

July 31, 1934.

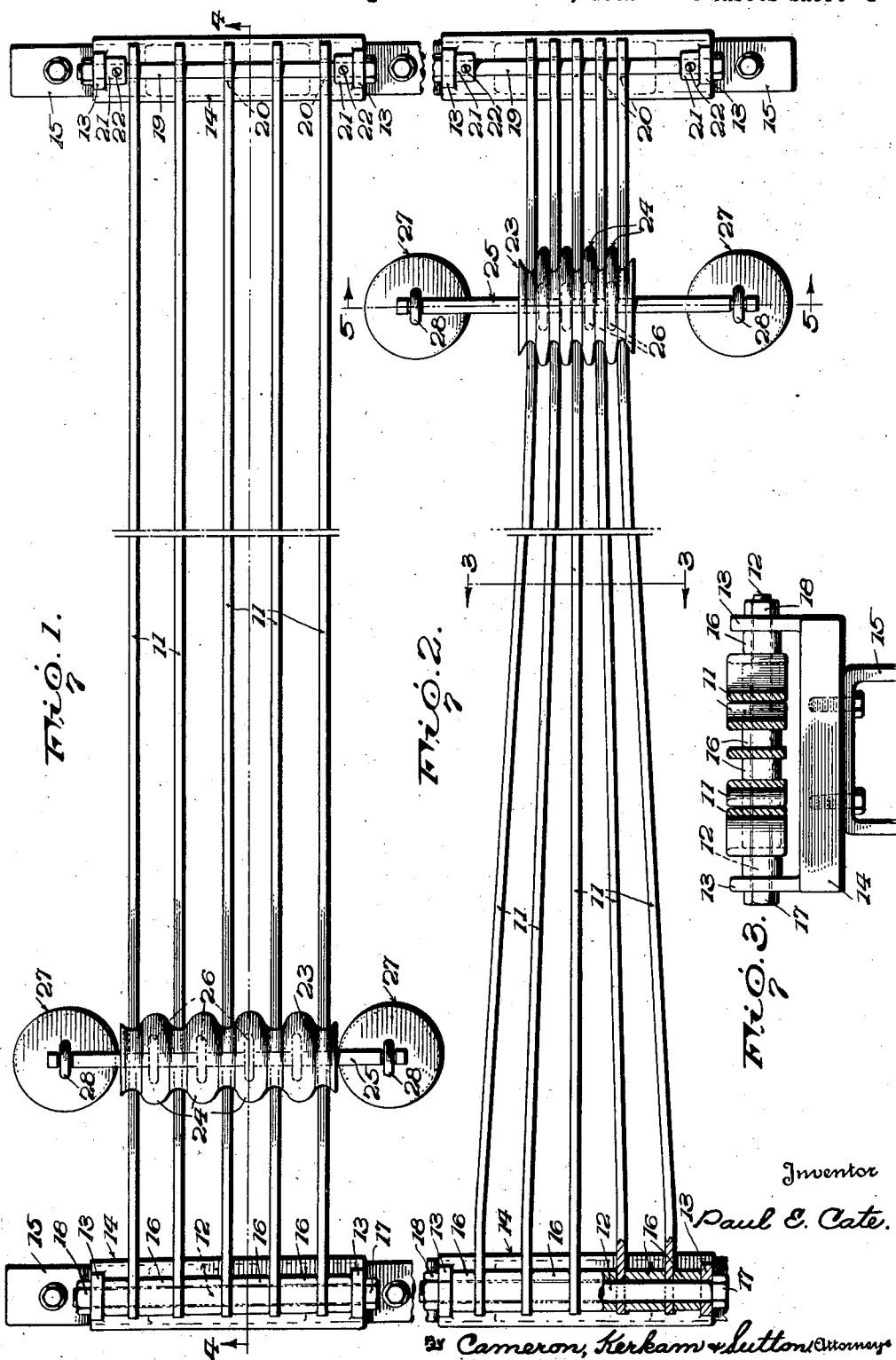
P. E. CATE

1,968,124

METHOD AND APPARATUS FOR CORRUGATING TUBES

Original Filed June 1, 1932

4 Sheets-Sheet 1



July 31, 1934.

P. E. CATE

1,968,124

METHOD AND APPARATUS FOR CORRUGATING TUBES

Original Filed June 1, 1932 4 Sheets-Sheet 2

FIG. 4.

