Sept. 19, 1944. G. F. McMAHON 2,358,407

METHOD OF MAKING ARC CONFINING STRUCTURES

Original Filed Dec. 9, 1940 2 Sheets-Sheet 1

Fig. 1.

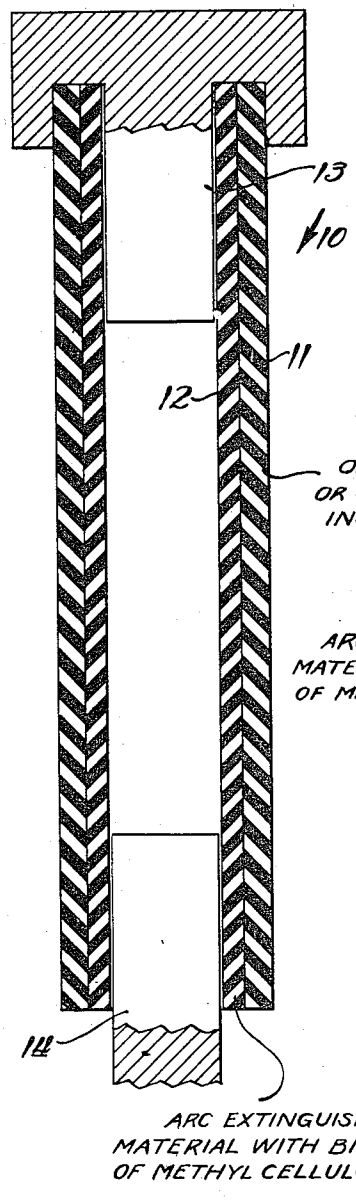
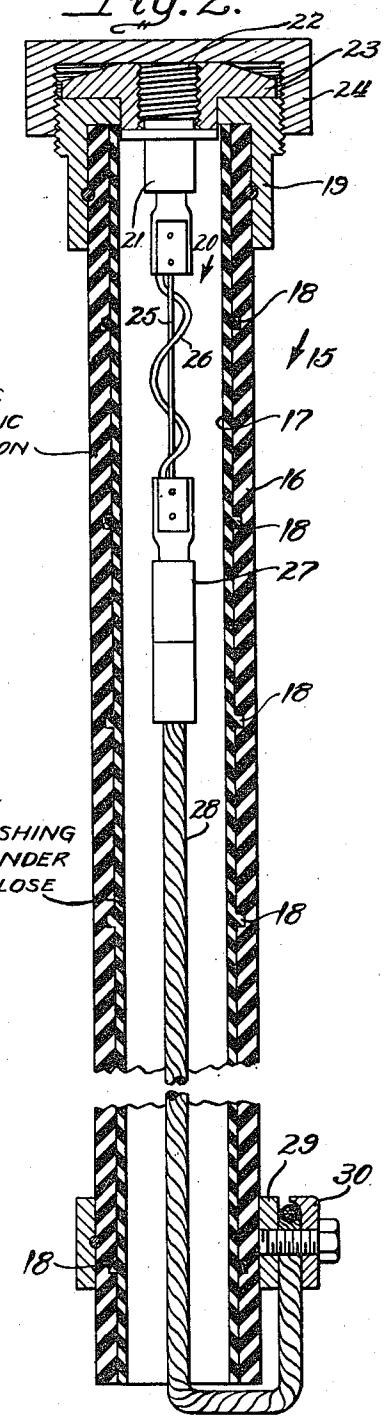


Fig. 2.



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Fig. 3.

