

UNITED STATES PATENT OFFICE

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FIBROUS CONDUIT AND METHOD AND
COMPOSITION FOR SAMERichard G. Coker and Auburn Woods, Jr., Harts-
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pany, a corporation of South CarolinaNo Drawing. Application July 28, 1943,
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This invention relates to fibrous tubes and more particularly to multi-ply, wound, water resistant, paper tubes that are suitable for use as conduits above or below ground. Such conduits may be employed for housing electric wires or cable and may be used in lieu of the usual heavier and more expensive metal pipe, tile or wood conduits. Also, they may be utilized for conducting fluids such as water. Commercial adaptations of the conduit for fluids include uses as water pipe, sewage drainage tile, gutters and down spouts.

Attempts have been made heretofore to produce a fibrous conduit which would answer the above mentioned purposes and serve as a less expensive substitute for metal pipe, especially in times of war when metal pipe is needed for other essential uses. Such fibrous conduits have been made usually from pulp or paper fibers pressed so as to form a homogeneous type of tube, which is later impregnated to render it water resistant. The method of manufacture of this homogeneous tube involves picking up or "couching-off" a wet paper web from a paper machine, onto a rotating mandrel, followed by compressing and drying of the thus formed tube on the mandrel. Such a procedure is slow and painstaking and the length of the tube so formed is definitely limited to the width of the paper machine or wet paper web. The drying and pressing operations are also relatively expensive manufacturing procedures.

To avoid the limitations and difficulties of manufacture of the above described homogeneous type of compressed paper tube, it has been desired to utilize a wound paper tube; that is, a tube formed from a plurality of paper plies wound convolutely or spirally. The wound tube is far simpler and less expensive to manufacture but it has heretofore proven commercially unsatisfactory since it was subject to water penetration and would delaminate when immersed in water. The principal problem has been to provide a water resistant adhesive that would not only prevent delamination of the paper plies but would allow the penetration of the impregnating material necessary to waterproof and strengthen and otherwise make a satisfactory tube.

The adhesives heretofore used either would not stand the high temperatures required for

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best impregnation of the tube with the waterproofing material, or would not cooperate or coact as defined above with the impregnating material, such as to obtain thorough impregnation and optimum water resistance. In addition to these requirements the adhesive must be workable on the high speed, large production, tube winding machines.

Various adhesives have been available heretofore that would answer one or two of the above mentioned requirements but they were deficient in at least one of the essential characteristics and were therefore not satisfactory. Likewise, a number of the waterproofing, impregnating compounds were found unsuitable either from the standpoint of water repellency, or because of incompatibility with the bonding adhesive.

Our researches have provided the solution to these difficult commercial problems, and in accordance with the present invention, we have been able to avoid the use of the expensive pressed tube and have overcome the previous deficiencies of the wound, multi-ply paper tube. This very valuable commercial result has been obtained primarily by bonding the paper plies, during winding of the paper tube, with a certain thermosetting resin composition, followed by a subsequent impregnation of the wound and bonded tube with a water resistant thermoplastic material; such material and the bonding resin having the important characteristics and coactive functions described above. We have found that this combination of thermosetting bond between the plies and subsequent thermoplastic impregnation at high temperatures makes the wound multi-ply paper tube an economical and efficient conduit.

For the purpose of bonding the several paper plies in the tube of our invention, we have found it advantageous to use a thermosetting resin of the type of urea formaldehyde resin or phenol formaldehyde resin. However, any other thermosetting, water resistant, bonding agent which has the essential characteristics described above may be used. Moreover, a thermoplastic resin that will resist the temperatures of the subsequent impregnation and will coact with the latter during the manufacture of the conduit might be used in place of the thermosetting resin.

