Jan. 20, 1925. 1,523,951

W. M. FULTON

TUBULAR CORRUGATED WALL AND METHOD FOR MAKING THE SAME

Filed June 6, 1921 3 Sheets-Sheet 1

Fig. 1.

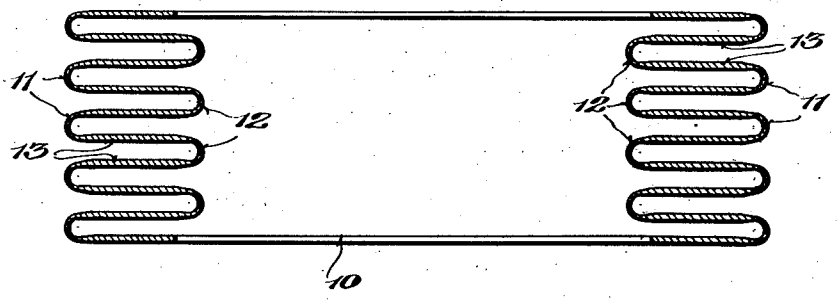


Fig. 2.

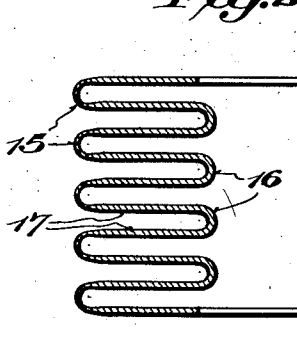


Fig. 3.

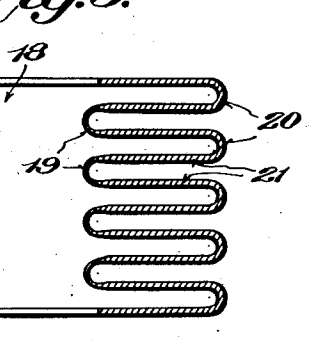


Fig. 4.

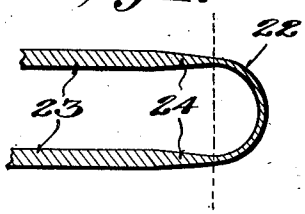


Fig. 5.

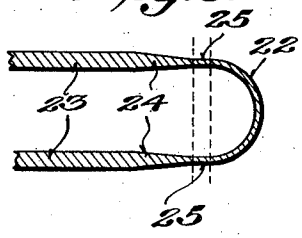
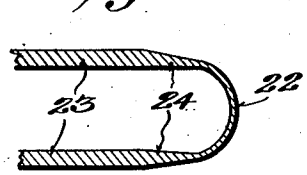


Fig. 6.



Inventor
Weston M. Fulton,

By Mauro, Cameron, Levin & Kerkam

Attorneys

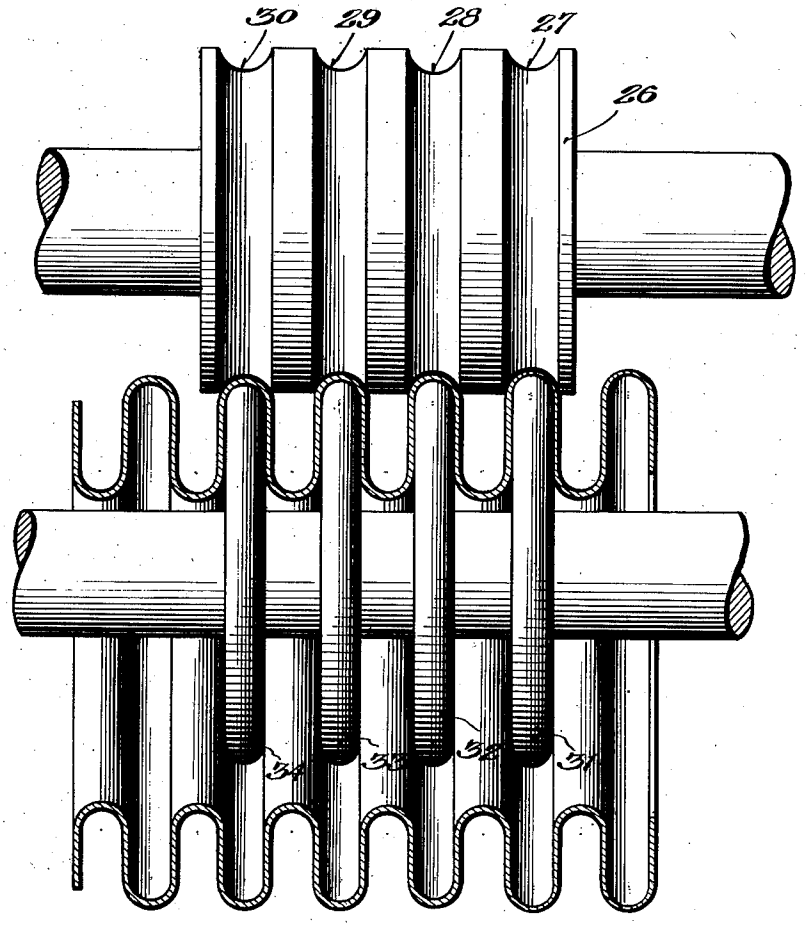
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W. M. FULTON

