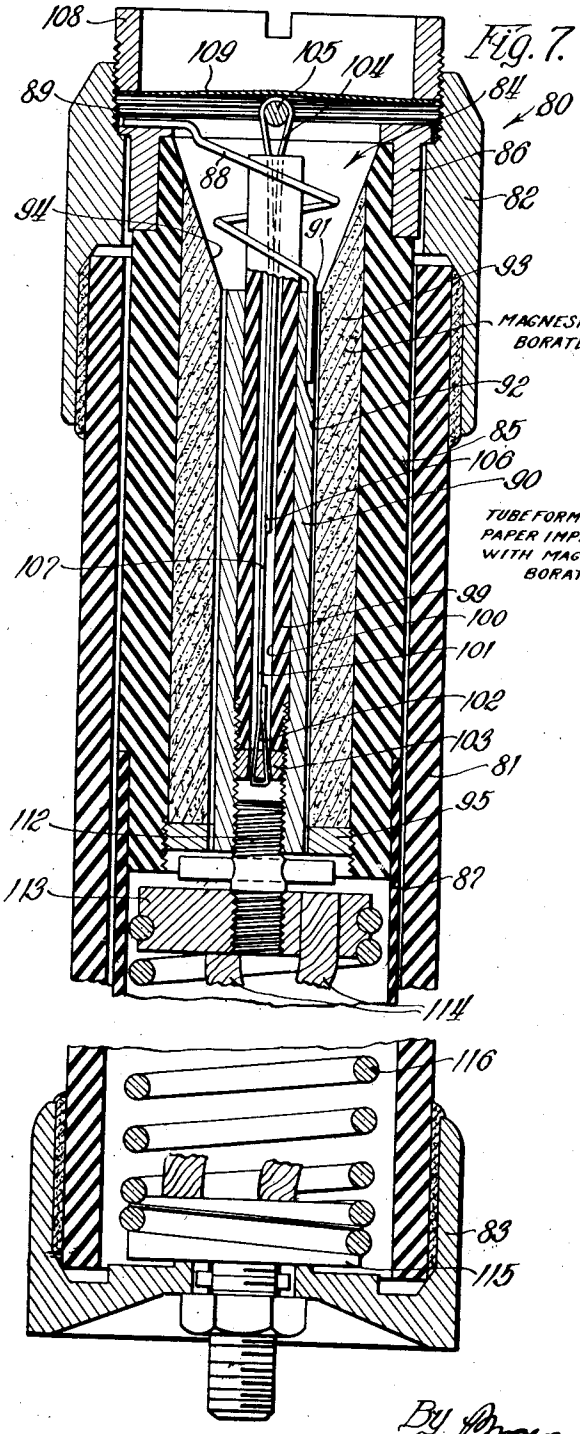
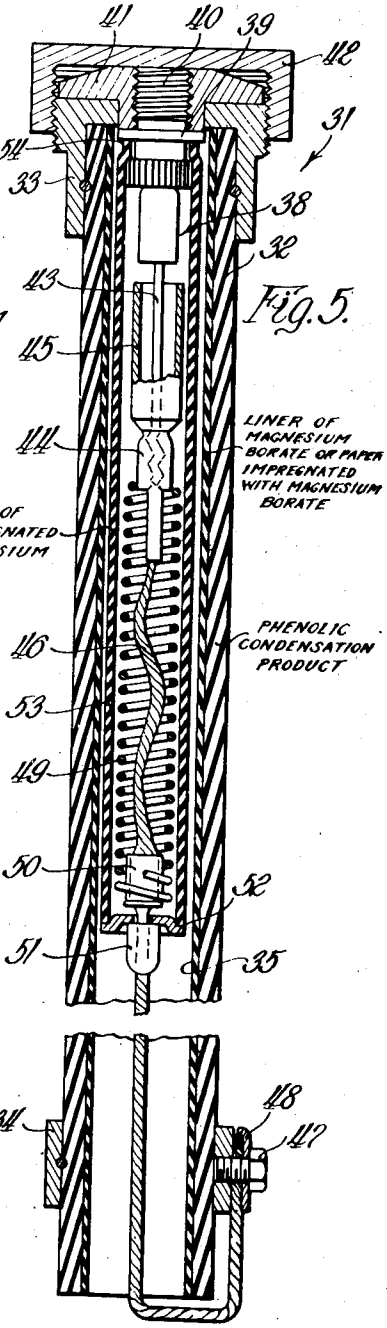


Fig. 5.



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CIRCUIT INTERRUPTING MEANS

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Fig. 8.

