April 16, 1929. W. M. FULTON 1,709,011

EXTRUDED TUBULAR WALL AND METHOD OF MAKING SAME

Filed Jan. 14, 1922 2 Sheets-Sheet 1

Fig. 1.

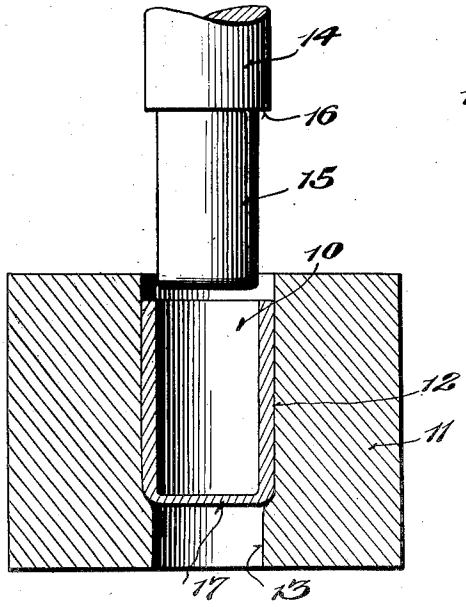


Fig. 2.

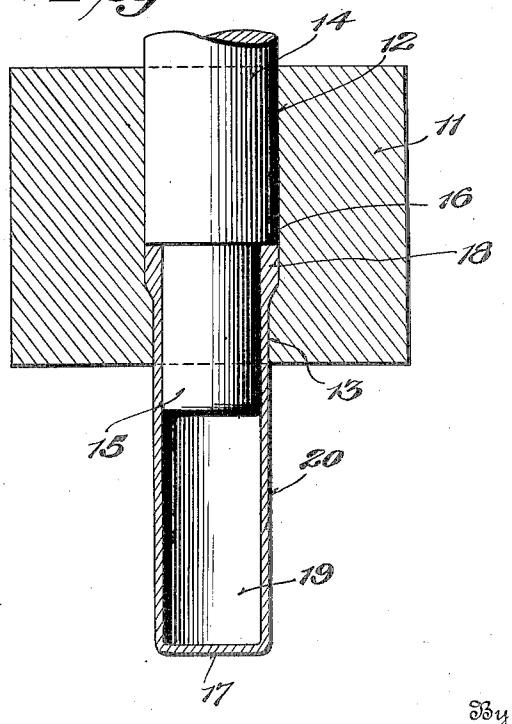
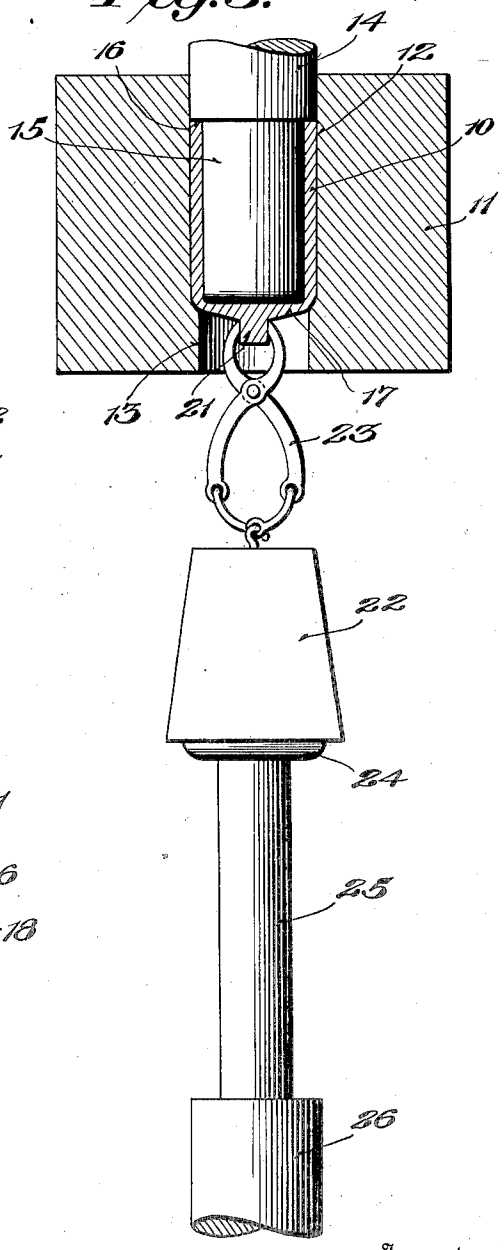


Fig. 3.



