PROTECTION OF WIRE-SPLICES

Filed Oct. 18, 1955

FIG. 1

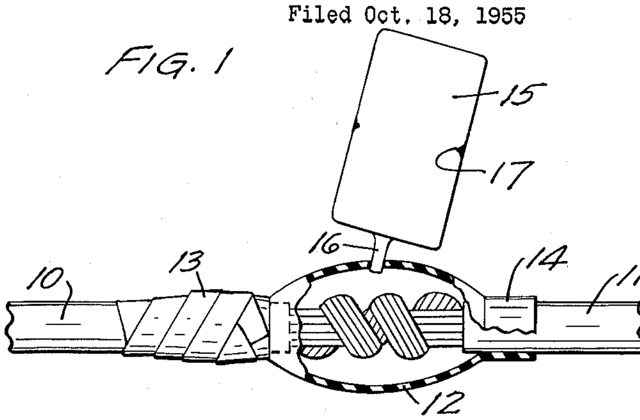


FIG. 2

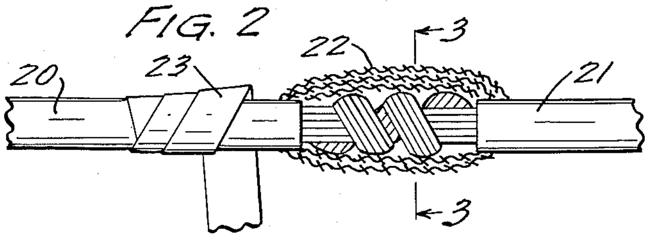


FIG. 3

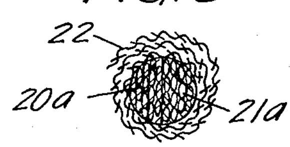


FIG. 4

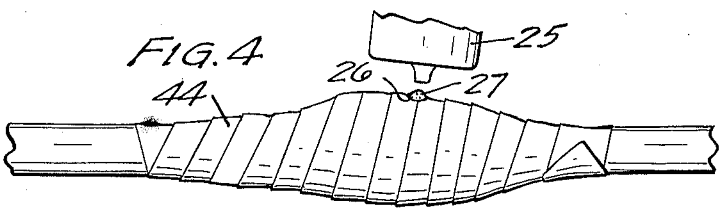


FIG. 5

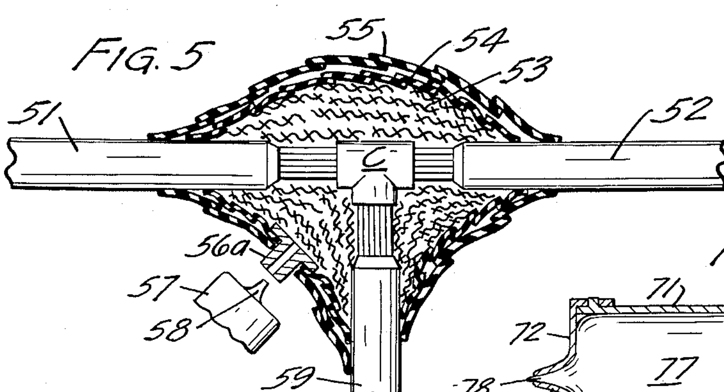


FIG. 7

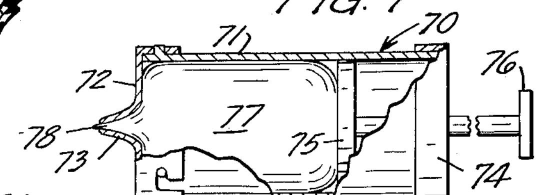


FIG. 6a

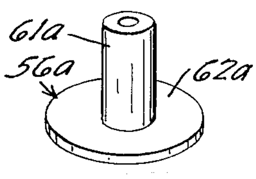
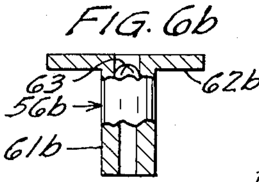


FIG. 6b



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PROTECTION OF WIRE-SPLICES

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This invention relates to the protection of splices in wires and cables, and provides for the encapsulation of spliced areas with liquid resinous insulating and protecting materials which are then solidified in place. The encapsulated splice area is completely covered and protected with a solid, tough, waterproof insulating covering. The method is applicable to the protection of a wide variety of shapes and sizes of splices. The coverings are applied quickly and easily regardless of the contour of the underlying article. The resinous material completely fills all voids within the splice area and, when solidified, provides positive and complete protection.