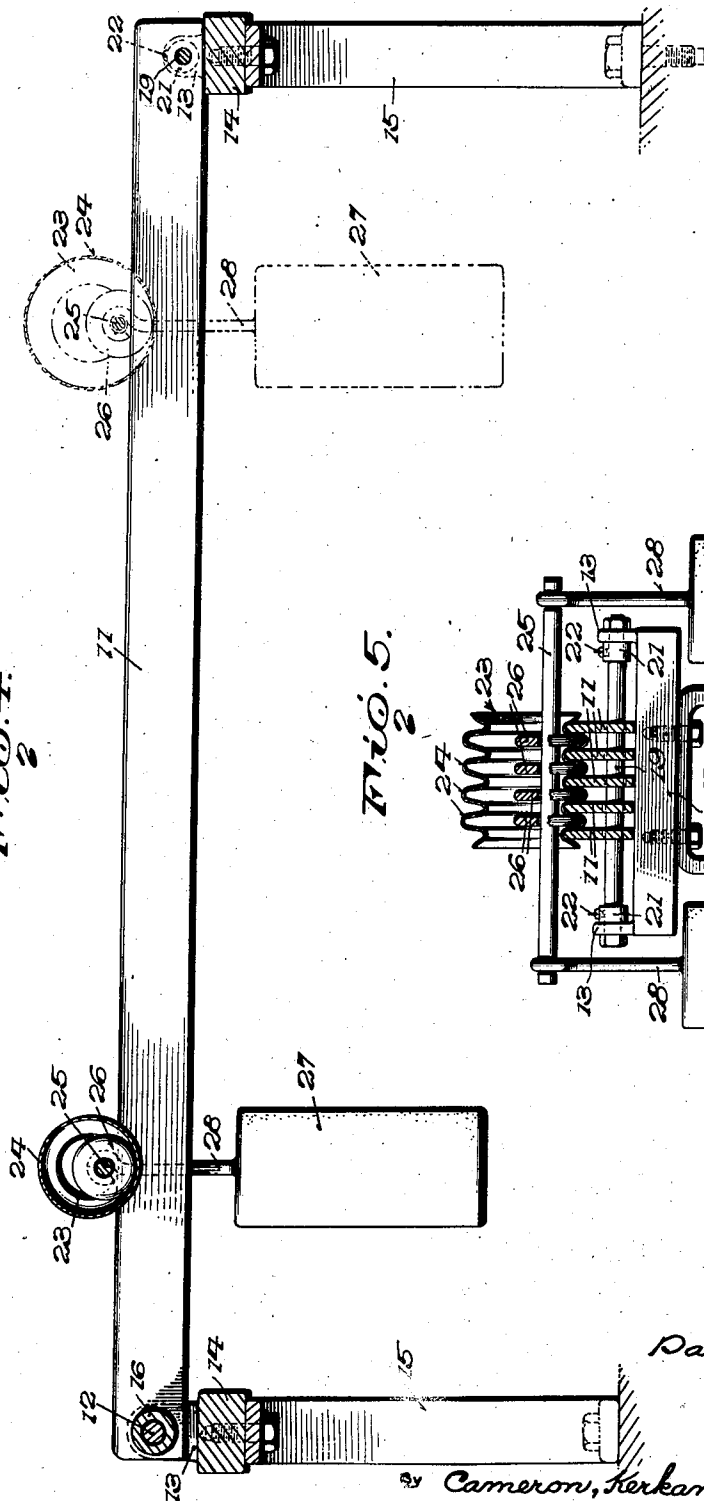
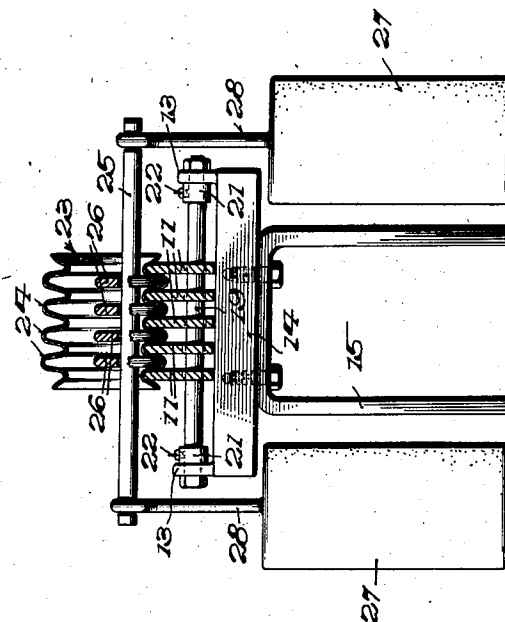


FIG. 5.



