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METHOD OF MANUFACTURING HOLLOW ARTICLES COMPOSED OF RESIN IMPREGNATED YARN WINDINGS

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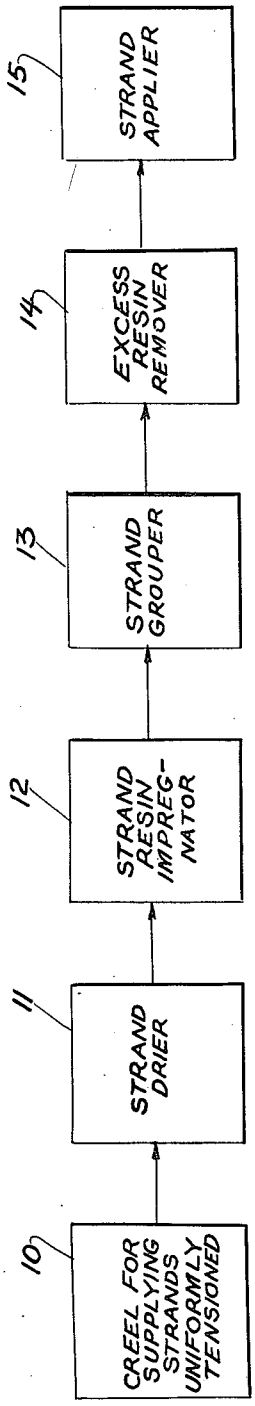


FIG. 1.

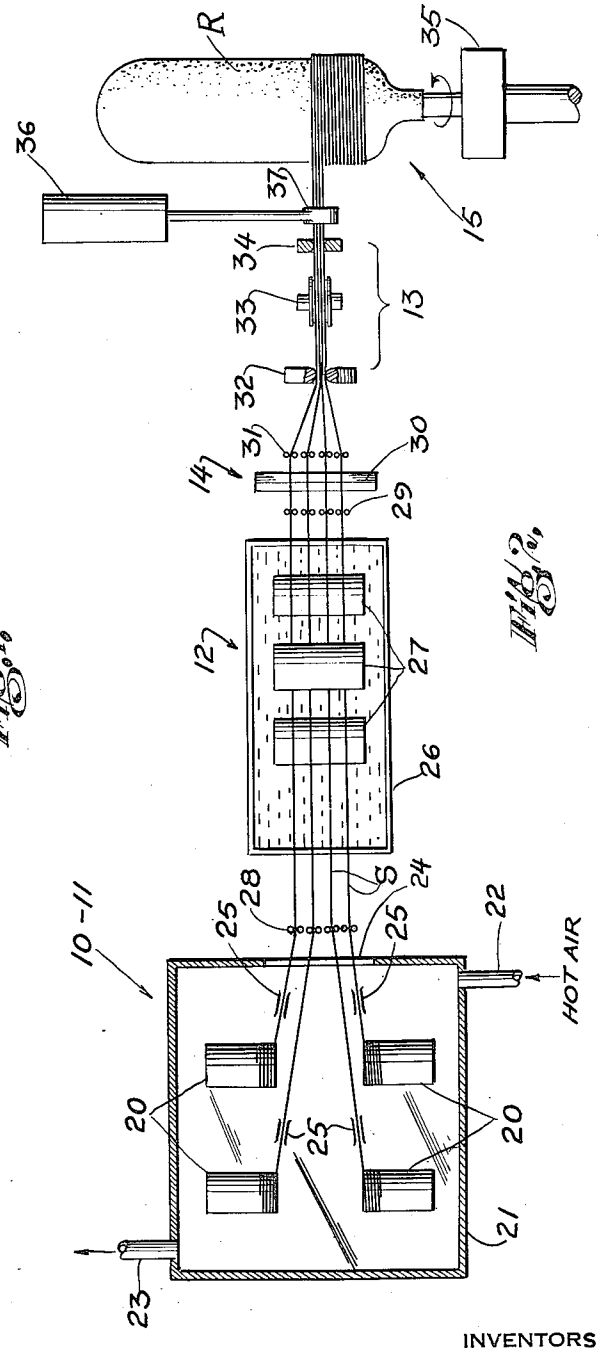


FIG. 2.

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METHOD OF MANUFACTURING HOLLOW ARTICLES COMPOSED OF RESIN IMPREGNATED YARN WINDINGS

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1 Claim. (Cl. 154—83)

The present invention relates to a method of and apparatus for manufacturing hollow articles partially composed of resin impregnated yarn windings, and, more particularly, to the conditioning and handling of the yarn preliminary to its application as a winding in the manufacture of receptacles, such as cylinders or spheres and tubes or conduits, for confining fluid medium under high pressure.

