Nov. 22, 1955 R. EWING ET AL 2,724,189

FIBRE CONDUIT

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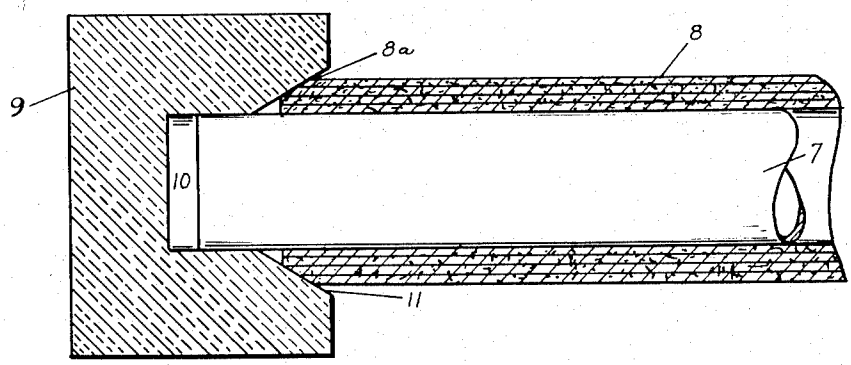


Fig. 1

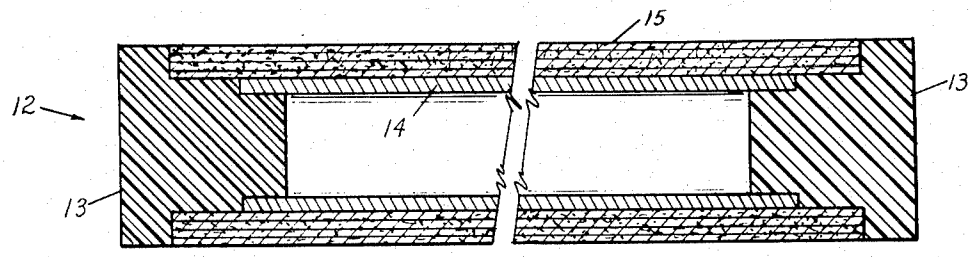


Fig. 2

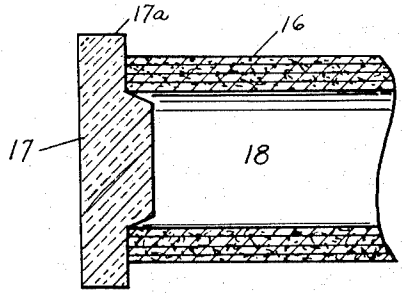


Fig. 3

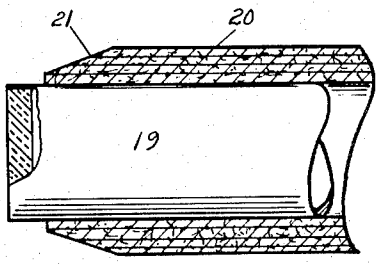


Fig. 4

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FIBRE CONDUIT

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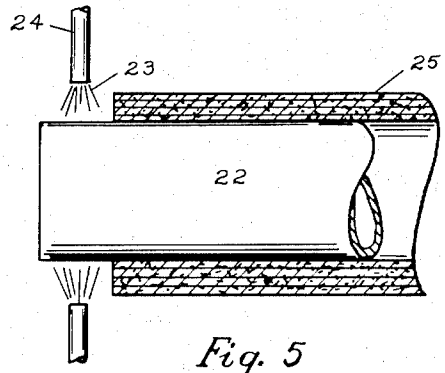


