W. M. FULTON.
COLLAPSIBLE AND EXPANSIBLE VESSEL.
APPLICATION FILED JULY 19, 1904.

975,519.

Patented Nov. 15, 1910.

Fig. 1.

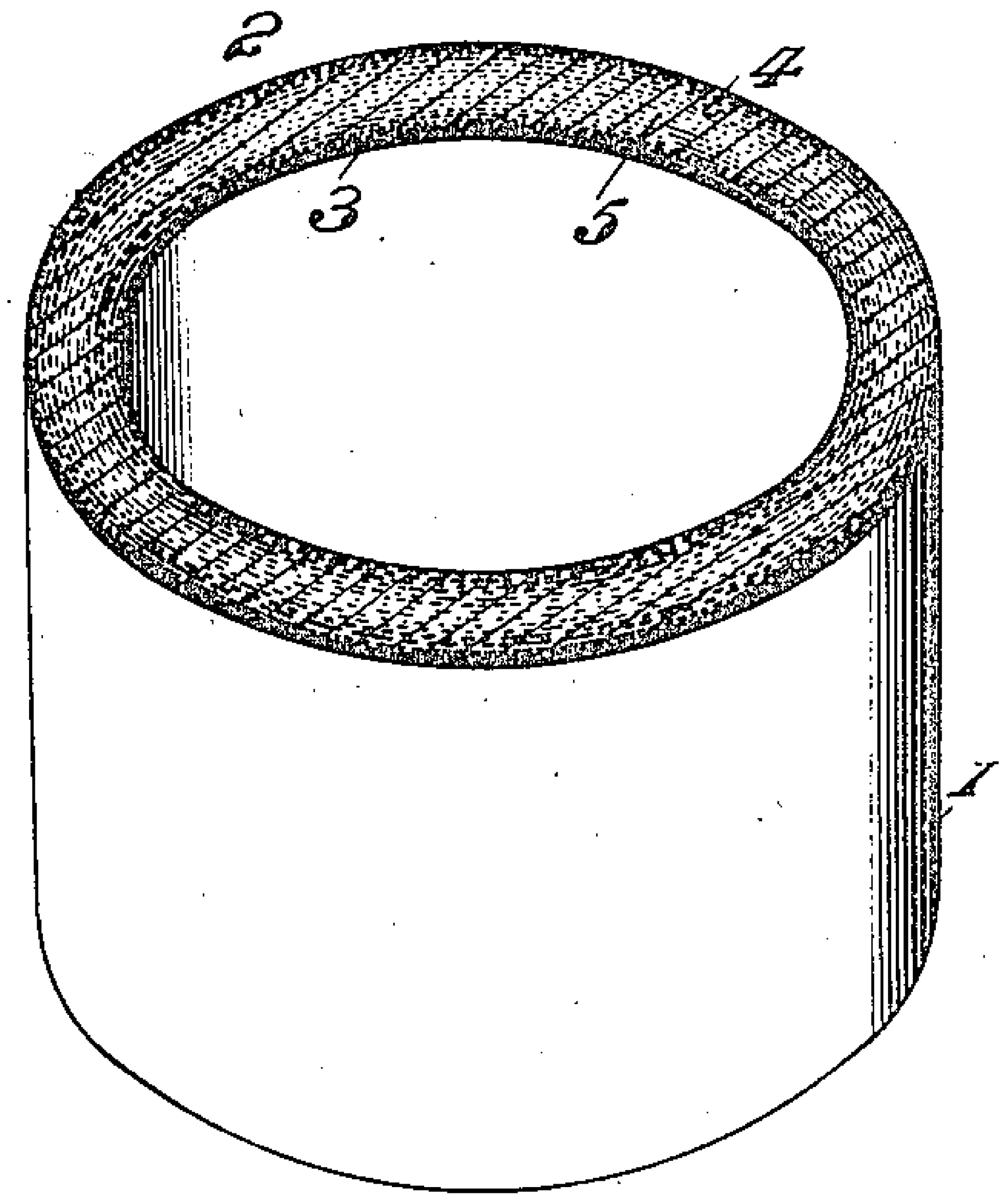


Fig. 2.