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EXTRUDED TUBULAR WALL AND METHOD OF MAKING SAME

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Fig. 4.

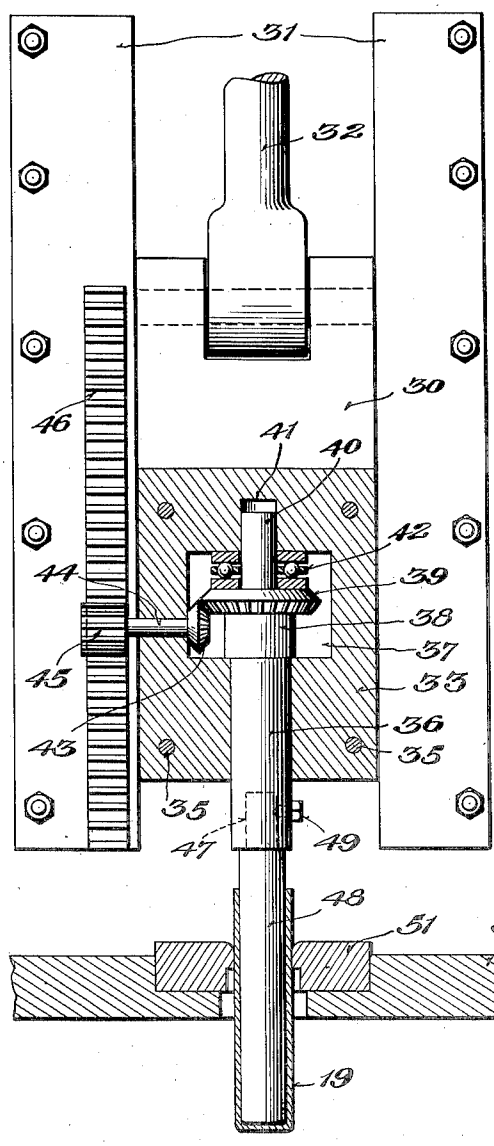


Fig. 5.

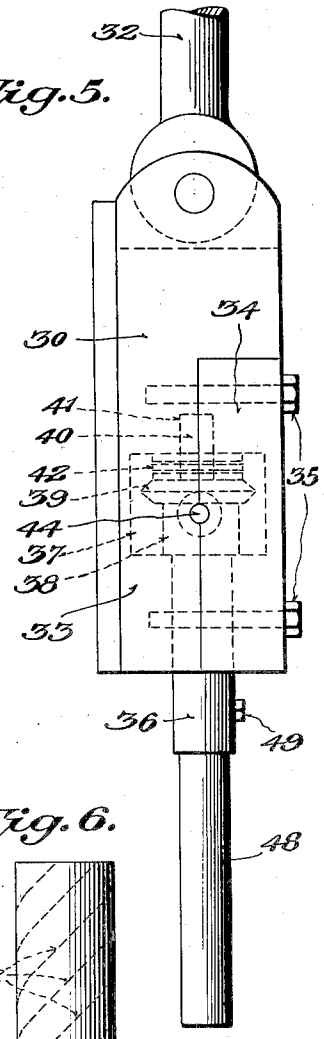


Fig. 6.

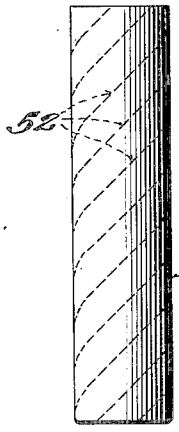
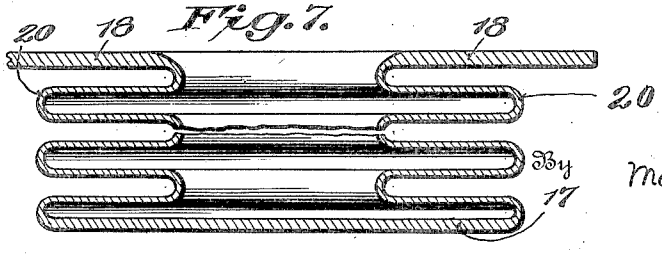


Fig. 7.



