This invention relates to an inflatable tube for use in casting hollow concrete slabs.

In United States Patent No. 2,299,070, issued October 20, 1942, and in companion Patents 2,999,071, 2,999,072 and 2,999,111, issued on the same date, elongated concrete slabs provided with longitudinal passages of generally circular cross-section are disclosed. Such slabs have been manufactured for many years and, as disclosed in said patents, casting such slabs involves the use of inflatable tubes to provide the passages.

In casting concrete slabs, it is important to provide a tube having a smooth uniform diameter for the entire length of the slab to define the passage through the slab. It has not been possible to provide a tube of this character which is so cheap as to be expandable with each slab. Instead, a tube must be reclaimed for future use although the extent of such future use will be determined by the ruggedness of the tube.

After the concrete has set, an inflatable tube should be reclaimed by removing the same from the slab. In the slabs referred to in the patents, two or more tubes per slab are used. Inasmuch as slabs of this type are cast in lengths up to 30 and 40 feet, and sometimes longer, the problem of removal of a tube from a slab is not simple. If a tube has any tendency to stick to the concrete then it is possible to damage the tube in attempting to remove the same from a finished slab. It must be remembered that in the manufacture of the slab, the concrete with the inflated tube in position is disposed for a number of hours in steam where the temperature may range to about 150 or more degrees F. and where the humidity is approaching 100 percent. The tube itself must have substantial strength and be capable of withstanding the rough handling incident to pulling the tube against rough concrete.

Furthermore, in order to have a uniform bore in the finished slab, it is essential that the inflatable tubes maintain their characteristics with regard to inflated shape substantially constant not only throughout the length of a tube at any one time but also over the life of the tube in various castings.

For many years an inflatable tube, as disclosed in the above identified patents, has been used. This inflatable tube, as disclosed in said patents, is more fully disclosed in United States Patent No. 1,949,650 to Lindas. The Lindas construction discloses a cylindrical tube which construction resembles the construction of a conventional casing for an automobile tire. Thus, the Lindas patent discloses two sets of fabric cords, each set having the cords in parallel relation with the cords of one set disposed at about 30 degrees to the cords of the other set. The two sets of cords are symmetrically disposed with reference to the length of the tube so that in effect, each set is about 15 degrees to the length of the tube. This arrangement of cords is embedded in rubber. In theory, as a tube of this type is inflated, the angle between the two sets of cords will become larger, thus permitting the diameter of the tube to increase. The patent points out that the maximum angle between the two sets of cords should be about 52 degrees.

The Lindas construction does not depend upon any elasticity of the cord material for increasing the tube diameter. This is borne out by the fact that the length of the Lindas tube decreases as the diameter increases. In fact, elasticity of the cords would be detrimental as it would introduce a new variable.

One serious fault with the Lindas construction develops during use of such an inflatable tube. Since the cords resemble woven material on a bias, a rubberized material of this character has the undesirable characteristic that the elastic properties of the rubber are a controlling factor in the response of the tube to air pressure. Where tubes of 30 or 40 feet are desired, it is a practical impossibility to fabricate a uniform rubber within the limits required for uniform diameter.

Even if such a tube is provided, various parts of the tube along the length are subjected to different conditions of heat and humidity and stress during use. Hence, the mechanical characteristics of the rubber become changed at different regions along the tube. Consequently, a Lindas type tube, when inflated, after some use will exhibit what is designated as "ballooning." This is a fundamental defect in the Lindas type tube.

The present invention provides an inflatable tube construction whose dimensions during inflation will remain substantially constant throughout the length of the tube and throughout the life of the tube. The new inflatable tube provides a construction which is simple and durable and whose characteristics may be closely controlled. The invention in general provides an inflatable tube which has the desirable property of increasing the tube diameter during inflation without necessarily decreasing the length of the tube. In fact, the new tube embodying the present invention may have its length remain substantially constant during inflation or the length may even increase with inflation.

The invention in general contemplates a generally cylindrical inflatable tube whose cylindrical wall consists of substantially three layers. The inner layer of the wall consists of rubber or other plastic material which is elastic, flexible, impermeable to air under pressures up to about 100 pounds per square inch, will withstand heat and moisture prevailing in a steam room, will withstand extremes of weather and is generally durable.

The principal function of the inner layer is to seal the pores of the next or center layer. The center layer is the reinforcing member of the inflatable tube and is designed to take the full force of air pressure used for inflating the tube. The center layer is a woven material with the threads running along the length of the tube and around the tube. The threads extending around the tube which, for convenience, may be designated as the wool, will be of a material having limited elasticity of the order of about ten to twenty percent of its length as maximum. Such a material as nylon which, while strong, will yield to a substantial degree, is suitable. In addition to nylon, wool may also be used but wool is too expensive for practical use.

