

Feb. 12, 1929.

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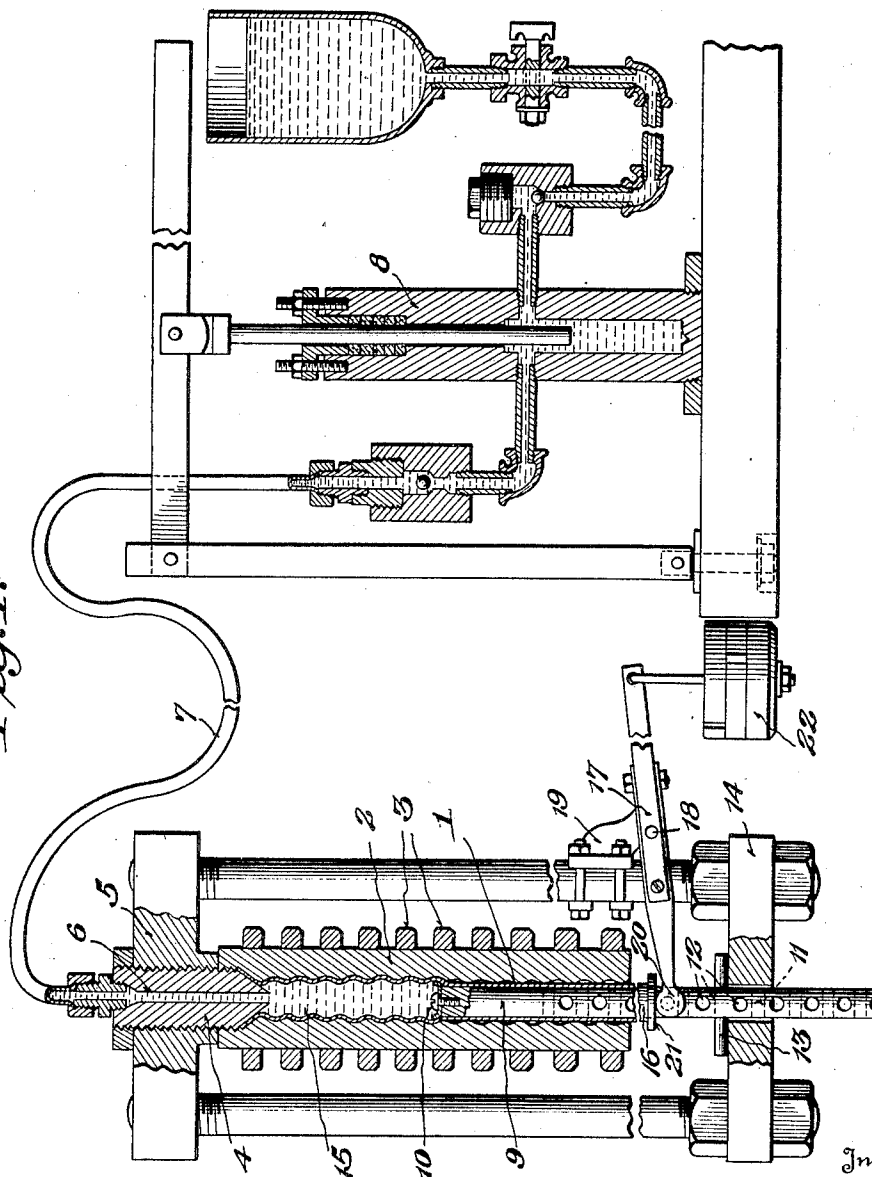
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METHOD AND APPARATUS FOR MAKING FLEXIBLE TUBULAR WALLS

Filed Dec. 6, 1924

4 Sheets-Sheet 1

Fig. 1.



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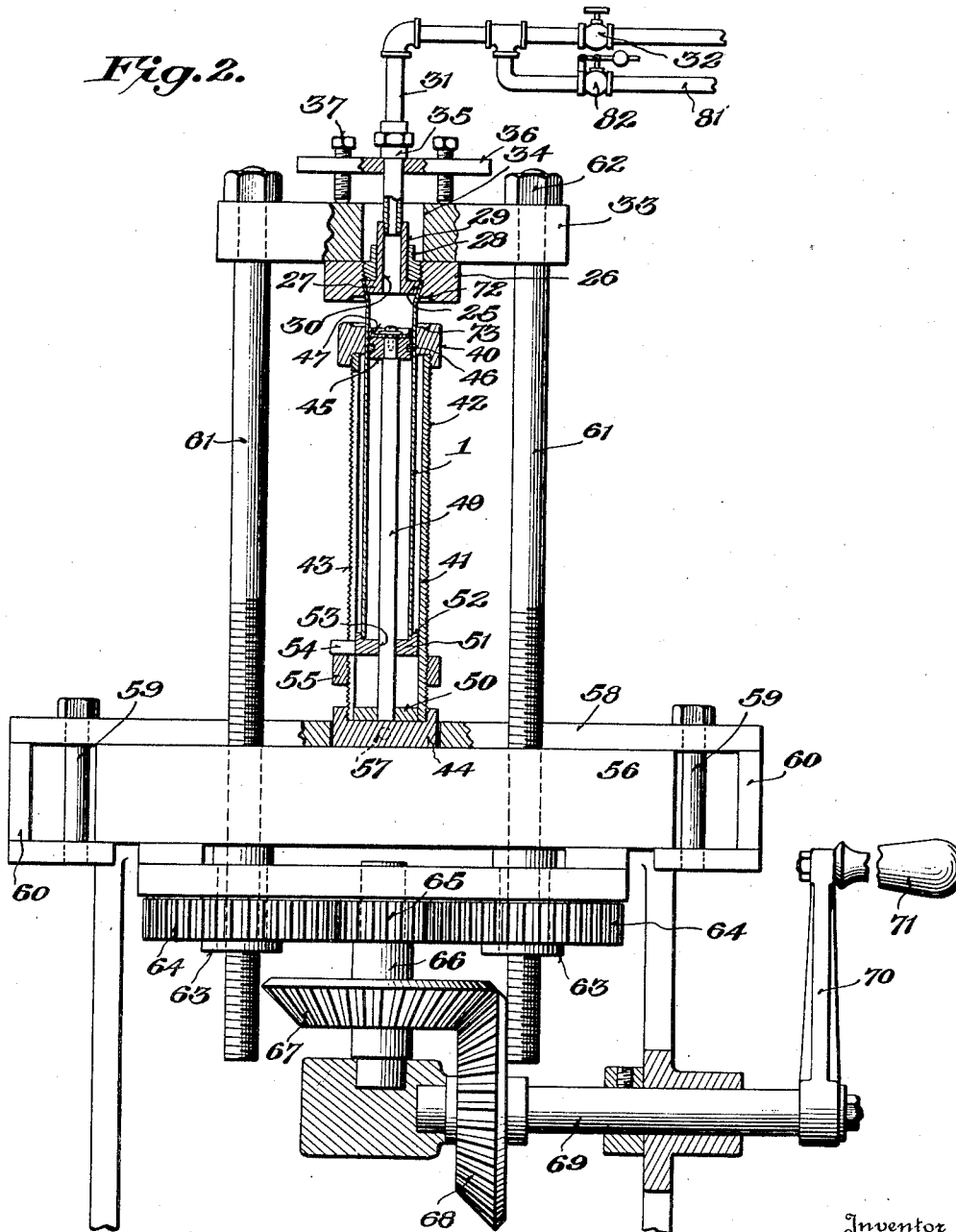
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METHOD AND APPARATUS FOR MAKING FLEXIBLE TUBULAR WALLS

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4 Sheets-Sheet 2



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4 Sheets-Sheet 3

Fig. 3.