Fig. 5

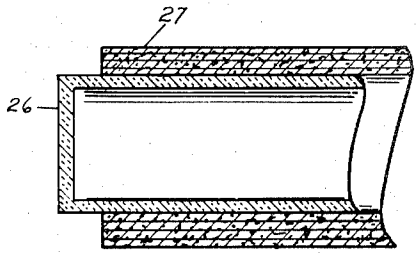


Fig. 6

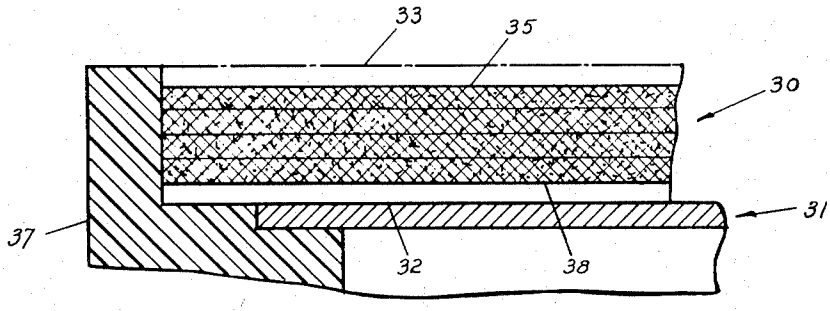


Fig. 7

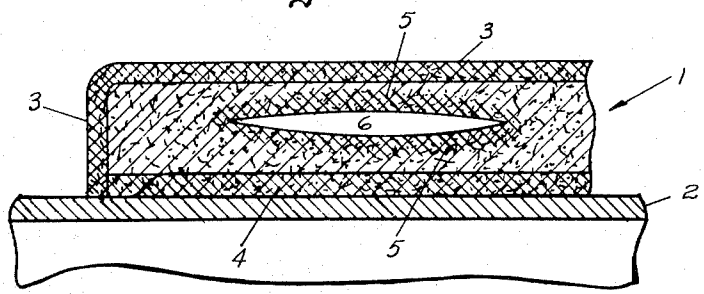


Fig. 8

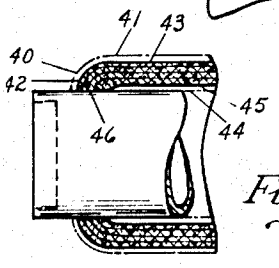


Fig. 9

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FIBRE CONDUIT

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Application October 11, 1951, Serial No. 250,926

6 Claims. (Cl. 34—7)

This invention relates to an improvement in the method of drying and producing fibre conduit which are formed of wound paper pulp or other fibrous material.

Fibre conduit impregnated with pitch has been found to be an excellent encasing means for electric cables because it can be imbedded in the ground or in concrete. The pitch prevents roots from penetrating it; its light weight makes it easy to transport and install and the cost is low. However, there has been one flaw in this otherwise satisfactory piping means. It is the problem of delamination, which is a splitting apart of layers within the conduit. This causes weakness in the conduit structure and often unevenness on the inner surface of the same. Delamination is a condition that is apt to grow worse. Being a weak spot, the weakness is increased when covered with wet concrete and during curing of the same to the extent that the layers of the conduit may fray and catch on the cables that are subsequently pulled through it. Each time a cable is replaced or new cable added and pulled through the conduit, the loose layers catch and rip farther until that section of conduit becomes full of obstruction and has to be replaced with the attendant expense and labor, as the breaking up and removal of concrete is not easily done.

It can readily be seen why so many efforts have been made to solve this problem of delamination. E. G. Hensler, in his patent entitled "Method of Making Paper Tubes," No. 2,532,494 and assigned to the assignee of this invention, thought that he had solved the problem by adding a narrow fibre strip at the end of the tube and then drying by directing warm air blasts at the end of the added fibre strip and through the mandrel. This method has not eliminated the problem of delamination. Others, also, have worked on the problem without much success.

It was not until our inventive ideas were used that this problem was finally solved.

A principal object of this invention is to provide a means for drying the fibre tube by withdrawing the moisture uniformly through the outer peripheral wall only.

Another object is to provide a means of eliminating heat transfer on the inside of the tube during drying.

Still another object is to provide a means of cooling the inner surface of the tube during drying.

A further object is to provide a means of drying fibrous material from one surface in such a manner that air pockets will not occur.

Also, an object is to provide a means whereby the end of the fibre tube will dry at the same rate as the interior section.

Another object of this invention is to provide a means of drying fibre tube whereby the shrinkage involved in the drying process takes place in such a manner that the fibre tube becomes a uniformly integrated solid tube.

Various methods of achieving these objectives are shown in the accompanying drawings in which:

Fig. 1 is a fragmentary horizontal sectional view of the fibre tube on a sleeve with an insulating block enveloping the end of the sleeve and the end of the fibre tube.

Fig. 2 is a fragmentary horizontal sectional view of the fibre tubing on a composite sleeve consisting of an insulating material forming the ends of the sleeve.

Fig. 3 is a fragmentary horizontal sectional view of the fibre tubing without a sleeve but with an insulating plug at the end.

Fig. 4 is a fragmentary horizontal sectional view of the fibre tube on a sleeve, the fibre tube having tapered ends.

Fig. 5 is a fragmentary horizontal sectional view with the fibre tubing on a sleeve with a cooling means applied to the sleeve.

Fig. 6 is a fragmentary horizontal sectional view of a fibre tubing wound around a sleeve that is made of insulating material.

Fig. 7 is an enlarged fragmentary horizontal sectional view of the fibre tubing dried by the method shown in Figs. 1 and 2.

Fig. 8 is an enlarged fragmentary horizontal sectional view of the fibre tubing showing a void created by unsuccessful drying.

Fig. 9 is a fragmentary horizontal sectional view of the fibre tubing of Figs. 5 and 6 showing their shape after drying.