The warp threads of the fabric forming the center layer may be of cotton which has substantially no stretch or may also be of an elastic material like nylon. The gauge or thickness of the threads or yarn making up the warp and woof need not be the same even if both threads are of the same material.

The important feature of the center fabric layer is the ability to expand the diameter of the tube without necessarily affecting the length of the tube and to have this expansion characteristic substantially uniform over the length of the tube and during the life of the tube.

The third layer of the inflatable tube wall is on the outside and comprises a protective layer of flexible material having some elasticity. Thus, the outer layer may conveniently be of rubber.

The ends of the inflatable tube need not necessarily be elastic and in one practical construction described here

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3,104,441

INFLATABLE CORE TUBE FOR MOLDING CONCRETE

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Filed May 4, 1959, Ser. No. 510,780

4 Claims. (Cl. 22—126)

United States Patent Office

Patented Sept. 24, 1963
require the use of metal clamping rings on the outside to lock the ends to the tube wall. Since the inflatable tubes are used in conjunction with bulkheads having apertures for accommodating the tubes, it becomes necessary for the inflated tubes to have an outer diameter which is larger than the outer diameter of the end portions of the tube where the clamping rings are used. This is to permit the tubes to be pulled out of the casting forms. Thus, an additional reason for circumferential elasticity of the inflatable tube is present.

The reinforcing center layer of elastic fabric should have the property of returning the tube to its normal uninflated diameter after deflation. This will result in the walls of the tube pulling away from the concrete and thus will promote stripping. Rubber, as an outer layer, has the additional advantage that it will not permanently adhere to concrete. Hence, while the rubber may stick to the concrete, the shrinking of the inflatable tube away from the concrete will pull the rubber free in such manner as to result in minimum damage to the inflatable tube. When the tube pulls away from the concrete as set forth above, each elemental area of the tube exerts its shrinking force directly on the tube wall. Where a tube is pulled longitudinally while stuck to the concrete, there is an accumulative holding force along the length of the tube so that a forcible pull on the tube can readily damage parts of the tube along the length thereof.

In order that the invention may be understood, reference is made to the drawings wherein:

FIGURE 1 is a plan view with certain parts broken away of a casting form for casting slabs, the casting form having a number of inflatable tubes embodying the present invention.

FIGURE 2 is a sectional detail on line 2—2 of FIGURE 1.

FIGURE 3 is a transverse section on line 3—3 of FIGURE 2 illustrating the inflatable tube construction.

FIGURE 4 is an enlarged sectional detail of a portion of the wall of the new inflatable tube.

FIGURE 5 is a view of a portion of the inflatable tube showing the normal condition of the tube with little or no air pressure and showing in dotted lines the expanded condition as a result of inflation.

FIGURE 6 is an enlarged view of a part of the fabric used in the inflatable tube.

FIGURE 7 is a roughly enlarged view of a small piece of the fabric, the full lines showing the spacing of the threads under normal tube conditions and the dotted lines showing the increased spacing between threads as the result of inflation.

Referring first to FIGURES 3 to 7 inclusive, the inflatable tube embodying the present invention has a wall generally indicated by 10. Wall 10 has inner layer 11 of any desired thickness of rubber or other elastomeric material having the properties previously referred to for providing the air impermeable surface.

Inner layer 11 cooperates with fabric reinforcing layer 12 of a woven material. Woven material 12 has longitudinal or warp threads 13 and circumferential or woof threads 14. Woof threads 14 are of a fabric such as nylon which has the property of substantial elongation under stress and has sufficient elasticity to return to its original dimension. It is important that the woof threads 14 be operated within their elastic limits. Warp threads 13 may also be of nylon although a non-elastic material such as cotton may be used.

The closeness of the weave is not important although a loose weave is preferred. Thus, as one example, a nylon fabric where threads 13 and 14 have a spacing between them about equal to the diameter of the threads may be used. In an actual example, the fabric had about 24 threads to the inch. Finer thread with closer spacing may also be used. The loose weave coupled with the smooth nylon surface of the threads cooperate to provide a desirable stretching action of the fabric.

As is well known, nylon has a naturally slippery surface. Hence, the slight movement of the threads with respect to each other during inflation and deflation—this is illustrated in FIGURE 7 by the dotted lines—will not damage the threads due to frictional causes. Even if the threads are of cotton, the smooth surface nylon threads can slide easily with respect to the cotton and permit the tube to expand its diameter or contract during deflation many times without undue wear or localized strain of threads. This smooth action promotes uniform change in dimension in response to air pressure throughout the entire extent of a tube.