In some cases the bonding agent for the paper

plies may consist solely of the above mentioned thermosetting resin. However, in usual commercial practice, we have found it advantageous to combine with the thermosetting resin a substance that will give added tackiness to the bonding agent. The purpose of this is to accelerate the gluing or bonding action during the manufacture of the tube, especially during the initial winding of the paper plies to form the tube. Practical examples of carbohydrate substances to be combined with the thermosetting resin for this purpose are dextrine and starch. Other suitable adhesives or glues may also be used.

For effecting the necessary impregnation and waterproofing of the bonded paper plies, the wound tubes are treated with a thermoplastic, water resistant material or composition. This treatment is advantageously carried out under sufficiently high temperature conditions to render the impregnating material fluid and highly penetrative of the paper tubes. The impregnating material may be of the asphalt or coal tar pitch or similar bituminous types, some of which may require solvents, although we prefer for maximum impregnation to use a solid, heat liquefiable, material without solvent. We have found it desirable to employ a coal tar pitch that is dry and hard at normal temperatures but will become penetrative, without addition of solvent, when heated to a temperature of several hundred degrees. Its penetration is not prevented by the resin-adhesive composition; it thoroughly permeates and impregnates the paper plies, and the high temperature of this pitch during impregnation effects final hardening of the thermosetting resin.

This impregnation treatment of the wound paper tubes may be effected at atmospheric pressures but the rate and degree of impregnation may be substantially improved by applying vacuum or superatmospheric pressures or a combination of both. One desirable procedure is to enclose the wound, bonded tubes in a chamber and evacuate the space so as to remove air from the tubes, and then introduce a quantity of hot coal tar pitch, at normal or superatmospheric pressure, which will fill the voids or interstices normally present in the paper tubes. By proper control, the pitch may also form a surface coating on the tubes to increase water resistance.

Another commercially practical procedure for impregnating the tubes is to immerse the tubes first in a bath of the heated pitch at atmospheric pressure and then subject the same to a vacuum, and subsequently break the vacuum and apply a positive pressure to force additional amounts of the pitch into the paper tube structure. By one or more of these procedures sufficient amount of the heated impregnating material can be introduced in the tube to increase the original weight of the tube by 100% to 150%.

While it is not entirely essential, we have found it of advantage to dry the wound tubes following the winding operation and before subjecting them to the impregnating treatment just above described. One advantage of this preliminary drying is to liberate as vapor most of the water content of the paper and of the bonding agent, such as the aqueous composition of thermosetting resin and dextrine, and thereby avoid excess foaming or steaming that might otherwise be caused by boiling off this water under the high temperature conditions of the impregnating treatment. The drying operation may be carried out at room temperature or at any suitable

elevated temperature such as 100° F. or higher, which temperature will also effect incipient hardening or setting of the thermosetting resin.

The final setting of the thermosetting resin may be and is advantageously effected in commercial practice simultaneously with the impregnating treatment, in which the impregnating thermoplastic material is heated sufficiently to render it fluid and highly penetrative of the paper tubes. For this purpose heating of the material to a temperature of about 300° F. will also serve to effect full hardening or setting of the resin bonding agent previously applied between the paper plies. No separate subsequent heating of the impregnated tubes is required and the setting of the resin and impregnating of the paper plies is accomplished concomitantly in the impregnating bath.

The tubes used in our invention may be either convolutely or spirally wound, and in either case the paper plies are bonded with the thermosetting resin and impregnated with the waterproofing material as above described. In commercial practice it is usually advantageous to employ spirally wound tubes since they can be made more rapidly and on automatic winding machinery and are unlimited in length of tube. In other words, the spirally wound tube may be manufactured in a continuous manner and may be cut in any long length desired, such as the length of trucks or freight cars on which the tubes may be shipped. An automatic tube winding machine suitable for this purpose is manufactured by Samuel M. Langston Company, of Camden, New Jersey.

