Aug. 21, 1934. W. M. FULTON 1,970,650

METHOD OF MAKING FLEXIBLE CORRUGATED TUBULAR METAL WALLS

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Fig. 1.

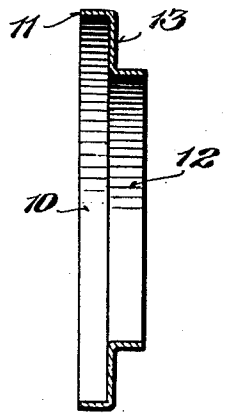


Fig. 2.

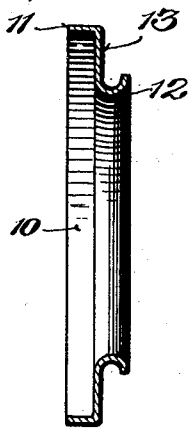


Fig. 3.

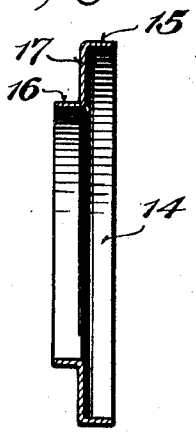


Fig. 4.

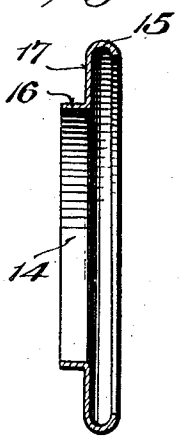


Fig. 5.

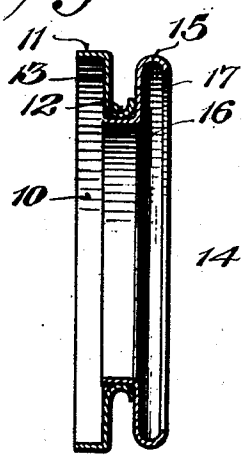
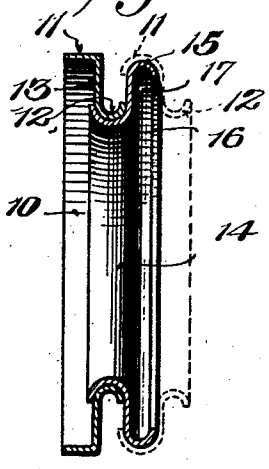


Fig. 6.



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Fig. 7.

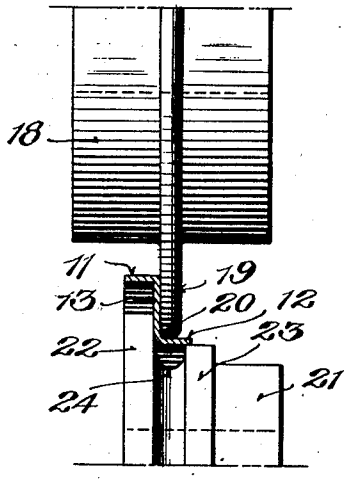


Fig. 8.

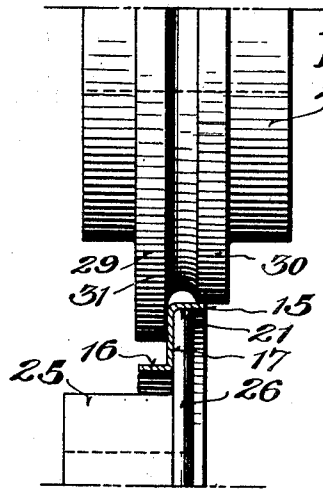


Fig. 9.

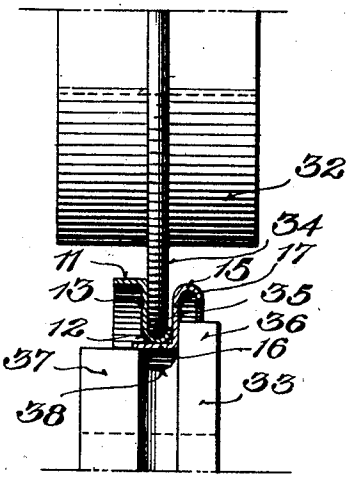
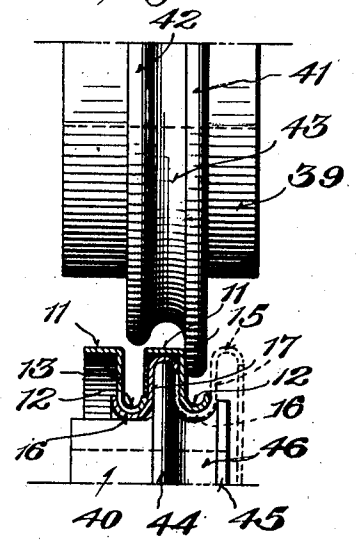


Fig. 10.



