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N. C. FOSTER

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METHOD FOR CASTING TUBULAR MEMBERS

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Fig. 1.

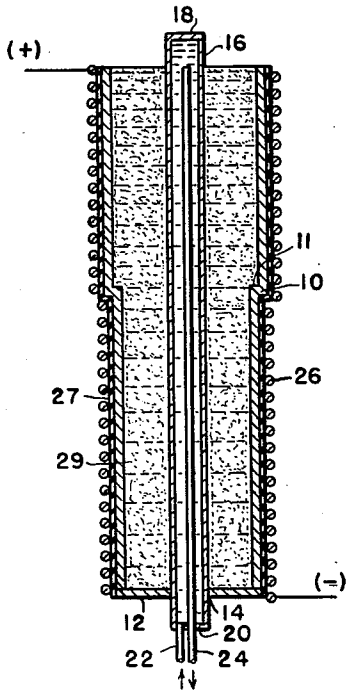


Fig. 2.

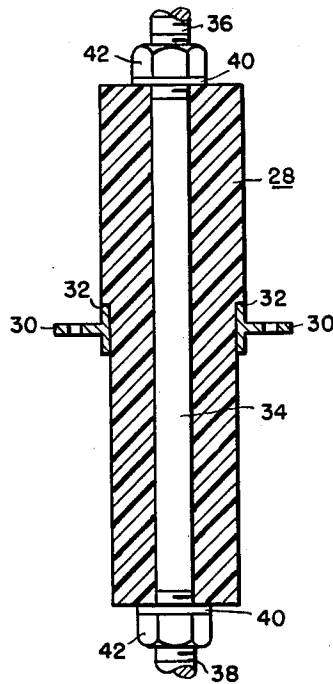
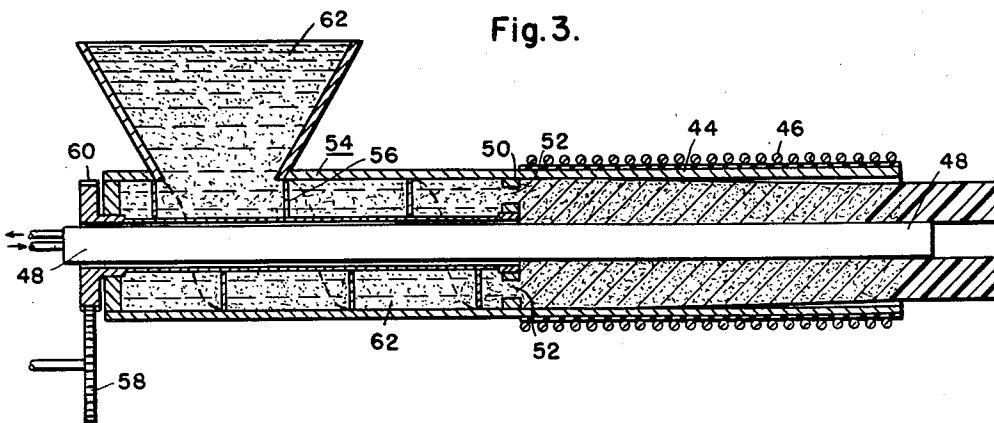


Fig. 3.



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## METHOD FOR CASTING TUBULAR MEMBERS

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4 Claims. (Cl. 18—58)

This invention relates to a method for casting tubular members having a passageway therethrough.

This invention is particularly suited for casting tubular members suitable for use as electrical insulating bushings for circuit breakers and other electrical apparatus. At present, circuit breaker bushings are manufactured by hot rolling shellac or phenolic-treated paper on a mandrel. The mandrel is removed and the bushing is then machined to a proper size and shape. Finally, the bushing is given as many as six coats of varnish to reduce moisture absorption by the paper. At best, the varnish only reduces the rate of moisture permeability so that if the bushings are stored for long periods of time in humid atmospheres, their power factors become prohibitively high.

It would be desirable to mold bushings of the above described type from casting resins. However, many difficulties arise. If the bushing is molded as a solid member, a wasteful machining operation is required to bore a center hole for a conductor, such as copper or aluminum. Attempts have been made to cast the bushing around the conductor, but these have not been successful due to polymerization shrinkage and the difference in the coefficients of expansion of the resin and the metal conductor. This usually results in cracks in the cast bushing. Similar problems exist if the resin is cast around a split, sectional mold.