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UNITED STATES PATENT OFFICE.

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EXTRUDED TUBULAR WALL AND METHOD OF MAKING SAME.

Application filed January 14, 1922. Serial No. 529,282.

This invention relates to flexible corrugated tubular walls and methods and apparatus for making the same.

While a variety of methods have heretofore been suggested for producing relatively thin tubular blanks in which are to be formed relatively deep corrugations to render the tubular wall flexible in the direction of its axis, the method universally employed in making these blanks, so far as I am aware, is that disclosed in my Patent No. 1,049,572 dated Jan. 7, 1913, because of the superior durability and flexibility obtained by the practice of the process there disclosed.

Notwithstanding the superiority of this method of producing relatively thin tubular blanks in the manufacture of flexible corrugated tubular walls over methods previously suggested, there are certain inherent defects in this method of procedure which affect the physical characteristics of the resulting flexible walls and which more particularly tend to limit their capacity to withstand repeated flexure without rupture. Each time that the blank is subjected to a drawing operation which reduces the diameter of the same—and it is customary to subject the blank to a number of drawing operations so as to reduce the diameter and thickness of the blank by small increments and thereby avoid imposing undue strain upon the metal in its walls—a portion of the end of the blank is worked over into the tubular wall. As the entire tubular wall is subjected to cold working during each drawing operation, while the bottom wall is substantially unaffected, it follows that the tubular wall is composed of a plurality of zones each of which is subjected to one less cold working operation, from the top to the bottom.

It is also customary to subject the blank to an annealing operation between some or all of the drawing operations so as to remove the brittleness which is produced in the metal by the drawing operation. Experience has demonstrated that these annealing operations do not eliminate all of the effects of the cold working operations so that the resulting tubular wall is composed of a plurality of zones having different physical characteristics. On the other hand, the bottom of the blank is subjected to each annealing operation although not possessing the physical characteristics obtained by cold working the metal, which tends to produce undesirable effects, while, as successive zones of the bottom of the original cup are worked over into the tubular wall during successive drawing operations, the successive zones of the tubular wall from the bottom up have been subjected to repeated annealing operations, progressively decreasing in number, before they are subjected to any cold working operation.

Therefore the physical characteristics of the metal in the successive zones is not the same and the flexibility and durability of the metal differs in the different zones. As the life of a tubular wall of this character is no greater than the life of the weakest corrugation, the life of the wall is determined by the durability of the weakest zone produced in the tubular wall by the successive cold working and annealing operations.

It is an object of this invention to provide a method for making flexible corrugated tubular walls which avoids the production of a blank having a plurality of zones of different physical characteristics and which produces a wall of more uniform flexibility and durability throughout.

Owing to the relatively large friction between the contacting surfaces of the punch and die, it is common practice to make the lower end of the punch somewhat smaller than the upper end, i. e. give the punch a slight taper, so as to facilitate the withdrawal of the blank from the punch, which results in the drawn blank being somewhat thicker at its bottom or closed end than at its upper or open end. To eliminate this inequality in thickness it is necessary to pass the blank through a final drawing operation which employs a punch of uniform diameter, and during this operation to draw

the excess metal in the lower portion of the blank into the upper portion of the tubular wall. This operation not only subjects the tubular wall to an unequal cold working operation but it also tends to upset the distribution of the physical characteristics obtained by the preceding operations.

It is an object of this invention to provide a method for making flexible corrugated tubular walls which avoids the necessity for disturbing the physical characteristics of the tubular wall by drawing out any inequality in thickness produced by prior operations and which enables the formation of a tubular blank the lateral wall of which is of substantially uniform thickness in the first instance.

It is a further object of this invention to provide a method for making flexible corrugated tubular walls which substantially eliminates the likelihood of elongated blow holes or gas pockets being formed in the resulting flexible wall.