TUBULAR CORRUGATED WALL AND METHOD FOR MAKING THE SAME

Filed June 6, 1921 3 Sheets-Sheet 2

Fig. 7.



Inventor
Weston M. Fulton

By Mauro, Cameron, Lewis & Kerkam
Attorneys

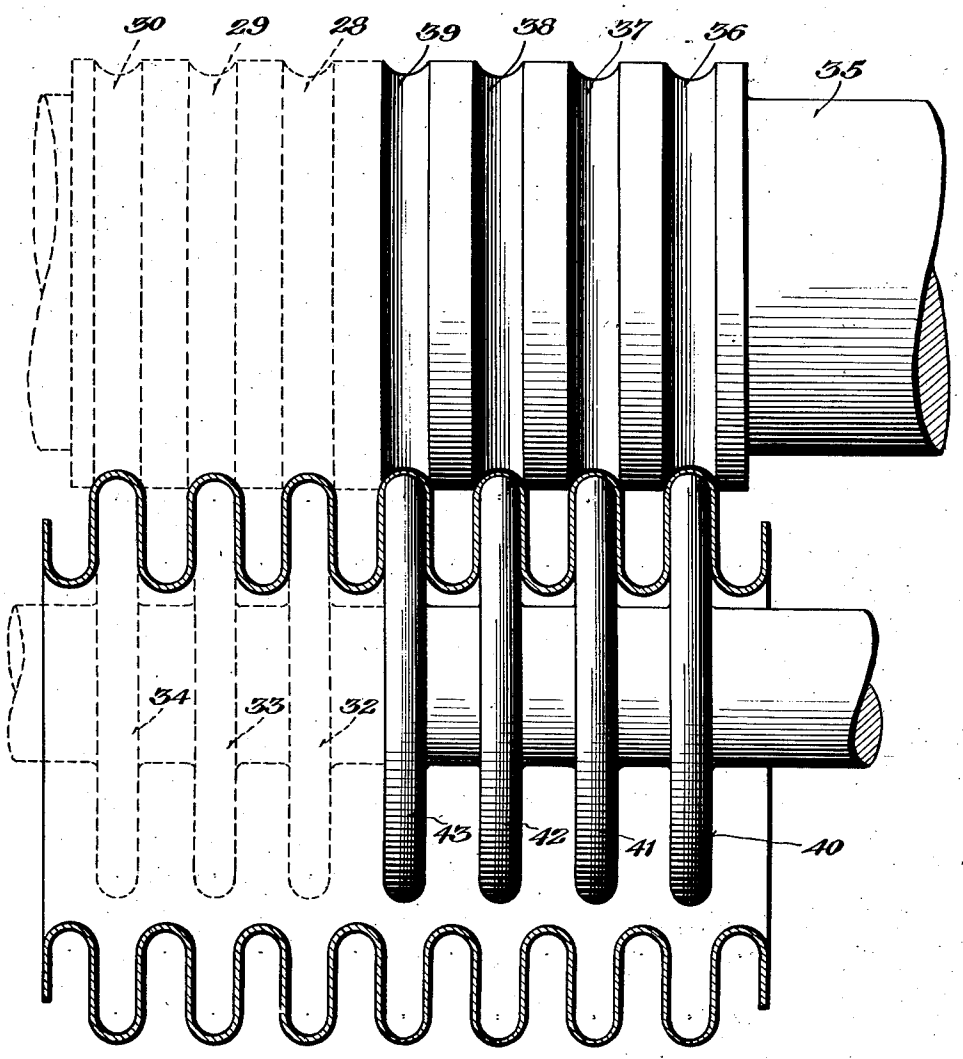
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W. M. FULTON