The object of this invention is to provide a method of casting in a mold having a central mandrel, polymerizable liquid compositions to produce tubular members having a passageway therethrough, by cooling the polymerizable liquid compound only at the surface of the passageway to a degree that it remains liquid during the casting operation, the remainder of the polymerizable liquid compound polymerizing to a solid tube, thereby producing a tubular member having no cracks therein and readily releasable from the mold.

Other objects will become more apparent from the following description thereof.

For a fuller understanding of the nature and objects of the invention, reference may be had to the following detailed description, taken in conjunction with the accompanying drawing, in which:

Figure 1 is a transverse sectional view of one form of molding apparatus of this invention;

Fig. 2 is a transverse sectional view of a circuit breaker bushing cast in the molding apparatus illustrated in Fig. 1; and

Fig. 3 is a transverse sectional view of a modification of the molding apparatus of this invention.

I have discovered a method for casting from polymerizable compositions, resinous tubular members having a longitudinal passageway therethrough. The members are cast from polymerizable liquid compositions such as the liquid polyesters, examples of which will be hereinafter given. The tubular members produced in accordance with this invention are sound, homogeneous and have no cracks therein. This is accomplished by keeping a thin layer of the casting composition at the passageway

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through the member, and in contact with the mandrel, liquid during the molding operation wherein the main body of the composition is heated to cause it to polymerize. As the casting composition polymerizes, it shrinks from the walls of the mold and against the liquid layer which acts as a cushion and is displaced, thereby effectively preventing cracking. When the cast resinous member is removed from the mold, the thin liquid layer forming the passageway therethrough is heated by the heat of polymerization present in the remainder of the cast tubular member and gels practically immediately and thus no "runout" occurs.

Referring to Fig. 1 of the drawing, there is illustrated an exemplary form of apparatus for carrying out the invention. A sheet metal mold 10 of any desired cross-section, having an upper open end and a closed bottom end is mounted in an upright position. The mold 10 may have one or more shoulders 11. The bottom end of the mold is closed by a disc member 12 having an opening 14 therethrough. A hollow cylindrical mandrel 16 having closed ends 18 and 20 is mounted through the opening 14 with a sufficiently tight fit to prevent liquid escape therethrough, and extends the length of the mold to the open end thereof. The mandrel 16 is to form a passageway through the tubular members to be cast in the mold 10. The cross-section of mandrel 16 may be circular, hexagonal or of any desired geometrical shape. Mounted in the mandrel 16 is a pipe 22 for continuously circulating a coolant, such as tap water, through the interior of mandrel 16. The closed end 20 of mandrel 16 is provided with an overflow pipe 24 mounted therein for the discharge of the circulated coolant. During the entire molding operation, the mandrel 16 cools the adjacent polymerizable composition to a degree that a thin layer thereof surrounding the mandrel remains liquid.

The mold 10 is provided with a heating element 26 such as Nichrome wire wrapped around a layer of insulation comprising asbestos 27 cemented to the mold 10 with water glass. The Nichrome wire is connected to a suitable source of electrical current (not shown).

Instead of using a heating element such as the one described, the mold 10 may be constructed of ultra violet transmitting glass or like transparent material and the resinous composition cured by means of actinic light such as ultra violet rays, etc.

A tube is cast by pouring a liquid polyester resin 29, for instance, in the open end of the mold 10 which has been heated to a temperature of about 100° C. while tap water is circulated through the mandrel 16. As the main body 29 polymerizes to a solid, it shrinks away from the walls of the mold 10, but a thin layer around the mandrel 16 remains liquid. The solid resinous member is completely polymerized in 15 minutes and is removed by inverting the mold 10, whereupon the member will slide out freely therefrom.

Illustrated in Fig. 2 of the drawing is a circuit breaker bushing 28 cast from a polyester resin in the mold 10. The bushing 28 illustrated in Fig. 2 of the drawing is supported by bracket means 30 butted against a shoulder 32. Passing through the bushing 28 is a copper conductor 34. The passageway through the bushing was so molded that there is a tight fit between the bushing and the conductor. The conductor 34 is fixedly mounted in the bushing by threads at the ends of the conductor as at 36 and 38 and cooperating silicone rubber washers 40 and nuts 42.

