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2,536,243

HOLLOW ARTICLE

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FIG. 1

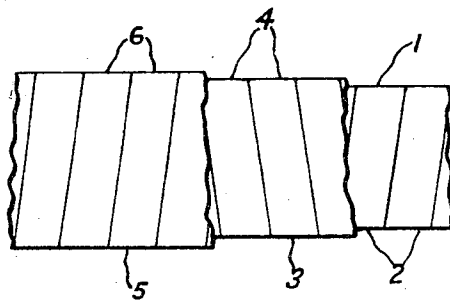


FIG. 2

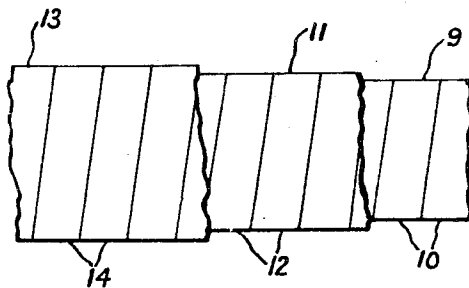


FIG. 3

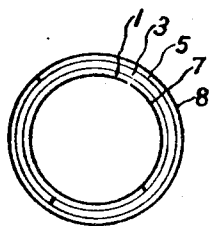
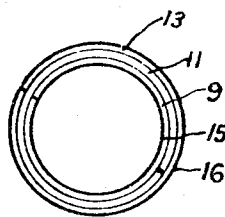


FIG. 4



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HOLLOW ARTICLE

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4 Claims. (Cl. 138—73)

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This invention relates to hollow articles and in particular to light-weight tubes and pipes.

For some purposes, for instances in the construction of aircraft, there is a demand for a strong but light rigid tube of substantial bore, for instance several inches in diameter, which can be simply and economically produced from readily available materials. The present invention enables this demand to be met.

The tubes or pipes of the invention comprise a plurality of concentric similar shells, each formed of textile fabric heavily coated with film-forming thermoplastic material, the lines of junction between the fabric edges in successive shells being out of register with one another, and successive shells being bonded together by the thermoplastic material. Preferably each shell is in the form of a helical strip of textile fabric, heavily coated with film-forming thermoplastic material and with adjacent turns abutting, the lines of such abutment in successive shells being non-coincident and the shells being bonded together by means of said thermoplastic material.

The helices of successive shells may be of the same or of opposite hand. When they are of the same hand and of substantially the same pitch and formed of strips of the same width (which is a convenient arrangement) the line of abutment of successive turns in one shell must be displaced axially with respect to that of the next shell, and may be so displaced with respect to that of every other shell. When successive helices are of opposite hand and of the same pitch and width of strip, the line of abutment of successive turns in one shell may be coincident with that in the next shell but one, but in that case the tube will be weaker at the intersection of the lines of abutment of successive turns in successive shells and care must be taken to avoid apertures at these weak points. It is better, therefore, when successive helices are of opposite hand and of the same pitch and width of strip for the line of abutment of successive turns in one shell to be displaced axially with respect to that of the next shell but one.

Satisfactory products can be obtained using as the fabric a plain woven cotton fabric of open mesh. Other fabrics can, however, be employed. Thus it is of advantage when a product of high strength/weight ratio is required to employ a fabric made of or containing high tenacity yarns of regenerated cellulose, for example yarns having a tenacity of 2 gms. per denier or more, for example 4 or 5 to 6 gms. per denier such as may be obtained by completely saponifying yarns of cellulose acetate which have been highly stretched in the presence of steam, hot water, or an organic

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swelling agent. The fabrics used may contain such yarns in either warp or weft or both. Moreover, fabrics containing cotton yarns in admixture with high tenacity regenerated cellulose yarns may be used. In order to facilitate adhesion between the coating and the fabric, the fabric may also contain yarns of an organic derivative of cellulose or other artificial organic film-forming material which is compatible with the film-forming material with which the fabric is to be coated. Thus, for instance, a fabric which is to be coated with cellulose acetate or cellulose acetate-propionate may contain in admixture with yarns of a non-thermoplastic textile material such as cotton, yarns of cellulose acetate, cellulose acetate-propionate, cellulose acetate-butyrate or other lower fatty acid ester of cellulose. Strips of fabric cut on the bias may be used with advantage when forming bent tubes or tubes in which successive turns of fabric overlap instead of abutting. Although woven fabrics are preferably employed, the use of fabrics of other construction, for instance knitted or netted fabrics is not excluded.