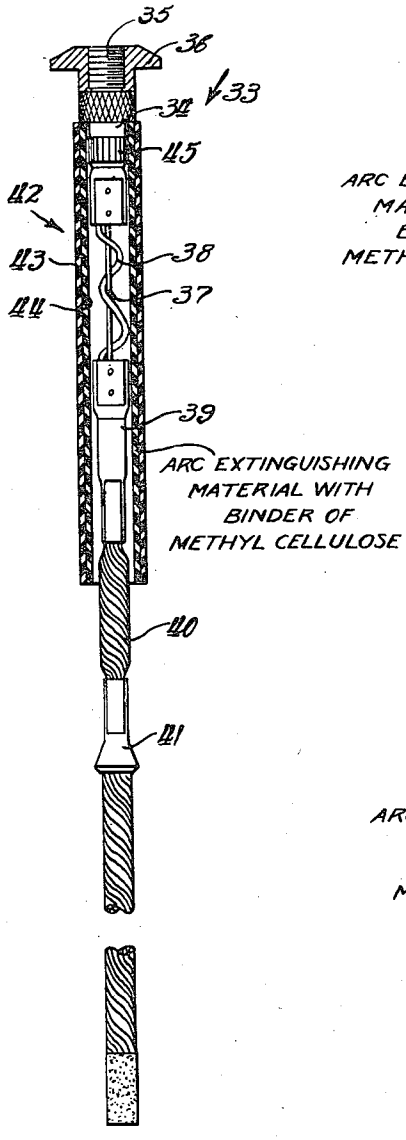


Fig. 4.

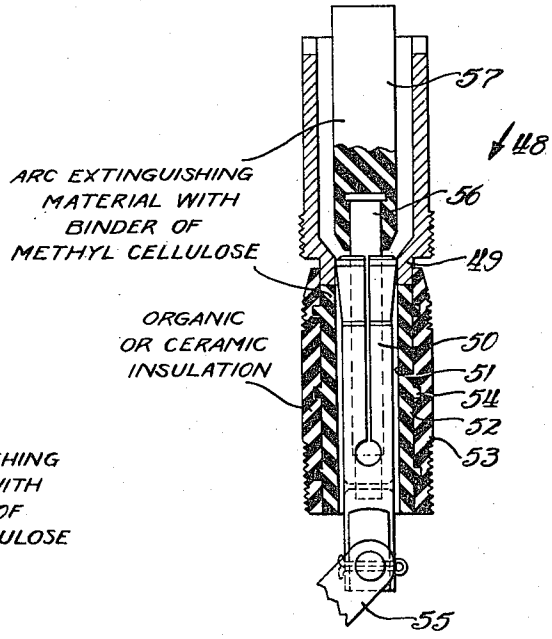
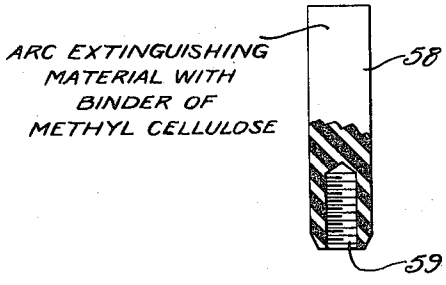


Fig. 5.



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UNITED STATES PATENT OFFICE

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METHOD OF MAKING ARC CONFINING STRUCTURES

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Original application December 9, 1940, Serial No. 369,162, now Patent No. 2,325,416, dated July 27, 1943. Divided and this application November 6, 1942, Serial No. 464,702

3 Claims. (Cl. 106—193)

My invention relates, generally, to circuit interrupting apparatus and it has particular relation to arc extinguishing material used therefor and methods of making and moulding the same. This application is a division of my copending application, Serial No. 369,162, filed December 9, 1940, now Patent No. 2,325,416, issued July 27, 1943.

In electrical apparatus, particularly circuit interrupting devices, arc confining structures are provided around the path of the arc that is formed on operation thereof. The surface of these structures which is subjected to the direct heat of the arc is preferably formed of a material which will evolve an arc extinguishing medium that will sweep out the arc, deionize the arc space and prevent its restriking.

The material from which the arc extinguishing medium is evolved should be of high dielectric strength both before and after operation of the circuit interrupter. In some instances a material may be satisfactory from an insulating standpoint before it has been subjected to the heat of an arc but afterwards it may be unsatisfactory because of the formation of a conducting path over its surface as a result of carbonization of some of the material. This is known as "tracking" and is undesirable since a leakage path is provided over the surface of the arc confining structure which may result in a dangerous condition in the circuit in which the circuit interrupting device is connected.

For many applications in electrical circuit interrupting devices, such as expulsion fuse tubes, sleeves for replaceable fuse links and plugs of insulating material used for arc confining purposes, it is simpler and more economical to extrude the arc extinguishing material into the desired shape. In so far as I am aware it has not been practicable in the past to extrude some of the more desirable arc extinguishing materials such as boric acid and magnesium borate.

Circuit interrupting devices in which arc extinguishing materials are employed are used out of doors in many instances where they are subjected to the weather. It is preferable that any extinguishing material which is used be impervious to water so that it will not swell, for example, and impair or prevent proper operation of the device.

An object of this invention is to reduce the carbon content of the insulating structure surrounding an arc path in a new and improved manner.