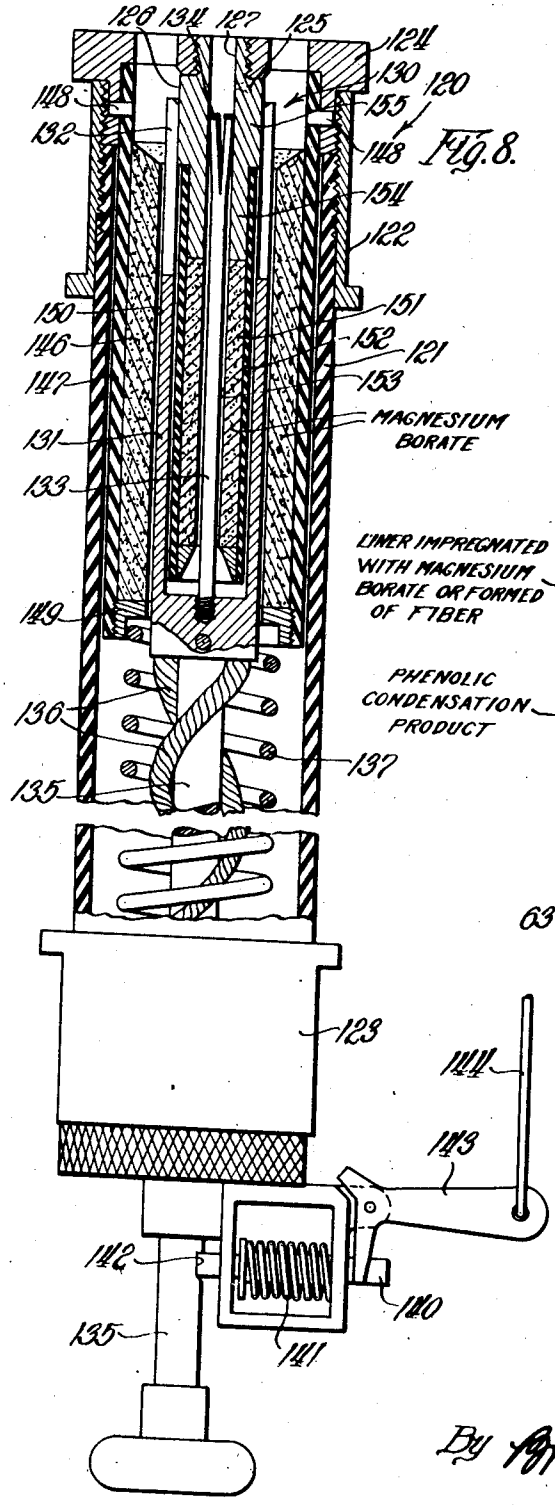
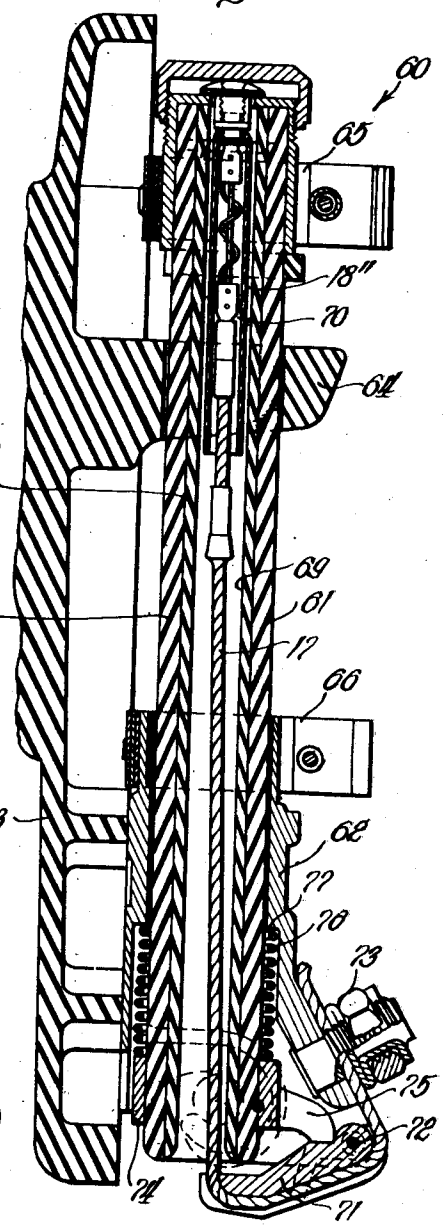


Fig. 6.



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Patented Aug. 26, 1941 2,253,719

UNITED STATES PATENT OFFICE

2,253,719

CIRCUIT INTERRUPTING MEANS

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Application April 10, 1939, Serial No. 266,991

54 Claims. (Cl. 200—120)

This invention relates, generally, to new and improved materials for use with electrical apparatus and for flame proofing purposes, and it has particular relation to the composition and use of such materials for insulation and arc extinguishing purposes in circuit interrupters of both the fusible element and separable contact type.

When an electric circuit is opened by a circuit interrupter, the arc that is formed should be promptly extinguished. Various methods and means have been proposed for effecting arc extinction. It is common practice now to provide material along the arc path which will evolve an arc extinguishing medium due to the heat of the arc that will assist in one way or another in effecting its extinction. Usually the arc extinguishing material is tubular in form or is provided with a bore from the inner surface of which the arc extinguishing medium is evolved in the form of gas or vapor. Many of the materials that have been proposed for this purpose are unsatisfactory for one reason or another, or they are not as efficient as is the class of arc extinguishing materials disclosed herein.

A material, to be suitable for arc extinguishing purposes, should have the following characteristics:

(1) Non-inflammable and stable under normal operating conditions;

(2) Non-corrosive to metals and other materials with which it is associated;

(3) Non-poisonous;

(4) High dielectric qualities both before and after arc extinction;

(5) Evolution of a sufficient quantity of gas or vapor to effect satisfactory arc extinction and which gas or vapor is non-poisonous and will not support combustion;

(6) Little or no carbonization of the surface acted upon by the arc, and no deposition of carbon on the associated parts of the circuit interrupting apparatus.

In order to facilitate a more complete understanding of these various characteristics, a brief discussion of each of them will be set forth. It will be understood that it is preferable to employ a single material which possesses all of these desirable characteristics, so that the construction of the circuit interrupter can be as simple as possible for a given set of operating conditions.

Under normal operating conditions in a fuse or circuit interrupter of the separable contact type, certain of the parts are subjected to relatively high temperatures. Consequently, the materials adjacent such high temperature conditions, and particularly those which are employed for arc extinguishing purposes, should be non-inflammable. Likewise they should be stable so that they will not deteriorate even though they are subjected to comparatively high operating temperatures over long periods of time. If the material is unstable and deteriorates, it ordinarily would not be capable of performing properly its arc extinguishing function when finally called upon to do so.

Since circuit interrupting apparatus is composed of metallic parts and insulating material, it is, of course, desirable that any material which is employed for arc extinguishing purposes be incapable of corroding the associated metallic and insulating parts.

The material that is used for arc extinguishing purposes should be non-poisonous, since it must be handled by workmen in the manufacturing establishment, and possibly by repair men and operators in the field.

The class of electrical apparatus to which the present invention is directed is ordinarily operable at relatively high voltages, i. e., 1000 volts and upwards. When these voltages are employed, the material that is used for arc extinguishing purposes should have relatively high dielectric properties. It should be of this character under normal operating conditions in order to maintain the parts in proper insulated relationship. After the arc is extinguished, it should still retain its high dielectric properties, so that there is little or no likelihood of leakage across it which might result in dangerous conditions on a circuit that otherwise was considered to be deenergized.

In order to effect efficient arc extinction, the arc extinguishing material that is employed should be capable of evolving a sufficient quantity of gas or vapor due to the heat of the arc that will be capable of extinguishing the same by providing a deionized space at current zero, and also provide a blast action which tends to sweep the conducting materials out of the arc space. Of course, such gas or vapor should be non-poisonous, so that there is no likelihood of injury to a person coming in contact with it. The gas or vapor should not be capable of supporting combustion, and should be non-conducting, so that the presence thereof will tend to extinguish the arc and prevent its striking on metallic parts in the vicinity of the device or restriking. The gas or vapor that is evolved should create very little pressure in order to avoid the occurrence of destructive pressures in the device.