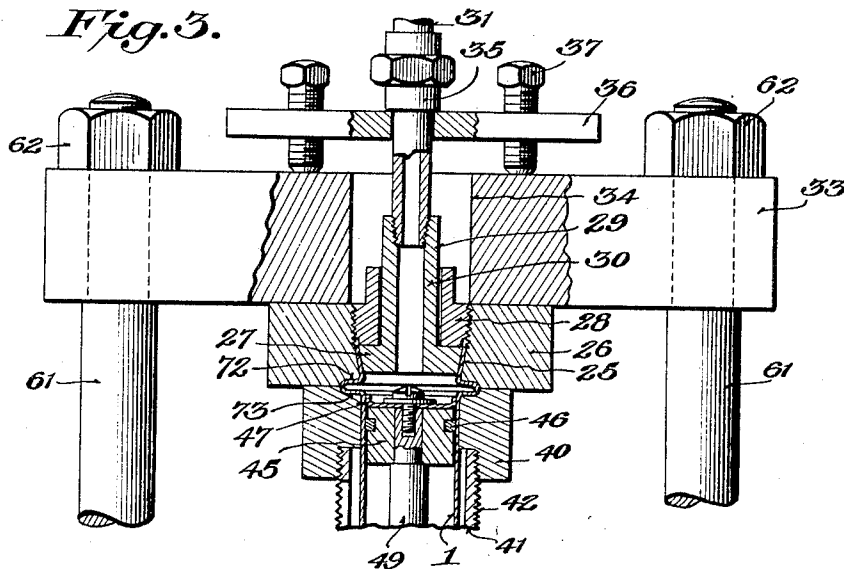
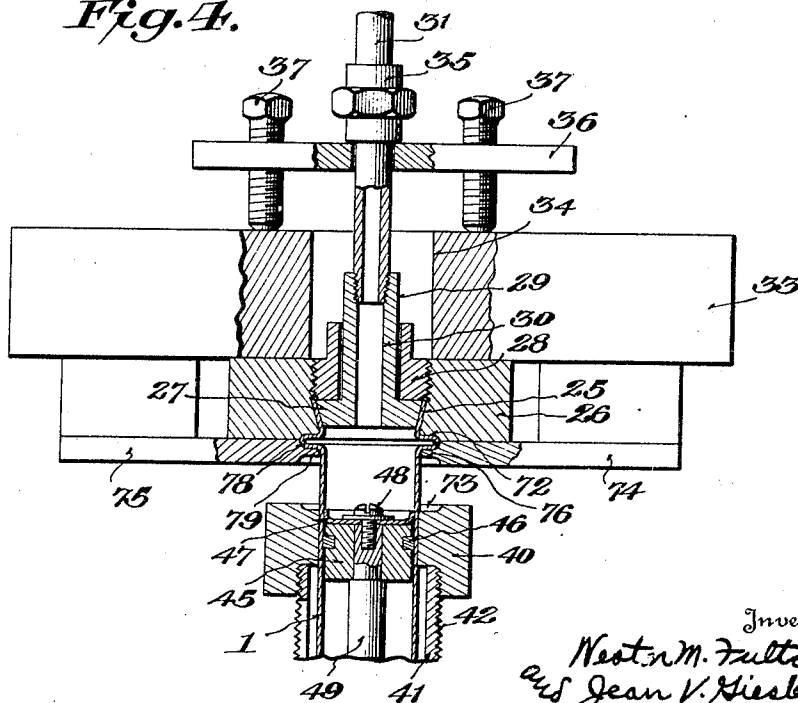


Fig. 4.



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METHOD AND APPARATUS FOR MAKING FLEXIBLE TUBULAR WALLS

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4 Sheets-Sheet 4

Fig. 6.

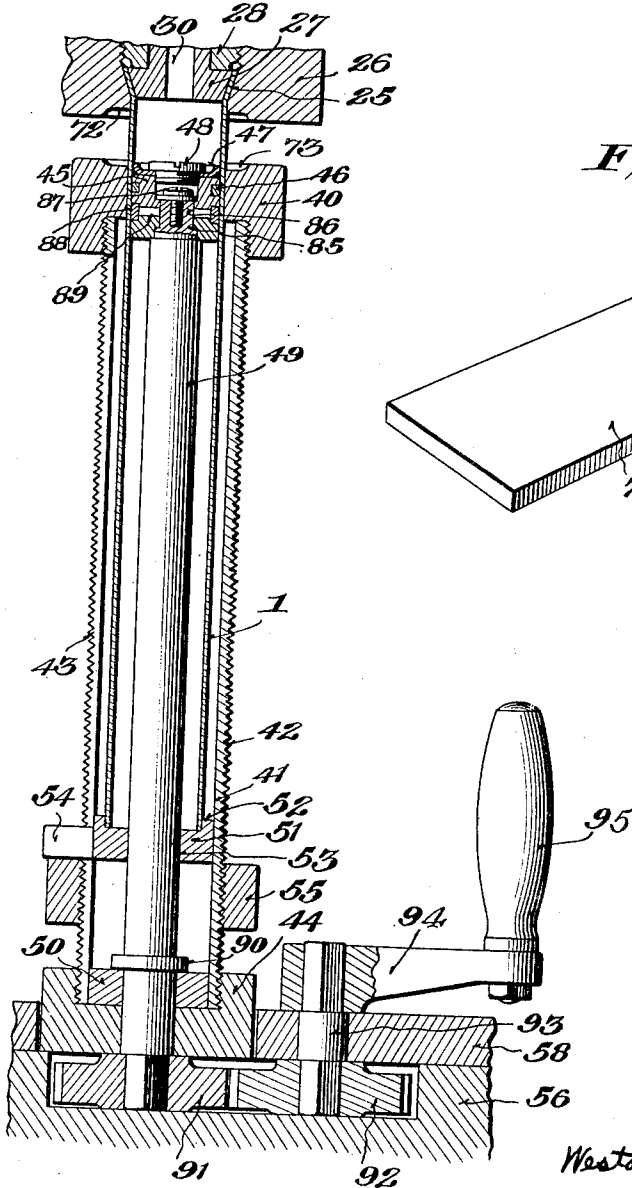
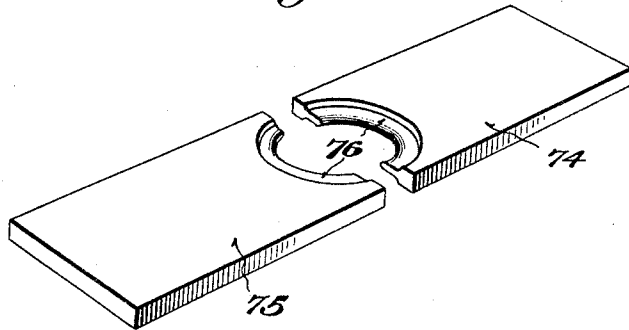


Fig. 5.



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UNITED STATES PATENT OFFICE.

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METHOD AND APPARATUS FOR MAKING FLEXIBLE TUBULAR WALLS.

Application filed December 8, 1924. Serial No. 754,444.

This invention relates to relatively-thin, flexible, tubular corrugated walls and more particularly to methods and apparatus used in their manufacture, this application being
5 in part a continuation of our application filed June 22, 1920, for method of making flexible corrugated tubular walls, for which Patent No. 1,522,051 was granted on January 6, 1925.
10 Corrugated walls have heretofore been manufactured by various mechanical methods, such as by stamping, spinning, rolling, the use of expanding dies, etc. These methods however, owing to the character of the
15 treatment of the wall by the mechanical elements engaging the same, have resulted to a greater or less extent in an undesirable stretching and thinning of the material of the wall. These methods, then, have not only produced
20 a corrugated wall the thickness and strength of which are not uniform, but also have tended to develop weak spots in the material of the wall which rupture prematurely. It is an object of this invention to provide a
25 method and apparatus for making flexible corrugated tubular walls which substantially avoid undesired, or all, stretching and thinning of the wall such as is characteristic of mechanical methods heretofore employed.
30 It has also been suggested to corrugate walls by forcing the wall by hydrostatic pressure into a corrugated die or form. If the wall has been held against longitudinal displacement during the pressing operation,
35 the formation of the corrugations has been attended by an undue stretching and thinning of the material as much or more than in the mechanical methods heretofore discussed. Similarly, if the wall has been sub-
40 jected to hydrostatic pressure throughout its extent at the surface to be corrugated, a similar result has been obtained because the application of equal force on each side of the respective ridges in the die has dis-
45 placed the material of the wall transversely without permitting a corresponding longitudinal movement thereof. It is an object of this invention to provide a method and apparatus for making flexible corrugated
50 tubular walls employing transverse pressure which substantially avoid undesired, or all, stretching and thinning of the wall such as has been attendant on the aforesaid methods employing hydrostatic pressure.