Illustrated in Fig. 3 of the drawing is a modification of the apparatus in accordance with the invention, for producing thermoset tubular members of continuous length. A mold 44 is provided with a heating element 46 and a cooling mandrel 48 in the same manner as the construction illustrated in Fig. 1 of the drawing. The mold 44 has a barrier 50 provided with a plurality of

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passageways 52 leading to a screw type plastic extruder 54. A screw conveyor 56 driven by gear 58 and pinion 60 continuously forces a polymerizable resin composition 62 through the passageways 52 into the mold 44 at a rate sufficient to allow the composition to polymerize and produce a solid continuous tubular member issuing from the open end of the mold 44. The cooling mandrel 48 passes through the axis of the screw conveyor 56, as shown in the drawing, and is cooled in the same manner as the mandrel 16 illustrated in Fig. 1 of the drawing.

The following examples illustrate the formulation of suitable casting compositions for use in the practice of this invention, which may be cured in molds at temperatures of from 60° C. to 150° C.

#### Example I

A casting resin mixture was prepared from the following ingredients:

- 70 parts by weight of a mixture of 75% of castor-oil-maleate (0.02% quinydrone as inhibitor) and 25% monostyrene by weight
- 30 parts by weight 365 mesh mica
- 0.7 part by weight aluminum acetyl acetate
- 0.7 part by weight cobalt naphthenate solution (6% cobalt)
- 0.7 part by weight 60% solution of methylethyl ketone peroxide.

The resulting mixture was a syrupy liquid. It was evacuated to remove air. The mixture was then poured into the mold illustrated in Fig. 1 of the drawing, which was heated to a temperature of 100° C. The mandrel 16 was cooled to about 20° C. by continuously passing tap water therethrough. After about 15 minutes, the mixture had gelled and polymerized to a solid which had shrunk away from the walls of mold 10. The resinous casting was then removed by inverting the mold whereupon it slid out. No cracking or sticking occurred.

#### Example II

A mixture of the following was prepared:

- 70 parts by weight of a composition comprising 30% of styrene and 70% of phthalic maleic anhydride propylene glycol polyester resin
- 30 parts by weight 365 mesh mica
- 0.14 part by weight each of cobalt naphthenate and a 60% solution of methyl-ethyl ketone peroxide.

This mixture was vacuum treated to remove air and was cast in the mold illustrated in Fig. 1 of the drawing which was heated to 80° C. A solid thermoset casting was removed after 10 minutes treating time. A harder casting than the one of Example I was obtained from the above resin.

Completely-reactive compositions suitable for use in this invention may include any fluid polymerizable composition that, upon being heated to a predetermined temperature, polymerizes into a relatively-hard resinous body. The fluid resinous composition may comprise a single polymerizable component such, for example, as diallyl phthalate, diallyl succinate, diallyl maleate, diallyl adipate, allyl alcohol, methallyl acrylate, diallyl ether, allyl acrylate, allyl crotonate or a partially condensed organosiloxane having a ratio of R to Si of from 1:1 to 1:1.8. It will be noted that many suitable compositions comprise at least one unsaturated group  $>C=C<$  capable of vinyl-type additive polymerization. The best results have been secured with monomers containing two or more of these unsaturated groups capable of polymerization upon being subjected to heat. It will be understood that mixtures of any two or more of the polymerizable monomers may be employed. Numerous other multi-component completely-reactive compositions are known to the art. Such compositions include, in many cases, an unsaturated resinous component—particularly an unsaturated

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alkyd resin—and an unsaturated polymerizable liquid monomer. Particularly good results have been secured by employing as the resinous alkyd resin the reaction product of an ethylenic dicarboxylic acid or anhydride thereof such, for example, as maleic acid, fumaric acid, maleic anhydride, monochloromaleic acid, itaconic acid, itaconic anhydride, citraconic acid and citraconic anhydride. The unsaturated dicarboxylic acid or anhydride or mixtures thereof are reacted with a polyhydric alcohol such as glycol, glycerol, or pentaerythritol or mixtures thereof. Castor oil has been employed, successfully in reactions with maleic anhydride, and the resultant castor oil maleate ester admixed with a polymerizable unsaturated monomer, for example, monostyrene, in the proportions of from 10 to 95 parts by weight of the monostyrene and from 90 to 5 parts by weight of the ester. In the preparation of the unsaturated alkyd esters, the unsaturated alpha-beta dicarboxylic acid or anhydride may be replaced with up to 90% of the weight thereof of a saturated aliphatic dicarboxylic acid or aryl dicarboxylic acid or anhydride, such, for example, as succinic acid, adipic acid, sebacic acid, phthalic acid, phthalic anhydride or the like. Also, mixtures of polyhydric alcohols may be employed. In some instances, epoxides have been employed in lieu of glycols—particularly with dicarboxylic acids instead of their anhydrides.