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1,970,650

METHOD OF MAKING FLEXIBLE CORRUGATED TUBULAR METAL WALLS

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Application March 31, 1930, Serial No. 440,582

1 Claim. (Cl. 29—157)

This invention relates to flexible, corrugated, tubular metal walls and methods of making the same.

It has heretofore been proposed to make flexible, expansible and collapsible, tubular metal walls by shaping annular members and uniting them in series, alternately at their inner and outer peripheries, so as to make up a bellows-like structure. Structures of this character as heretofore produced, however, have been provided with soldered, crimped or analogous joints at the outer and inner peripheries of the annular members, so that the stresses existing during expansion and contraction of the bellows-like structure have been concentrated at these soldered, crimped or other joints, with the result that such joints have failed after a relatively small number of flexures.

It has also been the practice to make flexible, corrugated, tubular metal walls by forming relatively deep corrugations in a single piece of metal drawn or otherwise formed to tubular shape, and structures of this character have been capable of withstanding a relatively great number of flexures without rupture, but in order to deform a tube of relatively thin metal into deeply-corrugated shape it has been necessary to deform the metal progressively by small increments so as to prevent overstressing of the metal, with intermediate annealing operations, so that the cost of manufacture has been relatively high by reason of the number and character of operations involved.

It is an object of this invention to provide a flexible, corrugated, tubular metal wall, and a method of making the same, whereby the wall may be composed of separate elements that may be formed and connected by a minimum number of simple operations so that the cost of manufacture may be reduced, and yet the wall will be capable of withstanding a relatively large number of flexures.

Another object of this invention is to provide a flexible, corrugated, tubular metal wall of the character referred to, and a method of making the same, whereby the wall may be made of any desired length and at the same time it will approximate in its characteristics the deeply-corrugated walls heretofore made from one piece of metal.

Another object of this invention is to provide a flexible, corrugated, tubular metal wall of the character referred to, and a method of making the same, whereby some of the movement at the bends of the corrugations which accompany expansion and contraction of the wall is in the form of slippage between the elements of the wall instead of by bending entirely as in the case of walls made from one piece of metal.

Another object of this invention is to provide a flexible, corrugated, tubular metal wall of the character referred to, and a method of making the same, whereby walls of this character may be inexpensively produced from metal elements that are not sufficiently large to be employed in the manufacture of one-piece walls, so that small pieces of metal may be utilized in the production of walls of this character.

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

The process of the present invention is capable of being carried out in a variety of ways and the product of the present invention is capable of receiving a variety of mechanical expressions, an exemplification of the process and product being hereinafter described and illustrated on the 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.

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

Fig. 1 is an axial section of one of the two sizes of metallic elements which go into the production of a flexible, corrugated, tubular metal wall embodying the present invention;

Fig. 2 is an axial section of the blank of Fig. 1 after the first operation thereon;

Fig. 3 is an axial section of the other size of element used;

Fig. 4 is an axial section of the blank of Fig. 3 after the first operation thereon;

Fig. 5 is an axial section illustrating how the elements of Figs. 2 and 4 are connected;

Fig. 6 is an axial section to illustrate how successive elements may be connected;

Fig. 7 is a diagrammatic view illustrating how the blank of Fig. 2 may be formed from the blank of Fig. 1;

Fig. 8 is a diagrammatic view illustrating how the blank of Fig. 4 may be formed from the blank of Fig. 3;

Fig. 9 is a diagrammatic view illustrating how the blanks of Figs. 2 and 4 may be connected; and

Fig. 10 is a diagrammatic view illustrating how successive pairs of elements may be connected.

A flexible, corrugated, tubular metal wall is built up of a plurality of annular elements which

are so interrelated by mechanical joints that the elements are interlocked by curved surfaces of relatively large radius of curvature, which preferably permit relative movement axially thereof. These elements, as hereinafter explained, are made of two sizes, and the elements of different size are connected in alternation until a flexible, corrugated, tubular wall of the desired length is obtained. The elements may be made of any suitable material, and of any suitable size and thickness to produce a wall of the desired cross sectional area and flexibility. The form which the elements take will vary with the desired cross section of the resulting wall (whether circular, elliptical, polygonal, etc.), and these elements may be made in any suitable way, as by drawing the blanks from annular disks, cupping circular disks and punching out the central portions thereof, etc.