A chief cause of the lowering of the dielectric properties of the arc extinguishing material is the carbonization of its surface after it has been acted upon by the arc. For efficient arc extinguishing purposes, therefore, a material should be employed which, preferably, does not carbonize on its surface under the heat of the arc. Further, in order to maintain the insulating qualities of the device, there should be no deposition of carbon on the various parts which would be likely to form creepage paths over the surface thereof.

In view of the foregoing, an object of the invention, generally stated, is to provide an arc extinguishing material which possesses all of the foregoing desirable characteristics.

A further object of the invention is to provide an arc extinguishing material having a large percentage (about 50%) comprising water of crystallization which is evolved as water vapor due to the heat of an arc.

Still another object of the invention is to provide a material for use in electrical apparatus that not only is capable of evolving an arc extinguishing medium due to the heat of an arc, but also possesses adhesive properties which permit it to be formed or compacted into a rigid member without requiring the use of another binding agent and which enable it to impregnate fibrous or other materials likewise without requiring a binding agent.

A still further object of the invention is to provide an arc extinguishing material that is relatively insoluble in water and which is capable of thoroughly impregnating fibrous material, such as filter paper (cellulosic organic material), fiber glass, and asbestos (inorganic materials), and binding their fibers together.

An object of the invention is to provide an improved method of manufacturing insulating material for use with electrical apparatus and having arc extinguishing properties.

Still another object of the invention is to provide a new composition of matter having flame proof and high electrical resistance characteristics, and a method for manufacturing the same.

A further object of the invention is to provide a fibrous material capable of withstanding relatively high temperatures (red heat) without carbonization. Asbestos is a suitable fibrous material for this purpose.

Still another object of the invention is to improve the dielectric properties of asbestos by impregnating it with magnesium borate.

A still further object of the invention is to so construct a fuse link that its operation is substantially independent of the diameter of the expulsion tube or housing in which it may be used.

A still further object of the invention is to increase the arc extinguishing properties of an expulsion fuse tube.

Other objects of the invention will, in part, be obvious, and in part appear hereinafter.

The invention, accordingly, is disclosed in the embodiments thereof shown in the accompanying drawings, and it comprises the features of construction, combination of elements, arrangement of parts, and novel steps which will be exemplified in the construction and process hereinafter set forth, and the scope of the application of which will be indicated in the appended claims.

For a more complete understanding of the nature and scope of the invention, reference may be had to the following detailed description, taken in connection with the accompanying drawings in which:

Figures 1, 2, 3 and 4 are longitudinal sectional views of fuse links employing the arc extinguishing material of the present invention in various respects;

Figure 5 is a longitudinal sectional view of a spring type of fuse link positioned in an expulsion tube, the sleeve of the fuse link and the expulsion tube being constructed in accordance with the present invention;

Figure 6 is a longitudinal sectional view of another form of fuse link than that shown in Figure 4, positioned inside of an expulsion fuse tube, the fuse link being biased by an external spring which likewise causes movement of the expulsion tube;

Figure 7 is a longitudinal sectional view of a heavy duty fuse type of circuit interrupter employing the arc extinguishing material of the present invention; and

Figure 8 is a longitudinal sectional view of a separable contact type of circuit interrupter in which the arc extinguishing material of the present invention is employed.

Referring now particularly to Figure 1 of the drawings, it will be observed that the reference character 10 designates, generally, a replaceable fuse link of a type that is now well known in the art. The fuse link **10** comprises fusible and strain elements **11** and **12** which are secured at their ends to terminals **13** and **14**. The terminal **13** is provided with a threaded stud **15** onto which an adapter **16** is threaded. The stud **15** and the adapter **16**, or the stud **15** alone, provide for connection to one line terminal, while a flexible lead **17**, secured to the terminal **14**, provides for connection to the other line terminal.

Now, it is desirable to surround the fusible means, comprising the fusible and strain elements **11** and **12**, with a material that is adapted to evolve an arc extinguishing medium due to the heat of an arc formed between the terminals **13** and **14** on blowing of the fusible and strain elements **11** and **12** which will assist in quickly and efficiently extinguishing the arc. For this purpose, a sleeve **18**, having these properties, as will be presently described, is provided around the fusible and strain elements **11** and **12** in telescopic relation with the terminals **13** and **14**. It will be observed that the terminal **13** is provided with a knurled portion **19** over which the upper end of the sleeve **18** is forced, and whereby relative rotation between the terminal **13** and the sleeve **18** is prevented. The upper end of the sleeve **18** is crimped into a groove **20** that is formed in the terminal **13**. If desired, a retaining ring may be provided around the outside of the upper end of the sleeve **18** for holding it securely in the groove **20**.

It has been the practice in the past to form the tube or sleeve **18** of fiber. While this material is capable of evolving a limited amount of an arc extinguishing medium due to the heat of an arc, it is not entirely satisfactory. It does not evolve a sufficient quantity of arc extinguishing medium. Under low current operation, i. e., a few amperes to several hundred amperes, the expulsive effect is not sufficient to entirely sweep out the layer of carbonized material that is caused by the heat of the arc. As a result the inner surface of the fiber tubes or sleeves of the prior art may, in some cases, provide a relatively low resistance path for leakage current to flow over.

According to the present invention, the tube or sleeve 18 is formed of fibrous material such as paper, although it may be formed of asbestos. In the case of paper, it is preferable to use filter paper or alpha cellulose which are practically pure cellulose. Preferably the fibrous material is impregnated with a material which has all of the desirable characteristics enumerated hereinbefore.

Magnesium borate has been found to have all of these characteristics and to be capable of use not only as an impregnant, but also as a solid arc extinguishing material, either in powder form or formed into a tube as will be described hereinafter.

Magnesium borate is generally considered to have eight molecules of water of crystallization, in which 56.7% of its weight comprises water of crystallization. Magnesium borate can also be prepared in a form which has six molecules of water of crystallization, in which case 49.5% of its weight comprises water of crystallization. This amount of water of crystallization is appreciably more than that found in boric acid which has 43.6% by weight of water of crystallization. The use of boric acid as an arc extinguishing material is disclosed in Patent 2,077,282, to Strom et al. Magnesium hydroxide has only 30.8% by weight of water of crystallization. This material is disclosed as an arc extinguishing material in the copending application of McMahon and Ramsey, Serial No. 62,118, filed February 3, 1936, now Patent No. 2,183,751.

Magnesium borate possesses all of the desirable characteristics outlined hereinbefore and, because of its relatively high water content (about 50% or more), it is capable of evolving a relatively great amount of water vapor for arc extinguishing purposes.