TUBULAR CORRUGATED WALL AND METHOD FOR MAKING THE SAME

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Fig.8.



Inventor
Weston M. Fulton

By Mann, Cameron, Lewis & Kirkaw

Attorneys

Patented Jan. 20, 1925. 1,523,951

UNITED STATES PATENT OFFICE.

WESTON M. FULTON, OF KNOXVILLE, TENNESSEE, ASSIGNOR TO THE FULTON COMPANY, OF KNOXVILLE, TENNESSEE, A CORPORATION OF MAINE.

TUBULAR CORRUGATED WALL AND METHOD FOR MAKING THE SAME.

Application filed June 6, 1921. Serial No. 475,498.

To all whom it may concern:

Be it known that I, WESTON M. FULTON, a citizen of the United States, and a resident of Knoxville, Tennessee, have invented new and useful Improvements in Tubular Corrugated Walls and Methods for Making the Same, which invention is fully set forth in the following specification.

This invention relates to flexible tubular corrugated walls and methods for making the same, and it has for an object the provision of a wall of this character which is highly sensitive to pressure variations and which, at the same time, is both durable and efficient in operation.

A demand exists for flexible tubular corrugated walls which are capable of responding to variations of pressure where the pressure is of relatively small magnitude, as in the case of CO_2 recorders, gas pressure indicators, draft indicators, etc., in which the tubular corrugated wall may have to extend and contract substantial amounts in response to variations in a pressure as small as one or two inches of a water column. Heretofore, efforts have been made to supply highly-sensitive tubular corrugated walls capable of responding to variations in relatively small pressures by constructing the wall of relatively thin metal and providing therein relatively deep corrugations. Walls of this character, however, as well as the methods heretofore used in making the same, have possessed more or less serious defects and disadvantages, among the more important of which are the following:—

The manufacture of a tubular corrugated wall of relatively thin metal requires a relatively large number of delicate and expensive operations and the exercise of great care in working the metal: otherwise, the metal is torn apart or stressed beyond its elastic limit by the operations which form the corrugations therein. Even with the exercise of extreme care and the employment of a large number of operations in progressively forming the corrugations, as well as the frequent annealing of the metal to take out the temper which is worked into the same by the operations to which it is subjected, the number of walls which are ruptured or overstressed during the formation of the corrugations is relatively large, so that the wastage incident to prior manufacturing processes of this character is relatively great. Moreover, a wall of relatively thin metal tends to buckle under the treatment to which it is subjected in forming the corrugations, and this causes strains to be set up in the metal which in turn cause a jerky or irregular motion of the wall in extending and contracting under pressure variations. Additionally, when the radially-directed or lateral walls of the corrugations are relatively thin, they tend to bend back and forth under changes of pressure, resulting in a lost motion as pointed out in my prior Patent No. 947,229 granted January 25, 1910, and therefore the wall fails to extend and contract with sensitive accuracy in response to variations of pressure.

It is an object of this invention to provide a flexible tubular corrugated wall which is highly sensitive to variations in relatively small pressures and which, at the same time, can be manufactured with the exercise of less care and by fewer, less delicate and less expensive operations than have heretofore been necessary in making highly sensitive walls of this character. Another object of this invention is to provide a flexible tubular corrugated wall which is highly sensitive to relatively small pressure variations and which can be manufactured more economically and with the elimination of much of the waste which is incident to the methods of manufacturing walls of this character heretofore employed. Another object of this invention is to provide a flexible tubular corrugated wall and method of making the same whereby the buckling and resultant strains incident to the formation of such walls of very thin metal is avoided, and the irregular and jerky motion of extension and contraction incident to the operation of such walls as heretofore constructed is eliminated. Another object of this invention is to provide a flexible tubular corrugated wall and method of making the same whereby the lateral walls of the corrugations may be made relatively strong and resistant to the tendency to bend back and forth under pressure variations, so as to eliminate the lost motion and lack of accurate response in extending and contracting under pressure variations which are characteristic of tubular corrugated walls of relatively thin metal.