Various methods are available for coating the fabric. Thus, for example, spreading methods may be employed; the fabric may be drawn through a bath containing a solution of film-forming material in a volatile solvent; or a layer of the film-forming material may be pressed on to each side of the fabric by hot rolls, the conditions being such as to ensure thorough impregnation of the fabric. Under suitable conditions of heat and pressure pre-formed films of the film-forming material can be bonded to the fabric by this last mentioned method. It is preferable, however, to employ instead of a pre-formed film a sheet of composition of the consistency of dough formed by mixing the film-forming material with a plasticiser or plasticisers on heated malaxating rolls.

The coating may contain 40 or 50% or even more based on the weight of the film-forming material of a plasticiser or mixture of plasticisers, but in general it is desirable to avoid the use of higher proportions of plasticiser than are necessary to avoid brittleness in the coating. Among plasticisers that can be employed with cellulose acetate, cellulose acetate-stearate or cellulose acetate-propionate as the coating material are triacetin, triethyl citrate, diethyl tartrate, dimethyl phthalate, diethyl-phthalate, dimethoxyethyl-phthalate, methylmethoxy-ethyl-phthalate, methyl-phthalyl-ethyl-glycolate, ethyl-phthalyl-ethyl-glycolate and tri-(monochloroethyl)-phosphate. Esters of phosphorus which have a softening effect on cellulose acetate with-

out being solvent plasticisers, for example tricresyl phosphate, and triphenyl phosphate may also be present, preferably in admixture with a greater proportion of solvent plasticiser. The plasticiser or plasticisers employed should preferably be of very high boiling point.

The accompanying diagrammatic drawings show by way of example tubes of two different constructions, in accordance with the invention.

In the drawings:

Fig. 1 is an elevation of part of a tube comprising three successive shells, each in the form of a helical strip of heavily doped fabric, the helices of the first and third shells being of the same hand and that of the second shell of opposite hand.

Fig. 2 is an elevation of part of a tube similar to that of Fig. 1 but in which all three helices are of the same hand.

Fig. 3 is an end view of the tube of Fig. 1.

Fig. 4 is an end view of the tube of Fig. 2.

Referring to Figs. 1 and 3, the inner shell 1 is formed by winding on a mandrel (not shown) a strip of textile fabric so that successive turns 2, 2 abut. The second shell 3 is formed by winding a similar strip, successive, abutting, turns of which are shown at 4, 4, upon the shell 1 but in the opposite direction, so that the helix constituting this shell 3 is of opposite hand to that of shell 1. The third or outer shell 5 is formed by winding a similar strip upon the shell 3 in the same direction as the first strip, again with the turns 6, 6 abutting. This strip however is started about half the width of the strip along the axis from the start of the first strip so that the line of abutment of the turns 6, 6 of the outer shell is displaced axially from that of the turns 2, 2 of the inner shell and no turn of the outer shell coincides with one of the inner shell. All three helices are of the same pitch. The tube is provided with an internal continuous coating of thermoplastic film-forming material 7 and an external coating 8 of the same material (not shown in Fig. 1).

Referring now to Figs. 2 and 4, the inner shell 9 with abutting turns 10, 10 is of the same construction as the inner shell 1 of Figs. 1 and 3; the second shell 11 of abutting turns 12, 12 is wound on the shell 9 in the same direction but starting about half the width of the strip along the axis from the start of the shell 9; the outer shell 13 of abutting turns 14, 14 is wound upon the shell 11 in the same direction as that shell, and with the same start as the shell 9 so that each of the turns 14, 14 of the outer shell registers with one of the turns 10, 10 of the shell. All these helices are of the same pitch. The tube is provided with an internal continuous coating of thermoplastic film-forming material 15 and an external coating 16 of the same material.