Outside of fabric layer 12 is protective layer 16 of rubber or the like. Protective layer 16 should be thick enough to withstand substantial wear and tear. In practice, an inflatable tube with the three layers may have a thickness of about \( \frac{1}{4} \) inch with the fabric layer displaced substantially midway between the inner and outer surfaces.

In the actual manufacture of such a tube, winding of a length of fabric around a mandrel will be involved. Hence, there may be more than one layer of fabric, particularly where the edges overlap, as illustrated in FIGURE 4. In fact, if the fabric is not strong enough to be used in a single layer, it may be wound around a mandrel several times.

The material illustrated in FIGURES 4 and 7 may be manufactured by having a layer of rubber or the like and a steel mandrel then disposing one or more layers of a rubberized nylon fabric onto a mandrel. This would result in a tube having a much thinner wall thickness. This tube would have the advantage of being lighter and easier to handle; and the disadvantage that it is more susceptible to physical damage.

A length of tube 10 is capped at both ends to form an inflatable tube. Ends of heavy rubberized fabric of the same general construction as the side wall may be permanently cemented or attached to the tube. Whether the ends are elastic or not makes no difference and in fact it is better that the ends be substantially non-stretchable so that the ends of an inflated tube will always be smaller than the body of the tube.

End walls for an inflatable tube may be provided in a simple manner. Thus metal member 20 has annular sleeve portion 21, the outer surface of which has annular rises 22. Annular portion 21 of the metal end member has an outer diameter substantially equal to the diameter of the tube prior to inflation. The end of the tube is pulled over sleeve portion 21 and metal straps 23 are provided for banding the tube material over the metal member. Each strap may be a steel strip and may be locked in place in a manner similar to metal bands used in baling, packaging and the like. As a rule, such strips are provided with a fixture having a slot through which the strip may be threaded and then folded sharply back. In any event, it is essential that the strip and locking means should lie well within the outside diameter of the tube in its inflated condition.

Metal member 20 may be of aluminum, brass, or iron, or of plastic. Member 20 is provided with threaded sleeve 24 at one end of the tube, said sleeve including a fitting with an air valve for permitting the tube to be inflated or deflated as desired, as illustrated in FIGURE 4. A number of inflatable tubes may be disposed in a casting mould 30, as illustrated in FIGURES 1 and 2 of any desired construction. The ends of the casting region may be defined by bulkheads 31 and 32. The bulkheads have openings therethrough for accommodating tubes. The diameter of the openings in the bulkheads will be larger than the outside diameter of the caps
at the ends of the tube and this diameter will be equal to the inflated diameter of the tube as used in casting.

It is possible to inflate the tube to a somewhat larger diameter than the clearance openings in the bulkheads in which case the tubes will be locked in the casting mould.

After the concrete is set, the tubes are deflated and may be readily pulled out.

The bulkheads may have means for accommodating steel reinforcing rods either in a tensioned or untensioned condition as desired. As a rule, the casting moulds are long enough to accommodate the longest slab to be cast. The bulkheads may be adjusted in various positions along the length of the casting form to control the length of the cast slab.

Instead of nylon, other fibers having elastic properties may be used and it is understood that the designation of nylon includes such equivalent fibers. It is also understood that the rubber used for coating the fabric either on the inside or the outside surface thereof has negligible effect insofar as the expansion and contraction characteristics of the tube are concerned and that instead of rubber, similar materials suitable for use may be substituted.

What is claimed is:

1. An inflatable tube construction having a length of the order of about 30 feet and transverse dimensions of a lower order, said tube construction being used to provide long passageways through concrete slabs during the casting thereof and requiring a high degree of precision with regard to maintaining at a constant value the transverse dimensions of the tube throughout the length thereof so that the passages through the slabs remain constant throughout their length, said tube comprising a tubular body of woven fabric with the threads running circumferentially and longitudinally of the tube, said circumferential threads being of elastic nylon, said fabric having flexible material bonded thereto on opposite sides thereof for sealing the fabric, said material having the characteristic of being substantially unaffected by temperatures of the order of about 150° F. and high humidity and being resistant to abrasion, said tube having end walls with at least one end wall provided with means for permitting fluid flow to pass between the outside and the inside of the tube, said tube being otherwise sealed so that it may be expanded by fluid pressure within the tube, the transverse expansion characteristics of said tube under fluid pressure being independent of any significant change in longitudinal dimensions and said tube being characterized by substantially uniform elasticity throughout the effective length thereof under concrete curing conditions with the fabric elasticity determining substantially completely the elasticity of the tube.

2. The tube construction according to claim 1 wherein said material on both sides of said fabric is rubber.

3. The construction according to claim 1 wherein said fabric consists entirely of nylon.

4. The construction according to claim 1 wherein said fabric has a loose weave with the adjacent threads being separated by a distance about equal to the thread diameter.

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