Magnesium borate constitutes an alkaline earth compound. In its water soluble form, the solution has a hydrogen ion concentration or pH value of about 8. At this stage the borate is in the crystalloidal or incompletely formed crystal state. If allowed to stand for a time, crystals are produced which are slightly soluble in cold water and insoluble in hot water. If the crystalloidal solution is allowed to evaporate, a transparent film is formed. Under ordinary operating conditions, it is non-corrosive and is relatively non-poisonous in either the solid form or vaporized form. Not only is it non-inflammable, but also, the evolved arc extinguishing medium being water vapor is also non-inflammable. Since the arc extinguishing medium comprises water vapor, comparatively low pressures are generated on the occurrence of an arc.

Crystalloidal magnesium borate has adhesive and varnish-like properties and it is well suited for impregnating fibrous materials such as paper, cloth, asbestos, etc. When these materials are impregnated with magnesium borate, they are substantially flame proof. In addition, they possess excellent arc extinguishing properties and have the appearance of ceramic or porcelain-like bodies.

The sleeve or tube 18 may be formed of several layers of paper, for example filter paper, that has been impregnated with magnesium borate. Preferably the tube 18 is formed by rolling a relatively thin sheet of paper that has been impregnated with magnesium borate to the desired shape and size. The paper may first be dipped into a crystalloidal solution of magnesium borate and then wound under pressure on a mandrel. After the tube has thus been formed, it is allowed to dry in air until the laps or layers of the paper are stuck together. Since magnesium borate is inherently adhesive, the use of an additional binding agent, which would be undesirable from a cost standpoint as well as possibly introducing undesirable effects on the arc extinguishing characteristics, is not required. Preferably, the dry tube is further impregnated or dipped into a magnesium borate crystalloidal solution, redried and allowed to crystallize several times. In some cases where it is desired to make relatively thick walled tubing, the impregnation should be carried out in a vacuum and pressure process. In order to hasten drying, the impregnated tube can be baked in the atmosphere at low temperature or under a vacuum. As the borate crystallizes within the fiber structure of the paper, both strength and hardness are imparted thereto as the fibers are cemented and bonded together. A good grade of filter paper will absorb as much as 150% or more of its weight of magnesium borate, and this will remain intact in the paper with its water of crystallization. The tubes may be vacuum dried to remove excess water and improve the insulating qualities with no harm being done to them.

If it is desired to water-proof the impregnated fiber tube, the outer surface can be coated with varnish. In doing this, care should be taken to apply the varnish to the outer surface only, since it is inflammable and, if applied to the inner surface, would promote flame and carbonization.

Instead of forming the sleeve or tube 18 of paper or asbestos, it may be formed by an extrusion process. For this purpose wood flour, asbestos flour, paper pulp, siliceous, carbonaceous or other finely divided material are first impregnated or mixed thoroughly with crystalloidal magnesium borate. The resulting plastic mass is extruded by suitable extruding dies into the desired size and shape of tubing.

Generally, the foregoing steps may be employed for the manufacture of boards, sheets, etc., having a base of asbestos, paper, or other material. Such material is first suitably impregnated with magnesium borate and then is pressed into the desired shape and form with or without the application of heat. Alternatively, the material may be in the form of flour which is mixed with the magnesium borate and then pressed into the desired shape and form and allowed to age until the maximum strength is obtained.

In some cases it is desirable to provide a fibrous material that is capable of withstanding relatively high temperatures, for example red heat, with no resulting carbonization. For this purpose, asbestos can be impregnated with magnesium borate. When subjected to such high temperatures, even though the water is removed thereby, still the asbestos retains substantially its original shape and strength due to the presence of the borate.

Not only is asbestos made more resistant to high temperature, but also, by impregnation with magnesium borate, its electrical insulating qualities are greatly improved.

Magnesium borate differs greatly from a great many inorganic insulating compounds in that it alone has adhesive properties which are unusual.

In Figure 2 of the drawings there is shown, generally, at 21 a fuse link that is somewhat

similar in construction to that of the fuse link illustrated in Figures 2 and 3 of Patent No. 2,091,453, to Ramsey. The fuse link 21 comprises relatively infusible terminals 22 and 23 which are interconnected by a fusible element 24, such as a silver wire, and a strain element 25, such as a nickel-chromium wire. Surrounding the fusible and strain wires is a filling 26 of arc extinguishing material within a sleeve 27 of suitable insulating material such as paper. A pin 28 extending through the terminal 22 and through the filling 26 of arc extinguishing material and the sleeve 27 serves to hold the same in place.

The filling 26 of arc extinguishing material is formed by making a mixture of wood flour or asbestos flour and an aqueous solution of magnesium borate and pouring it into the sleeve 27 with a wedge through the center and allowing it to set. After the mixture dries or sets, due to the crystallization of the borate, the wedge is removed and through the opening left thereby the terminal 22 is slipped to a position where the fusible and strain elements 24 and 25 are fully surrounded by the filling 26 of arc extinguishing material, as shown. The pin 28 is then inserted.

In Figure 3 of the drawings, a replaceable fuse link 10' is shown that is generally similar to the fuse link 10 of Figure 1. The lower terminal 14' is slightly different in construction. If desired, the sleeve or tube 18 may be formed of fiber, as in the prior art, or it may be formed of fibrous material impregnated with magnesium borate as described hereinbefore.

Within the sleeve or tube 18 there is provided a sleeve of woven fiber glass 29 that is impregnated with magnesium borate. The fusible and strain elements 11 and 12 are surrounded by this impregnated fiber glass sleeve.

Still another form of fuse link is illustrated at 10'' in Figure 4 of the drawings. The fuse link 10'' is generally similar to the fuse link 10 of Figure 1. The terminals 13'' and 14'' are slightly different, and the sleeve or tube 18'' is slightly longer than the sleeve 18. It may be formed of fiber, as in the prior art, or may be formed of impregnated fibrous material as described. Within the tube or sleeve 18'' and between the terminals 13'' and 14'' there is a filling of magnesium borate powder 30 which embeds both the fusible element 11 and the strain element 12.

In Figure 5 of the drawings, a circuit interrupter, designated generally at 31, of the expulsion type, is illustrated. It comprises a fuse tube or housing 32 having terminals 33 and 34 at its ends. It will be understood that the terminals 33 and 34 are adapted to be mounted in suitable fuse clips which form the line terminals.