Another object of this invention is to provide for extruding arc extinguishing material into the desired shapes.

A further object of this invention is to provide water resistant arc extinguishing materials.

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

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

Figure 1 is a longitudinal sectional view of a circuit interrupting device having separable contact members in which the present invention is incorporated;

Figure 2 is a longitudinal sectional view of an expulsion fuse device in which the present invention is incorporated;

Figure 3 is a view, in side elevation, of a replaceable fuse link, the insulating sleeve therefor being shown in longitudinal section;

Figure 4 is a view, partly in side elvation and partly in section, of a circuit interrupting device employing separable contact members and a plug of insulating material formed in accordance with the present invention for confining and extinguishing the arc; and

Figure 5 is a view, partly in side elevation and partly in section, showing an alternate form of plug construction for the device shown in Figure 4.

According to this invention a relatively small amount of binding material, such as a cellulose ether is suitably combined with one or more different arc extinguishing materials to produce the desired shape for use in circuit interrupting apparatus. The binder is preferably methyl cellulose. Methyl cellulose is used on account of the ease with which it adapts itself to combinations with other materials.

Methyl cellulose is a water soluble cellulose ether that is obtained by methylating cellulose such as cotton. Solutions of methyl cellulose are not affected by changes in acidity or alkalinity over a relatively wide range.

The arc extinguishing materials with which the binder of cellulose ether is employed are preferably those which will evolve water vapor and other gases when subjected to the heat of an arc. Certain inorganic materials are suitable for this purpose. Magnesium compounds such as magnesium borate, magnesium hydroxide, magnesium oxide and basic magnesium carbonate can be employed. Also, inorganic acids, such as boric acid, silicic acid, molybdic acid, and

arsenicus acid, can be employed. Various combinations of these arc extinguishing materials can also be employed with the binder of cellulose ether.

Varying amounts of the binding material are used depending upon the amount that is necessary. The data thus far obtained indicates that it is unnecessary to employ more than 5% by weight of methyl cellulose as the binder when the foregoing inorganic arc extinguishing materials are employed. Usually, the amount of binder varies from 0.5% to about 4% by weight. Since a relatively small amount of binder is employed, it will be obvious that the carbon content thereof is negligible. Arc confining structures which are formed of one or more of the foregoing inorganic arc extinguishing materials with a binder of methyl cellulose are substantially free from tracking so that their dielectric properties are substantially unimpaired even after being subjected to repeated severe arcing.

In preparing the mix methyl cellulose is dissolved in water so as to produce a thick viscous liquid. The inorganic arc extinguishing material is added to the aqueous solution of methyl cellulose in powder form. Preferably the powder is fine enough to pass through a 200 mesh sieve, although satisfactory results can be obtained if it is capable of passing through only a 100 mesh sieve. The resulting mixture is very thick and quite rigid and of such character that, when extruded or formed to the desired shape, it is capable of retaining the same after the extruding apparatus has been removed so as to permit removal of the extruded shape for drying and aging.

Methyl cellulose is supplied commercially in four different viscosity grades in the form of white fibers, namely, "low," "medium," "high," and "extra high" viscosity types. The "low" grade requires more per unit volume of water to make a thick viscous solution than the "extra high" grade to make a solution of the same viscosity. In other words, when a solution of high methyl cellulose or solid content is desired, the "low" grade is used and when a low solid content is desired the "extra high" grade is used. This is important since the strength, shrinkage, etc., are partly controlled by adjusting this factor to suit the needs.

Standard methyl cellulose stock solutions can be made up as indicated in the following table, dissolving the material in cold water or by adding hot water at the start and then cold water.

Solution No.	Viscosity type	Grams	Water, c. c.	Methyl cellulose approx., per cent
1	Extra high	25	1,000	2.50
2	do	12.5	1,000	1.25
3	do	10.0	1,000	1.00
4	Low	100	1,150	8.0
5	do	50	1,000	5.00
6	do	25	1,000	2.50

The dried, finely divided powder is placed in a mixer and the correct volume of any selected methyl cellulose solution added and the whole thoroughly kneaded and mixed. If more than one powder is used, the powders are mixed in the dry state before adding the methyl cellulose solution. Generally the "dough" resulting from the mixture should be slightly more plastic when used to form liners inside tubing and more rigid or solid if formed into rods, plugs, or similar solid bodies.

It is desirable to keep the water content as low as possible at all times and at the same time still be able to form the object desired. This is to reduce shrinkage on drying out.