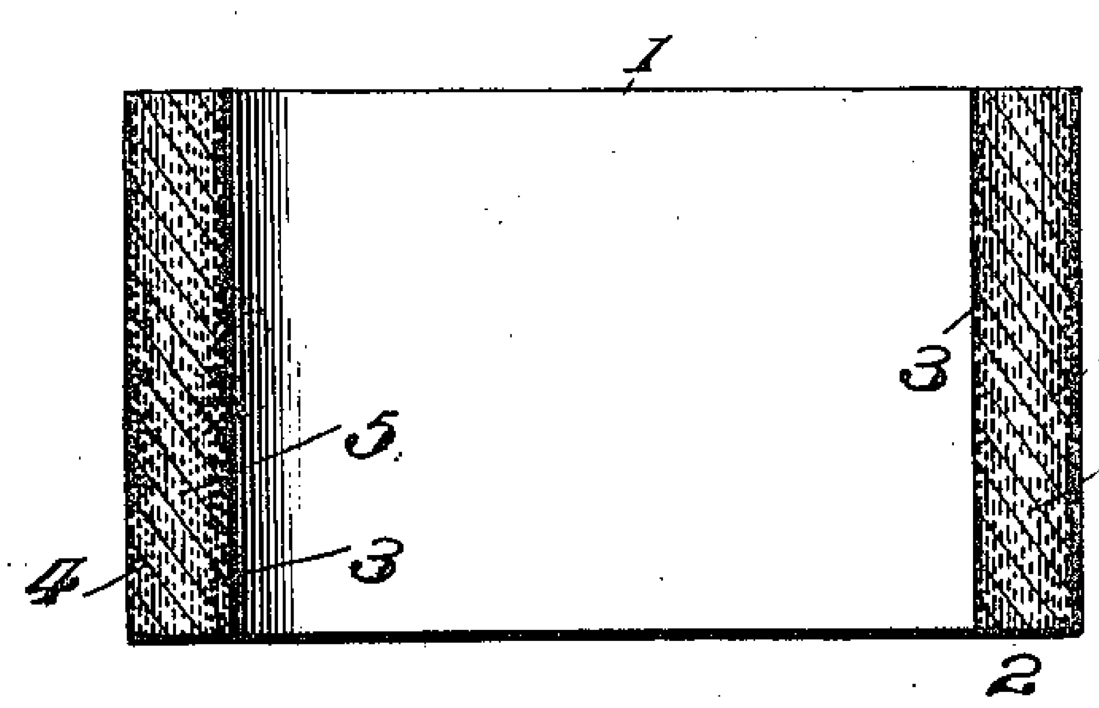


Fig. 3.