Fig. 1 illustrates one of the two sizes of blanks and Fig. 3 illustrates the other of the two sizes of blanks that are employed. The blank 10 of Fig. 1 is of annular formation and has an axially extending flange 11 at its outer periphery and an axially extending flange 12 at its inner periphery, the two flanges being connected by a radially extending portion 13 of suitable width to secure the desired depth of corrugation as will be apparent from the following explanation. The blank 14 is of smaller size but similar shape, being provided with an axially extending flange 15 at its outer periphery, an axially extending flange 16 at its inner periphery and an intermediate radially extending portion 17 connecting said flanges. The flange 15 has a smaller diameter than the flange 11 and the flange 16 has a smaller diameter than the flange 12.

The flange 12 on element 10 is bent into a generally semi-circular form as shown in Fig. 2. This shaping of the flange 12 may be effected in any suitable way, as by rolling, spinning, die pressing, etc., Fig. 7 showing more or less diagrammatically a suitable pair of rolls for effecting this bending operation. The roll 18 is provided with a radially extending flange 19 of suitable width and curved at its peripheral portion 20 to conform with the curvature to be given to the outer face of the flange 12. Roll 21 is provided with a pair of flanges 22 and 23, the former of which projects radially to a greater distance than the latter, and said rolls are shown as connected by a fillet 24 corresponding with the curvature to be given to the inner face of the flange 12 when the bending operation is to be continued until the curved flange is bottomed on the roll 21, although this is not essential, as the bending operation can be discontinued before the flange 12 bottoms on the surface connecting the flanges 22 and 23, in which event said connecting surface need not conform to the curved surface to be given to the inner face of the flange 12. The flange 22 owing to its greater diameter than the flange 23 acts to guide the portion 13 of the element 10 during the bending operation.

Element 14 may then be associated with the element 10 in the manner hereinafter explained and the flange 15 thereof be bent subsequently to such connection, but I prefer to bend the flange 15 as shown in Fig. 4 before associating element 14 with element 10. This bending operation may also be done in any suitable way as heretofore pointed out, Fig. 8 showing a pair of rolls for performing this operation. Roll 25 is provided with a flange 26 having its periphery curved at 27 to conform with the curvature to be given to the inner face of the flange 15, and roll 28 is provided with a pair of flanges 29 and 30, flange 29 projecting beyond flange 30 to guide the portion 17 of element 14 during the bending operation, as heretofore explained. If the bending operation is to be continued until the flange 15 is bottomed, as preferred, the flanges 29 and 30 are connected by a fillet 31 conforming to the curvature to be given to the outer face of the flange 15.

The curvature given the flanges 12 and 15 may vary within considerable limits and as hereinafter explained may be greater than that desired in the final wall, or it may be selected in conformity with the desired final curvature of the corrugations, in which event the curvature selected should be of generally semi-circular shape passing smoothly into the lateral wall formed by the section 13 or 17. The radii of curvature are therefore relatively large and as hereinafter explained the curved surfaces thereby formed are preferably coextensive with the desired spacing of the lateral walls of the corrugations.

At this stage of the operations flange 16 of element 14 should fit slidably within the curved flange 12 of element 10, and flange 11 of element 10 should fit slidably over the curved flange 15 of element 14. The two elements 10 and 14 may be connected at either their outer flanges or at their inner flanges. I have shown them connected at their inner flanges, and to this end flange 16 is inserted into flange 12 as illustrated in Fig. 5, and then flange 16 is bent in any suitable way to embrace the curved flange 12, as illustrated in Fig. 6. Flange 16 should be of such length that it will extend approximately through more than 90° of curvature, and preferably through substantially 180° of curvature, to embrace the curved flange 12 as shown, and when so bent into contact with curved flange 12, the two elements 10 and 14 are interlocked so as to prevent disconnection of the same. Referring to Fig. 9 I have illustrated a pair of rolls 32 and 33 for connecting the elements 10 and 14, roll 32 being provided with a flange 34 curved at its periphery 35 to conform with the curvature of the outer surface of flange 12, and roll 33 being provided with a pair of flanges 36 and 37 connected by a fillet 38 where the rolling operation is to be continued until bottoming occurs. Flange 36 extends to a greater radial distance than flange 37 so that the portion 17 of element 14 is guided during the bending operation, but if desired the roll 33 may be made in the form of the upper roll illustrated in Fig. 10 so that the portion 13 of the element 10 will also be guided during the bending operation.