It has also been suggested in the manu- 55
facture of tubular corrugated walls to position the wall in operative relation to a corrugated tubular die, position opposed plungers in the tube so as to protect from hydrostatic pressure all but a small portion of the wall, 60
and subject the exposed portion of the wall to hydrostatic pressure while moving one or both of the plungers axially of the tube to progressively expose fresh portions of the wall to the hydrostatic pressure. This 65
method has been productive of corrugated walls wherein the material has been stretched and thinned to a less extent but has not entirely overcome the undesirable stretching and thinning of the material because, for 70
the material to flow into each corrugation of the die as it is subjected to the hydrostatic pressure, the uncorrugated portion of the wall must move axially with freedom, 75
whereas it has frictional engagement with the die and the plunger or plungers, whereby free movement of the uncorrugated portion of the wall is opposed, with a resultant undesirable stretching and thinning of the material. Moreover, as the hydrostatic pressure 80
must be increased with the increase in thickness of the wall and as the friction increases with the hydrostatic pressure, experience has demonstrated that with an increase of thick- 85
ness of the wall the tendency to effect an undesirable stretching and thinning of the wall has also increased. It is an object of this invention to provide an apparatus and method for making flexible corrugated tubular walls by progressively subjecting the 90
wall to transverse pressure while avoiding undesired, or all, stretching and thinning attendant on the methods heretofore employed.
It has also been suggested to corrugate tubular walls by subjecting the wall to end 95
pressure while the tube is filled with a liquid. This method has effected the corrugations by subjecting the material of the wall to a crushing or buckling pressure, the contained liquid constituting a variable counter-die 100
that prevents collapse of the wall other than into the corrugations of the forming die. This method of procedure, however, is defective when applied to relatively thin walls be- 105
cause the subsection of relatively thin material to only a buckling or crushing pressure not only tends to cause buckling in the weaker portions of the wall but also is pro-

ductive of what is known in the art as "body wrinkles", which cannot afterward be removed. It is an object of this invention to provide an apparatus and method for making flexible corrugated tubular walls wherein pressure is applied to the wall longitudinally to aid the formation of the corrugations but under such conditions as do not tend to produce buckling or the formation of "body wrinkles".

Another object of this invention is to provide an apparatus for making flexible corrugated tubular walls by the combined action of forces of bending and compression, or forces acting radially and axially of the tube.

A further object of this invention is to provide an apparatus for making flexible corrugated tubular walls using fluid pressure wherein predetermined sections of a tube are successively subjected to simultaneous radial and axial forces to effect the formation of the corrugations one at a time, desirably between relatively movable die elements.

Another object of the invention is to provide a method and apparatus for making flexible corrugated tubular walls wherein relatively-deep, narrow corrugations, preferably having their sides at substantially right angles to the axis of the tube, are formed in one operation by the simultaneous action of radially and axially acting forces, if desired the corrugations so formed being subsequently treated to render their bends of the desired resilience.

A further object of the invention is to provide a method of making a flexible tubular corrugated wall which is of substantially uniform thickness throughout, and the thickness or superficial area of which is substantially the same as the thickness or superficial area of the blank from which the wall is formed, or the thickness may be increased or the superficial area may be decreased with respect to said blank.

A further object of this invention is to provide a method and apparatus for making flexible tubular corrugated walls wherein all stretching of the metal may be avoided if desired, or stretching to the desired extent effected, and wherein the axially acting pressure or the radially acting pressure, but preferably both, may be gradually applied so as to effect the formation of the corrugations without undesired or any stretching and thinning of the material of the wall.

Other objects relate to the provision of a method and apparatus for manufacturing flexible tubular corrugated walls which are simple and rapid in operation, which enables tubes of any suitable length to be provided with corrugations of any suitable character, and which are economical and efficient in service.

Broadly, the invention includes an apparatus for making flexible corrugated tubular walls wherein the wall is subjected to separate but simultaneous transverse and longitudinal forces so as to form the corrugations by transverse pressure while applying a longitudinal force to the wall to aid the flow of the material into the corrugations of the die; also a method and apparatus whereby either, but preferably both, of said forces may be separately applied and gradually increased, so as to maintain such a relation of the forces as to prevent any stretching or thinning of the material of the wall, or only stretching and thinning of said material to a predetermined extent; also a method and apparatus for corrugating a wall by intermittently exposing successive portions of said wall to said forces, preferably between relatively movable die elements, to form corrugations therein one at a time; also a method and apparatus for forming in one operation, by the combined action of radially and axially acting forces, relatively-deep, narrow corrugations, preferably having their lateral walls at substantially right angles to the axis of the tube, and if desired, subsequently treating said corrugations to render them resilient to the desired extent. The invention also includes a method of making a flexible tubular corrugated wall which is of substantially uniform thickness and has its superficial area substantially the same as or less than the superficial area of the blank from which it was formed, or its mean thickness substantially the same as or greater than the mean thickness of the blank from which it was formed, as well as the flexible tubular corrugated wall so produced.

The invention is capable of receiving a variety of mechanical expressions and of being carried out in a variety of ways, some of which are illustrated on the accompanying drawings, but it is to be expressly understood that the selected exemplifications are for the purpose of illustration only and are not to be construed as a definition of the limits of the invention, reference being had to the appended claims for that purpose.

Referring in detail to the drawings wherein the same characters of reference are employed to designate corresponding parts in the several figures,

Fig. 1 is a more or less diagrammatic view of suitable apparatus for carrying out the present invention;

Fig. 2 is a more or less diagrammatic view of a second apparatus for carrying out the present invention;

Fig. 3 is an enlarged fragmentary view corresponding to Fig. 2 but illustrating the position of the parts after one corrugation has been formed in the tubular wall;

Fig. 4 is a corresponding view illustrating the position of the parts when a second corrugation is about to be formed in the tubular wall;

5 Fig. 5 is a perspective view of the elements which are moved into position to protect the formed corrugations and constitute a die element in the formation of a succeeding corrugation; and

10 Fig. 6 is a detail view illustrating means for clamping a tube in one of the die elements when a predetermined stretching of the material is desired.

In accordance with the present invention, 15 the wall to be corrugated, which may be of any suitable thickness and of a wide variety of shapes, is mounted in operative relation to a suitable die or form. In the construction shown in Fig. 1 a tubular wall 1 is 20 positioned in operative relation to a tubular corrugated form or die 2 which may conveniently be made in halves and the halves clamped firmly together by a plurality of rings 3 driven on to the tapered external 25 surface of the form or die 2. One end of the wall is suitably clamped fixedly in the die, as by a threaded tapered plug 4 which has threaded engagement with both the die 2 and the frame work 5. Said plug is 30 shown as provided with a passage 6 with which communicates suitable piping 7 leading from any suitable apparatus for developing pressure, such as the pump diagrammatically illustrated at 8 for developing 35 hydrostatic pressure, this term being used as generic to the application of pressure by the use of oil, water, or any other suitable fluid. It is to be expressly understood, however, that the apparatus shown for developing 40 pressure is to be taken as typical of any suitable means for supplying pressure to effect the corrugating of the wall.

Mounted within the tubular wall 1 in the form shown, is a piston or plunger 9 provided with a suitable packing 10 to prevent 45 the leakage of fluid between said plunger and the wall of the tube. The rod or stem 11 of said plunger is shown as provided with a plurality of apertures 12 which are spaced 50 by distances equal to the spacing of the ridges of the form or die 2. A pin 13 is adapted to be inserted in the respective apertures 12 and to coact with the base 14 of the frame to predetermine the position of 55 the plunger 9 and prevent the pressure within the confined space 15 from forcing the plunger beyond its predetermined position. The illustration of the pin 13 insertible in the apertures 12 for cooperation with frame 60 14 is to be taken, however, as merely typical of any suitable device for indexing or predetermining the extent of movement of the plunger 9 each time a fresh portion of the wall is to be exposed to the hydrostatic pressure. 65

Cooperating with the free end of the tube 1 is any suitable means employing weight, spring, hydraulic, pneumatic or other pressure for exerting a longitudinal force on said wall to overcome frictional opposition 70 to longitudinal movement thereof and insure that the wall shall move longitudinally and flow freely into the corrugations of the die under the transverse pressure exerted thereon. In the form shown, a collar 16 is 75 mounted freely on the rod or stem 11 of the plunger 9 so as to engage the lower end of the tubular wall 1, and means of any suitable construction are provided to exert a predetermined axial pressure on said collar 16 80 and wall 1. The apparatus illustrated comprises a lever 17 pivoted at 18 on a bracket 19 projecting from the frame and formed at its inner end as shown at 20 to engage a 85 flange 21 on the collar 16. The other end of the lever carries a weight 22 which may be varied predeterminedly. It is to be understood, however, that the weight is only shown as typical of any suitable means for exerting 90 a force of compression on the wall 1.