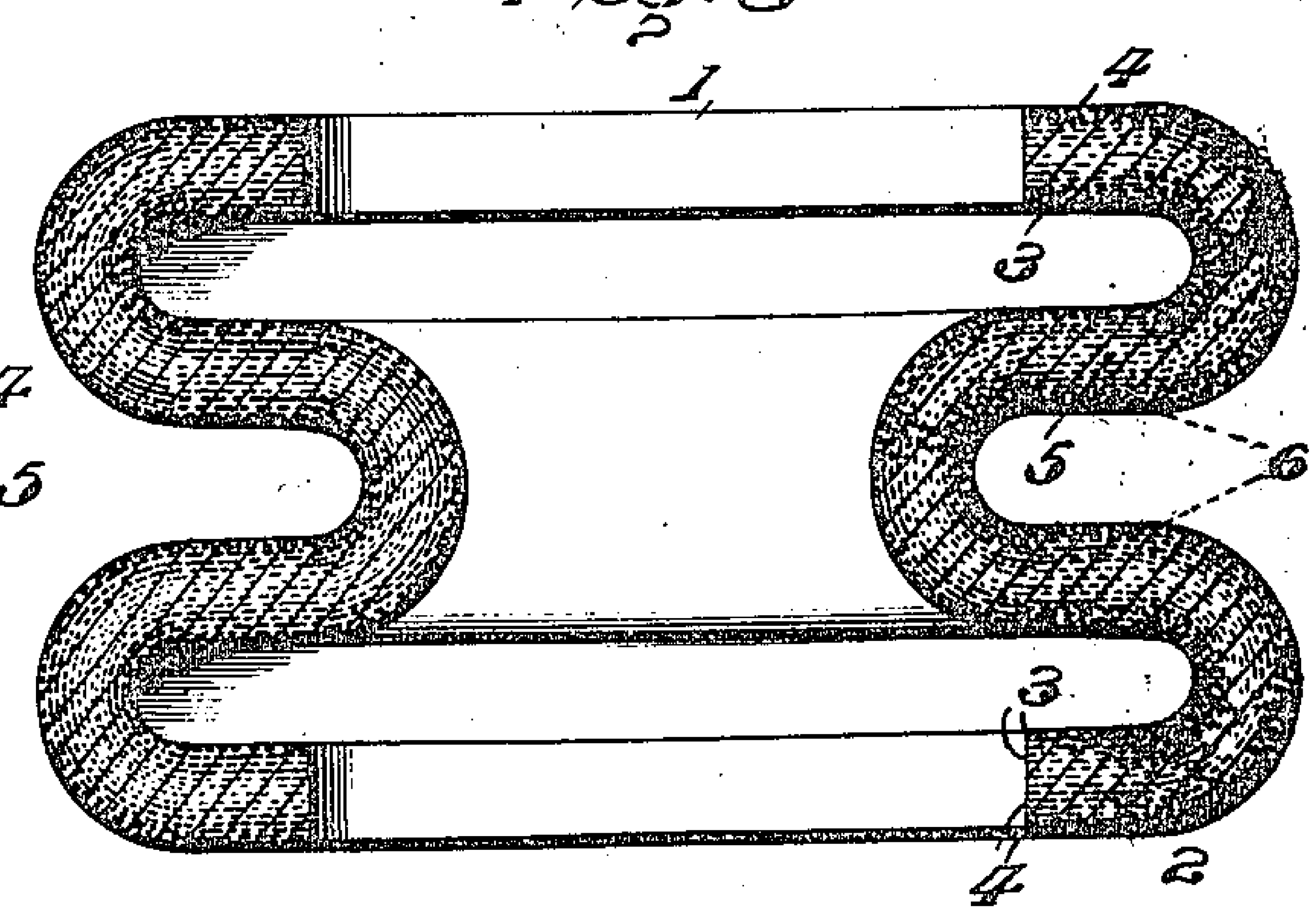
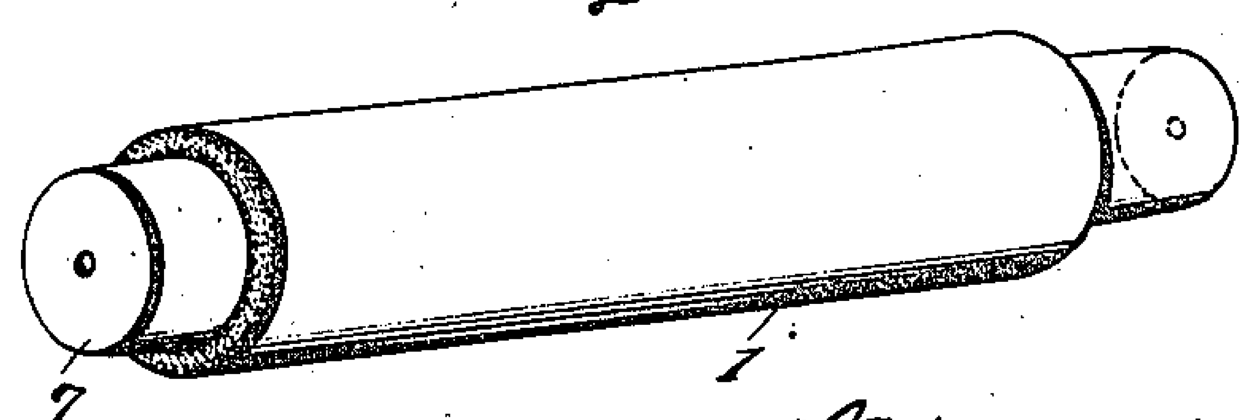


Fig. 4.



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UNITED STATES PATENT OFFICE.

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COLLAPSIBLE AND EXPANSIBLE VESSEL.

975,519. Specification of Letters Patent. **Patented Nov. 15, 1910.**

Application filed July 19, 1904. Serial No. 217,286.

To all whom it may concern:

Be it known that I, Weston M. Fulton, of Knoxville, Tennessee, have invented a new and useful Improvement in Collapsible and Expansible Vessels, which invention is fully set forth in the following specification.

This invention relates to corrugated sheet metal walls for use in collapsible and expansible vessels, and has for its object the production of walls for such vessels which shall have great flexibility and durability and freedom from cracking under the severe conditions imposed in continued use.