Tubular corrugated walls are sometimes employed as pressure-responsive elements where they are subjected on opposite sides to

relatively large differences in pressure and yet where they are required to respond sensitively to relatively small changes in pressure. A relatively large difference in pressure on the two sides of a corrugated wall tends to collapse the folds of the corrugations which form reentrant recesses in the space under the higher pressure; thus, if the higher pressure exists interiorly of the wall, it tends to collapse into engagement each pair of lateral walls on either side of each inner bend of the corrugations; on the other hand, if the higher pressure exists exteriorly of the wall, it tends to collapse into engagement each pair of lateral walls on either side of each outer bend of the corrugations. This phenomenon manifests itself under relatively light pressures when the corrugated walls is made of relatively thin metal and experience has demonstrated that the lateral walls of the corrugations may be so collapsed into engagement under pressures which are only about one-third of those which are required to rupture such walls. It is an object of this invention to provide a flexible tubular corrugated wall in which certain bends of the corrugations may be made relatively strong to resist collapse while other bends of the corrugations may be rendered highly sensitive to changes in pressure.

Another object of this invention is to provide a method for thinning the bends of a tubular corrugated wall which will effectively gauge the extent of the reduction in thickness so as to insure that the bends of the corrugations shall be thinned to a substantially uniform and predetermined thickness.

Another object of the invention is to provide a flexible tubular corrugated wall having one or both of the outer and inner bends of its corrugations thinner than the lateral portions of said corrugations, together with a method for making the same, whereby, if desired, the thinned portions may be made of substantially uniform thickness; whereby, if desired, the thinned portions may extend for a short distance into the lateral portions of the corrugations; whereby, if desired, the thinned portions may be connected to the thicker portions by regions of tapering thickness; and whereby, if desired, the bends of the corrugations may be made more resilient than the lateral portions thereof.

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

Stated broadly, the invention comprises a flexible tubular corrugated wall having one or both of the outer and inner bends of its corrugations made thinner than the lateral portions thereof by a predetermined amount; also the method of making a flexible tubular corrugated wall by predeterminately thinning one or both of the outer and inner bends of its corrugations, perferably by rolling or other cold working operations.

The invention is capable of being embodied in a variety of ways some of which are illustrated on the accompanying drawings, but it is to be expressly understood that the drawings are for purposes 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.

In said drawings wherein the thickness of the wall is shown greatly exaggerated for clearness of illustration:—

Fig. 1 is an axial section of a flexible tubular corrugated wall embodying the present invention;

Fig. 2 is a half axial section of another wall embodying the present invention;

Fig. 3 is a half axial section of still another wall embodying the present invention;

Figs. 4, 5 and 6 are enlarged fragmentary sections of a corrugation and illustrate different extents to which the thinned portions of the bends of the corrugations may be extended toward or into the lateral portions thereof;

Fig. 7 is a schematic elevation of cooperating rolls for carrying out the method of the present invention; and

Fig. 8 is a schematic elevation of another set of cooperating rolls which may be used with or in place of the rolls of Fig. 7 in carrying out the present invention.

In conformity with the present invention, a flexible tubular corrugated wall is provided having one or both of the outer and inner bends of its corrugations made thinner than the lateral walls of said corrugations by a predetermined amount, as distinguished from any accidental and more or less irregular and defective thinning of the metal incident to some manufacturing methods heretofore suggested. In the form shown in Fig. 1, the tubular corrugated wall 10 has both the outer bends 11 and the inner bends 12 of its corrugations predeterminately thinner than the lateral portions 13 of said corrugations. In the form shown in Fig. 2, the tubular corrugated wall 14 has the outer bends 15 of its corrugations predeterminately thinner than the inner bends 16 and the lateral walls 17 of said corrugations, the inner bends 16 and the lateral walls 17 preferably being of substantially uniform thickness. In the form shown in Fig. 3, the tubular corrugated wall 18 has the inner bends 19 of its corrugations thinner than the outer bends 20 and the lateral walls 21 of said corrugations, said outer bends 20 and the lateral walls 21 preferably being of substantially uniform thickness. The form shown in Fig. 1 is particularly de-