Typical examples of the method employed, the apparatus and materials used, and the completed article resulting, are illustrated in the appended drawing, in which:

Figure 1 represents one method of insulating and protecting a wire-splice, employing a unitary package of resinous materials, and being shown partly in section;

Figure 2 represents the preliminary steps, Figure 3 being a section of Figure 2 as indicated, and Figure 4 represents the final product, of an alternative method;

Figure 5 is an illustration, partly in section, showing the insulating and protecting of a T-splice, using an injection port as shown in perspective in Figure 6*a*, or an alternative port as shown in side elevation and partly in section in Figure 6*b*; and

Figure 7 is an alternative apparatus, shown mainly in section, for injecting liquid solidifiable insulating resin into the splice area.

Figure 1 illustrates a line or running splice between two insulation-covered stranded conductors **10** and **11**, which is protected and insulated with resinous material introduced from a capsule **15**, and maintained in position during the solidification period by a preformed, somewhat rigid, and preferably transparent envelope **12** of any desired specific configuration but here illustrated as globular. The envelope is shown as held in place on the outer surface of the insulated conductor **10** by means of a wrapping of adhesive tape **13**, and on the insulated conductor **11** by the close-fitting but elastic and slidable friction seal portion **14** of the envelope **12**; but both ends may be sealed by either method. The envelope is perforated so as to permit the entry of the open end tip **16** of the capsule **15**, through which the solidifiable liquid resin provided in the capsule is introduced, under pressure, into the envelope and around the spliced areas of the conductors.

Rather than employ a preformed fitted envelope **12**, suitable strips of plastic or elastic film or sheet material, such as stretchable elastic vinyl film coated with pressure-sensitive tape adhesive, may be wound loosely around the splice area to form a non-rigid envelope of approximately the same configuration as envelope **12**. The film or tape is fastened in place on each of the insulated conductors, and perforated to permit the entry of the resinous mixture. The liquid resin is forced through the aperture into the envelope and around the splice by

pressure applied to the flexible capsule **15**, thereby distending the non-rigid envelope to substantially the shape of the preformed envelope **12** of Figure 1.

A preferred procedure is indicated in Figures 2–4. The splice area connecting the conductors **20** and **21** is first wrapped with a strip or strips of insulating screen **22** to a shape and thickness capable of providing adequate protection for the cable. The screen is further covered and held in place by an overlapping and closely conforming spiral wrapping of non-porous adhesive tape **23**. The spliced conductors **20***a*, **21***a*, and the wrapping of screen **22** are shown in cross-section in Figure 3, taken at section 3—3 of Figure 2. The tape wrapping is sealed tightly to itself and to the insulated cable to form a smooth covering **44** as illustrated in Figure 4, and the covering is perforated, as at **26**, to provide for entry of the resin from the capsule **25**. The liquid solidifiable resin from the capsule is forced through the perforation into the space within the tape wrapping, where it penetrates the screen **22** and fills all voids within the splice area. Air or gas retained around the splice is forced out either through openings unavoidably remaining at the ends of the tape wrapping **44**, or between the several strands of the conductors, or through suitable further perforations provided for the purpose. The capsule is removed, as indicated in Figure 4 which shows a drop **27** of the resin protruding from the perforation in the wrapping **44**, and the resin is permitted to solidify. A further wrapping of adhesive tape may be placed around the filled envelope to seal the openings during the latter period if found desirable.

The porous screen filler provides support for the flexible covering **44**. The combination of filler and cover thus provides an envelope which is analogous to the somewhat rigid envelope **12** of Figure 1 in maintaining its original shape and position during introduction of the liquid resin.