Like numerals represent like parts in the following specification.

With this method of making fibre tubing the fibre pulp is wound on a sleeve which fits over a mandrel during the winding and when winding has been completed the sleeve with its layers of wound fibre tubing is removed from the mandrel for the drying process.

In Fig. 8, we show the problem that we are trying to overcome. A wet fibre tube **1** on a sleeve **2** is dried by the process of evaporating the moisture out of the fibre tube **1**. Each pound of water takes 1100 B. t. u.'s to evaporate it. This evaporation takes place at the fastest rate along the outer surface **3** because of its immediate contact with the air and proceeds inwardly. The next surface to dry is the inner surface **4** along the sleeve **2**. The sleeve is a conductor and transmits heat by convection and conduction to the inner surface of the fibre tube. Evaporation cannot take place on the inner surface because of the sleeve but the heat conducted by the sleeve **2** forces the moisture away from the sleeve outwardly until it escapes through the outer surface **3**. While evaporation is taking place, shrinkage is also taking place until the point is reached where there is no more moisture in a section of the fibre tubing and shrinkage ceases. That section is set and forms a porous unyielding crust through which the further evaporation of the wet inner section between the surfaces takes place. The evaporation of this inner section and subsequent shrinkage tends to form dry layers which bow toward both dry surfaces as shown at **5**. This shrinkage within the set outer crust creates voids **6** in the fibre tubing. These voids **6** are weak spots and cause delaminations, cracking and breaking. This, of course, is a serious danger that must be avoided.

Tests have shown that moisture can travel along the unbroken sheet considerably faster than it can travel from sheet to sheet where the points of fire contact are much fewer. The factors that control these relative rates of moisture removal apparently are the factors that govern the tendency to split. This theory corresponds with the known facts that higher drying temperatures and thicker tubes exhibited an increased tendency to split.

When the tubes are dried on sleeves the splits occur at the ends of the tubes, seldom extending more than six inches inward from the end and very rarely extending all the way to the other end of the tube. The use of sleeves has been a tremendous help, as the drying time without

sleeves takes as long as three to five days, with splits sometimes extending most of the tube length. The tubes on the sleeves are placed in drying rooms and air, heated to 145°, is brown through. This process takes about 18 hours.

We have found that by thermally insulating the sleeve ends or by thermally enclosing the sleeve ends and ends of the fibre tubes, splitting can be eliminated.

We show five methods of achieving this, and illustrate them more or less symbolically, especialy, the layers of fibrous pulp which may be considerably more in number.

In Fig. 1 we show a sleeve **7** surrounded by a fibre tubing **8** and an insulating block **9**. This insulating block **9** has an opening **10** and a diagonally shaped lip **11**. The end of the sleeve **7** is injected into the opening **10** of the insulating block **9** until the end **8***a* of the fibre tubing **8** is wedged against the diagonal lip **11**. In this manner, the insulating block **9** prevents the end of the tube from drying faster than the middle of the tube and also prevents heat from being conducted down the sleeve to the inner surface of the fibre tube.

A variation of the same principle is illustrated in Fig. 2 in which a sleeve **12** is composed of insulating ends **13** integral with the body section **14** which may be made of some conductive material such as aluminum. Fibre tubing **15** is wound around this sleeve **12**, and the insulating ends **13**, possibly made of some plastic material, prevent drying at the ends or from the inside to take place faster than in the rest of the tubing.

Fig. 3 illustrates a way of attaining uniform drying of a fibre tube **16** without a sleeve, by using insulating end plugs **17** at both ends that extend somewhat into the inner opening **18** of the fibre tube **16** and also extends like a cap across the end of the fibre tubes at **17***a*. This insulating plug aids in uniform drying because it prevents evaporation at the end of the fibre tube and reduces heat transfer to the inner surface of the fibre tube. This method is used on tubes of heavier wall thickness.

Another method of reducing splitting at the ends of the fibre tubing is shown in Fig. 4. Sleeve **19** has a fibre tube **20** wrapped around it. The fibre tube **20** has tapered ends **21**. This taper, by making the tube thinner near the end, helps to prevent splitting in the tube such as is illustrated in Fig. 8.

The methods illustrated in Figs. 3 and 4 are an improvement over present methods in the prevention of splitting and air pockets but are not as effective as the methods shown in Figs. 1 and 2.

In Fig. 5 another form is shown. Heat transfer along the mandrel is retarded by cooling the sleeve **22** with some cooling means **23** such as an air spray or an atomized water spray from a tube **24**. The cooling of the sleeve **22** reduces heat transfer along the sleeve and aids in forcing all evaporation to take place from the outer surface of the fibre tube **25**.