signed for uses where the wall must be sensitively responsive to variations in relatively small pressures; the form shown in Fig. 2 is particularly designed for uses where the wall may be subjected to relatively high interior pressures and yet must be sensitively responsive to relatively small changes in pressure; the form shown in Fig. 3 is particularly designed for uses where the wall may be subjected to relatively high exterior pressures and yet must respond sensitively to relatively small changes in pressure; the forms shown in Figs. 2 and 3, however, while particularly designed to resist a relatively large difference in the exterior and interior pressures, are also possessed of marked utility where the wall must respond sensitively to relatively small pressure variations even though the wall be not subjected to relatively high interior or exterior pressures, because either of these constructions is much more sensitive to pressure variations than if the entire wall were made of the thickness of the lateral portions of the corrugations, although they are less sensitive to pressure variations than the type of structure shown in Fig. 1.

The thinner portions in the bends of the corrugations are preferably connected to the thicker portions in the lateral walls of the corrugations by regions of tapering thickness, so that there will be no abrupt change in the thickness of the metal at which strains may concentrate. The portions of reduced thickness may extend for a short distance into the lateral portions of the corrugations or the region of tapering thickness may extend for a short distance into the bends of the corrugations. In the form shown in Fig. 4 the entire bend 22 of the corrugation is made of reduced thickness and connected to the lateral portions 23 of the corrugations by regions 24 of tapering thickness at the ends of the curve of the bend. In the form shown in Fig. 5 the entire bend 22 of the corrugation is made of reduced thickness and the thinned portion is also extended for a short distance 25 into each of the lateral walls 23 of the corrugation, where it is connected to the main portion of each lateral wall by a region of tapering thickness 24. In the form shown in Fig. 6, the regions of tapering thickness 24 extend for a short distance into the bend of the corrugation. In each instance the major portion of the bend of the corrugation is preferably made of substantially uniform thickness and the major portion of each lateral wall of the corrugation is also preferably made of substantially uniform thickness.

A flexible tubular corrugated wall as heretofore described may be made in any suitable way. I preferably make the same from relatively thick metal, i. e. metal of the thickness that is to exist in the lateral walls of the completed corrugated wall, and form corrugations therein in any suitable way, as by the method disclosed in my prior Patent No. 971,838, granted October 4, 1910. Then, when the corrugations are nearing or have reached their completed form, I subject the bends of said corrugations to one or more operations by which the metal at said bends is reduced in thickness to a predetermined amount. This latter result may be accomplished in any suitable way, as by machining or abrasive operations, but I prefer to effect the reduction in thickness by cold working operations, preferably by rolling. Suitable apparatus for thinning the bends of the corrugations by a rolling operation is illustrated in Fig. 7, wherein a roll 26 is provided with a plurality of grooves 27, 28, 29 and 30 which are designed to cooperate with a set of rolls 31, 32, 33 and 34, the configuration of the periphery of said rolls and grooves being selected to conform with the size and shape of the corrugations to be acted upon and the radii of curvature of each groove and its cooperating roll differing by an amount equal to the thickness of the metal at the bend of the corrugation to be acted on or produced. One roll of the set 31–34, the roll 31 for example, is made of an increased diameter corresponding to the predetermined extent to which the bends of the corrugations are to be reduced in thickness. Thus, assuming that the bends of the corrugations are to be reduced in thickness .004 of an inch, the roll 31 has a diameter .008 of an inch greater than rolls 32, 33 and 34. Roll 26 and the set of rolls 31–34 are rotated in any suitable way and also suitably mounted so that they may be moved toward and away from each other. Each bend of the corrugations is subjected to the action of the roll 31 and its cooperating groove 27 until the thickness of the wall at said bend is reduced to the predetermined amount, whereupon the rolls 32, 33 and 34 engage the succeeding bends of the corrugations in the grooves 28, 29 and 30 and prevent a further reduction in the thickness of the corrugation being acted upon by the roll 31.