In accordance with our invention, a commercially advantageous but non-limiting example of the manufacture of a spiral-wound, resin bonded, pitch impregnated tube suitable for conduit, is as follows:

The several paper plies, for example ten plies of 10 point chip board or other suitable type of penetrative paper slit into widths of about 4 to 5 inches, are supplied from reels or bobbins of this paper. The plies are drawn forward simultaneously but in spread-out fashion, through a bath of the bonding composition which comprises the following:

	Pounds
Urea-formaldehyde resin (70% solids) -----	28
Dextrine—High solubility-----	70
Dextrine—Viscous, low solubility-----	21
Water -----	196

Upon emerging from this bath of bonding paste or composition, the excess material is removed from each paper ply by suitably arranged scraper-knives, and the thus coated plies are then converged in slightly overlapping relationship and fed to a mandrel. The plies are wrapped around this mandrel in spiral formation and in tight overlapping arrangement so as to form a cylindrical, spirally wound tube. This tube is continuously rotated and advanced from the finishing end of the mandrel where the advancing hollow tube is cut into desired lengths.

To prevent sticking of the adhesive coated paper plies to the mandrel at the inner surface of the paper tube, and likewise to avoid a sticky or tacky surface on the outside of the paper tube, the bonding adhesive may be omitted from the innermost and outermost paper plies which are used in forming the tube.

In the above bonding composition, the dextrine component imparts desired tackiness, and at the same time does not hinder later impregnation by

the waterproofing pitch. The added tackiness permits more rapid bonding of the paper plies while they are being wound around the mandrel on the automatic winding machine. Accordingly, the machine may operate at a relatively rapid rate such as 50 to 100 feet per minute of wound tubing. The dextrine or starch or similar material, however, will not alone form the permanent and firm bond that is required for the conduit tubes of our invention, especially where such tubes are to be used for water conduits or are exposed directly to the weather. We have found that in the absence of the urea formaldehyde or similar thermosetting resin that tubes bonded in this manner will delaminate upon immersion in water and will not possess the high resistance to water that we obtain by a combination of such a resin and a carbohydrate type of adhesive as discussed above.

After the tubes are wound and cut into the desired length they are stored in a hot room or oven, maintained at a temperature of about 150° F. to 175° F., for a sufficient length of time, usually several hours, to remove the excess moisture, as described above. Any incipient setting of the resin caused by this drying operation does not prevent subsequent penetration and impregnation by the hot pitch.

The next stage in the operation of preparing the tube for conduit purposes, is to immerse the air dried tubes in a chamber containing coal tar pitch which is heated to about 300° F. An advantageous commercially available product of this type is "Fiber Pitch" manufactured by the Barrett Company and which is identifiable as follows: It is a coal tar pitch made by a vacuum distillation process such as disclosed in Patent 1,759,816 issued May 20, 1930. It has a melting point of about 140° F. to 180° F., a free carbon content of about 5% to 9% and a specific gravity of 1.242. The tubes are preferably arranged in vertical, parallel position in the chamber and may be so held by means of a removable, partitioned basket or any other conventional means.

The tubes are allowed to soak in the hot Fiber Pitch for about thirty minutes' time at atmospheric pressure. The impregnating chamber is then closed tightly and the contents of the chamber, including the tubes and the hot pitch in which they are immersed, are subjected to a vacuum of about 28 inches mercury, for about thirty minutes. A positive pressure of about 20 lbs. per square inch is then applied for about thirty minutes, which forces more pitch into the paper tubes. The above conditions have been found to be satisfactory for the commercial production of a paper tube conduit of about one fourth inch wall thickness.

When using a tube of a heavier wall construction such as for example a one inch wall thickness, the temperature of the pitch is increased to about 310° F. to 315° F. and the soaking and pressure impregnating operations are increased in time to about 45 minutes each.

After the impregnating operation above described has been completed, the tubes are elevated from the chamber, in the basket or crate, and are permitted to drain in suspended position until the excess pitch has run off of the tubes. Where it is desired to leave an excess or substantial surface coating of the pitch on the tubes, the above operation is modified to the extent that the temperature is lowered slightly to make the pitch more viscous and the tubes are withdrawn from the chamber slowly. This permits the excess

pitch on the surface of the tubes to cool and harden over the entire tube surface. Or the tubes may be cooled and redipped to accomplish the same result. After the impregnated tubes have reached normal temperatures, they are then ready for handling or shipment or for direct use.