The structure provided in Figure 5 is somewhat similar to that of Figures 2–4 in employing a sealed wrapping **54** of overlapping non-porous adhesive tape and a built-up porous screen spacer portion **53**. There is in addition an outer pressure wrap **55** of overlapped flexible strip material having high tensile strength and low-stretch. A material such as a strip of glass cloth, or filament-reinforced pressure-sensitive adhesive tape, or transparent film pressure-sensitive adhesive tape having adequate tensile strength and resistance to stretch, is useful for this purpose. Paper tapes are not ordinarily as high in tensile strength but are useful for less critical applications. An injection port **56***a* provides a port of entry for the liquid solidifiable resinous composition which is to be forced into the interior of the covering from a capsule **57** having a tip **58**. The port **56***a* is shown in Figure 6*a* in more detail; it consists of a tube **61***a* having a terminal flange or collar **62***a* which is taped to the screen-covered splice area as shown in Figure 5. This type of port must be manually plugged as soon as the envelope is filled and the nozzle **58** is withdrawn; or the nozzle **58** may itself serve to plug the port if held in place during solidification of the resin. A modified self-sealing port **56***b* illustrated in Figure 6*b* includes a one-way valve member **63** consisting of a cross-slit hemispherical flexible cup affixed within the tube **61***b* near the flange **62***b*.

The stranded conductors **51**, **52** and **59** of Figure 5 are connected in a T-splice by means of a conventional connector member C, which may be, for example, a screw-threaded brass fitting or a lead or solder casting. The resulting splice is quite complicated in contour as compared with that of Figure 2, yet the protective covering is applied with facility and the protected splice is equally symmetrical and attractive in appearance. The resin completely fills all initial voids in the covered area, the air being displaced as described in connection with Figures 2–4. The tip 58 may be held in place over the port to prevent loss of resin while the resin solidifies; or other means of sealing the tip during the solidification cycle, such as the self-closing port of Figure 6*b*, may be employed. The port 56*a* may be placed at any convenient location on the splice covering, since the resin as it is forced around the splice will completely fill all voids and remove all enclosed air. To assist in removal of air, a single strand of plastic filament, e.g., from the screen 53, may be placed along the cable beneath the end of the outer wrapping of tapes 54 and 55. Such a device also provides indicator means for determining when the envelope is completely filled with resin, since at that point a small bead of resin will be seen slowly emerging from the tape covering along the filament.

Another means of forcing liquid solidifiable resin into the splice-covering is illustrated in Figure 7, which shows a refillable gun member 70 consisting of a cylinder 71, a removable forward end member 72 having a tip 73, a rearward end member 74, and a plunger member 75 operated by a handle member 76. Mechanical advantage may be provided at the handle member by screw thread, lever systems, or the like, not shown. A flexible bag 77 fitting within the cylinder 71 contains the resin mixture. A corner 78 of the bag serves as a tip or snout portion, which is pulled through the tip 73 and cut to fit into the tube 61*a* of the port member 56*a* of Figures 5 and 6*a*. Pressure applied to the handle 76 then expels the resin from the bag 77 and forces it through the opening at the corner 78 into the interior of the covered splice area. The depleted bag is removed and discarded, leaving the gun 70 clean and in readiness for another cycle.

Solidifiable liquid resinous insulating material such as molten asphalt, waxes, thermoplastic resins, etc. have long been used as potting compounds for protecting electrical components and such materials may be used here. However the use of self-curing liquid resinous mixtures provides a number of additional advantages and is preferred. For example, the cured solidified resin is no longer thermoplastic.