To corrugate a tubular wall in the apparatus so far outlined, the wall is clamped in the die or form 2 by the plug 4 and the plunger 9 is inserted into said wall until only that 95 portion of the wall overlying the uppermost corrugation of the die is exposed within the confined space between the plug 4 and the plunger 9. The plunger is retained in this position by insertion of the pin 13 in the aperture 12 which is flush with the surface 100 of the base 14, the frame being adjusted if necessary to properly position the aperture with respect to the frame. Collar 16 being engaged with the free end of the tube 1 and weight 22 applied, hydrostatic pressure is 105 admitted to the confined space between plug 4 and plunger 9, the pump illustrated providing means for gradually applying and increasing this pressure, and the wall is forced 110 into the corrugation or inter-ridge space of the die by the combined action of the hydrostatic pressure acting radially and the pressure of the weight acting axially or longitudinally of the tube, the uncorrugated 115 portion of the wall slipping over the plunger and die to supply the material which forms the corrugation. The pin 13 is then withdrawn from its aperture and introduced into the next adjacent aperture. Hydrostatic pressure is then again admitted to the 120 confined space between the plug and plunger and its first operation is to move the plunger until the plunger is displaced by the predetermined amount which is represented by the spacing of the aperture 12 and which 125 conforms with the spacing of the ridges or corrugations of the die. When the pin 13 engages the base 14 the plunger can be displaced no further and the hydrostatic pressure is increased to force the wall into the 130

next corrugation of the die under the combined action of the bending and compression forces. This procedure is repeated, alternately predetermining the extent of displacement of the plunger and forming the corrugations by the combined action of the radially and axially acting forces until the entire wall has been progressively corrugated by intermittent application of pressure.

During the formation of these corrugations the longitudinal force exerted on the wall 1 tends to compress said wall into the corrugations of the die and aids the transverse pressure or bending force in forming the corrugations. The quantity of force exerted longitudinally of the wall can be varied considerably in accordance with the nature of the wall being operated upon. It should be less than the strength of the material of the wall to resist crushing or buckling so as to insure against any tendency to buckling or the formation of "body wrinkles", while on the other hand, it should be at least as great as the frictional opposition to movement of the wall longitudinally of the die so as to insure that the wall shall flow freely under the transverse bending pressure and prevent any undesirable stretching and thinning of the material of the wall. By selecting a longitudinal force between these extremes the formation of the corrugations under the transverse bending pressure is greatly facilitated and this longitudinal force may be selected of such a value as to enable the formation of the corrugations by hydrostatic pressure much less than would be necessary if the longitudinal forces were not employed. In fact, it has been found from experience that, particularly in the manufacture of relatively thick corrugated tubes of small diameter, the hydrostatic pressure may be reduced as much as seventy-five percent (75%) or more when applying longitudinal force to the wall, and at the same time a wall of more uniform thickness be obtained than when using the higher hydrostatic pressure in the absence of longitudinal force.

The method heretofore described of corrugating walls may be employed to form the final or relatively-deep, narrow corrugations in the wall in the first instance, or it may be employed for the formation of initial corrugations in the wall as illustrated, and the corrugations thereafter deepened by similar or other suitable corrugating operations. In the preferred practice of this invention the initial corrugations formed by the above described method are deepened and narrowed by one or more rolling operations, such for example as described in Fulton Patent No. 971,838, granted Oct. 4, 1910, so as to work resilience to the desired extent into the bends of the

corrugations. This rolling method may also be employed to complete corrugated walls which are formed by hydrostatic pressure alone whether with or without the application of a longitudinal force.

In the embodiment shown in Figs. 2 to 5 inclusive, the tube 1, which may be of any suitable length, size, shape, etc., is suitably clamped at its end 25 in a die element 26 by means of a tail-piece 27 which is tapered to clamp the tube end 25 against a correspondingly tapered surface in the die element 26, said tail-piece 27 being retained in clamping position by means of an annular nut 28 which surrounds the stem 29 of the tail-piece and engages interior threads on the die element 26. A passage 30 extends through said tail-piece 27 and communicates through a pipe 31 with any suitable source of pressure, such as a pump as diagrammatically illustrated in Fig. 1 or an accumulator, whereby any suitable liquid or gas under pressure may be admitted through the pipe 31 and passage 30 to the interior of the tube 1. A valve 32 is interposed in the pipe 31 at a suitable point in order to control the time and extent of application of the pressure as hereinafter explained.

Die element 26 with its tail-piece 27 is supported in any suitable way, being shown as attached to a yoke member 33 provided with a centrally arranged aperture 34 through which the pipe 31 communicates with the passage 30 in said tail-piece. Pipe 31 is provided in any suitable way, in the construction illustrated, with a collar 35 against which abuts a strap 36, and a plurality of screws 37 threaded through said strap 36 engage the face of the yoke member 33 to clamp the die element 26 and parts carried thereby fixedly in position. By tightening the screws 37 the strap 36 can be forced against the collar 35 so as to hold the die element 26 firmly and tightly in unitary relation with the yoke member 33.

Cooperating with the die element 26 is a second die element 40 which is mounted on an upstanding tubular support 41 provided with exterior threads as shown at 42. Said tubular support is provided with one or more longitudinally extending slots 43 for a purpose to be explained, and at its lower end said tubular support is threaded into a supporting member 44. Axially arranged within said tubular support 41 is a piston 45 provided with one or more suitable packing rings 46 and a cup leather 47 suitably attached thereto as by a screw 48. Piston 45 is supported by a rod 49 which extends axially of the tube 41 and is suitably supported in the supporting member 44, as by an annular block 50 which fits the interior of the tubular support 41 and the exterior of the end of the piston rod 49. Said piston

with its packing ring and cup leather, however, is to be taken as typical of any suitable means for providing a fluid-tight joint with the interior of the tube in radial alignment with the die element 40. The piston 5 45 is thereby fixed in position with respect to the die element 40 with the tube 1 projecting within the tubular support 41 between said piston 45 and the die element 40, 10 said piston forming a fluid-tight joint with said tube.

The lower end of the tube 1 is received in a thrust element 51 which is provided with a peripheral upstanding collar 52 to guide 15 the end of the tube. Thrust element 51 fits slidably within the tubular support 41 and has a central aperture 53 through which the piston rod 49 extends. Said thrust element 51 also has one or more radially projecting 20 lugs 54, corresponding in number with the slots 43, which project through said slots and cooperate therewith to prevent rotation between said thrust element and tubular support while permitting relative axial 25 movement thereof. Mounted below said thrust element 51 on the tubular support 41 is an annular nut 55, threaded on the threads 42 of said tubular support and adapted to be brought into contact with the lug or lugs 30 54 of the thrust element 51 to constitute an abutment therefor during the formation of the corrugations as will be explained hereinafter. The supporting member 44 is 35 mounted in any suitable way on a plate 56, the same being shown as removably retained in position, as by a set screw 57, in an aperture in a strap piece 58 which is clamped to the face of said plate 56 in any 40 suitable way, as by means of bolts 59 and spacing pieces 60.