The aforesaid operation of reducing the thickness of the metal at the bend of the corrugation is repeated with each successive bend until there is an insufficient number of corrugations not yet acted on to be engaged by the rolls 32, 33 and 34. The wall is then removed from the said rolls and the thinning operation may be completed on an apparatus such as illustrated in Fig. 8. In the structure here shown, the roll 35 is provided with a plurality of grooves 36, 37, 38 and 39 which cooperate with a series of rolls 40, 41, 42 and 43. In this structure all of the rolls 40–43 are of equal diameter and

correspond in size to the roll 31 of the apparatus shown in Fig. 7. The remaining corrugations are subjected successively to the thinning action of the roll 43 coacting with its opposed groove 39, and as each bend is reduced to the predetermined thickness, the rolls 40, 41 and 42 engage the preceding bends of the corrugations in the cooperating grooves 36, 37 and 38 and prevent further thinning by the action of the roll 43.

Thereby the thinning of the bends of the corrugations is accurately gauged so as to insure that all of said bends shall be of substantially uniform thickness.

If desired, the entire thinning operation may be carried out by cooperating rolls which include both rolls of increased diameter as in the apparatus in Fig. 8 and rolls of lesser diameter as in the apparatus of Fig. 7, said rolls cooperating with an opposed roll having a corresponding number of cooperating grooves. This is illustrated in dotted lines in Fig. 8 wherein the roll 35 is provided with additional grooves 28, 29 and 30, and the cooperating set of rolls also includes rolls 32, 33 and 34 of the lesser diameter for coaction with the bends of the corrugations which have not yet been thinned, the same reference characters being employed for these additional rolls and grooves as in the embodiment of Fig. 7. In this construction the reduction in the thickness of the wall at the bends is gauged by the rolls 32, 33 and 34 engaging succeeding bends of the corrugations, which have not yet been thinned, in the grooves 28, 29 and 30, as well as by the rolls 40, 41 and 42 engaging the preceding bends of the corrugations, which have already been thinned, in the grooves 36, 37 and 38. I prefer, however, to use two separate apparatus as shown in Figs. 7 and 8, as the addition of the further rolls and cooperating grooves complicates the apparatus and renders the gauging operation more difficult.

If the inner bends of the corrugations are also to be thinned, the cooperating rolls heretofore described are interchanged, the grooved roll being positioned interiorly and the set of rolls being positioned exteriorly, and the inner bends of the corrugations are then thinned successively by the action of the apparatus heretofore described.

This thinning of the bends of the corrugations may be effected after the corrugations have been given the form which they are to have in the completed wall, or the bends of the corrugations may be subjected to one or more thinning operations prior to the shaping of the corrugations into their final form and such corrugations thereafter be subjected to further treatment to deepen and narrow the same, or said bends may be subjected to thinning operations both before and after they have reached their final form.

If it is desired that the portions of reduced thickness extend for a short distance into the lateral walls of the corrugations, I prefer to subject the bends of the corrugations to a thinning operation prior to the final operation or operations by which the corrugations are brought into their final form, and then reduce the radius of curvature of the corrugations by one or more further rolling operations, which may be carried out as disclosed in my prior Patent No. 971,838. As the radius of curvature of the bends of the corrugations are thus reduced, some of the thinned portions of the wall at the bends is transferred into the lateral portions and the resulting wall at the bends is constructed as shown diagrammatically in Fig. 5. In place of reducing the thickness of each entire bend, I may so construct the periphery of the cooperating rolls that the region of reduced thickness extends through less than the entire length of each bend—so that the construction at the bend is as shown diagrammatically in Fig. 6. Whether or not the portion of reduced thickness extends throughout the entire length of each bend, and whether or not the reduced portion extends into the lateral walls of the corrugations, and whether or not the corrugations be subjected to subsequent operations after the reduction in thickness of the bends, such cold working operations by which the bends of the corrugations are reduced in thickness increases the resiliency of the metal at said bends and may therefore impart to said bends a higher elastic limit than is possessed by the lateral portions of said corrugations.