In a previous application for Letters-Patent, Serial No. 213,864, filed June 23d, 1904, I have described a process for electrically welding sheet steel. Collapsible vessels of sheet steel having electrically welded seams are flexible and quite durable under certain conditions of use, but it is desirable at times to have the flexible wall of a collapsible and expansible vessel made of metals not readily welded, such as copper and brass, and which resist the oxidizing action of air and moisture. Such vessels are especially useful when the same are to be employed, for example, as the expansible and contractible portion of a steam gage, or as the thermo-sensitive portion of devices for gaging the temperatures of liquids. In devices of this character, steel readily corrodes and is not serviceable even when protected by metal coatings of tin, zinc or nickel, because the best of such coatings are porous and crack in use, exposing the iron to oxidation and rusting. For these reasons it is desirable to use in vessels of this kind a metal or alloy that will not readily corrode, such as copper or brass. In making the walls of collapsible vessels out of sheet copper or sheet brass, a seam is necessarily formed, and it has been found that the seams rapidly give way to the bending strains and break; therefore, seamless wrought tubing is preferable for constructing such vessels. I have found that even seamless wrought tubing is liable to develop weakness at the bends in the corrugations, thus unfitting it for use in constructing the walls of corrugated collapsible vessels. In most of the methods practiced in the manufacture of seamless tubing, there is formed a hard surface (both the interior and exterior surface of the tube) of greater density than the intermediate portion of the tube, that is, the portion lying between the exterior and interior surfaces thereof. Thus, for example, when a tube is drawn between a mandrel and a die, the operation results in condensing and hardening the surface portions of the metal wall, leaving the interior or intermediate portion of the wall more or less unaffected in these respects. The dense surface layers possess quite a different molecular structure from the intermediate layer or portion in their physical qualities, such as hardness, brittleness, expansion and contraction under the influence of heat and also in elasticity. In the case of brass tubing made in this way, and particularly when the metal of the tubing is of any considerable or appreciable thickness, the coefficient of expansion of the dense surface layers (whether of the interior or the exterior surface) differs so widely from that of the intermediate layer that the ordinary changes in atmospheric temperatures cause the tube to crack. Although annealing reduces to an appreciable degree this difference in molecular structure between the intermediate and surface layers, and prevents cracking for ordinary purposes, yet such annealing fails to render the drawn tubing serviceable for making the walls of flexible corrugated collapsible vessels which are to withstand repeated expansion and contraction. The same is true of other kinds of wrought seamless metal tubing, such as rolled tubes. When such wrought tubings are employed as the walls of corrugated expansible and contractible vessels, the greatest strains, and therefore the cracking, makes its appearance immediately at or adjacent to the point where the bend occurs, and where, consequently, the greatest stress is set up.

The object of the present invention is to provide walls for such expansible and contractible vessels, which shall be seamless, and free from a liability to crack even under the conditions imposed by long use and severe strains due to great internal pressures, and which preferably also shall be free from oxidation and the cracking resulting from such oxidation.

With this object in view, the invention consists in the expansible and contractible walls of a vessel formed from a wrought seamless tube, such as a drawn or rolled tube, having a portion of the thickness of the original tube removed at and adjacent to the point of bend for each corrugation, so that the metal which remains and constitutes the wall at the bend or corrugation shall be of a substantially uniform molecular structure, and consequently of uniform hardness, toughness and elasticity. Preferably, this result is secured by taking a wrought tube, such, for example, as a drawn tube, of copper, brass, or other similar alloy, and removing all of the tube except one of the layers above indicated, which remaining layer shall be of substantially uniform density, hardness, brittleness and elasticity. For example, by removing the exterior surface or portion and the interior surface or portion of the tube, leaving only the intermediate or middle portion of the tube, that is, the portion lying between the exterior surface portion and the interior surface portion thereof, and then corrugating this intermediate portion of the tube, so as to form the walls of the expansible and contractible vessel, the said walls will not only be seamless, but the metal at the point of bend (and in this case throughout the entire body of the wall) will be of substantially uniform molecular structure, and of uniform hardness, brittleness and elasticity throughout the thickness of the wall.

The inventive idea involved is capable of being embodied in a variety of forms, one of which, for the purpose of illustrating the invention, is shown in the accompanying drawings, in which—

Figure 1 shows a wrought tube, either drawn or rolled from a cast ingot in the usual way; Fig. 2 is a longitudinal section of the same; Fig. 3 is the tube of Fig. 1 corrugated; and Fig. 4 shows the tube on a mandrel for the purpose of removing the exterior surface portion thereof.