For joining the finished impregnated tubes together in end to end relationship to provide a long conduit, any suitable coupling means may be used. For example the tubes may be ground to provide complementary plug and socket elements at the ends of the tubes so that they will interfit in a fluid-tight manner, using an encircling outer band or sleeve over the joint if necessary.

It will be understood by those skilled in this art that various modifications and changes may be made in the foregoing example without departing from the scope of our invention. The above formula for the resinous impregnating composition may be changed considerably and at least some of the benefits of this invention still obtained. For example, the urea formaldehyde component of the composition may be reduced somewhat or may be substantially increased in amount up to say twice the amount used in the above composition, or 56 lbs. Generally speaking, the percentage of the urea formaldehyde resin in the adhesive composition may vary considerably, such as for example, 10% to 50%, with an advantageous average percentage of about 20% based on dry weight.

Where it is necessary or desirable, a single dextrine or starch may be used in place of the two dextrines given in the above composition. The practical advantage of using these two dextrines is that the high solubility dextrine makes it possible to dissolve or disperse a large amount of the material in the water content of the composition; and the lower solubility, more viscous dextrine gives the composition a paste-like characteristic which is helpful in the application of the resinous adhesive to the paper plies.

Instead of the urea formaldehyde resin used in the above composition, a phenol formaldehyde resin of the Bakelite type, or a melamine resin, or a combination of such resins may be used.

These and various other modifications of the procedures and compositions described hereinabove come within the purview of the appended claims.

We claim:

1. A water resistant, fibrous tube suitable for use as a conduit comprising a tube formed from a plurality of originally separate fibrous plies bonded together with a water resistant, resinous, adhesive material containing about 10% to 50% thermosetting resin and the remainder a tacky carbohydrate, and the composite tube impregnated throughout with a water resistant, thermoplastic material, which permeates said resinous adhesive bonding material.

2. A fibrous conduit comprising a paper tube formed from a plurality of paper plies wound in superimposed relationship, said plies being bonded together with a water resistant, thermosetting, resinous composition containing approximately 20% thermosetting resin and the remainder a tacky carbohydrate and said wound tube being thoroughly impregnated with a thermoplastic water resistant composition, which permeates said resinous bonding composition.

3. A water resistant, wound, fibrous tube suitable for use as a conduit comprising a tube

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formed from a plurality of originally separate fibrous plies bonded together with a water resistant, resinous, adhesive material that will withstand a temperature of at least 300° F., and the composite tube impregnated throughout with a water resistant, thermoplastic material, said resinous material being impregnated with said thermoplastic material and coating therewith to resist water penetration and delamination of the tube when subjected to water, said resinous adhesive material containing a tacky carbohydrate which effects quick temporary bonding of the fibrous plies, and a thermosetting resin which effects final permanent bonding of the fibrous plies and prevents delamination thereof.

4. A fibrous conduit comprising a wound paper tube formed from a plurality of paper plies wound in superimposed relationship, said plies being bonded together with a water resistant, thermosetting, resinous composition and said wound tube being thoroughly impregnated with a thermoplastic water resistant composition, said resinous material being impregnated with said thermoplastic material and co-acting therewith to resist water penetration and delamination of the tube when subjected to water, said resinous composition containing approximately 10% to 50% thermosetting resin and the remainder a tacky carbohydrate, said carbohydrate effecting quick temporary bonding of the paper plies and said thermosetting resin effecting permanent bonding of the plies and preventing delamination thereof.