The yoke member 33 and plate 56 are so arranged that one may be moved with respect to the other in the direction of the 45 axis of the tube 1 so that an axial thrust may be exerted on said tube to apply a force of compression longitudinally of the same. In the form shown, the yoke member 33 is the movable member, and is mounted on a pair of screw threaded rods 61, being 50 suitably retained thereon as by nuts 62. Said screw threaded rods pass through apertures in the plate 56 and on the opposite side of said plate cooperate with nuts 63 which are suitably provided, preferably integrally 55 therewith, with surrounding gears 64 of equal size. The two gears 64 mesh with an intermediate gear 65 mounted on a stub-shaft 66 which is suitably journaled in the frame of the machine and carries a beveled 60 gear 67 that meshes with a second beveled gear 68 on an operating shaft 69. In the form shown said shaft 69 is provided with an operating crank 70 terminating in a handle 71 whereby the axial pressure or 65 thrust to be exerted on the tube 1 may be

applied by hand, and the time and extent of application of such forces thereby left to the skill of the operator. It is to be understood, however, that the shaft 69 may be operated in any other suitable way and 70 the crank 70 is therefore to be taken as typical of any suitable apparatus for controlling the application of axial force to the tube so that the said force may be gradually 75 applied to the tube in the manner herein-after described. When the crank 70 is rotated, the gears 68, 67, 65 and 64 cause simultaneous and equal rotation of the nuts 63, and the two threaded rods 61 are thereby 80 caused to move simultaneously and equally to move the yoke member 33 toward or away from the plate 56, the former movement exerting a force of compression axially of the tube 1 which is abutted on the thrust piece 51 and clamped at its opposite end between 85 the die element 26 and the tail-piece 27.

The die element 26 and the die element 40 are suitably formed, as shown at 72 and 73 respectively, to constitute a die for a corrugation of the character to be formed, so 90 that when said die elements are brought into contact with each other, the two surfaces 72 and 73 together form a recess conforming with the shape of the corrugation to be made, as shown in Fig. 3. This corruga- 95 tion is preferably made of final depth and width at one operation, i. e. it is made as a relatively-deep, narrow corrugation having lateral sides which are at substantially right angles to the axis of the tube, as illustrated 100 in Fig. 3.

Also mounted on the machine in any suitable way, preferably so that they can be moved rectilinearly into and out of operative position, are a plurality of pairs of 105 plates 74 and 75 which are shaped at their adjacent ends, as shown in Fig. 5, so that when brought into endwise engagement the abutting ends form a circular opening into which projects a circular rib 76 which exactly corresponds with the shape of the 110 space to be left between two outwardly directed corrugations. In other words, as shown in Fig. 4, the formed surface 78 on the upper face of said rib 76 mates with the 115 formed surface 72 on the die element 26 and completely and accurately encases the first corrugation, while the opposite formed surface 79 corresponds with the formed surface 72 on die element 26 and is in position to 120 cooperate with the formed surface 73 on die element 40 to form a second corrugation. As many pairs of die elements 74 and 75 are provided as there are corrugations to be formed in the tube 1 and after each cor- 125 rugation is formed a pair of these die elements is moved into operative position as shown in Fig. 4, where they become in effect a part of the die element 26 and not only protect the corrugation or corrugations 130

which are already formed from being deformed by subsequent operations, but also cooperate with the die element 40 to constitute dies for the succeeding corrugations to be formed.

In operation a tube 1 is mounted within the tubular support 41 with its upper end projecting between the die element 40 and the piston 45, the latter forming a fluid-tight joint therewith. Said end is clamped in the die element 26 by means of the tail-piece 27 and nut 28 so as to form a second fluid-tight joint between said die element and the end of said tube. Die element 40 and die element 26 are so spaced that the length of the tube 1 between the formed surfaces 72 and 73 exactly corresponds with the amount of metal which is to go into the first corrugation, this amount being determined in the manner to be explained, and the lower end of the tube 1 is engaged with the thrust element 51 with the nut 55 in abutting engagement therewith by rotating said nut on the tubular support 41.

Pressure is now admitted to the confined space within the tube 1 between the piston 45 and the tail-piece 27 by manipulation of the valve 32, the amount of pressure thus admitted to said confined space preferably being such as to place the metal of the wall 1 under a slight tension but without imposing any set or stretch therein such as would be produced if the pressure were sufficient to cause the tube 1 to bulge to any considerable extent. The pressure in said confined space is then gradually increased, as by manipulation of the valve 32, at the same time actuating the operating shaft 69 to exert an axial thrust on said tube through the yoke member 33 and die element 26. It is preferable to increase both of these pressures gradually and simultaneously, as experience has demonstrated that an application of the axial pressure without increase of the radial pressure exerted by the fluid tends to produce a buckling or wrinkling of the section of the tube between the die elements 26 and 40, while an increase of the radial pressure without application of the axial pressure tends to produce an undesirable stretching of the section of tube between said die elements. Experience has also demonstrated that the radial pressure should rise rather rapidly but gradually for approximately the first third of the time that the die element 26 is being moved toward the die element 40, after which the radial pressure may be and preferably is maintained substantially constant, and to this end a by-pass 81 is provided in communication with the inlet pipe 31 and includes an adjustable relief valve 82 of any suitable character so as to maintain a substantially constant predetermined pressure on the fluid in the confined space between

the piston 45 and the tail-piece 27 during the remainder of the operation. The axial pressure on said tube should also increase rather rapidly but gradually for approximately the first seventh of the time that the die element 26 is being moved toward the die element 40, and then should continue to increase more slowly for approximately the next three sevenths of this period, after which the axial pressure should remain substantially constant or even be slightly diminished during the remainder of the operation. As the metal of the tubular wall bends into corrugated shape its effective area at an angle to the axis of the tube is increasing, and this results in a gradual increase in the resistance to the movement toward each other of the lateral elements of the corrugation being formed, because of the increasing effective area upon which fluid pressure may act; hence there should be a gradual increase of the pressure longitudinally of the metal in order to cause it to flow into the space between the die elements 26 and 40 without an undesirable stretching of the metal. If the radial pressure is also increasing there is a consequent increase in the resistance of the movable elements toward each other which must also be taken into consideration.

The combined radial and axial pressures are applied until the die elements 26 and 40 come into contact with each other, at which time the formed surfaces 72 and 73 constitute a completed die for the corrugation, and during the approach of said die elements the metal of the tube between the same has under the combined action of the radial and axial forces been bent and compressed so that it flows into and assumes the corrugated form determined by the shape of the formed surfaces 72 and 73.

The first corrugation having thus been formed, the yoke member 33 with its die element 26 is backed off, pulling the tube 1 between the piston 45 and the die element 40 until a fresh section of the tube, equal in length to that formerly acted upon, is exposed between said die elements 26 and 40. Any suitable means, as a pawl and ratchet mechanism (not shown), may be provided for limiting the extent of the backward movement of the yoke member 33 or its actuating mechanism, so as to index the advancement of the tube and exactly position the die element 26 with respect to the die element 40 so that a predetermined length of tube is exposed between the same. A pair of die plates 74 and 75 are now moved into position to embrace the first corrugation between the formed surfaces 72 and 78 as illustrated in Fig. 4, and to present a pair of die surfaces 79 and 73 for the formation of the next corrugation. The advancement of the tube 1 by the backward movement of the yoke mem-

ber 33 has withdrawn the end of tube 1 from the thrust piece 51 or, if the latter fits snugly on the end of said tube, has withdrawn the thrust element 51 from contact with the nut

5 55. In either event the nut 55 is advanced by rotation on the tubular support 41 until the thrust element 51 and nut 55 constitute an abutment for the end of the tube 1 during the next application of axial pressure.
10 Radial pressure is again admitted to the confined space between the piston 45 and the tail-piece 27 and this pressure holds the first corrugation in contact with the formed surfaces 72 and 78 so that the subsequent ap-
15 plication of axial pressure does not cause a collapse or deformation of the corrugation already formed. As previously pointed out, this pressure should not be such as to cause any substantial stretching of the metal in
20 the portion of the tube about to be corrugated. The second corrugation is now formed in the manner heretofore described by the gradual application of increasing axial and radial pressures until the die elements are again brought into contact, after
25 which the movable die element is again backed off to the predetermined amount, a fresh pair of die plates 74, 75 are moved into position, and these operations repeated
30 until the entire tube or the desired portion thereof has been corrugated.