Methyl cellulose mixtures have the property of making an easy flowing plastic body when subjected to pressure without the water being squeezed out of the compound or plugging up the mold cavity or extrusion nozzle through separation of the solids from the water.

The following are examples of various mixes that can be made according to the present invention which are suitable for extruding purposes.

Example 1

70 grams of 100 mesh or finer magnesium hydroxide powder were added to 52 grams of a 5% methyl cellulose solution, using the "low" viscosity grade. The whole was kneaded and mixed thoroughly and placed in an extruding or pressure tool and formed into rods or cylinders of approximately 5/8" O. D. which were then baked at 60–80° C. and dried. The resulting product contained about 3.5% methyl cellulose and the balance was magnesium hydroxide.

Example 2

53 grams of 100 mesh or finer magnesium borate powder were added to 34 grams of a 2.5% "extra high" viscosity methyl cellulose solution, thoroughly kneaded and mixed and used to make liners for insulating tubing such as a phenolic condensation product. The liners in this case were 3/8" I. D. x 5/8" O. D. x 8 1/2" long. No cracking appeared on drying out or mild baking at 60–80° C. with or without a vacuum for several hours. The product was a good arc extinguishing material and a good insulator when tested at high voltages. This product when dry contains approximately 1.59% methyl cellulose and the balance magnesium borate.

Example 3

45 grams of 100 mesh or finer magnesium borate powder were mixed with 5 grams "heavy" magnesium oxide 100 mesh or finer powder. To this was added 26 grams of a very thick solution of "low" viscosity methyl cellulose containing 8% of methyl cellulose. The whole was kneaded and mixed thoroughly and used to line larger diameter tubes than those of Example 2 above, the liner in this case being 5/8" I. D. x 7/8" O. D. x 4 3/4" long.

The dried tube liner after baking at 60–70° C. contained approximately 3.7% methyl cellulose and the balance magnesium borate and magnesium hydrate in the following proportions: magnesium borate 83.0% and magnesium hydrate 13.3%. During this process, the major portion of the magnesium oxide is converted into the hydrate because of the reaction of the water of the methyl cellulose solution.

Example 4

25 grams of magnesium oxide and 75 grams of magnesium borate powders were thoroughly mixed and to this was added 44 grams of a 5% aqueous solution of "low" viscosity grade methyl cellulose. The whole was thoroughly kneaded and mixed and inserted in an extrusion press and used to form tube liners 3/8" I. D. x 5/8" O. D x 8 1/2" long and also rods .617" O. D. x 2 3/8" long. On drying the tube liners shrank 1/32" in length and the rod diameter decreased .012". No cracks appeared in either the tubes or rods.

The final composition, calculating to a dry basis was as follows: magnesium borate 66.14%, magnesium hydrate 36.18%, and methyl cellulose 1.94%. As in Example 3, the greater portion of the magnesium oxide is converted into the hydrate.

Example 5

111 grams of pure boric acid powder which passed through a 100 mesh sieve were mixed with 55 grams of a 2.5% "extra high" grade methyl cellulose aqueous solution. The whole was thoroughly kneaded and mixed and used to form small rods, about ¼" O. D. and tubing $\frac{5}{16}$" O. D. with a $\frac{1}{32}$" wall inside other insulating tubing. The methyl cellulose content on a dry basis was approximately 1.22% by weight.

Liners using methyl cellulose binder can be extruded into glass and porcelain tubes as well as into tubes formed of organic insulating material such as fiber or phenolic condensation material.

Liners for insulating tubes are extruded by placing a core of suitable material such as metal inside of the housing in which the liner is to be extruded and centering the same therein. The housing with the core therein is suitably held in extruding apparatus and the material for forming the liner is forced into the space between the core and the inner surface of the housing. After the space has been filled, the core is withdrawn and the housing is placed in an oven where it is baked to drive off excess moisture.

Liners that are formed of magnesium borate with a binder of methyl cellulose are substantially free from cracks and have good mechanical and arc extinguishing properties. Because the amount of methyl cellulose binder comprises a relatively small part of the liner, the amount of carbon that is deposited is negligible and consequently it is substantially free from tracking.

Rods or plugs can be satisfactorily formed of magnesium hydroxide with a binder of methyl cellulose. When formed or extruded into this form they do not crack and when properly aged are highly resistant to water.