The fuse tube or housing 32 is provided with a liner 35 that is formed preferably of magnesium borate, or paper, or other fibrous material impregnated with magnesium borate. The tube or housing 32 itself may be formed of a phenolic condensation product or glass. Because of the presence of the magnesium borate in the liner 35, the arc extinguishing properties and expulsive effects of the expulsion type circuit interrupter 31 are considerably improved over the prior art constructions.

The fuse tube or housing 32 with the liner 35 may be constructed by first preparing the liner 35 in the manner described for the manufacture of the tube or sleeve 18 for the fuse link 10 of Figure 1. After the liner 35 has been properly formed, the tube or housing 32 may be formed thereon by winding around it paper that has been impregnated with a phenolic condensation product or varnish. Another method of construction is to completely fill a tube or housing 32 formed of a phenolic condensation product or glass with wood pulp impregnated with magnesium borate. After the inserted material has thoroughly dried, it is bored out to provide the desired longitudinal aperture therethrough.

Within the fuse tube or housing 32 there is provided a replaceable fuse link, shown generally at 38. The fuse link 38 may be of any of the so-called "Universal" type of fuse links now found on the market, or it may be the type of fuse link shown in Figures 1, 3 and 4 hereof. The particular fuse link 38 illustrated in Figure 4, however, is constructed in accordance with the disclosure in the copending application of Lindell, Serial No. 70,280, filed March 23, 1936. It comprises a terminal 39 having a threaded stud portion 40 upon which a cap 41 is threaded. The cap 41 is held in place against the terminal 33 by means of a cap 42. A fusible element 43 interconnects the terminal 39 and another terminal 44. A corona shield 45 is integrally formed with the terminal 44, as shown. A flexible lead 46 is connected to the terminal 44 and extends out of the lower end of the fuse tube or housing 32 where it is connected to the lower terminal 34 by means of a screw 47 cooperating with a washer 48. A coil tension spring 49 serves to tension the fusible element 43 and to bias the terminal 44 downwardly. The upper end of the spring 49 is secured to the terminal 44, while its lower end is secured to a fitting 50 that is deformed onto the flexible lead 46. Another fitting 51 is deformed onto the flexible lead 46, and it bears against an anchor plate 52 that rests upon the lower end of a sleeve or tube 53 which surrounds the spring 49 and fusible element 43 and is crimped at its other end as indicated at 54 on the terminal 39 and bears against a flange integrally formed therewith.

Preferably, the sleeve or tube 53 is formed of fibrous material, such as paper, impregnated with magnesium borate, as described hereinbefore for the tube or sleeve 18 forming a part of the fuse link 10 of Figure 1.

It has been found that when a fuse link, such as the fuse link 38, is provided with a sleeve 53 impregnated with an arc extinguishing material such as magnesium borate, it may be employed in an expulsion fuse tube of the prior art, having a fiber liner, with satisfactory results. Ordinarily, when fuse links of the prior art are employed in expulsion fuse tubes having fiber liners, the life of the latter is relatively short due to the deposition of carbon on the surface. However, when a fuse link is employed having a tube or sleeve formed of fibrous material impregnated with magnesium borate, such carbon deposit is not formed and the life of such expulsion tubes is materially prolonged. Accordingly, it is within the scope of the present invention to provide fuse links of the type shown in Figures 1, 2, 3, 4 and 5 in expulsion fuse tubes having fiber liners.

In Figure 6 of the drawings, a portion of a drop-out fuse device incorporating the present invention is illustrated. The fuse device, shown generally at 60, is constructed along the lines of the fuse device shown in the copending application of Ramsey, Lindell and Van Ryan, Serial

No. 115,690, filed December 14, 1936. The fuse device 60 is intended to be mounted on a box formed of insulating material, such as porcelain, that is customarily mounted on the cross-arm of a pole supporting an electric power line. Since the box for housing the fuse device 60 forms no part of the present invention, a showing thereof is omitted herein.

The fuse device 60 comprises a fuse tube or housing 61, formed of insulating material such as a phenolic condensation product, and it is slidably mounted in a sleeve 62 that is secured by suitable means to a door or cover 63 that is formed of insulating material, such as a phenolic condensation product. Because of space limitations, the operating eye for the door or cover 63 has been omitted from the showing in the drawing. The door 63 is provided with an apertured guide portion 64 through which the fuse tube or housing 61 can slide. At its upper end the fuse tube or housing 61 is provided with a terminal clip 65 for detachable connection to a cooperating stationary contact member on the rear wall of the box. Likewise, the sleeve 62 is provided with a contact clip 66 which is arranged to have contact engagement with a cooperating contact member also positioned on the rear wall of the box.

A liner 69 is provided inside of the fuse tube or housing 61, and it is preferably formed of fibrous material, such as paper, thoroughly impregnated with magnesium borate. Its action, when subjected to the heat of an arc, will be as described hereinbefore.

A fuse link, shown generally at 70, is positioned within the fuse tube or housing 61. The fuse link 70 is similar in construction to the fuse link 10'' shown in Figure 4 of the drawings. However, the filling of powdered magnesium borate 30 is omitted. The fuse link 70 is provided with the sleeve 18'' which, as previously described, is preferably formed of rolled paper impregnated with magnesium borate. It has been found that, when the sleeve 18'' is formed as described, the liner 69, if formed of fiber in accordance with the prior art, has a much longer life due to the fact that its surface is not so readily carbonized.

As shown in Figure 6, the fuse link 70 is provided with a flexible lead 17 that extends out of the lower end of the fuse tube or housing 61 and over a flipper 71 that is pivoted at 72 to the sleeve 62. The free end of the flexible lead 17 is secured in a terminal clamp assembly 73 so that it is in good electrical contact with the sleeve 62. At the lower end of the tube or housing 61 there is provided a collar 74 having an arm 75 extending therefrom for engagement with the upper side of the flipper 71 close to its axis of rotation at 72. A coil compression spring 76 between the upper side of the collar 74 and a shoulder 77 of the sleeve 62 serves to bias the fuse tube or housing 61 downwardly. This downward movement is restrained by the fuse link 70 acting through the flexible lead 17, flipper 71, and arm 75.

In Figure 7 of the drawings, a circuit interrupter is illustrated, generally, at 80 which is constructed generally along the lines of one of the circuit interrupters shown in the patent of McMahon and Ramsey, referred to herein. The circuit interrupter 80 is provided with a tubular housing 81, preferably formed of glass, having at its ends terminals 82 and 83 that are secured thereto by cement.