It is sometimes desirable to positively prevent slippage between the piston 45 and the tube 1, particularly when a predetermined
35 amount of stretching is to be given the tube during the formation of the corrugations. In the embodiment shown in Fig. 6 provision is made for thus positively clamping the tube 1 between the piston 45 and the die element
40 40. As here shown, the piston rod 49 is provided with an extension 85 which has a plurality of cam surfaces 86, the piston being shown as secured to the rod 49 by means of a screw and washer 87. The piston 45 carries
45 one or more clamping rings 88, and between said rings 88 and the cam surfaces 86 are a corresponding number of pins or lugs 89 which when actuated by the cam surfaces 86 exert a thrust on the clamping rings 88
50 and force the latter into clamping engagement with the tube 1.

The opposite end of the piston rod 49 is provided with a thrust collar 90 and is extended beyond the supporting member 44,
55 where it carries a pinion 91 secured thereon by spline or equivalent means. Pinion 91 is in mesh with a pinion 92 on a stub-shaft 93 which carries a crank 94 provided with a handle 95. By oscillating the crank 94 the piston rod 49 is rotated through the pinions
60 91 and 92 so as to actuate the cam surfaces 86 and either relieve or exert thrust on the pins 89 to respectively release the clamping rings or cause them to be forced into clamping
65 engagement with the tube 1.

In making flexible corrugated walls, it is highly desirable to maintain substantially uniform thickness of the metal and to prevent stretching of the metal or permit such stretching only to a predetermined amount. 70
In forming such corrugations there are three cases to be considered:—

1. Wherein the corrugations have the walls thinned to a predetermined amount by reason of a predetermined amount of stretching occurring in the metal during the formation of the corrugations. 75

2. Wherein the superficial area of the corrugations after they have been formed is substantially equal to the superficial area 80 of the tube in which the corrugations are formed and, the volume of metal being the same and the superficial area being the same, the mean thickness of the metal is therefore substantially the same after the
85 corrugating operation as it was before the corrugating operation. This is the preferred embodiment.

3. Wherein the metal of the wall is actually thickened during the formation of 90 the corrugations.

The present invention provides a method and apparatus for obtaining any one of these three conditions. Thus in the embodiment of Fig. 1, the axial pressure exerted 95 on the tube during the formation of the corrugations may be so selected with respect to the radial pressure that the superficial area of the resulting corrugations is substantially the same as that of the superficial 100 area of the tube in which the corrugations are formed, or the longitudinal elements of the corrugated tube may be made the same as the longitudinal elements of the tube in which the corrugations are formed, with
105 an attendant stretching of the metal circumferentially—which is the embodiment claimed in our aforesaid application of which this application is a continuation in part—or the axial pressure may be so
110 selected as to actually thicken the metal of the wall, while a wide variety of conditions within these three cases may obviously be obtained.

Any one of these three conditions may 115 also be obtained by use of the embodiment of the invention shown in Figs. 2 to 6 inclusive by predeterminedly spacing the relatively movable die elements between which the respective corrugations are formed. 120
Taking L as the distance between the points where the two formed surfaces 72 and 73 engage the tube 1 at the initial setting of the die elements 26 and 40, said dimension may be readily determined by equating the 125 superficial area of an outwardly directed corrugation, between parallel radially extending planes which pass through the centers of curvature of two successive inwardly directed bends, with the superficial area of 130

a cylinder of L length, and solving for L—in the case where the final superficial area is to be the same as the original superficial area; or by equating the volumes of metal using the predetermined thicknesses and solving for L—in the cases where a predetermined increase or decrease or equality in the mean thickness of the metal is desired.

From the dimension L, the predetermined spacing of the die elements 26 and 40 for the various cases can be readily determined, taking into consideration the depth in an axial direction of the formed surfaces which constitute the die; for example, where the sides of the corrugations are to be at substantially right angles to the axis of the tube and the radius of curvature is to be the same for the outer and the inner bends of the corrugations, the predetermined spacing of the die elements 26 and 40 is equal to L minus 4R, where R is the radius of curvature of said bends. In the cases where the superficial area of the resulting corrugations is to be no greater than the superficial area of the original tube, or the mean thickness of the corrugations is to be no greater than the mean thickness of the original tube, care must be exercised in applying the radial pressure so that it shall not be sufficient to unduly stretch the metal circumferentially while the axial pressure is being applied. In these cases the radial pressure should be little more, if any, than is sufficient to prevent the formation of body wrinkles, the axial thrust doing the major portion of the work in forming the corrugation; but as the extent of the pressure which is necessary to prevent the formation of body wrinkles will vary with the thickness of the tube and the length of the tube section exposed to the fluid pressure, the limit of the radial pressure to be used cannot be definitely stated. The extent to which the axial pressure is increased will also vary with the amount of radial pressure used, the thickness of the tube, etc., but must be such as to cause the metal to flow into the shape of the die.

When the corrugated tube is made in the apparatus of Figs. 2 to 6 inclusive, the corrugations may be, and preferably are, treated so as to obtain the desired distribution or amount of resilience in the walls of the corrugations. This treatment may be of any suitable character and carried out in any suitable way, as by rolling the bends of the corrugations. During these rolling operations the corrugations may be deepened and narrowed to a further extent if desired, or the shape and size of the corrugations may be left unchanged and the working of the metal effected by relative slippage of the rolls or otherwise. If desired, the process may be carried out with the wall raised above normal atmospheric temperatures so as to reduce the amount of resilience that is

imparted to the metal by the cold working operations incident to the formation of the corrugations.

It will therefore be perceived that a method and apparatus have been provided whereby a flexible corrugated tubular wall of any desired length may be formed without stretching or thinning of the metal, or by stretching the metal only to a desired extent, and which at the same time avoids the formation of body wrinkles in the metal of the wall. Moreover, the corrugating operation is effected by the simultaneous application of forces of bending and compression acting radially and axially of the tube, and means have been provided whereby these forces may be separately controlled and gradually applied. Means have also been provided whereby the corrugations may be formed one at a time and the formed corrugations may be protected against deformation during the formation of the subsequent corrugation, and said corrugations may be given any suitable conformation and made of final depth and width with their lateral sides at substantially right angles to the axis of the tube at one operation. At the same time a flexible corrugated tubular wall may be formed having the thickness or superficial area which is substantially the same or greater or less than that of the blank from which the wall is formed, and the dimensions and characteristics of the resultant wall may be accurately predetermined.

While the method of corrugating walls above described is shown as applied to the formation of corrugations from the interior of a tube, it is to be understood that the invention is applicable to the formation of corrugations from the exterior of a tube and, in fact, is not only applicable to the corrugating of tubular walls of any suitable cross section but also to the corrugating of nontubular walls of any suitable conformation. Furthermore, while the preferred practice of the invention embraces the progressive corrugating of the walls by intermittently subjecting successive portions thereof to the bending and compression forces, the invention is not limited thereto. Again, while the invention has particular utility in the formation of corrugations in relatively thin walls to provide walls which are readily flexible and suitable for use in diaphragms, temperature and pressure-responsive members, etc., it is also applicable to the formation of corrugations in relatively thick walls and, in fact, reduces the amount of pressure that must be exerted to form corrugations in relatively thick walls. The shape of the corrugations, their depths and widths may also be widely varied in conformity with the needs of the uses to which the finished wall is to be put and the functions to be performed. While the methods

of procedure and suitable apparatus for use therein have been described with considerable particularity, it is to be expressly understood that the invention is not limited thereto, for various changes may be made in the order and character of the steps of the process and in the details of construction, arrangement and proportion of the parts of the apparatus without departing from the spirit of this invention. Reference is therefore to be had to the claims hereto appended for a definition of the limits of the invention.

What is claimed is:—

1. The method of making flexible corrugated tubular walls which includes positioning a tube in operative relation to a die, and by the combined action of forces acting radially and axially of said tube forming the wall of said tube into corrugations which have substantially the same superficial area as that of said tube before corrugations were formed therein.

2. The method of making flexible corrugated tubular walls which includes positioning a tube in operative relation to a die, and by the combined action of separately applied forces acting radially and axially of said tube forming the wall of said tube into corrugations which have substantially the same thickness as that of said tube before corrugations were formed therein.