Referring to the drawings, 1 indicates a wrought metal seamless tube, as a die-drawn tube of metal, such as brass, for example, the thickness of the tube being highly magnified for the sake of illustrating the molecular condition of the wall. The inner surface portion of the tube is indicated by 3, and the outer surface portion thereof by 4. These portions have been compressed and hardened in the act of forming the tube, as by contact with the mandrel and the die respectively, in the case of a drawn tube. The intermediate portion of the tube is indicated by 5. This portion has been removed from, and has not been subjected to, the compressing action experienced by the surface portions of the tube during the manufacture thereof. The relative density of the portions is indicated by the dotted shading. It will be seen that the wall of the wrought tube, as of a die-drawn tube, is not of homogeneous structure in passing through the wall from one side to the other thereof, but is composed of layers more or less clearly defined, which possess different degrees of hardness, brittleness, and consequently elasticity, and also different coefficients of expansion. This lack of uniform constitution produces deleterious effects which become serious when such tubing is made into a corrugated collapsible and expansible vessel.

Referring to Fig. 3, wherein are illustrated the walls of a corrugated vessel in section, a single corrugation is shown between the lead-lines from the reference numeral 6. If the wall of this vessel is collapsed, the outer layer 4 of said wall will be compressed, while the layer 3 will be drawn out or put under tension. The middle layer 5, which is relatively neutral, will serve to intensify the strain on layers 3 and 4, by virtue of the fact that it separates them from each other. When the wall is expanded, the reverse action takes place. These repeated strains acting upon these several layers of different molecular structure alternately and in opposite directions, cause an ultimate separation of the layers and cracks in the surface layers 3 and 4, which, when once formed in the surface rapidly extend through the wall and render it useless.

For the purpose of obviating the difficulties resulting from the different molecular structure of the several layers 3, 4 and 5, I remove one, and preferably two, of the nonhomogeneous layers composing the sheet of metal, at and adjacent to the point or portion of the wall where the bend of the corrugation occurs. The most convenient, and therefore the preferred way, to accomplish this result is to remove one, and preferably two, of said layers throughout the entire extent of the body of the wall. These layers may be removed in any convenient or efficient manner, the particular way of accomplishing this removal not being material to the present invention, it only being essential that such layer or layers be removed without materially affecting the molecular construction of the remaining layer or layers. To illustrate one method of accomplishing this removal, a wrought seamless tube is formed, preferably of brass, by any of the well-known methods for forming such tubes, such as drawing from a cast ingot. This tube then has its outer surface layer 4 removed in any suitable way, as by placing it upon a mandrel 7, as shown in Fig. 4, and the surface layer 4 turned off. The inner surface layer 3 may then be removed in any suitable manner, as by turning or boring, leaving the intermediate portion 5, which is then deeply corrugated, as indicated in Fig. 3, and there results a flexible elastic corrugated wall of substantially uniform molecular construction, which wall may be elongated and compressed, and which will withstand repeated strains without danger of cracking.

Although I prefer to remove two of the layers as indicated in the above example, yet in some cases only one may be removed, and the advantages of the invention to a certain degree will still be retained. I have found, however, that by removing from 50 to 80% of the entire wall, the best results are obtained, and I preferably employ seamless drawn tubing, though in some instances, seamless brazed tubing may be used, if desired.

By the term "wrought" seamless tubes, as used herein, I mean seamless tubes which have been formed by any method of treating the metal thereof which gives to the surface or surfaces of the tube a different molecular structure, resulting in greater density, brittleness, hardness and variation in coefficient of expansion than the intermediate portion of the metal constituting the wall of the tube. Examples of such tubes are the ordinary die-drawn and rolled tubes familiar in the art.

What is claimed is:—

1. A wall for an expansible and collapsible vessel consisting of a corrugated wrought metal tube having one of the surface portions of the wrought tube removed opposite the bends in the corrugations.

2. A wall for an expansible and collapsible vessel consisting of a corrugated seamless wrought metal tube having the interior and exterior surface portions of the wrought tube removed opposite the bends in the corrugations.

3. A wall for an expansible and collapsible vessel consisting of a corrugated drawn metal tube having one of the surface portions of the drawn tube removed opposite the bends in the corrugations.

4. A wall for an expansible and collapsible vessel consisting of a corrugated drawn metal tube having the interior and exterior surface portions of the drawn tube removed opposite the bends in the corrugations.

5. A wall for an expansible and collapsible vessel consisting of a corrugated seamless wrought metal tube having one of its surface portions removed.

6. A wall for an expansible and collapsible vessel consisting of the corrugated intermediate portion of a seamless wrought metal tube.

7. A wall for an expansible and collapsible vessel consisting of the corrugated intermediate portion of a seamless drawn metal tube.

In testimony whereof I have signed this specification in the presence of two subscribing witnesses.

WESTON M. FULTON.

Witnesses:
JOE B. SAMUEL,
J. F. VOORHEES.