The alkyd esters may be dissolved in a liquid unsaturated monomer having the group  $>C=C<$ . Suitable liquid unsaturated polymerizable monomers are: monostyrene, alpha methyl styrene, 2,4-dichlorostyrene, para-methyl styrene, vinyl acetate, methyl methacrylate, ethyl acrylate, diallyl phthalate, diallyl succinate, diallyl maleate, allyl alcohol, methallyl alcohol, acrylonitrile, methyl vinyl ketone, diallyl ether, vinylidene chloride, butyl methacrylate, allyl acrylate, allyl crotonate, 1,3-chloroprene and divinyl benzene, or mixtures of two or more of any of these monomers.

The unsaturated reactable composition preferably contains a polymerization catalyst. Suitable polymerization catalysts for olefinic compositions include peroxides, ozonides, perhalides, and peracids. Examples of suitable catalysts are benzoyl peroxide, tert-butyl perbenzoate, tert-butyl hydro-peroxide, di-t-butyl peroxide, di-t-butyl diphenylphthalate, 1-hydroxy cyclohexyl hydroperoxide-1 and ascaridol. 0.1% or less of the polymerization catalyst, based on the weight of the composition, may be employed, but more rapid reaction is obtained if the amount of the catalyst is higher—preferably from ½% to 5% by weight. The polymerization catalyst when admixed in the completely-reactive composition, may cause it to increase in viscosity slowly at ordinary temperatures; and, therefore, it may be desirable to maintain the catalyzed composition to a temperature of 10° C., or lower, thereby increasing the tank life of the composition, as well as including an inhibitor such as hydroquinone.

Other completely reactive resins may comprise complex epoxides. Such epoxides may be prepared by reacting one mole of a dihydric phenol such as bis(p-hydroxyphenyl)-dimethylmethane with from one to two moles of an epihalohydrin or dihalohydrin. Glycidol ethers and their reaction products with phenols as set forth in Patent 2,506,486 are suitable epoxides. These epoxides may be admixed with boron trifluoride-piperidine reaction product or amines, as catalysts, or dicarboxylic acid anhydrides, and upon heating the mixtures will thermoset. Reference should be had to U. S. Patents 2,582,985; 2,512,997; 2,506,486 and 2,324,483 for examples of the preparation and use of such epoxides.

It is intended that all matter contained in the above description or shown in the accompanying drawing shall be interpreted as illustrative and not in a limiting sense.

I claim as my invention:

1. In the method of producing tubular resin members

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having a passageway therethrough, the steps comprising introducing a polymerizable resinous composition in liquid form into a mold of desired configuration, curing the composition by heating to a temperature of from 60° C. to 150° C. for a period of time sufficient to polymerize the composition to a solid while cooling a thin layer of the composition at the surface of the passageway to a temperature sufficient to keep the composition liquid in said thin layer, and removing the solidified resin forming the tube from the mold.

2. The method of claim 1 in which the curing of the resinous composition is accomplished by actinic rays.

3. A process for preparing a tubular member having a passageway extending longitudinally therethrough which comprises (A) introducing a liquid polymerizable resinous composition into a mold having (1) a molding cavity of a configuration of the tube to be cast, and (2) a centrally disposed mandrel extending beyond the ends of the cavity for forming a passageway through the tube, (B) curing the resinous composition by heating to a temperature of from 60° C. to 150° C. for a period of time sufficient to polymerize substantially all the resinous

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composition to a solid while (C) simultaneously passing coolant through the mandrel to maintain the temperature of a thin layer of the resinous composition surrounding the mandrel low enough whereby that layer remains liquid, and (D) removing the resulting solidified tubular member from the mold.

4. The method of claim 3, in which the curing of the resinous composition is accomplished by actinic rays.

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