April 30, 1929. W. R. ZIMMERMAN 1,711,075

METHOD OF MAKING FLEXIBLE CORRUGATED METAL WALLS

Filed Oct. 6, 1925

Fig.1.

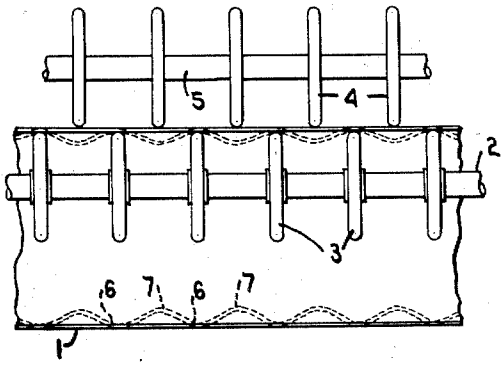


Fig.2.

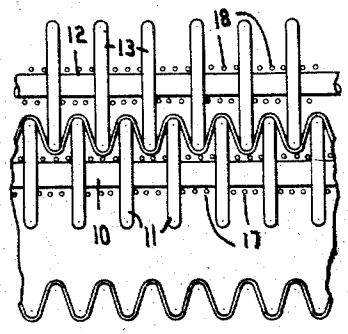


Fig.4.

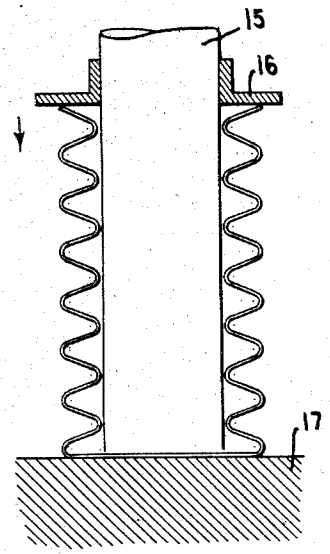


Fig.3.

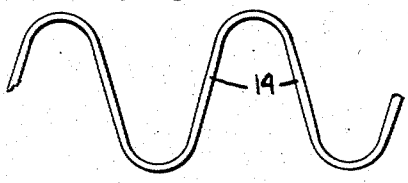
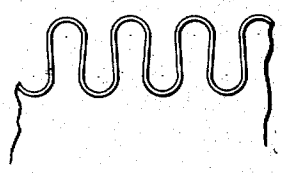


Fig.5.



INVENTOR.
William R. Zimmerman
BY
Fay, Oberlin & Fay
ATTORNEYS.

Patented Apr. 30, 1929. 1,711,075

UNITED STATES PATENT OFFICE.

WILLIAM R. ZIMMERMAN, OF CLEVELAND, OHIO, ASSIGNOR TO THE BISHOP AND BABCOCK MANUFACTURING COMPANY, OF CLEVELAND, OHIO, A CORPORATION OF OHIO.

METHOD OF MAKING FLEXIBLE CORRUGATED-METAL WALLS.

Application filed October 6, 1925. Serial No. 60,786.

The present invention relates to an improved method of making flexible corrugated metal walls, commonly termed "metal bellows", and is particularly directed to a mechanical method of making such bellows which shall insure greater accuracy in the wall thicknesses and particularly at the bends of the corrugations than is possible with the methods now in use for mechanically forming tubes into bellows. A further object of the invention is the provision of a method for more accurately tempering the metal and controlling the characteristics of the metal in the walls during the formation of the walls into corrugations, while a still further object is the provision of an improved metal bellows having greater uniformity and sensitiveness in action than those now in use. To the accomplishment of the foregoing and related ends, said invention, then, consists of the means hereinafter fully described and particularly pointed out in the claims.

The annexed drawing and the following description set forth in detail one method and one product exemplifying my invention, such disclosed procedure and product constituting, however, but one of various applications of the principle of my invention.

In said annexed drawing:—

Fig. 1 is a side elevation partially in section showing apparatus for performing the initial step in my improved method of making bellows; Fig. 2 is a similar view illustrating the second step; Fig. 3 is a longitudinal section showing the formation of the corrugations after the conclusion of the second step; Fig. 4 is a view in longitudinal section illustrating the last step in the method; and Fig. 5 is a longitudinal section of the bellows at the conclusion of the process.

My improved method consists, briefly stated, in first forming a series of suitably spaced encircling indentations and projections around a thin tube while maintaining the length of the tube constant so that the metal is entirely stretched during this operation; then increasing the depth of the inwardly and outwardly extending corrugations while simultaneously collapsing the tube longitudinally, thus both stretching and bending the metal in the corrugations; and finally still further collapsing the tube while guiding the movement of the several corrugations to prevent cocking of these during the completion of the forming operation.

In Fig. 1 I have shown the first of the above steps in the formation of metallic bellows and in this Figure there is shown a thin cylindrical tube 1 which is disposed about a shaft 2 provided with a series of spaced corrugating rolls 3, all of which are fixed against either relative longitudinal or rotational movement with respect to the shaft. The tube, when so mounted upon the rolls 3, is then brought into contact with a second series of rolls 4 also fixed upon a shaft 5 and arranged to contact the outer surface of the tube at points equidistant along its length from the points engaged by the adjacent inner rolls 3. During this initial operation the cylindrical tube is formed with a series of outwardly projecting corrugations 6 and inwardly projecting corrugations 7, provided the outer and inner rolls are formed to exert about equal pressure upon the tube wall while the depth of the inner and outer corrugations will depend upon the relative pressure exerted by the two sets of rolls, although in any event both inner and outer corrugations will be formed during this operation. The tube length does not shorten during this first operation. The metal in each corrugation is therefore stretched and worked more than is the case, however, if the tube length is allowed to shorten during operation, in which case the tube wall is formed into corrugations by a combined metal stretching and bending operation, in which case the bending of the metal tube wall causes a very slight working of the metal and does not increase its temper or hardness to any appreciable degree.