At one end of the housing 81 there is provided a replaceable fuse cartridge, designated generally at 84. The cartridge 84 is provided with a shell 85, formed preferably of a phenolic condensation product and having at its upper end a cylindrical terminal 86 which interfits with and engages the terminal 82. A sleeve 87 depends from the shell 85 and serves to protect the inner surface of the glass housing 81 from the effects of arcs formed on operation of the circuit interrupter. A fusible element 88 in the form of a coil of silver wire is provided, one end being positioned in a groove 89 in the terminal 86, the edges being peened over to provide mechanical and electrical engagement therewith, while the other end is electrically and mechanically connected to a tubular movable terminal 90 by being positioned in a longitudinal slot 91 therein, the edges of which are peened over. The tubular terminal 90 is movable within the bore 92 of a body 93 of solid arc extinguishing material.

The body 93 of solid arc extinguishing material is preferably formed of magnesium borate. The magnesium borate in powder form is compacted to the shape shown. Instead of using pure magnesium borate, a composition of comminuted fibrous material impregnated with magnesium borate may be employed. When an arc acts upon the surface of the bore 92, an arc extinguishing medium, comprising water vapor, is evolved therefrom and acts, as previously indicated, to assist in extinguishing the arc by blast action which helps to remove conducting materials from the arc space and to deionize it at current zero. The upper end of the mass 93 of arc extinguishing material is flared outwardly as indicated at 94 to provide an arcing chamber. A nut 95 threaded into the lower end of the shell 85 serves to hold the mass 93 of solid arc extinguishing material in place.

Within the hollow terminal 90 there is provided a sleeve 99 of insulating material having a bore 100 therein. The sleeve 99 may be formed of fiber, or it may be formed of paper impregnated with magnesium borate, or it may be extruded as previously described. Within the bore 100 in the sleeve 99, there is provided a strain element 101 in the form of a high strength wire, the lower end 102 of which is looped around a strain wire nut 103 threaded into the lower end of the terminal 90. The upper end 104 of the strain wire 101 is looped over a cross-pin 105 that rests upon the terminal 86. The end of the strain wire 101 that is looped over the cross-pin 105 is brought back into the bore 100 of the sleeve 99 and is secured, as by welding, to the main portion of the strain wire 101, as indicated at 106. Obviously, this construction is such that the section 107 of the strain wire 101 will be fused first, thereby forming the arc at the lower end of the bore 100 in the sleeve 99.

The cartridge 84 is held in place by means of a clamp nut 108 that is threaded, as shown, into the terminal 82. A disc 109, preferably formed of mica and transparent, is provided underneath the clamp nut 108 for preventing the entrance of extraneous material.

A stud 112 is threaded into the lower end of the terminal 90, and it, in turn, is threaded into a spring and cable fastener 113. Flexible leads 114 are provided for interconnecting the spring and cable fastener 113 with another spring and cable fastener 115 that is secured, as shown, to the terminal 83. A coil tension spring 116 is connected at its ends, as shown, to the spring and cable fasteners 113 and 115, and serves to bias the terminal 90 for movement through the bore

92 in the mass 93 of solid arc extinguishing material.

Referring now particularly to Figure 8 of the drawings, a circuit interrupter shown, generally, at 120 of the separable contact type, is illustrated. The circuit interrupter 120 is constructed along the lines of the circuit interrupter shown in Conrad Patent No. 1,336,069, as modified by the construction shown in the patent of McMahon and Ramsey, and referred to hereinbefore.

The circuit interrupter 120 is provided with a housing 121 of insulating material, such as a phenolic condensation product, and has ferrules 122 and 123 at its ends, as shown. A terminal 124 is threaded into the ferrule 122, and it is provided with a depending terminal stud 125 having an outer contact surface 126 and a bore providing an inner contact surface 127. A movable terminal member, shown generally at 130, is provided for cooperating with the terminal stud 125. The terminal member 130 is provided with a generally cylindrical terminal portion 131 terminating in contact fingers 132 that are adapted, as shown, to engage the outer contact surface 126. The terminal member 130 is also provided with a contact rod 133, the upper end of which is split to form fingers 134 that have contact engagement with the inner contact surface 127 of the terminal stud 125. The terminal member 130 is carried by an operating rod 135 and is connected to the ferrule 123 by suitable flexible conductors 136. A coil tension spring 137 serves to bias the terminal member 130 downwardly toward the ferrule 123.

The operating rod 135 is held in position by means of a bolt 140 that is urged by a coil compression spring 141 into a notch 142 in the operating rod 135. When the bolt 140 is in position in the notch 142, the terminal member 130 is held in the position shown and the tension spring 137 is stressed.

In order to release the operating rod 135 and move the terminal member 130 to the open circuit position, a lever 143 is provided for pulling the bolt 140 out of the notch 142. A tension member 144 is provided for remote operation of the lever 143.

Now, in order to extinguish the arcs that are drawn on operation of the circuit interrupter 120, and particularly the arc that is drawn between the contact surface 126 of the terminal stud 125 and the contact fingers 132, a mass 146 of arc extinguishing material is provided. It is positioned within a shell 147, preferably formed of a phenolic condensation product, that is secured by means of pins 148 to the terminal 124, as shown. A retainer nut 149, threaded into the lower end of the shell 147, serves to hold the mass 146 of arc extinguishing material in position.

The mass 146 of arc extinguishing material is preferably formed of magnesium borate that has been compacted from the powder form into the generally cylindrical form shown, providing a bore 150 therein. It can also be formed of finely comminuted fibrous material, such as asbestos, or cellulosic material, like paper, wood pulp, etc., impregnated with magnesium borate, the resulting mass being formed into the shape shown.

The arc that is formed between the contact fingers 134 and the inner surface 127 of the terminal stud 125 is extinguished by the evolution of an arc extinguishing medium from a mass 151 of solid arc extinguishing material that surrounds the rod 133 and is positioned within a shell 152, formed preferably of fiber. The mass 151 of arc extinguishing material is formed of magnesium borate or impregnated fibrous material as described for the mass 146. It is provided with an inner bore 153 through which the rod 133 moves.

It will be observed that the shell 152 extends beyond the lower portion 154 of the terminal stud 125. When the contact fingers 132 move out of engagement with the upper portion 155 of the terminal stud 125 leaving the contact surface 126 and engaging the outer surface of the shell 152 of insulating material, the circuit is still maintained through the contact fingers 134 in engagement with the contact surface 127 of the bore of the terminal stud 125. Under low current operation, no arc is formed between the contact fingers 132 and the contact surface 126. When the contact fingers 134 leave the contact surface 127, an arc is formed which, due to its heat, evolves an arc extinguishing material, as described, from the inner surface of the bore 153 in the mass 151 of solid arc extinguishing material.