The tubes shown may be about 3 inches in diameter and about 0.09 inch thick. A suitable width of fabric for the production of such tubes is about 1 to 2 inches. The fabric used may be a plain woven cotton fabric such as a cheese cloth, of weight about 1.5 ounces per square yard; or a plain woven cotton bandage fabric, for example of weight about 1 ounce per square yard, may be used; or the fabric may be of similar construction to the cotton fabrics specified but composed of high tenacity regenerated cellulose yarn; or they may contain, in the warp or weft, in addition to the yarns of cotton or regenerated cellulose, yarns of the cellulose derivative present in the dope with which they are to be coated.

A suitable cellulose acetate dope for coating the fabric is as follows, the parts being by weight:

- 430 parts cellulose acetate
- 17 parts dimethyl phthalate
- 110 parts triacetin
- 480 parts acetone
- 240 parts benzene
- 240 parts industrial alcohol

The fabric is coated with this dope until after drying its weight is about 20 ounces per square yard.

If a more highly water-resistant product is required, the cellulose acetate may be replaced by cellulose acetate-butyrate, or the fabric may be given an initial coating, up to a weight of about 6 ounces per yard, with a dope of the following composition:

- 30 parts of cellulose acetate
- 10 parts of diphenylol propane-formaldehyde synthetic resin
- 11 parts of dimethyl phthalate
- 4 parts of triphenyl phosphate
- 80 parts of acetone
- 35 parts of industrial alcohol
- 45 parts of benzene

The fabric coated with this composition is then brought up to a weight when dry of about 20 ounces per square yard with the dope described above.

An ethyl cellulose dope which can be used in place of either of the cellulose acetate dopes specified above is:

- 45 parts of ethyl cellulose
- 34 parts of castor oil
- 35 parts of a petroleum fraction of boiling point 75-95° C.
- 24 parts of acetone
- 30 parts of industrial alcohol
- 4 parts of chrome yellow
- 25 parts of titanium oxide

This composition gives products of higher water-resistance than the cellulose acetate dope. Another composition giving high water resistance is:

- 12 parts of cellulose acetate-stearate
- 13 parts of acetone
- 35 parts of ethyl acetate
- 11 parts of ethyl lactate
- 12 parts of benzene
- 12 parts of xylene
- 4.3 parts of red oxide

Each of the two last mentioned compositions may be applied in the same amount as the first composition. The application can be effected by spreading, after which the fabric strips are dried until the bulk of the volatile solvent is removed, and are preferably used while still tacky in building up the tubes. In this operation the first helix (1 of Figs. 1 and 3, or 9 of Figs. 2 and 4) is preferably formed by winding the coated fabric strip on a steel mandrel provided with a surface layer, e. g. of gelatin or polyvinyl alcohol, to which the cellulose derivative base of the dope does not adhere. The second helix (3 of Figs. 1 and 3 and 11 of Figs. 2 and 4) is then formed on the first, and the third helix (5 of Figs. 1 and 3 and 13 of Figs. 2 and 4) is formed on the second, as described above. In forming the helices either the mandrel or the source of supply of the coated fabric strip may be traversed. In forming the second and successive helices, each turn as it is

being formed may be bonded to the surface of the preceding helix by pressure exerted by a resiliently mounted heated roll. With the cellulose derivatives specified above temperatures of about 150-160° C. are generally suitable. The hot roll may be employed to drive the mandrel. The tubes may be provided with internal coatings (7 of Fig. 3 and 15 of Fig. 4) and external coatings (8 of Fig. 3 and 16 of Fig. 4) of the same dope as is used in impregnating the fabric, or of a less concentrated dope based on the same cellulose derivatives, may be applied, for example, by brushing or spraying.

The tubes may be made in short lengths as described above or by a continuous process in which the tube is continuously drawn off from the mandrel as it is formed. The welding together of the various layers of fabric to ensure satisfactory bonding at all points can, by the choice of suitable material for the coating, be accomplished by the use of heat and pressure alone. The application between the winding of successive layers of a composition adapted to facilitate the bonding together of the layers, however, enables lower temperatures to be used, e. g. 50-60° C. in the case of cellulose acetate. After completion of the winding, the tubes may be subjected to pressure applied over their whole exterior surface, for instance by compression in a mould or by extruding a sheath of soft metal such as lead round the tube while it is still on the mandrel. This metal sheathing may be applied as a step in the continuous production of tubes, the metal sheath being removed at a later stage. When the tubes after the completion of the winding contain residual volatile solvent this may be removed by evaporation in a warm atmosphere. The tubes may be provided with means for attachment to other tubes; thus, for instance, by the use of an appropriately shaped mandrel, tubes can be formed with a spigot at one end and a socket at the other. The tubes may, if desired, be given a metallic finish, for instance by spraying methods.