5. A wound paper tube comprising a plurality of spirally wound paper plies, a resinous, adhesive composition bonding said plies together to form a cylindrical tube construction, and a thermoplastic impregnant substantially permeating said plies and the interstices thereof, said adhesive composition being permeated by said thermoplastic impregnant and co-acting therewith to make the paper tube resistant to water penetration and delamination of the paper plies, said adhesive composition containing a tacky carbohydrate which provides quick temporary bonding of the paper plies, and a thermosetting resin which provides permanent bonding of the paper plies and prevents delamination thereof, said thermoplastic impregnant providing resistance to water penetration into the paper tube.

6. A water resistant, spirally wound paper tube comprising a plurality of overlapping paper plies bonded together with an adhesive material containing a thermosetting resin and a tacky carbohydrate, and said plies and adhesive being impregnated with coal tar pitch, said tacky carbohydrate serving to bond the overlapping paper plies at their points of contact, said thermosetting resin serving to effect a permanent strong bond between said overlapping paper plies, and said cold tar pitch impregnating the wound paper tube throughout and serving to resist water absorption when the tube is exposed to water.

7. A method of forming a paper tube suitable for use as a conduit comprising winding a paper tube from a plurality of paper plies, binding said plies together during the winding thereof with a water resistant composition containing thermosetting resin, and immersing said thus wound tubes in a thermoplastic material heated to a temperature sufficient to effect thorough impregnation of the tube with said thermoplastic material and the heated thermoplastic material effecting heating of the thermosetting resin and final setting and hardening of said resin.

8. A method of producing a paper tube suitable

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for use as a conduit comprising spiral-winding a plurality of paper plies and bonding said plies during the winding thereof with an adhesive composition containing a thermosetting resin and a carbohydrate adhesive, air drying the thus wound tubes, and impregnating the air dried tubes with heated thermoplastic material at a temperature sufficiently high to effect thorough impregnation and setting of the thermosetting resin, said adhesive maintaining the bond between the paper plies during the impregnating treatment and co-acting with the thermoplastic material to provide a water tight paper tube construction.

9. A method of producing a paper tube suitable for use as a conduit comprising winding a plurality of paper plies and bonding said plies during the winding thereof with an adhesive composition containing a thermosetting resin, heating said tubes at a temperature of at least 100° F. to effect substantial removal of the water content and thereby prevent foaming and steaming in the subsequent treatments and simultaneously effecting by said heating a preliminary setting of said thermosetting resin, and then immersing said tubes in a bituminous impregnating composition heated to a temperature of at least 300° F. to effect impregnation of the tubes with the heated thermoplastic material and to effect complete setting of said thermosetting resin, said thermosetting resin withstanding said impregnating temperature and co-acting with said thermoplastic material to render the tube resistant to water penetration and delamination.

10. A method of producing a fibrous conduit suitable for conducting fluids comprising spirally winding a plurality of paper plies to form a spiral-wound tube and bonding said plies during the winding thereof with an adhesive composition containing a thermosetting resin and a carbohydrate adhesive, drying said wound tubes at a temperature of about 150° to 175° F.; immersing said dried tubes in a heated bath of coal tar pitch at a temperature of about 300° F. to 315° F. to cause thorough impregnating of the wound tubes with said heated pitch, and subsequently applying pressure to said pitch and tubes to force additional amounts of the pitch into the tubes, and finally removing the tubes from said heated pitch, said adhesive composition and pitch being intimately associated between the paper plies and co-acting to produce therebetween a water resistant bond, which prevents delamination of the plies.

11. A wound paper tube comprising a plurality of wound paper plies, a resinous, adhesive composition bonding said plies together to form a cylindrical tube construction, and a thermoplastic impregnant substantially permeating said plies and the interstices thereof, said adhesive composition being permeated by said thermoplastic impregnant and co-acting therewith to make the paper tube resistant to water penetration and delamination of the paper plies, said adhesive composition containing a tacky carbohydrate which provides quick temporary bonding of the paper plies, and a thermosetting resin which provides permanent bonding of the paper plies and prevents delamination thereof, said thermoplastic impregnant providing resistance to water penetration into the paper tube.

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