It has been proposed to manufacture receptacles of the foregoing character by applying windings of resin impregnated yarn on an inner shell or a form, and curing the resin to provide a wall consisting of resin and yarn and having a thickness to withstand high pressure. Such receptacles are much lighter in weight than similar receptacles formed of metal, but, heretofore, difficulty has been encountered in producing such receptacles which can safely withstand the high pressures at which it is desired to confine the medium and which can survive the pressure fluctuations to which such receptacles are subjected in the normal use thereof. The difficulties which have been most pronounced are that the bursting strength of such receptacles is well below that desired and that the wall composition fatigues too quickly when subjected to the pressure fluctuations the receptacles are required to withstand under present safety regulations.

In accordance with the present invention, it has now been discovered that localized stresses caused by small imperfections in the winding are instrumental in greatly weakening such receptacles. It has been found that uneven dryness and tensioning of the yarn or strands of yarn and uneven impregnation thereof primarily are the cause of the aforementioned difficulties; and that uneven impregnation is induced by uneven dryness and uneven tensioning, and that uneven dryness affects proper tensioning.

Accordingly, an object of the present invention is to provide a method of and apparatus for producing high pressure medium confining receptacles having greater bursting strength and greater fatigue resistance than receptacles of comparable wall thickness heretofore produced.

Another object is to provide such method and apparatus which condition the windings in a manner to uniformly tension and impregnate the same, whereby localized weaknesses in the resulting receptacles are greatly minimized or entirely eliminated.

A further object is to provide such method and apparatus which are simple, practical and economical and do not slow down production.

Other and further objects of the invention will be obvious upon an understanding of the illustrative embodiment about to be described, or will be indicated in the appended claim, and various advantages not referred to herein will occur to one skilled in the art upon employment of the invention in practice.

A preferred embodiment of the invention has been chosen for purposes of illustration and description, and

is shown in the accompanying drawing, forming a part of the specification, wherein:

Fig. 1 is a block diagram illustrating the essential means and steps utilized in carrying out the present invention.

Fig. 2 is a schematic plan view illustrating apparatus in accordance with the invention.

As shown in Fig. 1 of the drawing, the essential means of the apparatus for performing the steps of the method utilized in connection with practicing the present invention comprise a creel **10** for supplying strands of yarn including means for uniformly tensioning the strands, means **11** for drying the strands, means **12** for resin impregnating the strands, means **13** for grouping together the strands, means **14** for removing excess resin from the strands, and means **15** for finally applying the resin impregnated strands as windings to produce the wall structure of hollow receptacles. The order of arrangement of certain of these means and the corresponding method steps performed thereby can be varied, whereby the present invention is in no way to be limited by the illustrative embodiment herein. For example, the strands may be dried prior to tensioning the same, and the strands may be grouped together after removing the excess resin therefrom.

In Fig. 2, the aforementioned means are illustrated schematically, and, as shown therein, the creel includes a plurality of yarn packages **20** each adapted to supply a strand or end of yarn S. Four of such packages are shown by way of example, although any suitable number greater than four may be utilized depending on yarn size and the type of winding to be applied. Such a creel may be of any conventional design and need not be illustrated in detail.

If desired, the yarn drying means **11** may be associated with the creel by providing an enclosure **21** for the creel having an inlet **22** and an outlet **23** for heated air acting as a drying medium, and having a slit **24** through which the strands are supplied. Similarly, yarn tensioning means **25** may be located adjacent each of the packages as in a conventional warping creel, and these tensioning means may be any device adapted to put into the various strands a substantially constant, uniform tension on the order of about 5 to 15 grams. For example, devices such as disclosed in United States Letters Patent 2,597,044 may be utilized for this purpose.

The impregnating means **12** or the zone in which impregnation takes place may include a receptacle **26** containing liquid resin and suitable rolls **27** for passing the strands through the resin or applying the resin to the strands by coming in contact therewith. Such impregnating devices are well known and need not be illustrated or described in detail.

In order to assure uniform impregnation of the strands and the individual filaments or fibers of which the strands may be composed, the strands are maintained out of contact with each other while in the impregnating zone. This may be accomplished by passing the strands between sets of spaced apart pins or a pair of combs **28** and **29** at each end of the impregnating bath.

The excess resin removing means **14** may be a blade or wiper **30** over which the strands pass in contact therewith, or, alternatively conventional squeeze rolls could be used for this purpose. If desired, the strands are maintained in the aforementioned spaced apart relation to provide for uniform resin impregnation of the strands after the excess is removed by the comb **29** at the incoming side of the means **14** and a comb **30** at the outgoing side. Preferably, the amount of resin permitted to remain on the yarn is just about sufficient to coat the individual fibers or filaments thereof with a film adapted to prevent abrasion therebetween and between strands

of yarn. This amount of resin is effective to bond the yarn upon curing of the resin and to produce a composition having a high yarn content and high structural strength.