Tubes or liners can be formed using varying amounts of magnesium borate and magnesium oxide with a binder of methyl cellulose. In this combination of materials magnesium hydrate is formed through the reaction between the oxide and the water used to carry the methyl cellulose. This reduces the setting time of the plastic mass. The resulting structure is somewhat stronger than if magnesium borate alone were used and it is less likely to crack than is the case if magnesium oxide alone were used.

Referring now particularly to Figure 1 of the drawings, it will be observed that the reference character 10 designates, generally, a housing or sleeve of insulating material for a circuit interrupter. The housing 10 is formed by an outer layer 11 of suitable insulating material such as a synthetic plastic or ceramic material, i. e., glass or porcelain, while the inner layer or liner 12 is formed of arc extinguishing material combined with a binder as described hereinbefore. The liner 12 may be extruded into the outer sleeve or housing 11, as previously described, after which it is suitably dried and aged.

At one end of the housing 10 is a stationary contact member or terminal 13 which is arranged to be engaged by a movable contact member or terminal 14. It will be understood that the contact members 13 and 14 are connected in an electric circuit which is to be interrupted and that, when the circuit is interrupted under load conditions, an arc will be formed between the contact members 13 and 14. The heat of the arc will cause an arc extinguishing medium, i. e., water vapor, to be evolved from the inner surface of the liner 12 which acts to deionize the arc space between the contact members 13 and 14 so as to prevent the arc being restruck.

Referring now particularly to Figure 2 of the drawings, it will be noted that the reference character 15 designates, generally, an expulsion fuse tube which has an outer layer 16 of insulating material, such as a synthetic plastic body or a ceramic material, and an inner layer 17 that is formed of arc extinguishing material in the manner previously described. The outer layer 16 is provided with a plurality of peripheral grooves 18 in its inner surface into which the plastic mass forming the inner layer 17 is extruded for holding the same in place.

At the upper end of the fuse tube 15 is a terminal 19 which is apertured so as to receive a fuse link, indicated generally at 20, therethrough. The fuse link 20 is universal in character and includes a relatively infusible terminal 21 having a threaded stud portion 22 for receiving a flanged head 23 that rests against the upper end of the terminal 19. A cap 24 is arranged, as shown, to be screwed on to the terminal 19 for holding the flanged head 23 in place. A strain element 25, formed of relatively high strength wire, such as nickel chromium alloy wire, and a fusible element 26, formed preferably of silver, are secured to the lower end of the relatively infusible terminal 21. The other ends of the strain and fusible elements 25 and 26 are secured in the upper end of another relatively infusible terminal 27 to which is secured a flexible conductor 28. The flexible conductor 28 extends out of the lower end of the expulsion fuse tube 26 and is connected to a second terminal 29 thereon by suitable clamp means 30.

When the liner 17 is formed of arc extinguishing material as disclosed herein, tests have shown that it is unnecessary to provide an additional sleeve of insulation for closely surrounding the strain and fusible elements 25 and 26 as is now generally considered necessary in the construction of universal fuse links. Even on relatively low current arcs, because of the relatively great availability of the water vapor in the liner 17, a sufficient amount of the arc extinguishing medium is evolved to sweep out the arc and deionize the arc space.

In Figure 3 of the drawings, there is shown generally at 33 a universal type link in which the present invention is incorporated. The fuse link 33 comprises a relatively infusible terminal 34 which is provided with a threaded stud portion 35 for receiving a flanged head 36. A strain element 37 and a fusible element 38, of material similar to the strain and fusible elements 25 and 26, respectively, of Figure 2, are connected to the lower end of the terminal 34 and to the upper end of another relatively infusible terminal 39. A flexible conductor 40 is secured to the lower end of the terminal 39 and it is provided with a special cone fitting 41 for adapting the fuse link 33 for use with certain types of fuse devices that are now well known to those skilled in the art. It will be noted that the flexible lead 40 extends beyond the fitting 41 for connection to a line terminal as may be desired.

Surrounding the strain and fusible elements

37 and 38 is a sleeve, shown generally at 42, of insulating material. The sleeve 42 is formed by an outer layer 43 of material such as fiber and an inner layer 44 of arc extinguishing material that is formed as previously described using a binder of methyl cellulose. The layer 43 of fiber is used for mechanical purposes and is preferably relatively thin, being only about 1/64 inch thick. Other thin walled plastic or ceramic bodies can be employed in lieu of fiber.