However, when the circuit interrupter 120 is called upon to interrupt a relatively large current flow, such as takes place under short circuit conditions, an arc will restrike between the contact fingers 132 and the contact surface 126. In such case, there will be two arcs—one inside the bore 150, and the other inside the bore 153. The heat from these arcs will evolve an arc extinguishing medium which, as described, will assist in extinguishing them.

Since it is obvious that certain further changes may be made in the above constructions, and different embodiments of the invention may be made without departing from the scope thereof, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

What is claimed as new is:

1. In electrical apparatus, a conductor from which an arc may be drawn, and a quantity of magnesium borate along the path of the arc from which an arc extinguishing medium is evolved due to the heat of the arc sufficient to extinguish the same.

2. In electrical apparatus, a conductor from which an arc may be drawn, and insulating means impregnated with magnesium borate in such position as to have a surface acted upon by the arc from which surface an arc extinguishing medium is evolved due to the heat of the arc sufficient to extinguish the same.

3. An electric circuit interrupter comprising, in combination, means between which an arc is formed on interruption of the circuit, and means including magnesium borate disposed along the path of the arc and adapted to evolve an arc extinguishing medium due to the heat of the arc.

4. An electric circuit interrupter comprising, in combination, separable terminals between which an arc is drawn on operation of the device, and insulating means disposed in such position as to surround and confine the arc and including a quantity of magnesium borate sufficient to evolve a medium due to the heat of the arc for extinguishing the same.

5. An electric circuit interrupter comprising, in combination, separable terminals between which an arc is drawn on operation of the device, and a tubular member of fibrous insulating material impregnated with magnesium borate

surrounding and confining the arc from the inner surface of which an arc extinguishing medium is evolved due to the heat of the arc sufficient to extinguish the same.

6. An electric circuit interrupter comprising, in combination, separable terminals between which an arc is drawn on operation of the device, and a tubular member of organic insulating material impregnated with magnesium borate surrounding and confining the arc from the inner surface of which an arc extinguishing medium is evolved due to the heat of the arc sufficient to extinguish the same.

7. An electric circuit interrupter comprising, in combination, separable terminals between which an arc is drawn on operation of the device, and a tubular member of cellulosic material impregnated with magnesium borate surrounding and confining the arc from the inner surface of which an arc extinguishing medium is evolved due to the heat of the arc sufficient to extinguish the same.

8. An electric circuit interrupter comprising, in combination, separable terminals between which an arc is drawn on operation of the device, and a tubular member of fibrous inorganic insulating material disposed in such position as to surround and confine the arc and impregnated with a quantity of magnesium borate sufficient to evolve an arc extinguishing medium due to the heat of the arc for extinguishing the same.

9. An electric circuit interrupter comprising, in combination, separable terminals between which an arc is drawn on operation of the device, and a tubular member of asbestos disposed in such position as to surround and confine the arc and impregnated with a quantity of magnesium borate sufficient to evolve an arc extinguishing medium due to the heat of the arc for extinguishing the same.

10. A fuse link comprising, in combination, a pair of terminals interconnected by fusible means, and a sleeve surrounding said fusible means and formed of finely divided fibrous material impregnated with magnesium borate.

11. A fuse link comprising, in combination, a pair of terminals interconnected by fusible means, and a sleeve surrounding said fusible means and formed of asbestos flour impregnated with magnesium borate.

12. In a fuse link, a rolled paper tube surrounding the fusible means and impregnated with magnesium borate.

13. In a fuse link, a rolled paper tube surrounding the fusible means and impregnated with an inorganic arc extinguishing material having adhesive characteristics.

14. In a fuse link, a tube of cellulosic material surrounding the fusible means and impregnated with magnesium borate.

15. An electric circuit interrupter comprising, in combination, means between which an arc is formed on opening of the circuit, and a tubular insulating member comprising rolled paper impregnated with magnesium borate.

16. An insulating sleeve for electrical apparatus upon the inner surface of which an arc may act comprising a tubular body of cellulosic material impregnated with magnesium borate and having its outer surface covered with water proof material.

17. Method of manufacturing an insulating sleeve having arc extinguishing properties which comprises, impregnating a sheet of cellulosic material by dipping it into a bath of inorganic arc extinguishing material, forming the impregnated sheet into a tube, and drying the tube.

18. Method of manufacturing an insulating sleeve having arc extinguishing properties for use with electrical apparatus which comprises, impregnating a sheet of insulating material with arc extinguishing material, forming the impregnated sheet into a tube, and impregnating the tube with arc extinguishing material.

19. Method of manufacturing an insulating sleeve having arc extinguishing properties for use with electrical apparatus which comprises, impregnating a sheet of cellulosic material by dipping it into a solution of magnesium borate, rolling the impregnated sheet into a tube, and re-impregnating the tube by dipping it into a solution of magnesium borate.

20. Method of manufacturing an insulating sleeve having arc extinguishing properties for use with electrical apparatus which comprises, impregnating a sheet of cellulosic material by dipping it into a solution of magnesium borate, rolling the impregnated sheet into a tube, successively dipping the tube into a solution of magnesium borate, drying the tube after each immersion, and applying a water proofing layer to the outside surface of the tube.

21. A fuse link comprising, in combination, a pair of conductors interconnected by fusible means, a sleeve of insulation surrounding said fusible means, and a quantity of magnesium borate within said sleeve embedding said fusible means.

22. A fuse link comprising, in combination, a pair of conductors interconnected by fusible means, a sleeve of insulation surrounding said fusible means, and a liner of fiber glass impregnated with magnesium borate within said sleeve surrounding said fusible means.

23. A fuse link comprising, in combination, a pair of conductors interconnected by fusible means, a sleeve of insulation surrounding said fusible means, and a quantity of magnesium borate in powder form within said sleeve embedding said fusible means.

24. An expulsion fuse tube having its inner surface at least formed principally by a magnesium compound capable of evolving an arc extinguishing medium due to the heat of an arc sufficient to extinguish the same.

25. An expulsion fuse tube having its inner surface at least formed principally by magnesium borate for evolving water vapor due to the heat of an arc sufficient to extinguish the same.

26. An expulsion fuse tube having a liner of fibrous insulating material impregnated with a magnesium compound capable of evolving an arc extinguishing medium due to the heat of an arc sufficient to extinguish the same.