3. The method of making flexible corrugated tubular walls which includes positioning a tube in operative relation to a die, applying pressure to the interior of said tube, and exerting a force longitudinally of said tube, to form corrugations in said tube without increasing the superficial area thereof.

4. The method of making flexible corrugated tubular walls which includes positioning a tube in operative relation to a die, applying pressure to the interior of said tube, and exerting a separately applied force longitudinally of said tube, to form corrugations in said tube without decreasing the mean thickness of said tube.

5. The method of making flexible corrugated tubular walls which includes positioning a tube in operative relation to a die, applying pressure to the interior of said tube, and exerting a force longitudinally of said tube, to form corrugations in said tube while decreasing the length of the longitudinal elements of said tube sufficiently to prevent an increase in the superficial area of said tube.

6. The method of making flexible corrugated tubular walls which includes positioning a tube in operative relation to a die, applying pressure to the interior of said tube, and exerting a separately applied force longitudinally of said tube, to form corrugations in said tube while decreasing the length of the longitudinal elements of said

tube sufficiently to prevent a decrease in the mean thickness of said tube.

7. The method of making flexible corrugated tubular walls which includes positioning a tube in operative relation to a die, applying pressure to the interior of said tube, and exerting a force longitudinally of said tube, to form corrugations in said tube while decreasing the length of the longitudinal elements of said tube.

8. The method of making flexible corrugated tubular walls which includes positioning a tube in operative relation to a die, applying pressure to the interior of said tube, and exerting a force longitudinally of said tube, to form corrugations in said tube while decreasing the length of the longitudinal elements of said tube sufficiently to increase the thickness of said tube.

9. The method of making flexible corrugated tubular walls which includes positioning a tube in operative relation to a die, and by the combined action of forces acting radially and axially of said tube forming the wall of said tube into corrugations the longitudinal elements of which are shorter than the longitudinal elements of said tube before corrugations were formed therein.

10. The method of making flexible corrugated tubular walls which includes positioning a tube in operative relation to a die, and subjecting said tube to interior pressure to form corrugations therein while shortening said tube during the formation of the corrugations so that the superficial area of the corrugated wall is not substantially greater than that of the original tube.

11. The method of making flexible corrugated tubular walls which includes positioning a tube in operative relation to a die, and subjecting said tube to interior pressure to form corrugations therein while shortening said tube during the formation of the corrugations so that the mean thickness of the corrugated wall is not less than that of the original tube.

12. The method of making flexible corrugated tubular walls which includes positioning a tube in operative relation to a die, and subjecting said tube to interior pressure to form corrugations therein while shortening said tube during the formation of the corrugations so that the mean thickness of said tubular wall is greater than that of the original tube.

13. The method of making flexible corrugated tubular walls which includes positioning a tube in operative relation to a die, and subjecting said tube to radial pressure to form corrugations therein while shortening the longitudinal elements of said tube during the formation of the corrugations.

14. The method of making flexible corru-

gated tubular walls which includes positioning a tube in operative relation to a die, subjecting said tube to radial pressure, applying a pressure axially of said tube, and forming corrugations in said tube by the combined action of said pressures while gradually increasing said radial pressure.

15. The method of making flexible corrugated tubular walls which includes positioning a tube in operative relation to a die, applying a pressure axially of said tube, subjecting said tube to a separately applied radial pressure and forming corrugations in said tube by the combined action of said pressures while gradually increasing said axial pressure during a portion of said forming operation.

16. The method of making flexible corrugated tubular walls which includes positioning a tube in operative relation to a die, subjecting said tube to fluid pressure, applying a pressure to said tube in the direction of its axis to aid said fluid pressure in collapsing said tube into said die, and gradually increasing said fluid pressure as the tube is being collapsed into said die.

17. The method of making flexible corrugated tubular walls which includes positioning a tube in operative relation to a die, subjecting said tube to fluid pressure, applying a pressure to said tube in the direction of its axis to aid said fluid pressure in collapsing said tube into said die, and increasing said axial pressure during the first portion of the time when the tube is being collapsed into said die.

18. The method of making flexible corrugated tubular walls which includes positioning a tube in operative relation to a die, subjecting said tube to fluid pressure, applying a pressure to said tube in the direction of its axis to aid said fluid pressure in collapsing said tube into said die, and increasing said axial pressure sufficiently to prevent stretching of the metal of the wall.

19. The method of making flexible corrugated tubular walls which includes positioning a tube in operative relation to a die, subjecting said tube to fluid pressure, applying a pressure to said tube in the direction of its axis to aid said fluid pressure in collapsing said tube into said die, and increasing said fluid pressure sufficiently to prevent wrinkling of the metal of the wall.

20. The method of making flexible corrugated tubular walls which includes positioning a tube in operative relation to a die, subjecting said tube to fluid pressure, applying a pressure to said tube in the direction of its axis to aid said fluid pressure in collapsing said tube into said die, and increasing said axial pressure during approximately the first half of said collapsing movement.

21. The method of making flexible corrugated tubular walls which includes position-

ing a tube in operative relation to a die, subjecting said tube to fluid pressure, applying a pressure to said tube in the direction of its axis to aid said fluid pressure in collapsing said tube into said die, and increasing said fluid pressure during the first portion of said collapsing movement.

22. The method of making flexible corrugated tubular walls which includes positioning a tube in operative relation to a die, subjecting said tube to fluid pressure, applying a pressure to said tube in the direction of its axis to aid said fluid pressure in collapsing said tube into said die, and simultaneously increasing both of said pressures.

23. The method of making flexible corrugated tubular walls which includes positioning a tube in operative relation to a die, subjecting said tube to fluid pressure, applying a pressure to said tube in the direction of its axis to aid said fluid pressure in collapsing said tube into said die, and maintaining such relation between said pressures as to prevent stretching of the metal of the wall.

24. The method of making flexible corrugated tubular walls which includes positioning a tube in operative relation to a die, subjecting said tube to fluid pressure, applying pressure to said tube in the direction of its axis to aid said fluid pressure in collapsing said tube into said die, and maintaining such a relation between said pressures as to thicken the metal of the wall.

25. The method of making flexible corrugated tubular walls which includes positioning a tube in operative relation to a die, subjecting said tube to fluid pressure, and applying a pressure to said tube in the direction of its axis while maintaining such relation between said pressures as to prevent wrinkling of the wall.

26. The method of making flexible corrugated tubular walls which includes positioning a tube in operative relation to a die, subjecting said tube to a fluid pressure which is insufficient to stretch the metal of the tube, and then applying an increasing pressure to the tube in the direction of its axis while gradually increasing said fluid pressure.

27. In apparatus for making flexible corrugated tubular walls, the combination of a die shaped to form one or more relatively-deep, narrow corrugations, means for applying a gradually increasing fluid pressure to the interior of a tube in operative relation to said die, and means for applying a pressure to said tube in the direction of its axis.

28. In apparatus for making flexible corrugated tubular walls, the combination of a die shaped to form one or more relatively-deep, narrow corrugations, means for applying a gradually increasing fluid pressure to the interior of a tube in operative

relation to said die, and means for applying a gradually increasing pressure to said tube in the direction of its axis.

29. In apparatus for making flexible corrugated tubular walls, the combination of a die shaped to form one or more relatively-deep, narrow corrugations, means for applying a fluid pressure to the interior of a tube in operative relation to said die, and means for applying a gradually increasing pressure to said tube in the direction of its axis.

30. In apparatus for making flexible corrugated tubular walls, the combination of a die shaped to form one or more corrugations, means for applying a fluid pressure to the interior of a tube in operative relation to said die in advance of exerting an axial thrust on said tube, and means for exerting a thrust on said tube in the direction of its axis sufficient to aid said fluid pressure in forming corrugations in said tube.

31. In apparatus for making flexible corrugated tubular walls, the combination of a die including spaced die elements adapted to engage a tube along spaced circumferential lines, means for admitting fluid under pressure to only that space within said tube which is defined between said die elements, means for exerting an end thrust on said tube, and means whereby successive portions of said tube are successively exposed to said fluid pressure.