Other artificial organic thermoplastic film-forming materials than those specified above can be employed in forming the coated fabric and the internal and external coatings of the tubes. Among these are other organic derivatives of cellulose, for instance cellulose-propionate, cellulose-butyrate, cellulose-acetate-propionate, cellulose-acetate-nitrate, propyl-cellulose, benzyl-cellulose, ethyl-hexyl-cellulose and ethyl cellulose acetate. Cellulose esters containing the acid radicals of acetic acid and a higher fatty acid are particularly useful. Polymethyl methacrylate, polystyrene, polyvinyl chloride-acetate and other polymerised unsaturated film-forming materials may also be employed.

The invention is not limited to the provision of tubes having a bore of several inches. Smaller or larger bored tubes may be made according to the invention. The tubes may be of various shapes, for example round or square in section and straight or curved. According to a modification of the invention tubes are formed by methods similar to those described above except that sheets of coated fabric wide enough to give the desired length of tube without helical winding are employed.

Having described our invention what we desire to secure by Letters Patent is:

1. A light, rigid tube which comprises a plurality of concentric similar shells each in the form of a helix with adjacent turns abutting, said helix being formed from a strip of non-thermo-

plastic textile fabric provided with a coating of water-insoluble film-forming thermoplastic material having as its principal constituent a cellulose derivative selected from the group consisting of ethers of cellulose and carboxylic acid esters of cellulose, said coating being many times the weight of the uncoated fabric, the lines of junction between the fabric edges in successive shells being out of register with one another and successive shells being bonded together by the thermoplastic material.

2. A light, rigid tube which comprises a plurality of concentric similar shells each in the form of a helix with adjacent turns abutting, said helix being formed from a strip of non-thermoplastic textile fabric provided with a coating of film-forming thermoplastic material having as its principal constituent cellulose acetate, said coating being many times the weight of the uncoated fabric, the lines of junction between the fabric edges in successive shells being out of register with one another and successive shells being bonded together by the thermoplastic material.

3. A light, rigid tube which comprises a plurality of concentric similar shells each in the form of a helix with adjacent turns abutting, said helix being formed from a strip of non-thermoplastic textile fabric provided with a coating of film-forming thermoplastic material having as its principal constituent ethyl cellulose, said coating being many times the weight of the uncoated fabric, the lines of junction between the fabric edges in successive shells being out of register with one another and successive shells being bonded together by the thermoplastic material.

4. A light, rigid tube which comprises a plurality of concentric similar shells each in the form of a helix with adjacent turns abutting, said helix being formed from a strip of non-thermoplastic textile fabric provided with a coating of film-forming thermoplastic material having as its principal constituent a mixed ester of cellulose containing the radicals of acetic acid and of a higher fatty acid, said coating being many times the weight of the uncoated fabric, the lines of junction between the fabric edges in successive shells being out of register with one another and successive shells being bonded together by the thermoplastic material.

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REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
441,846	Hurlburt	Dec. 2, 1890
477,593	Greenfield	June 21, 1892
557,830	Kinney	Apr. 7, 1896
730,845	Traylor	June 9, 1903
1,412,619	Knox	Apr. 11, 1922
2,062,336	Sexton	Dec. 1, 1936
2,123,275	Dym	July 12, 1938
2,188,332	Carothers	Jan. 30, 1940
2,200,042	Salz	May 7, 1940
2,230,792	Billing	Feb. 4, 1941
2,286,257	Farny	June 16, 1942
2,307,817	Austin	Jan. 12, 1943
2,332,373	Dorough et al.	Oct. 19, 1943

FOREIGN PATENTS

Number	Country	Date
153,430	Austrian	May 25, 1938