The terminal 34 is knurled, as indicated at 45, to provide for frictionally gripping the composite sleeve 42 and holding it in place on the terminal 34.

In Figure 4 of the drawings there is shown a circuit interrupting device which forms a part of a load break switch structure, the details of which are fully disclosed in the copending application of Lindell et al., Serial No. 349,898, filed August 2, 1940. The load break device 48 is intended for use with a disconnecting switch and is employed for effecting the final circuit interruption. However, its uses are not limited to this particular application.

The switch 48 comprises a stationary contact member 49 that is generally ring-like in character and it is arranged to be engaged by a rod-like contact member 50 that is disposed to be moved through a bore 51 that is provided by an extrueded plastic liner 52 which is formed as described hereinbefore using methyl cellulose as a binder for the arc extinguishing material. The liner 52 is held in place by a housing 53 of suitable insulating material such as a synthetic plastic or a ceramic material in which grooves 54 may be provided for the purpose indicated hereinbefore. The rod-like contact member 50 is arranged to be moved out of and into contact engagement with the contact member 49 by means of an operating member 55, only a portion of which is shown. Any suitable operating means can be provided for moving the rod-like contact member 50.

It will be understood that, when the rod-like contact member 50 is moved away from the stationary contact member 49 under load, an arc will be formed within the bore 51 which should be promptly extinguished so as to quickly effect circuit interruption with a minimum of disturbance. In order to effect this result an insert 56 is carried by and is movable with the rod-like contact member 50 and it is moulded into a plug 57 of arc extinguishing material having a binder of methyl cellulose that is formed as previously described. That is, the plug 57 is extruded around the insert 56. The plug 57 moves together with the rod-like contact member 50 and substantially fills the bore 51 so that the arc which is drawn between the contact members 49 and 50 is confined between the outer surface of the plug 56 and the inner surface of the liner 52. Under these circumstances the arc is quickly blown out and the arc space is deionized so as to prevent restriking.

In Figure 5 of the drawings there is shown a plug 58 which can be used, if desired in lieu of the plug 57. It will be observed that the plug 58, instead of having an insert extruded or moulded into the same, is drilled and tapped as indicated at 59 for receiving a threaded stud. The plug 58 is formed of arc extinguishing material with a binder of methyl cellulose in a manner previously described.

Since certain further changes can be made in the above constructions and different embodiments of the invention can be made without departing from the scope thereof, it is intended that all matter contained in the foregoing 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. The method of making an arc extinguishing structure having a high water content rendered available in the form of water vapor when the structure is subjected to the heat of an electric arc, which comprises, dissolving methyl cellulose in water in the proportion of about 5% methyl cellulose to 95% water by weight, thereby producing an aqueous solution of methyl cellulose, mixing with said solution powdered boric acid in amount to form a homogeneous plastic mass which when subjected to pressure will flow readily while retaining its homogeneity, molding the plastic mix under flowing pressure to the desired form and size of the structure to be produced, and drying the molded structure at a temperature to drive off excess moisture while retaining in the dried structure substantially all of the combined water of the mix.

2. The method of making an arc extinguishing structure having a high water content rendered available in the form of water vapor when the structure is subjected to the heat of an electric arc, which comprises, dissolving methyl cellulose in water in the proportions of from about 2.5% to 5% methyl cellulose to from about 97.5% to 95% water by weight, thereby producing an aqueous solution of methyl cellulose, mixing with said solution powdered boric acid in amount to form a homogeneous plastic mass which when subjected to pressure will flow readily while retaining its homogeneity, molding the plastic mix under flowing pressure to the desired form and size of the structure to be produced, and drying the molded structure at a temperature to drive off excess moisture while retaining in the dried structure substantially all of the combined water of the mix.

3. The method of making an arc extinguishing structure having a high water content rendered available in the form of water vapor when the structure is subjected to the heat of an electric arc, which comprises, dissolving methyl cellulose in water in the proportions of from about 0.5% to 5.0% methyl cellulose to from about 99.5% to 95% water by weight, thereby producing an aqueous solution of methyl cellulose, mixing with said solution powdered boric acid or magnesium borate in amount to form a homogeneous plastic mass which when subjected to pressure will flow readily while retaining its homogeneity, molding the plastic mix under flowing pressure to the desired form and size of the structure to be produced, and drying the molded structure at a temperature to drive off excess moisture while retaining in the dried structure substantially all of the combined water of the mix.

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