It will therefore be perceived that I have provided a flexible tubular corrugated wall in which the bends of the corrugations may be made as thin or even thinner than the metal heretofore employed in tubular corrugated walls designed for highly sensitive response to small pressure variations while, at the same time, the lateral walls of said corrugations remain relatively thick and strong so as to eliminate buckling during manufacture as well as the bending back and forth during operation which is characteristic of relatively thin lateral walls. Thereby, a wall has been provided which is highly sensitive to small pressure variations and which, at the same time, avoids the jerky and irregular motion heretofore present from the overstraining of the metal as well as also eliminates much if not all of the lost motion incident to the bending back and forth of the lateral walls. At the same time, a flexible tubular corrugated wall has been provided in which either the inner or the outer bends of the corrugations may be left relatively strong to resist collapse under the action of the pressure to which the wall is subjected while the wall is still sensitively responsive to relatively small pressure varia-

tions. Furthermore, this highly sensitive tubular corrugated wall is provided by a method of manufacture which avoids the delicate and expensive operations heretofore employed, which does not require excessive care in the treatment of the walls, and which eliminates substantially all of the wastage incident to the methods heretofore employed. Moreover, this method of manufacture may render the bends of the corrugations of increased resilience and leaves the wall strong and durable as well as sensitively and efficiently responsive to changes of pressure. Additionally, a method has been provided whereby the bends of the corrugations may be reduced in thickness by accurately gauged operations so that said bends shall be of substantially uniform thickness.

While the embodiments of the invention illustrated on the drawings have been described with considerable particularity, it is to be expressly understood that the invention is not limited 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, while changes may be made in details, dimensions and arrangements, and certain features used without other features, 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 said invention.

What is claimed is:—

1. A flexible, expansible and collapsible, tubular corrugated wall having the bends of its corrugations reduced in thickness by a predetermined amount.

2. A flexible, expansible and collapsible, tubular corrugated wall having one or both of the outer and inner bends of its corrugations made predeterminately thinner than the lateral portions of said corrugations, said thinner portions being connected to said thicker portions by regions of tapering thickness.

3. A flexible, expansible and collapsible, tubular corrugated wall having the outer bends of its corrugations made thinner than the lateral portions thereof by a predetermined amount.

4. A flexible, expansible and collapsible, tubular corrugated wall having the inner bends of its corrugations made thinner than the lateral portions thereof by a predetermined amount.

5. A flexible, expansible and collapsible, tubular corrugated wall having one or both of the outer and inner bends of its corrugations made predeterminately thinner than the lateral portions of said corrugations, said thinner portions extending for a short distance into said lateral portions.

6. A flexible, expansible and collapsible, tubular corrugated wall having one or both of the outer and inner bends of its corrugations made predeterminately thinner than the lateral portions of said corrugations, said thinner portions extending for a short distance into said lateral portions, and being connected to said thicker portions by regions of tapering thickness.

7. A flexible, expansible and collapsible, tubular corrugated wall having both the outer and the inner bends of its corrugations made thinner than the lateral portions thereof by a predetermined amount.

8. A flexible, expansible and collapsible, tubular corrugated wall having one or both of the outer and inner bends of its corrugations of substantially uniform thickness and thinner than the lateral portions of said corrugations.

9. A flexible, expansible and collapsible, tubular corrugated wall having one or both of the outer and inner bends of its corrugations of substantially uniform thickness and thinner than the lateral portions of said corrugations, said lateral portions also being of substantially uniform thickness.

10. A flexible, expansible and collapsible, tubular corrugated wall having one or both of the outer and inner bends of its corrugations of substantially uniform thickness and thinner than the major part of the lateral portions of said corrugations, said thinner portions extending for a short distance into said lateral portions.

11. A flexible, expansible and collapsible, tubular corrugated wall having one or both of the outer and inner bends of its corrugations of substantially uniform thickness and thinner than the lateral portions of said corrugations, said thinner portions being connected to said thicker portions by regions of tapering thickness.

12. A flexible, expansible and collapsible, tubular corrugated wall having one or both of the outer and inner bends of its corrugations predeterminately thinner and more resilient than the lateral portions of said corrugations.