The preferred resinous material is initially in the form of two or more separate components. When uniformly mixed together, this material is at first a thin liquid; but on standing for a short time, a reaction occurs and the mixture is converted to a solid, tough, cured form. Many resinous compositions are known which provide the desired result, but certain epoxy resin compositions are outstanding for a number of reasons and are preferred. With these mixtures the reaction is extremely rapid, the resin cures without evolution of volatile by-products, the cured resin is highly resistant to moisture and is found to be firmly adhered to all components of the splice area. One such mixture is produced by separately combining 46 parts by weight of "Thiokol LP–2" liquid organic polysulfide polymer with 8 parts of 2,4,6-tri(dimethylaminomethyl) phenol, and then intimately blending this mixture, just before use, with 46 parts of "Epon" resin No. 562, a liquid epoxy resin containing free epoxy radicals and produced from bisphenol and epichlorohydrin. Other epoxy resins and other curing or hardening agents are also useful. A coloring agent is frequently included in one of the two component parts of the final blend, in order visually to determine the effectiveness of the blending operation.

For use with two-part resinous compositions as just described, both the capsule 15 of Figure 1 and the plastic envelope 77 of Figure 7 are initially formed in two separate compartments, the two components of the reactive blend being separately contained therein. The structure is indicated in Figure 1 by the vestigial ring 17 on the inner circumference of the capsule 15, the ring being the remainder of a thin impervious rupturable separator membrane initially separating the two resin-forming materials. Just prior to application, the membrane is ruptured by squeezing an end of the capsule, and the two materials are then well blended by shaking and squeezing. The closed end of the tip 16 is then cut off and the reacting mixture forced into the splice area.

The envelope 77 of Figure 7 is somewhat similarly constructed except that the envelope walls are completely flexible. The walls are releasably held together along a central line of the envelope and the two reactive components are separately contained in the two compartments thus provided. When desired for application, the contacting areas are separated to permit the resin-forming components to be mixed together. The corner 78 is passed through the tip 73 and the end 72 assembled on the cylinder 71 with the bag 77 inside. The handle and plunger assembly is added, and the whole is then ready for use in forcing the reacting resin-forming mixture into the covered splice area.

Passage of air along the voids within the cable between the several wires of the stranded conductor has been mentioned. The air is forced from the splice area by the fluid resin, which then fills and seals the interstices between the conductor strands, thus completely isolating the splice area. In some instances it may be desirable to permit the continuous passage of an insulating fluid along the conductor, in which case it is only necessary to prewrap the stranded conductor with a protective web such as an impervious adhesive tape or film, thus to prevent access of the liquid resin to the spaces between the strands.

Shielded cables require connections between the shielding as well as between the conductors. This may effectively be accomplished by placing a section of foil, wire, or wire gauze over the preliminary covering of insulating screen and in contact with the metal shield of the cable at the extremities of the splice area. The whole is then covered with liquid-retaining and pressure-resistant wrappings, precautions being taken to provide a port of entry for the subsequently applied resinous mixture to the splice area.

The insulating screen employed in the splice coverings of Figures 2 and 5 provides a simple, effective means for spacing the outer liquid-retaining covering from the spliced conductor. A sufficiently thick and uniform layer of cured resin is thus assured around the splice area so that any desired degree of electrical and mechanical protection is provided. Coarse woven screen of plastic insulating material such as nylon, polyvinylidene chloride, or polyester polymers is particularly effective as the porous flexible insulating sheet material. The epoxy resin wets the surfaces of such polymers and bonds to such surfaces when cured in contact therewith, so that the final product is substantially homogeneous and highly insulative as well as resistant to moisture and oil. Other fabric- or screen-type webs or fibrous matts which provide adequate free space for penetration of the resinous liquid and which are non-conductive and otherwise satisfactory are also useful.

The use of a built-up screen spacer thus makes possible the protective covering of splices of the widest variations in contour with a single kit of materials including insulative screen strip, liquid-impervious sealing tape, self-hardening insulating resin composition, and pressure applying means for applying the latter. In some instances, particularly on larger installations, an additional element in the form of a high tensile strength tape or other means of providing a pressure-resistant covering may be added. However, for smaller units and for operations involving large numbers of splices of identical contour and dimension, equally effective and efficient protective coverings are provided with kits in which a relatively rigid, close-fitting casing, such as the envelope 12 of Figure 1, replaces both the screen and the outer wrapping.