Inventor
Paul E. Cate.

By Cameron, Kerkam & Sutton Attorneys

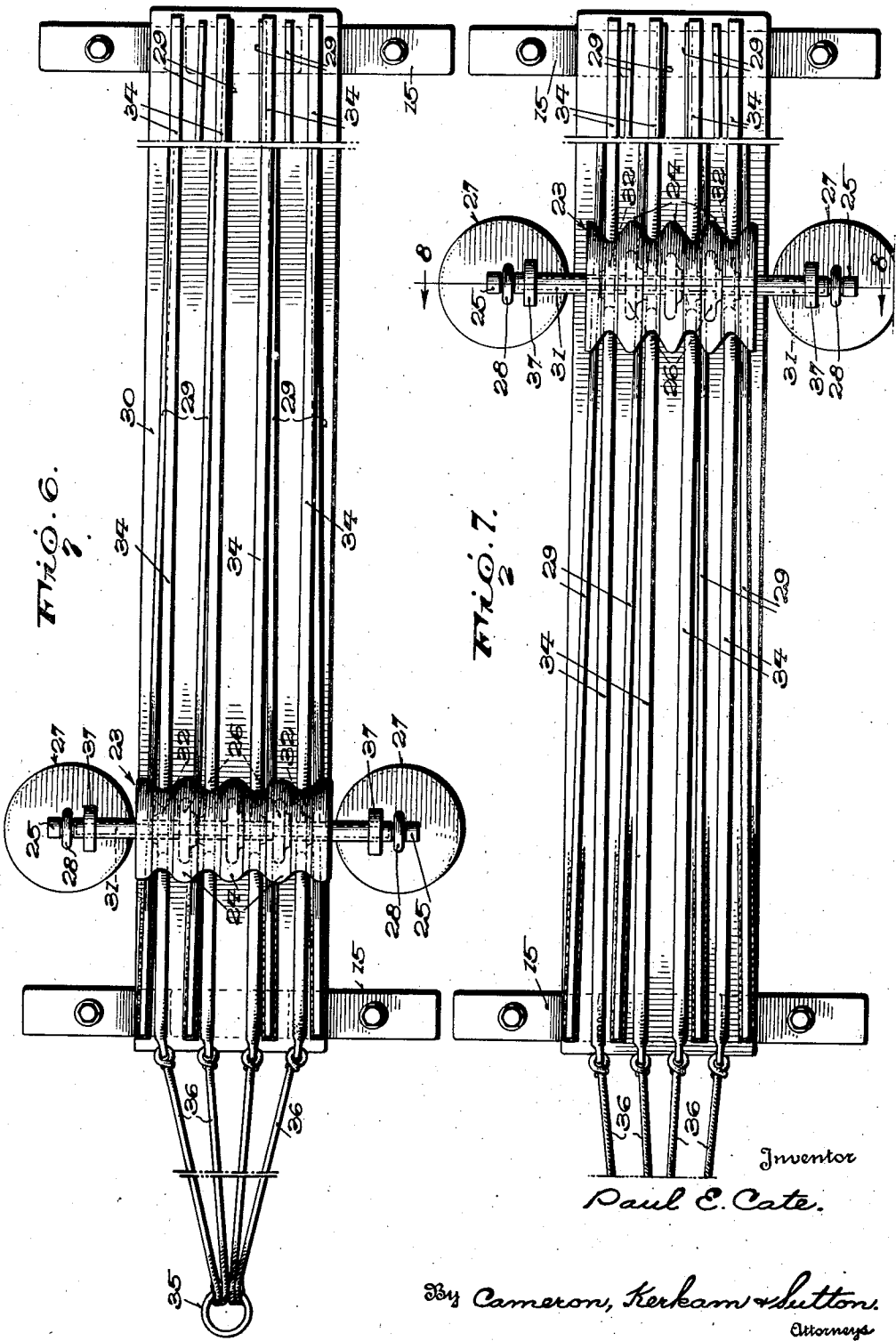
July 31, 1934.