Fig. 6 illustrats a sleeve **26** made of some insulating material. This prevents heat transfer to the inner surface of the fibre tube **27**, thus directing all evaporation to take place off the outer surface.

The desired result of our method is shown in Figs. 7 and 9. Fig. 7 illustrates the shape taken by the fibre tubes of Figs. 1 and 2. A fragment of a fibre tube **30** is shown on a fragment of a mandrel **31**. As wet tubing it occupies the space from the circumference **32** of the sleeve **31** to the outer line **33**. As evaporation takes place along the outer edge **33**, shrinkage takes place. When all the moisture is evaporated out of a portion of the fibre, shrinkage ceases and that portion becomes hard and set. The line **35** within the original outer surface **33** of the tube **30** represents the new outer line after shrinkage.

The inner part of the fibre tube is still wet so evaporation must continue through the pores in the outer crust along the line **35**. Since heat does not travel along the sleeve because of insulating ends **37**, it is not conveyed or conducted to the inner surface. Any drying means such as air and heat must do its evaporating through the outer surface **35**. As this takes place, shrinkage continues but as it occurs from the outer edge the next section to dry is the section adjacent the outer crust thus as it shrinks it shrinks toward the hard outer ring. This continues until the entire tube is devoid of moisture and shrunk to its ultimate extent, each layer adhering to another outer pre-dried, pre-shrunk layer. This inside diameter **38** will then be greater than when the fibre was wound around the sleeve and the fibre tubing will be one strong porous piece without dangerous voids and delaminations. A satisfactory tube is the result.

Fig. 9 illustrates the shape taken by the fibre tubes of Figs. 5 and 6 when they dry. The sleeve is insulated but not the ends of the fibre tubes, consequently evaporation and subsequent shrinkage takes place off the end surface **40** as well as the side surface **41**. When the surfaces **40** and **41** are dry, they will have shrunk to the lines **42** and **43** and the inner surface of the tube will have shrunk from the outer diameter of the sleeve **44** to the larger I. D. **45**. Since the evaporation takes place toward the outer surfaces **40** and **41**, the ends do not shrink away from the sleeve but instead dry to the shape illustrated with a smaller I. D. on the inner side of the end at **46**. This smaller I. D. **46** is removed during the machining process so that the entire inner surface becomes a uniformly larger diameter than the outer diameter of the mandrel.

We claim:

1. A method of drying a moist fibre conduit formed of a plurality of wound paper pulp layers comprising the steps of providing an insulating barrier means adjacent to at least one end thereof, applying a fluid drying medium solely to the exterior surface of said conduit, and continuing the drying process to remove moisture therefrom in a direction towards the outer surface only and until the conduit is thoroughly dry and set.

2. A method of drying a moist fibre conduit formed of a plurality of wound paper pulp layers on a sleeve comprising the steps of sealing an end of said sleeve and providing an insulating barrier means immediately contiguous the adjacent end of the conduit, applying a drying fluid of low moisture content solely to the exterior surface of said conduit, and continuing the drying process to remove moisture therefrom in a direction towards the outer surface only and until the conduit is thoroughly dry and set.

3. A method of drying a moist fibre conduit formed of a plurality of wound paper pulp layers on a sleeve comprising the steps of providing an insulating barrier plug for an end of said eleeve and adjacent to the corresponding end of said conduit, applying a heated fluid of low moisture content solely to the exterior surface of said conduit, and continuing the drying process to remove moisture therefrom in a direction towards the outer surface only and until the conduit is thoroughly dry and set.

4. A method of drying a moist tubular fibrous article on a sleeve projecting axially therefrom, comprising the steps of directing a heat insulating and cooling fluid towards the extending portion of said sleeve, applying a fluid drying medium solely to the exterior surface of said tubular article, and continuing the drying process to remove moisture therefrom in a direction towards the outer surface only and until the article is thoroughly dry and set.

5. A method of drying a moist fiber conduit formed of a plurality of wound paper pulp layers which has previously been formed on a thermally insulating sleeve, and comprising the steps of providing an insulating barrier means immediately contiguous at least one end of the sleeve and adjacent end of the conduit, applying a heated fluid drying agent solely to the exterior surface of said conduit, and continuing the drying process to remove moisture therefrom in a direction towards the outer surface only and until the conduit is thoroughly dry and set.

6. A method of drying a moist fiber conduit formed of

a plurality of wound paper pulp layers having tapered ends comprising the steps of providing an insulating barrier means immediately contiguous the tapered ends of the conduit, applying a heated fluid drying agent solely to the exterior surface of said conduit, and continuing the drying process to remove moisture therefrom in a direction towards the outer surface only and until the conduit is thoroughly dry and set.

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