This application is a continuation-in-part of the copending application Serial No. 386,992 of Emil Wayne

Bollmeier and Leo F. Vokaty, filed October 19, 1953.

What is claimed is as follows:

1. A method of protecting wire and cable splices comprising: surrounding the entire splice area with wrappings of open porous flexible and conformable insulating screen material to produce a compact, smoothly contoured support structure full of interconnected open voids; applying over and in contact with said support structure and adjacent cable area a close-fitting flexibly conformable liquid-tight pressure-resistant covering having a resin entry port; forcing a liquid self-curing insulating resinous composition under pressure through said port to fill all voids within said covering; and permitting the resinous composition to cure and solidify.

2. A method of protecting wire and cable splices comprising: smoothly wrapping the entire splice area with open porous flexible and conformable insulating screen material in strip form to produce a compact, smoothly contoured support structure full of interconnected open voids; applying over and in contact with the support structure and adjacent cable area a close-fitting flexibly conformable liquid-tight pressure-resistant covering of overlapped courses of non-porous adhesive tape, said covering having a resin entry port; forcing a liquid self-curing insulating resinous composition under pressure through said port to fill all voids within said covering; and permitting the resinous composition to cure and solidify.

3. A method of protecting wire and cable splices comprising: smoothly wrapping the entire splice area with open flexibly screen-like insulating sheet material in strip form to produce a compact, smoothly contoured support structure full of interconnected open voids; applying over and in contact with the support structure and adjacent cable area a close-fitting conformable liquid-tight pressure-resistant covering, including a first wrapping of flexible stretchable non-porous adhesive tape and a second wrapping of flexible stretch-resistant fibrous adhesive tape, and having a resin entry port; forcing a liquid self-curing insulating resinous composition under pressure through said port to fill all voids within said covering; and permitting the resinous composition to cure and solidify.

4. A method of protecting wire and cable splices comprising: smoothly wrapping the entire splice area with open flexible screen-like insulating sheet material in strip form to produce a compact, smoothly contoured support structure full of interconnected open voids; applying over an area of said support structure an injection port member having an extended conformable flat base and a centrally projecting tubular member interiorly integrally provided with a one-way valve member; applying over and in contact with said base and the remaining support structure and adjacent cable area a close-fitting conformable liquid-tight pressure-resistant covering, including a first wrapping of flexible stretchable non-porous adhesive tape and a second wrapping of flexible stretch-resistant fibrous adhesive tape, while providing vent openings for release of air from within said covering; forcing a liquid self-curing insulating resinous composition under pressure through said tubular valve member to fill all voids within said covering; and permitting the resinous composition to cure and solidify.

5. A cable splice structure in an insulated cable system, comprising: a splice area including interconnected bare conductor ends and adjacent insulated cable; a compact, smoothly contoured insulating support structure, full of interconnected open voids, surrounding the entire splice area; and a conformed close-fitting liquid-tight pressure-resistant flexible covering over and in contact with said support structure and the adjacent cable area, said covering being provided with a resin entry port.

6. The structure of claim 5 in which the resin entry port comprises a projecting tubular member having an extended flange-like base conformably pressed against the outer surface of said support structure by said close-fitting covering, said tubular member including an interior integral one-way entry valve.

7. In the protection of splice areas in insulated cable systems, the steps comprising: smoothly wrapping the splice with open-mesh flexible screen-like insulating sheet material in strip form to surround the entire splice area with a compact, smoothly contoured support structure full of interconnected open voids; and applying over said support structure and adjacent cable area a tightly-fitting, fully conformable, liquid-tight, pressure-resistant covering including a wrapping of flexible stretchable non-porous adhesive tape and a wrapping of flexible stretch-resistant fibrous adhesive tape, said covering having a resin entry port.

8. An insulated electrical conductor component including a splice or connection insulatively and protectively encapsulated within a smoothly contoured support structure of insulating open-mesh screen material contained within an outer insulating envelope of overlapped flexible strip material in closely conformed contact therewith and completely impregnated and filled with a cured solid resinous insulating composition.

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