It is a further object of this invention to provide a method for making flexible corrugated tubular walls whereby the same may have a relatively thick end flange integrally connected with the tubular wall without the disadvantages and defects inherent in the process heretofore employed for forming a thick end flange integral with the tubular wall.

Another object of this invention is to provide an improved method for making flexible corrugated tubular walls whereby the same may have a closed end wall integral with the tubular wall, and thereby avoid the necessity of soldering, brazing or otherwise attaching an end wall to the tubular wall as well as the weakness at the junction of the end wall with the tubular wall incident to such processes for forming the end wall integral with the tubular wall.

Another object of this invention is to provide in the manufacture of flexible corrugated tubular walls an improved method for displacing the grain of the metal at an angle to the axis of the tubular wall.

Another object of this invention is to provide a method for making flexible corrugated tubular walls whereby a relatively thin tubular blank of substantially the thickness suitable for forming the flexible corrugations may be produced in a single operation.

Another object of this invention is to provide a flexible corrugated tubular wall of extruded metal, or of metal which is both extruded and drawn, and which may have either a closed end wall, or a relatively thick end flange, or both, integral with the tubular wall and which, also, either with or without said integral end elements, may have the grain of the metal disposed at the desired angle to the axis of the tube.

Another object of the present invention is to provide improved apparatus for displacing the grain of a relatively thin tubular blank at an angle to its axis.

Other objects will appear as the description of the invention proceeds.

The invention is capable of being carried out in a variety of ways some of which are illustrated in the accompanying drawings and described hereinafter, but it is to be expressly understood that the selected embodiments have been chosen for purposes of illustration only and that reference is to be had to the appended claims for a definition of the limits of the invention.

Referring in detail to the drawings, wherein the same reference characters are used to designate the corresponding parts in the several figures, and wherein for the sake of clearness the tubular wall is shown as of a thickness disproportionate to its other dimensions,—

Fig. 1 is a diagrammatic view illustrating a suitable blank and apparatus for extruding the same;

Fig. 2 is a corresponding view illustrating the blank after the same has been extruded;

Fig. 3 is a corresponding view illustrating a means for applying a drawing force to aid in the extrusion of the blank;

Fig. 4 is a fragmentary elevation, partly in section, of suitable apparatus for displacing the grain of the blank;

Fig. 5 is an end elevation of the structure shown in Fig. 4;

Fig. 6 is a schematic view to illustrate the displacement of the grain; and

Fig. 7 is a diagrammatic view of a completed corrugated flexible tubular wall provided with a relatively thick integral flange and an integral end wall.

In accordance with the present invention, a relatively thin tubular blank is formed by extruding the metal through a suitable die. The extruding step of my method may be carried out in any suitable way, as for example in the manner disclosed in the patent to Lee No. 822,285 of June 5, 1906 or in the patent to Hooker No. 922,585 of May 25, 1909. A blank 10, of any suitable shape and material, but preferably of generally tubular formation, and made in any suitable way, as by forging, drawing, machining, etc., is positioned in any suitable apparatus for extruding the same, diagrammatically shown in Figs. 1 to 3 as comprising a die 11, having an enlarged bore 12 of substantially the external diameter of the blank 10 and a reduced bore 13 of the diameter to be given the extruded blank, and a punch 14 mounted in the ram of any suitable press (not shown) and provided with a pilot portion 15. The punch 14 has substantially the same diameter as the enlarged bore 12, while the diam-

eter of the pilot portion 15 corresponds with the internal diameter to be given the extruded blank, said pilot portion being of sufficient length to just contact the bottom of the blank 10 when the shoulder 16 between the pilot portion 15 of the body portion of the punch contacts with the upper edge of said blank.

Pressure is then applied to the upper edge of the blank by the shoulder 16 on the punch 14 and the blank 10 is extruded through the bore 13 into a relatively thin elongated tubular wall the external and internal diameters of which are determined by the diameter of the bore 13 and of the pilot portion 15 respectively. During this extruding operation the metal of the blank 10 is subjected only to pressure which tends to compact and densify the same and, the blank being entirely confined between the die and punch during the extruding operation, it may be worked in a single operation into a relatively thin tubular wall which has substantially the thickness suitable for forming the flexible corrugations.