P. E. CATE

1,968,124

METHOD AND APPARATUS FOR CORRUGATING TUBES

Original Filed June 1, 1932 4 Sheets-Sheet 3



July 31, 1934.

P. E. CATE

1,968,124

METHOD AND APPARATUS FOR CORRUGATING TUBES

Original Filed June 1, 1932

4 Sheets-Sheet 4

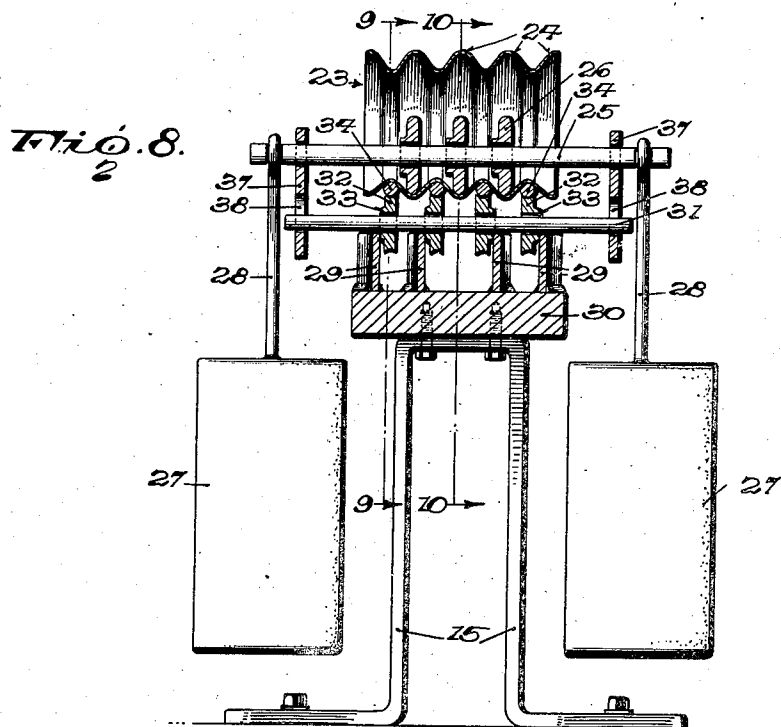


FIG. 9.

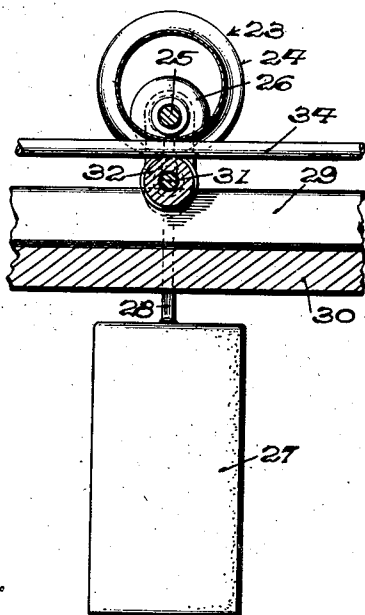
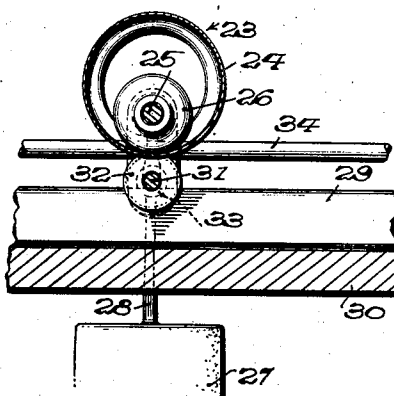


FIG. 10.



Inventor

Paul E. Cate.

By Cameron, Kerkam & Sutton
Attorneys

UNITED STATES PATENT OFFICE

1,968,124

METHOD AND APPARATUS FOR
CORRUGATING TUBES

Paul E. Cate, Knoxville, Tenn., assignor to The
Fulton Sylphon Company, Knoxville, Tenn., a
corporation of Delaware

Application June 1, 1932, Serial No. 614,821
Renewed April 24, 1934

23 Claims. (Cl. 153—74)

This invention relates to methods and apparatus for making flexible, tubular, corrugated metal walls for collapsible and expansible elements, and more particularly to the manufacture of metallic bellows by a rolling operation.