After the completion of the initial corrugations shown in Fig. 1 the partially corrugated tube, either with or without an anneal, depending upon the temper which has been worked into the metal during the first operation, which in turn depends upon the depth to which the corrugations are carried at this stage, is disposed upon a second shaft 10 with the various outwardly extending corrugations engaged by rolls 11, which are non-rotatably mounted on the shaft 10, but are longitudinally movable thereon. A second shaft

12, also carrying non-rotatable but longitudinally movable rolls 13, is then brought down upon the partially corrugated tube, the rolls 13 engaging in the crests of the inwardly extending corrugations. As the two shafts are made to approach each other both the inner and outer corrugations are deepened and are narrowed by the same action, since as the rolls are all floating on their shafts the tube length will shorten during this operation and the corrugations will be brought closer to each other, producing corrugations of the form shown in Fig. 3. Springs 18 are interposed between the various rolls 13 on the shaft 12 and the rolls 11 on the shaft 10 to provide proper initial spacing of these rolls and to also, to some extent stabilize the collapsing action of the rolls during the progress of the second operation illustrated in Fig. 2.

The vary thickness of the metal of the tube after the completion of the second operation is shown in Fig. 3, and it will be understood that the effect of the second operation will be to materially decrease the hardness and temper of the crests of both inner and outer corrugations, the temperature varying from a maximum at the crests of the corrugations to a minimum at the center of the intermediate flat connecting portions 14.

The final step in the forming of the bellows consists in collapsing or modifying the shape of the various corrugations by compressing the tube endwise. This step, which may be accomplished in various ways, is illustrated in Fig. 4 as being carried out by mounting the tube about a tubular member 15 having a diameter very slightly less than the desired final inside diameter of the bellows, after which the tubular plunger 16 is moved longitudinally of the element 15 against one end of the bellows, while the other end of the bellows is mounted upon a base 17. The effect of this collapsing operation is to greatly narrow and to slightly deepen the various corrugations, and to slightly increase the outside diameter of the bellows and to decrease the inside diameter. The action on each corrugation is almost purely a bending action, there being, however, a sufficient stretching of the metal at the bends to effect the increase in the diameter which is referred to and to bring the inner corrugations into substantial contact with the tubular guide 15. The function of the guide 15 is to determine and limit the inside diameter and to act also as a guide for the corrugations in the deformation, which is here carried out, in this way preventing the cocking of the corrugations, which sometimes results if the collapsing operation is performed without any such guiding means.

Other forms may be employed embodying the features of my invention instead of the one here explained, change being made in the form or construction, provided the elements stated by any of the following claims or the equivalent of such stated elements be employed, whether produced by my preferred method or by others embodying steps equivalent to those stated in the following claims.

I therefore particularly point out and distinctly claim as my invention:—

1. In a method of making corrugated metallic bellows from cylindrical tubes, the steps which consist in forming spaced alternated inwardly and outwardly extending encircling corrugations in a tubular wall while preventing the shortening of the tube, deepening and narrowing the inwardly formed corrugations while permitting the tube length to shorten, and then collapsing the corrugated tube longitudinally to bring the corrugations into substantial parallelism while preventing the corrugations from displacement out of planes at right angles to the axis of the tube.

2. In a method of making corrugated metallic bellows from cylindrical tubes, the steps which consist in mechanically forming spaced alternated inwardly and outwardly extending encircling corrugations in a cylindrical tube by stretching the metal of the tube wall into such corrugations, narrowing and deepening such inwardly formed corrugations by a combined bending and stretching action, and then converting such corrugations into corrugations having substantial parallel walls by a mechanical collapsing operation while preventing displacement of the various corrugations from planes at right angles to the axis of the tube.

3. In a method of making corrugated metallic bellows from cylindrical tubes, the steps which consist in mechanically forming spaced alternated inwardly and outwardly extending encircling corrugations in a cylindrical tube by stretching the metal of the tube wall into such corrugations while preventing the shortening of the tube between the outermost corrugations, narrowing and deepening such inwardly formed corrugations by a combined bending and stretching action, and then shortening the entire tube length a material amount by a change in the conformation of the various corrugations effected solely by an endwise pressure on the tube.

4. In a method of making corrugated metallic bellows from cylindrical tubes, the steps which consist in forming spaced alternated inwardly and outwardly extending encircling corrugations in a tubular wall while preventing the shortening of the tube between the outermost corrugations, deepening and narrowing such formed corrugations while permitting the tube length to shorten and then collapsing the corrugated tube longitudinally to bring the corrugations into substantial parallelism.

5. In a method of making corrugated

metallic bellows from cylindrical tubes, the steps which consist in forming spaced alternated inwardly and outwardly extending encircling corrugations in a tubular wall, deepening and narrowing the inwardly formed corrugations and then collapsing the corrugated tube longitudinally to bring the corrugations into substantial parallelism while preventing the corrugations from displacement out of planes at right angles to the axis of the tube.

Signed by me this 11th day of Sept., 1925.

WILLIAM R. ZIMMERMAN.