When it is desired that the finished wall have a closed end wall integral with the tubular wall, the end wall 17 of the blank may be suitably formed of substantially the thickness desired in the end wall of the completed wall and thereby the completed flexible wall may be provided with an integral end wall without additional operations or without the likelihood of a line of weakness at the junction of the same with the tubular wall.

In extruding the blank 10 the open end may be left with a zone of substantially the thickness of the original blank as shown at 18, which may be subsequently flanged over or otherwise suitably formed to constitute means of attachment, whereby may be provided a relatively thick end flange which is integral with the tubular wall and which at the same time gradually tapers into said tubular wall and thereby avoids the line of weakness at this place which characterizes the junction of the end portion with the tubular wall where the latter has been formed integrally by drawing operations only.

While the tubular blank 19 with its relatively thin elongated tubular wall 20 may be formed only by the method of extrusion, I have found that a somewhat greater strength and resilient texture can be given to the tubular wall by aiding the passage of the blank through the die by applying to the blank a drawing force. This drawing force may be applied to the blank in any suitable way, one such being diagrammatically illustrated in Fig. 3 wherein the original blank 10 is provided on its closed end with a boss or projection 21 which may be gripped by any suitable drawing apparatus, shown as in the form of a weight 22 provided with tongs 23 for firmly gripping said projection 21. As illustrated in this figure, the weight 22 with its tongs 23 may be elevated into operative position by a table 24 on a piston 25 which works in the cylinder 26 of any suitable pneumatic, hydraulic or other hoist.

The table 24 is first elevated by the piston 25 to such a position that the tongs 23 grip the projection 21, after which the table 24 is withdrawn, leaving the weight 22 suspended from the projection 21 and constituting a drawing force tending to draw the blank through the extruding die 11. Pressure is then applied to the extruding punch 14 as in the method heretofore described and the blank 10 is extruded through the bore 13 of said die under the combined action of the pressure of the punch 14 on one end of the blank 10 and the pull of the drawing force on the other end of said blank. It is to be expressly understood that, while a projection 21 on the closed end wall of the blank 10 has been shown, any other suitable means may be employed for applying a drawing force to the blank to aid its passage through the die 11 under the extruding pressure. When a projection 21 is employed, it may be planed off after the tubular wall has been completed, leaving the end wall 17 integral with the tubular wall, if desired.

In making relatively thin tubular blanks for flexible corrugated tubular walls of nonferrous metals, such as copper and certain grades of brass, the extruding operation, or the combined extruding and drawing operation, is preferably carried out as a cold working operation, i. e. at a temperature not appreciably above atmospheric temperature. In the case of some metals, however, such as cupro nickel and steel for example, the extruding operation, or the combined extruding and drawing operation, may be performed upon a hot blank, i. e. one that has been heated to a temperature appreciably above atmospheric temperature.

A relatively thin tubular blank produced by the method heretofore described has its grain extending parallel to the axis of the tube whereas, as pointed out in my prior Patents No. 1,049,572 dated Jan. 7, 1913 and No. 967,010 dated Aug. 9, 1910, it is desirable to have the grain of the blank disposed at an angle to the axis of the tube so that the greatest strength of the metal approximates in direction the resultant of the forces to which the metal is subjected when in use. Therefore, I preferably subject the relatively thin extruded, or extruded and drawn, wall to a treatment whereby the grain is displaced angularly of the axis of the tube. Any suitable method may be employed to accomplish this result, the preferred procedure being to pass the blank through a drawing die while maintaining relative ro-

tation between the blank and the die, so as to uniformly displace the grain of the metal in the tubular wall while slightly reducing its thickness.