The strand grouping means 13 may be a guide 32 such as a pair of pins, a ring, or converging tube for bringing the strands together, and may include a flanged pulley or wheel 33 for arranging the strands into a ribbon-like band adapted to be passed through a guide 34 and applied as the winding.

The strand applying means 15 is illustrated herein as a winder for applying a hoop winding on a cylindrical surface of a receptacle R, although such means could be winders for applying hoop and/or end-over-end windings on cylinders or great circle windings on spheres.

The winder shown herein comprises a spindle 35 on which the receptacle is mounted for rotation about its longitudinal axis, and a yarn traverse 36 including a guide 37 for positioning the winding on the receptacle. The winder serves to withdraw the strands from the creel and to draw the same through the impregnating bath and the grouping means.

After the winding is applied to provide a wall of desired thickness, the resin is cured by placing the receptable in an oven for at least about 4 hours, maintained at a temperature of about 212° F., whereby a solid wall structure composed of yarn and resin is produced. By conditioning the yarn in the manner described herein, it was found that the wall structure consisted of between 80% to 85% yarn and 20% to 15% resin. Cylinders having a capacity of about 500 cubic inches were constructed of such yarn-resin composition and were found to safely withstand internal pressures of about 3000 pounds per square inch in service and 5000 pounds per square inch under test, and exhibited no signs of fatigue after being alternately pressurized from 0 to 3000 pounds per square inch through 5000 cycles in about 24 hours.

The term yarn is used herein in a broad sense and is intended to include yarns formed of natural or synthetic fibers or filaments suitable for impregnation. Fiber glass yarn is preferred because of its high tensile strength and resistance to heat, although other types of high tenacity yarns may be used to good advantage, for example, multifilament yarns formed of materials such as nylon, vinylidene chloride, polyester and flexible metal.

Fiber glass yarn has a tensile strength of between about 300,000 pounds per square inch, a specific gravity of about 2.57, and is available in various sizes. For example, sixteen strands of size 140 (14,000 yards per pound, 204 filaments) fiber glass yarn, impregnated and grouped together in accordance with the method of the present invention, provide an excellent winding.

A wide variety of thermosetting or thermoplastic resins may be utilized, for example, epoxy or modified epoxy resins, polyester type resins and acrylic resins which are available in liquid form. Also, silicone resins and phenolic resins modified with a solvent may be used. A suitable wetting agent may be admixed in the resin to expedite impregnation of the yarn. Such resins upon curing are converted into a solid mass having a tensile strength on the order of about 5000 to 8000 pounds per square inch.

A specific example of practicing the method in accordance with present invention comprises supplying sixteen strands of size 140 fiber glass yarn which have been uniformly dried and tensioned to about 10 grams, passing the strands through liquid epoxy resin while maintaining the strands apart to assure uniform impregnation thereof, removing excess resin from the strands, grouping the strands together in a ribbon-like band, applying the band to a shell as a winding under a tension of about 3 to 10 pounds, and curing the resin to produce a wall structure surrounding the shell composed of about 85% fiber glass and 15% insoluble resin.

From the foregoing description it will be seen that the present invention provides a simple, practical and economical method of and apparatus for producing strong and durable wall structures for receptacles consisting of yarn and resin.

As various changes may be made in the form, construction and arrangement of the parts herein, without departing from the spirit and scope of the invention and without sacrificing any of its advantages, it is to be understood that all matter herein is to be interpreted as illustrative and not in any limiting sense.

We claim:

The method of manufacturing hollow articles for confining a fluid medium under pressure, which method comprises simultaneously exposing a plurality of strands composed of yarn filaments to a drying atmosphere to uniformly remove moisture therefrom, individually tensioning the strands to place the same under substantially constant uniform tension on the order of about 5 to 15 grams, individually impregnating the strands immediately after tensioning of the same by simultaneously applying a liquid resin thereto from a common source, removing resin from the strands to leave an amount of resin of about 15% by weight of the impregnated strands upon curing of the resin which amount is sufficient to coat the individual filaments and prevent abrasion therebetween, grouping together the impregnated strands into a ribbon-like band, applying the band as a winding of a plurality of layers to form a hollow article, and curing the winding to provide a wall for the hollow article having a yarn content of about 85% by weight, the wall of the hollow article being characterized in that it can safely withstand internal pressure of about 5000 p. s. i. and exhibits no sign of fatigue after being alternately pressurized from 0 to 3000 p. s. i. through 5000 cycles in about twenty-four hours.

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