13. The method of making a flexible tubular corrugated wall which includes forming a tubular wall with corrugations and predeterminately reducing the thickness of the wall at one or both of the outer and inner bends of said corrugations.

14. The method of making a flexible tubular corrugated wall which includes forming a tubular wall with corrugations and cold working one or both of the outer and inner bends of said corrugations to reduce their thickness to a predetermined amount.

15. The method of making a flexible tubular corrugated wall which includes forming a tubular wall with corrugations and subjecting one or both of the outer and inner bends of said corrugations to a rolling

operation to reduce their thickness by a predetermined amount.

16. The method of making a flexible tubular corrugated wall which includes forming a tubular wall with corrugations, predeterminately reducing the thickness of the wall at one or both of the outer and inner bends of said corrugations, and reducing the radius of curvature of said bends to transfer parts of said thinned portions into the lateral portions of said wall.

17. The method of making a flexible tubular corrugated wall which includes forming a tubular wall with corrugations, subjecting one or both of the outer and inner bends of said corrugations to a rolling operation to reduce their thickness to a predetermined amount, and reducing the radius of curvature of said bends by a rolling operation to transfer parts of said thinned portions into the lateral portions of said wall.

18. The method of making a flexible tubular corrugated wall which includes forming a tubular wall with corrugations and reducing the thickness of said wall at one or both of the outer and inner bends of said corrugations while gauging the extent of said reduction.

19. The method of making a flexible tubular corrugated wall which includes forming a tubular wall with corrugations and reducing the thickness of said wall by a rolling operation at one or both of the outer and inner bends of said corrugations while gauging with coacting rolls the extent of said reduction.

20. The method of making a flexible tubular corrugated wall which includes forming a tubular wall with corrugations, subjecting one or both of the outer and inner bends of said corrugations successively to coacting sets of rolls, one or more of the rolls of one set of which have a predetermined difference in diameter from that of other rolls of said set, and reducing the bends of the corrugations in thickness while gauging the extent of said reduction by the action of said rolls of different diameter.

21. A flexible, expansible and collapsible, tubular corrugated wall having one or both of the outer and inner bends of its corrugations reduced in thickness relative to its lateral walls.

22. The method of making a flexible tubular corrugated wall which includes forming a tubular wall with corrugations and reducing the thickness of one or both of the outer and inner bends of said corrugations while increasing the resiliency of said bends.

23. The method of making a flexible tubular corrugated wall which includes forming a tubular wall with corrugations and thinning one or both of the inner and outer bends of said corrugations relatively to said lateral walls.

24. The method of making a flexible corrugated tubular wall which includes forming a tubular wall with corrugations, reducing the thickness of one or both of the outer and inner bends of said corrugations, and subsequently deepening and narrowing said corrugations.

25. The method of making a flexible corrugated tubular wall which includes forming a tubular wall with corrugations, and reducing the thickness of one or both of the outer and inner bends of said corrugations by subjecting only the bends of said corrugations to the action of a roll.

26. A flexible, expansible and collapsible, tubular corrugated wall having one or both of the outer and inner bends of its corrugations reduced in thickness relative to its lateral walls and in a cold worked condition whereby they are resilient.

27. A flexible, collapsible and expansible, tubular corrugated wall having one or both of the outer and inner bends of its corrugations predeterminately thinner than the lateral portions of said corrugations.

28. A flexible, collapsible and expansible, tubular corrugated wall having one or both of the outer and inner bends of its corrugations predeterminately thinner and more resilient than the lateral portions of said corrugations.

29. The method of making a flexible tubular corrugated wall highly responsive to relatively small pressure variations which includes forming one or both of the inner and outer bends of its corrugations predeterminately thinner than the lateral portions thereof.

30. The method of making a flexible tubular corrugated wall highly responsive to relatively small pressure variations which includes subjecting one or both of the inner and outer bends of its corrugations to a cold-working operation to make said bends thinner than the lateral walls.

31. The method of making a flexible tubular corrugated wall highly responsive to relatively small pressure variations which includes subjecting one or both of the inner and outer bends of its corrugations to a rolling operation to thin said bends with respect to the lateral walls.

In testimony whereof I have signed this specification.

WESTON M. FULTON.