Any suitable apparatus may be employed for effecting the relative rotation of the blank and die as the former is drawn through the latter. One suitable apparatus for accomplishing this result is shown somewhat schematically in Figs. 4 and 5 wherein 30 designates the ram or punch holder of a press of any suitable construction, which ram or punch holder is appropriately reciprocated in the ways 31, as by the crank 32. The ram or punch holder 30, in the form shown, is composed of two sections (see Fig. 5), a main recessed body portion 33 and a recessed cover portion 34 which may be secured to the body portion 33 in any suitable way, as by the cap screws 35. Mounted in the ram 30 is a rotatable punch or mandrel holder 36 which is provided in the recess 37 with an enlarged portion 38 that carries, preferably integrally therewith, a bevel gear 39. Projecting beyond the bevel gear 39 is an extension 40 of reduced diameter which is received within and centered by a cylindrical recess 41 communicating with the main recess 37, said recess 41 constituting a bearing for the reduced end of the rotatable punch or mandrel holder 36. A ball bearing 42 of any suitable construction is also preferably interposed as a thrust bearing between the bevel gear 39 and the end of the recess 37. Meshing with the bevel gear 39 is a second bevel gear 43 on a short stub shaft 44 which projects laterally of the ram 30 and carries at its outer end a small pinion 45 which meshes with a rack 46 provided in any suitable way on one of the ways 31. The end of the punch or mandrel holder 36 which projects outwardly from the ram 30 is suitably constructed for attachment of a drawing punch or mandrel. In the form shown, the holder 36 is provided with a threaded recess 47 to receive the threaded end of the punch or mandrel 48, a screw 49 being employed to secure the mandrel fixedly within its holder. Mounted on the bed 50 of the press is a drawing die 51 of any suitable construction in alinement with the path of reciprocation of the mandrel 48.

A tublar blank 19 made in either of the manners heretofore described and of a thickness slightly in excess of that desired for the finished wall is mounted on the mandrel or punch 48 when the ram 30 is in its upper position and the press is then started to lower the ram and force the blank 19 on the mandrel 48 through the die 51. As the ram descends, the pinion 45 by coaction with the rack 46 rotates the stub shaft 44 whereby the bevel gear 43 rotates the bevel gear 39 and the holder 36 secured thereto. Therefore, the mandrel 48, together with the blank 19 supported thereon, is rotated at the same time that it is moved longitudinally, so that relative rotation is maintained between the blank and the die at the same time that the blank is moved longitudinally with respect to the die. The thickness of the tubular wall of the blank is thereby slightly reduced while, at the same time, the metal in said tubular wall is displaced angularly so that the grain of the metal is displaced helically as shown diagrammatically by the dotted lines 52 in Fig. 6. When the blank has been passed through the die 51 it may be removed from the mandrel 48 so as not to be subjected to the action of the die as the mandrel is rotated reversely and withdrawn through the same, or any suitable means may be interposed in the train of gearing for rotating the holder 36 so that withdrawal of the mandrel is not accompanied by rotation of the same.

By suitably proportioning the gearing in the train for rotating the mandrel 48, the extent to which the blank is rotated as it is moved through the die 51 may be proportioned to so displace the grain of the tubular wall that said grain will lie at the desired angle to the axis, whereby it will approximate in direction the direction of the resultant of the forces to which the flexible wall is subjected when in use—an angularity which will vary with the different uses to which a wall of this character is applied.

While the present invention is not limited to the above described method of displacing the grain angularly of the axis of the tube, this method possesses the advantage that the grain is uniformly displaced throughout the length and circumference of the tube so that it lies at the same angle to the axis throughout the tubular wall. Thereby this method of procedure possesses a marked advantage over the method disclosed in my Patent No. 1,049,572 above referred to, because in a tube produced by the method of my prior patent the grain lies parallel to the axis of the tube along two lines diametrically disposed with respect to each other, while in the neighborhood of these lines the angularity of the grain with respect to the axis is relatively small and gradually increases to lines 90° removed from the aforesaid lines. The present method, on the other hand, displaces the grain at a substantially uniform angle throughout the tubular wall of the blank, and this angularity of the grain can be controlled by proportioning the extent of rotation to the extent of longitudinal movement of the blank so that the direction of maximum strength of the metal may approximate the direction of the resultant forces to which the same is subjected.