32. In apparatus for making flexible corrugated tubular walls, the combination of a die including stationary and movable die elements adapted to engage a tube in axially spaced relation, a plunger adapted to fit within the tube, means for admitting fluid pressure to the space within said tube between one of said elements and said plunger, and means for moving said last-named element and plunger relatively in the direction of the axis of said tube.

33. In apparatus for making flexible corrugated tubular walls, the combination of a die including stationary and movable die elements adapted to engage a tube in axially spaced relation, a plunger adapted to fit within the tube, means for admitting fluid pressure to the space within said tube between one of said elements and said plunger, means for moving said last-named element and plunger relatively and axially to form a corrugation, and means whereby said plunger and element are moved relatively in the opposite direction to expose a fresh section of the tube to said fluid pressure.

34. In apparatus for making flexible corrugated tubular walls, the combination of a die including stationary and movable die elements adapted to surround a tube in axially spaced relation, a plunger adapted to fit within the tube, means for admitting

fluid pressure to the space within said tube between one of said elements and said plunger, means for moving said last-named element and plunger relatively and axially to form a corrugation and in the opposite direction to expose a fresh section of the tube to said fluid pressure, and means to prevent the collapse of the formed corrugation during the formation of subsequent corrugations.

35. In apparatus for making flexible corrugated tubular walls, the combination of a die including stationary and movable die elements adapted to surround a tube in axially spaced relation, a plunger adapted to fit within the tube, means for admitting fluid pressure to the space within said tube between one of said elements and said plunger, means for moving said last-named element and plunger relatively and axially to form a corrugation and in the opposite direction to expose a fresh section of the tube to said fluid pressure, and means movable into position to protect the formed corrugation and constitute a die element during the formation of the next corrugation.

36. In apparatus for making flexible corrugated tubular walls, the combination of a die including stationary and movable die elements adapted to surround a tube in axially spaced relation, a plunger adapted to fit within the tube, means for admitting fluid pressure to the space within said tube between one of said elements and said plunger, means for moving said last-named element and plunger relatively and axially to form a corrugation and in the opposite direction to expose a fresh section of the tube to said fluid pressure, and a plurality of elements successively movable into position to protect the successive corrugations as formed and to successively constitute a die element during the formation of subsequent corrugations.

37. In apparatus for making flexible corrugated tubular walls, the combination of a die including stationary and movable die elements adapted to surround a tube in axially spaced relation, a plunger adapted to fit within the tube, means for admitting fluid pressure to the space within said tube between one of said elements and said plunger, means for moving said last-named element and plunger relatively and axially to form a corrugation and in the opposite direction to expose a fresh section of the tube to said fluid pressure, and a plurality of two-part reciprocating die elements successively movable into position to protect the successive corrugations as formed and to successively constitute a die element during the formation of subsequent corrugations.

38. The method of making flexible corrugated tubular walls which includes positioning a tube in operative relation to rela-

tively movable die elements embracing a predetermined axial section of said tube, subjecting said tube section to the combined action of radial and axial pressures while moving the movable die element axially to exert an axial thrust on said tube and collapse said tube into corrugated form between said die elements, and repeating said operation upon successive sections of said tube.

39. The method of making flexible corrugated tubular walls which includes positioning a tube in operative relation to relatively movable die elements embracing a predetermined axial section of said tube, subjecting said tube section to the combined action of radial and axial pressures while moving the movable die element axially to collapse said tube into corrugated form between said die elements, interposing a die element to protect the formed corrugation, and repeating said operation upon successive sections of said tube.

40. The method of making flexible corrugated tubular walls which includes successively exposing sections of a tube between relatively movable die elements, and forming corrugations one at a time by the simultaneous action of radial and axial pressures to collapse successive sections of the tube between said die elements.

41. The method of making flexible corrugated tubular walls which includes positioning a tube in operative relation to relatively movable die elements embracing a section of the tube, subjecting said tube section to fluid pressure, exerting an axial pressure on said tube to aid said fluid pressure in collapsing said tube between said die elements, exposing a fresh section of said tube to said fluid pressure, subjecting said corrugation, and said fresh tube section to fluid pressure, exerting an axial pressure on said tube to form a second corrugation, and repeating said operations to form successive corrugations.

42. The method of making flexible corrugated tubular walls which includes positioning a tube in operative relation to a die and forming corrugations of final depth and width at one operation by the simultaneous application of radial and axial pressures.

43. The method of making flexible corrugated tubular walls which includes positioning a tube in operative relation to a die, forming corrugations of final depth and width at one operation by fluid pressure and an axial thrust to aid said fluid pressure, and treating said corrugations to impart the desired resilience thereto.

44. The method of making flexible corrugated tubular walls which includes positioning a tube in operative relation to a die and successively forming single corrugations of final depth and width at one operation by

the simultaneous application of fluid pressure and an axial thrust to aid said fluid pressure.

45. The method of making flexible corrugated tubular walls which includes positioning a tube in operative relation to a die, successively forming single corrugations of final depth and width at one operation by fluid pressure and an axial thrust to aid said fluid pressure, and treating said corrugations to impart the desired resilience thereto.

46. The method of making flexible corrugated tubular walls which includes positioning a tube in operative relation to a die, forming corrugations having sides at substantially right angles to the axis of the tube by fluid pressure and a pressure axially of said tube, and treating said corrugations to impart the desired resilience thereto.

47. In apparatus for making flexible corrugated tubular walls, the combination of means adapted to surround the tube to be operated on and determine the size and shape of the corrugations to be formed, a plunger adapted to enter said tube, means whereby said tube and plunger may be displaced relatively and axially to expose progressively successive sections of the tube, means for admitting fluid under pressure to act on the successive sections of the tube, and means for applying an axial force to said tube to aid said fluid pressure in the forming of the corrugations.

48. In apparatus for making flexible corrugated tubular walls, the combination of a plurality of relatively movable die elements which cooperate to form the die cavities for the corrugations, means for successively positioning successive sections of the tube in operative relation to a pair of die elements, and means for subjecting said tube to the combined action of radial and axial forces to form each successive tube section into a corrugation between the acting pair of die elements.

49. In apparatus for making flexible corrugated tubular walls, the combination of a plurality of relatively movable die elements which cooperate to form the die cavities for the corrugations, means for successively positioning successive sections of the tube in operative relation to a pair of die elements spaced axially of the tube, means for admitting fluid under pressure to said tube section, and means for moving the acting pair of die elements relatively and exerting an axial force on said tube to aid said fluid pressure in forming a corrugation between said acting pair of die elements.

50. The method of making flexible corrugated tubular walls which includes positioning a tube in operative relation to relatively movable die elements, successively exposing successive sections of said tube between a pair of die elements spaced axially

of the tube to predetermine the amount of metal to go into each corrugation, and forcing each successive section of the tube into a corrugation while moving the acting pair of die elements relatively.

51. The method of making flexible corrugated tubular walls which includes positioning a tube in operative relation to relatively movable die elements, successively exposing successive sections of said tube between a pair of die elements spaced axially of the tube to predetermine the amount of metal to go into each corrugation, and forcing each successive section of the tube into a corrugation by the combined action of forces acting radially and axially of the tube.

52. In apparatus for making flexible corrugated tubular walls, the combination of a plurality of die elements adapted to cooperate with a tube to be acted on, a plunger adapted to enter the tube, a die element movable with the plunger and adapted to cooperate with said first-named elements, means for moving said tube and said plunger and last-named die element relatively to

position successive sections of tube between successive ones of said first-named die elements and said last-named die element, and means for applying fluid pressure to said successive tube sections. 30

53. In apparatus for making flexible corrugated tubular walls, the combination of a plurality of die elements adapted to cooperate with a tube to be acted on, a plunger adapted to enter the tube, a die element movable with the plunger and adapted to cooperate with said first-named elements, means for moving said tube and said plunger and last-named die element relatively to position successive sections of tube between successive ones of said first-named die elements and said last-named die element, means for applying fluid pressure to the successive tube sections, and means for exerting a pressure axially of said tube to aid the fluid pressure in forming the corrugations. 45

In testimony whereof we have signed this specification.

WESTON M. FULTON.
JEAN V. GIESLER.