After a pair of elements 10 and 14 have been associated as shown in Fig. 6 an element 10 may be mechanically connected thereto, and then an element 14 connected to the second element 10, and so on until a wall of the desired length is built up, but I prefer to connect the elements 10 and 14 in pairs as heretofore explained, and then connect the pairs together until a wall of the desired length is built up. Whichever of these procedures is followed, the flange 11 of the second element 10 is bent around the curved flange 15 of the element 14 analogously as flange 16 is bent around the curved flange 12 so as to produce a mechanical interlock extending over more than 90° of surface of the bend to prevent subsequent disconnection of the elements. This bending operation may also be accomplished in any suitable way, Fig. 10 illustrating a pair of rolls 39 and 40 for performing this operation. Roll 39 is provided with a pair of flanges 41 and 42 connected by a fillet 43 when the bending is to be

continued until bottoming occurs, and roll 40 is provided with a pair of flanges 44 and 45, shown as connected by a fillet 46 to receive the formed bend on the second element 14 although this is not essential. Flange 41 preferably projects to a greater radial distance than flange 42 and flange 44 preferably extends to a greater radial distance than flange 45, so as to provide radial surfaces on the rolls which coact with and guide the radial surfaces on the elements 10 and 14 during the bending operation. These radial faces on the rolls may also be utilized to effect a planishing action on the radial surfaces of the elements, which has been found to have a beneficial effect.

By continuing this procedure successive elements 10 and 14 or successive pairs of elements 10 and 14 may be mechanically connected together by bending their flanges into a mechanical interlock as heretofore explained until a wall of the desired length has been built up. If particular forms of end members are desired at either or both ends of the flexible wall, they may be formed in any suitable manner to have the desired shape, size, character, etc., and provided with a flange for connection to the proper flange 12 or 15 of the end elements of the flexible wall in the manner heretofore described. In making these mechanical joints between the successive sections, or after the joints have been made, a lubricant, such as graphite, may be interposed between the curved surfaces so as to facilitate their sliding one over the other. Also, if desired, means may be associated with the mechanical connections so as to seal the joint therebetween and render them fluid tight.

While I prefer to form the elements so that when connected in the manner heretofore described they constitute a flexible, deeply-corrugated, tubular metal wall of the final dimensions desired, this is not essential, as the corrugations may be subsequently deepened or narrowed or both, or otherwise changed in shape, by cold working or other operations, such for example as by subjecting them to rolling operations of the character disclosed in my Patent No. 971,838, granted October 4, 1910, for Process of making tubular metal walls, during which operations temper and toughness may be worked into the bends of the corrugations, as desired.

It will therefore be perceived that a flexible, corrugated, tubular metal wall and process of making the same has been provided whereby the wall may be made up of separate elements which may be formed and connected by a minimum number of simple operations so that the cost of manufacture is reduced, and so that the wall may be made at a minimum expense from small pieces of metal. At the same time the resulting wall approximates in its characteristics the single-piece, highly-flexible, deeply-corrugated, tubular metal walls heretofore produced, because the mechanical joints between the elements do not produce high localized stresses and early rupture, as has been characteristic of the soldered, crimped and similar joints used in the prior art. The flanges are interlocked along curved surfaces of relatively large radius of curvature, and when the resulting corrugations have substantially parallel lateral walls at right angles to the axis, the sums of the radii of curvature of the mating flanges is preferably substantially equal to the axial spacing of said lateral walls.

Owing to the semi-circular curvature of the interlocking elements at the respective bends, the interengaged bends tend to slide over one another during expansion and contraction of the wall, so that the stresses at the bends are less than if the metal were integral. This relative movement between the respective elements therefore tends to facilitate expansion and contraction of the wall, and this may be increased by interposing a lubricant between the sliding surfaces. The elements may also be made free to have circumferential movement with respect to each other. This manner of procedure also permits a wall to be formed of any desired length, and by cold working or other operations the bends may be subsequently deepened or narrowed, or both, or given the desired shape or the desired degree of toughness, temper, etc. Means may also be readily associated with the joints for rendering them fluid tight, if desired, a suitable construction to this end being disclosed in the application of Jean V. Giesler, Serial No. 191,826, filed May 16, 1927, entitled Flexible corrugated tubular walls.

While one method of procedure and one product embodying the present invention have been described with considerable particularity, it is to be expressly understood that the invention is not restricted thereto, as the invention is capable of being carried out in other ways and of receiving other expressions, some of which will now readily suggest themselves to those skilled in the art, while changes may be made in the order and details of the steps and in the details of construction, arrangement and proportion of parts, without departing from the spirit of this invention. Reference is therefore to be had to the claim hereto appended for a definition of this invention.

What is claimed:

The method of making a flexible corrugated tubular metal wall which includes the steps of forming annular elements with axially directed flanges at the inner and outer periphery of each element, alternately telescoping the inner and outer flanges of succeeding elements, and rolling each engaged pair of flanges while in telescopic engagement into arcuate bends curved in the direction of the axis into a substantially semicircular curvature of sufficient extent to interlock the overlapping curved surfaces against separation within the range of their possible relative movement while at the same time providing relatively sliding movement between said overlapping curved surfaces during expansion and contraction of the bellows.

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