The relatively thin extruded, or combined extruded and drawn, wall, with its grain

preferably displaced angularly of the axis of the tube as just explained, is then provided with relatively deep or flexible corrugations to render the same flexible in the direction of its axis. The corrugating operation may be carried out in any suitable way, as by the method disclosed in my prior Patent No. 971,838 dated October 4, 1910 or by the method disclosed in the application filed by Jean V. Giesler and myself Serial No. 390,981 dated June 22, 1920. A flexible corrugated tubular wall produced by the process heretofore described is diagrammatically illustrated in Fig. 7, said wall also being shown as provided with a closed end wall and a relatively thick attaching end flange both formed integrally with the tubular wall as heretofore described.

It will therefore be perceived that a method of making flexible corrugated tubular walls has been provided whereby the tubular wall is no longer composed of a plurality of zones which have been subjected to different degrees of cold working and different conditions of annealing so that they possess different physical characteristics. Moreover, a relatively thin tubular wall is produced in a single operation and, as said wall has a substantially uniform thickness throughout, it is no longer necessary to subject said wall to a drawing operation to eliminate the taper in the wall which has been produced by the practice of the method heretofore employed. At the same time, the forcing of the metal through the die by the process of extrusion compacts and densifies the same so as to substantially eliminate the likelihood of elongated blow holes or gas pockets which become lines of weakness in the completed structure. The present process also enables the provision of a closed end wall, or a relatively thick attaching flange, or both, integrally with the tubular wall without causing lines of weakness where the tubular wall joins said end wall or attaching flange while, on the other hand, the extra operations heretofore required in order to supply a flexible wall with a closed end wall or relatively rigid attaching flange are avoided.

A method has also been provided whereby the grain of a relatively thin tubular wall may be displaced angularly of the axis of the tube, and at substantially uniform angle throughout the tubular wall. While this method has particular utility when applied to displacing the grain of a tubular wall formed by extrusion or by the combined action of extrusion and drawing, it is to be expressly understood that this method of displacing the grain is equally applicable to other tubular walls where it is desired to displace the grain at an angle to the axis of the tube and it is therefore to be expressly understood that it is within the contemplation of the present invention to apply this method to displacing the grain in tubes which have not been produced by extrusion whether with or without the assistance of a drawing force. It is also to be expressly understood that this method is not limited to the use of the apparatus heretofore described for causing relative rotation between the blank and the drawing die, as the present invention contemplates the use of any suitable means whereby relative rotation is effected between the blank and die as the same are moved axially with respect to each other.

While preferred embodiments of the present invention have been described with considerable particularity, it is to be expressly understood that the invention is not restricted thereto, as the invention may be carried out in a variety of ways some of which will now readily suggest themselves to those skilled in the art. Reference is therefore to be had to the appended claims for a definition of the limits of the invention.

What is claimed is:—

1. The method of making a flexible corrugated tubular wall which includes extruding a blank through a die to form a tubular wall of substantially uniform thickness and physical characteristics and of the relative thinness suitable for use in a corrugated wall which is highly flexible in the direction of its axis, and forming flexible corrugations in said tubular wall to render the same hghly flexible in the direction of its axis.

2. The method of making a flexible corrugated tubular wall which includes extruding a blank through a die to form a relatively thin tubular wall, applying a drawing force to said blank which of itself is insufficient to draw said tube to assist its passage through said die under the action of the force of extrusion, and forming highly flexible corrugations in said tubular wall.

3. The method of making a flexible corrugated tubular wall which includes extruding a blank through a die to form a relatively thin tubular wall, displacing the grain in said tubular wall at an angle to its axis without deforming and substantially reducing said wall, and then forming highly flexible corrugations in said tubular wall.

4. The method of making a flexible corrugated tubular wall which includes extruding a blank through a die to form a relatively thin tubular wall, applying a drawing force to said blank to assist its passage through said die, displacing the grain in the extruded tubular wall at an angle to its axis, and thereafter forming highly flexible corrugations in said tubular wall.

5. The method of making a flexible corrugated tubular wall which includes extruding

a blank through a die to form in a single operation a tubular wall having substantially the thickness suitable for forming highly flexible corrugations, and corrugating the tubular wall to render the same highly flexible in the direction of its axis.