27. An expulsion fuse tube having a liner of fibrous insulating material impregnated with magnesium borate for evolving water vapor due to the heat of an arc sufficient to extinguish the same.

28. A circuit interrupter comprising, in combination, a fuse tube, a fuse link within said fuse tube, and a sleeve of fibrous insulating material surrounding the fusible means of said fuse link, said sleeve being impregnated with a magnesium compound capable of evolving an arc extinguishing medium due to the heat of an arc sufficient to extinguish the same.

29. A circuit interrupter comprising, in combination, a fuse tube, a fuse link within said fuse

tube, and a sleeve of fibrous insulating material surrounding the fusible means of said fuse link, said sleeve being impregnated with magnesium borate for evolving water vapor due to the heat of an arc sufficient to extinguish the same.

30. A circuit interrupter comprising, in combination, an expulsion fuse tube having its inner surface at least formed principally by a magnesium compound capable of evolving an arc extinguishing medium due to the heat of an arc, and a fuse link within said fuse tube having a sleeve of fibrous insulating material impregnated with an inorganic arc extinguishing material surrounding the fusible means of said fuse link.

31. A circuit interrupter comprising, in combination, an expulsion fuse tube having its inner surface at least formed of magnesium borate for evolving water vapor due to the heat of an arc, and a fuse link within said fuse tube having a sleeve of fibrous insulating material impregnated with a magnesium compound capable of evolving an arc extinguishing medium due to the heat of an arc surrounding the fusible means of said fuse link.

32. An electric circuit interrupter comprising, in combination, means between which an arc is formed on opening of the circuit, and a tubular body of solid arc extinguishing material surrounding and confining the arc drawn between said means, said tubular body comprising magnesium borate.

33. An electric circuit interrupter comprising, in combination, means comprising a body of magnesium borate providing a bore, and a pair of arcing terminals one being stationarily mounted at one end of said bore and the other being movable therethrough whereby an arc drawn therebetween plays upon the inner surface of said bore and evolves water vapor therefrom due to the heat of the arc sufficient to extinguish the same.

34. An electric circuit interrupter comprising, in combination, means comprising a body of magnesium borate providing a bore, a pair of arcing terminals one being stationarily mounted at one end of said bore and the other being movable therethrough, and fusible means interconnecting said arcing terminals and restraining movement of said other terminal, said fusible means being adapted to blow on the occurrence of a predetermined overload whereupon said other terminal is released and an arc is formed between said terminals which plays upon the inner surface of said bore and evolves water vapor therefrom due to its heat sufficient to extinguish the same.

35. An electric circuit interrupter comprising, in combination, means comprising a body of magnesium borate providing a bore, and a pair of normally engaged switch members one being stationarily mounted at one end of said bore and the other being movable therethrough whereby an arc drawn therebetween plays upon the inner surface of said bore and evolves water vapor therefrom due to the heat of the arc sufficient to extinguish the same.

36. For use in a circuit interrupter of the class described an arc extinguishing material containing more than 44% by weight of water of crystallization.

37. An electric circuit interrupter comprising, in combination, separable terminals between which an arc is drawn on operation of the device, and a tubular member of fibrous insulating material impregnated with an adhesive inorganic arc extinguishing material capable of binding the fibers of said insulating material together and adapted to evolve an arc extinguishing medium due to the heat of the arc sufficient to extinguish the same.

38. As a new composition of matter having flame proof and high electrical resistance characteristics, fibrous material impregnated with an adhesive magnesium compound.

39. As a new composition of matter having flame proof and high electrical resistance characteristics, fibrous material impregnated with an alkaline-earth borate solution.

40. As a new composition of matter having flame proof and high electrical resistance characteristics, fibrous material impregnated with mangesium borate.

41. Method of flame proofing fibrous material which comprises impregnating the same with an adhesive magnesium compound.

42. Method of flame proofing organic fibrous material which comprises impregnating the same with magnesium borate.

43. Method of flame proofing paper which comprises impregnating the same with an adhesive alkaline-earth borate solution.

44. Method of producing a formed high electrical resistance non-inflammable body which comprises: mixing or impregnating fibrous or other materials with an adhesive alkaline-earth borate solution, and comprising, drying and aging the resulting product with or without the application of heat to impart strength and rigidity to the same.

45. As a new composition of matter a cement or plastic body containing magnesium borate.

46. A fuse link comprising, in combination, a pair of conductors interconnected by fusible means, a sleeve of insulation containing magnesium borate surrounding said fusible means, and means holding said sleeve to one of said conductors, the other conductor being free to move out of said sleeve on blowing of said fusible means.

47. A fuse link comprising, in combination, a pair of conductors interconnected by fusible means, an outer sleeve of insulation surrounding said fusible means, and a sleeve of insulation containing magnesium borate within said outer sleeve.

48. A fuse link comprising, in combination, a pair of conductors interconnected by fusible means, an outer sleeve of insulation surrounding said fusible means, a sleeve of insulation containing magnesium borate within said outer sleeve, and means for holding said sleeves to one of said conductors, the other conductor being free to move out of said sleeves on blowing of said fusible means.

49. A fuse link comprising, in combination, a pair of conductors interconnected by fusible means, an outer sleeve of insulation surrounding said fusible means, a sleeve of insulation containing magnesium borate within said outer sleeve, and a pin extending through said sleeves and into one of said conductors for preventing relative movement therebetween, the other conductor being free to move out of said sleeves on blowing of said fusible means.

50. An electric circuit interrupter comprising, in combination, means between which an arc is formed on opening of the circuit, and an insulating structure surrounding and confining the arc space having a lining including magnesium borate and an outer housing therefor including a thermosetting resin.

51. An electric circuit interrupter comprising,

in combination, means between which an arc is formed on opening of the circuit, and an insulating structure surrounding and confining the arc space having a lining formed by paper treated with magnesium borate and an outer housing formed by paper treated with a thermosetting resin.

52. An electric circuit interrupter comprising, in combination, means between which an arc is formed on opening of the circuit, and an insulating structure surrounding and confining the arc space having a lining formed by a rolled paper tube impregnated with magnesium borate and an outer housing formed by a rolled paper tube impregnated with a phenolic condensation product.

53. An electric circuit interrupter comprising, in combination, means between which an arc is formed on opening of the circuit, and an insulating structure surrounding and confining the arc space having a lining including magnesium borate and an outer insulating housing therefor.

54. As a new composition of matter having flame proof and high electrical resistance characteristics, fiber glass with its interstices containing magnesium borate.

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