6. The method of making a flexible corrugated tubular wall which includes extruding a blank through a die to form in a single operation a tubular wall having substantially the thickness suitable for forming highly flexible corrugations, subjecting said blank to a drawing force simultaneously with the extruding operation, and corrugating the tubular wall to render the same highly flexible in the direction of its axis.

7. The method of making a flexible corrugated tubular wall which includes extruding a blank through a die to form in a single operation a tubular wall having substantially the thickness suitable for forming highly flexible corrugations, subjecting the extruded tubular wall to treatment to displace its grain angularly of its axis, and thereafter corrugating the tubular wall to render the same flexible in the direction of its axis.

8. The method of making a flexible corrugated tubular wall which includes extruding a blank through a die to form in a single operation a tubular wall having substantially the thickness suitable for forming highly flexible corrugations, simultaneously subjecting said blank to a drawing force, working the tubular wall to displace its grain at an angle to its axis, and thereafter corrugating the tubular wall to render the same highly flexible in the direction of its axis.

9. The method of making a flexible corrugated tubular wall which includes forming a relatively thin tubular wall, moving said wall through a die while causing relative rotation between said wall and die to displace the grain at an angle to the axis of said wall without substantially thinning said wall, and thereafter corrugating said tubular wall to render the same flexible in the direction of its axis.

10. The method of making a flexible corrugated tubular wall which includes extruding a relatively thin tubular wall, displacing the grain in said tubular wall by passing the same through a die while causing relative rotation between said wall and die, and thereafter corrugating said tubular wall to render the same flexible in the direction of its axis.

11. The method of making a flexible corrugated tubular wall which includes simultaneously extruding and drawing a relatively thin tubular wall, displacing the grain in said wall by passing the same through a die while causing relative rotation between said wall and die, and thereafter corrugating said tubular wall to render the same flexible in the direction of its axis.

12. The method of making a flexible corrugated tubular wall which includes forming a relatively thin tubular blank with the grain of the metal extending parallel to its axis, displacing the grain angularly by moving said blank through a die while causing relative rotation between said blank and die, and then forming flexible corrugations in the tubular wall of said blank.

13. A relatively thin extruded tubular metal wall having relatively deep corrugations therein to render the same highly flexible in the direction of its axis.

14. A relatively thin extruded tubular metal wall having relatively deep corrugations therein to render the same highly flexible in the direction of its axis, and an end wall integral with said tubular wall.

15. A relatively thin extruded tubular metal wall having relatively deep corrugations therein to render the same highly flexible in the direction of its axis, and an end flange integral with and of greater thickness than said tubular wall.

16. A relatively thin extruded tubular metal wall having its grain uniformly displaced at an angle to its axis and provided with relatively deep corrugations to render the same highly flexible in the direction of its axis.

17. In a method of making flexible corrugated tubular walls, uniformly displacing the grain angularly of the axis of a relatively thin tubular wall without substantially thinning the same by forcing said wall through a die while producing relative rotation between said wall and die, and then forming flexible corrugations in said tubular wall.

18. The method of making a flexible corrugated tubular wall which includes elongating and thinning the tubular wall of a tubular blank by an extruding operation, displacing the grain in said tubular wall at an angle to its axis, and thereafter corrugating the tubular wall to render the same flexible in the direction of its axis.

19. The method of making a flexible corrugated tubular wall which includes forming a relatively thin tubular blank with the grain of the metal extending parallel to its axis, angularly displacing the grain to a uniform extent throughout said tubular wall in conformity with the probable angularity of the resultant of the forces to which the wall is to be subjected, and forming flexible corrugations in the tubular wall of said blank.

20. The method of making a flexible corrugated tubular wall which includes forming a relatively thin wall by an extruding operation, working the metal in said tubular wall to displace its grain uniformly and

angularly of the axis of said wall, and thereafter forming flexible corrugations in said tubular wall.

21. The method of making a flexible corrugated tubular wall which includes forming a relatively thin wall by an extruding operation, while simultaneously subjecting said blank to a drawing force, working the metal in said tubular wall to displace its grain uniformly and angularly of the axis of said wall, and forming flexible corrugations in said tubular wall.

In testimony whereof I have signed this specification.

WESTON M. FULTON.