Flexible, corrugated metal walls or bellows have heretofore been made by rolling the tube in which the corrugations are to be formed between exterior and interior rollers, but in practicing the known methods it is necessary to use rollers of several different sizes in order that the corrugations may be gradually formed, by successive rolling operations to the desired depth and width without subjecting the metal of the tube to excessive stress. Such a procedure, while especially well adapted for making certain kinds and sizes of bellows, is nevertheless possessed of certain disadvantages due to the successive rolling operations required.

It is therefore one of the objects of the present invention to provide a novel method and apparatus for forming a flexible, corrugated metal tube or bellows by a single, continuous rolling operation.

Another object is to provide an improved method and apparatus for making bellows wherein the corrugations are progressively deepened and narrowed to their final form in a single, continuous rolling operation.

A further object is to provide a method and apparatus for forming a flexible, corrugated bellows member from a metal tube by rolling wherein the corrugations are completely formed by the progressive action of a single set of continuously acting novel rolling means.

Still another object is to provide an improved method and apparatus for making a flexible bellows by rolling corrugations into a metallic tube which are characterized by the utilization of a novelly constructed rolling device capable of progressively deepening and narrowing corrugations to their final form during a single, continuous cycle of operation of said device.

A still further object is to provide a new and improved method and apparatus for forming metallic bellows by rolling which are more rapid, efficient and economical in operation than those of this general character hitherto known.

Another object is to provide a novel bellows rolling method and apparatus employing one or more, preferably a set of, interior rollers and non-rotatable means cooperating therewith and in engagement with the outside of the tube whereby the corrugations are progressively deepened and narrowed during rotation of the

tube by the movement of said rollers while said rollers and non-rotatable means have relative movement radially of the tube.

A further object is to provide a new and improved bellows rolling mechanism of simple, rugged construction which is capable of completely forming a bellows in one continuous operation.

These and other objects will appear more fully from a consideration of the detailed description of the invention which follows. Although two different embodiments of the invention have been described and illustrated in the accompanying drawings, it is to be expressly understood that these drawings are for the purpose of illustration only, and are not to be construed as a definition of the limits of the invention, reference for that purpose being had to the appended claims.

In the drawings, wherein like reference characters indicate like parts throughout the several views:

Fig. 1 is a plan view of one form of bellows rolling mechanism constituting one embodiment of the present invention, showing the mechanism in position for the beginning of the rolling operation;

Fig. 2 is a plan view of the mechanism of Fig. 1 showing the position of the elements near the end of the rolling operation;

Fig. 3 is a sectional view taken substantially on line 3—3 of Fig. 2;

Fig. 4 is a sectional view taken substantially on line 4—4 of Fig. 1;

Fig. 5 is a sectional view taken substantially on line 5—5 of Fig. 2;

Figs. 6 and 7 are plan views of another embodiment of the invention showing the bellows at the beginning and at an intermediate stage of the rolling operation;

Fig. 8 is a sectional view taken substantially on line 8—8 of Fig. 7; and

Figs. 9 and 10 are sectional views taken substantially on lines 9—9 and 10—10, respectively, of Fig. 8.

Referring now to Figs. 1—5, inclusive, there is disclosed therein a novel form of tube corrugating or bellows rolling mechanism embodying a rolling bed formed by the rounded upper edges of a plurality of laterally spaced, elongated guide members or strips 11 which are securely fixed or anchored in any suitable manner at one end (at the left as viewed in Figs. 1, 2 and 4), are flexible or resilient throughout their length so as to be capable of movement toward and away from one

another, and are suitably supported at the other end in such a manner as to permit such flexure or to permit lateral movement to take place. In the form shown, the guide members 11 are anchored at their left ends, the front end of the rolling mechanism, by mounting them on a bar or bolt 12 which is in turn fixedly supported in any desired manner, as in a pair of brackets 13 projecting upwardly from a suitable base member or support 14 elevated above the floor or machine foundation as by an inverted U member 15. Guide members 11 are mounted on bar or bolt 12 and maintained at predetermined distances apart by interposed spacer members 16, while the entire assembly is maintained in proper position by the engagement of head 17 of bar or bolt 12, and of a nut 18 threaded on the opposite end thereof, with the adjacent brackets 13.

As will appear more clearly as the description of the mechanism proceeds, any desired number of guide members 11 may be utilized, dependent upon the number of corrugations to be formed in the tube or bellows being rolled, and the widths of spacer members 16 may likewise be proportioned to conform to the distances between the adjacent corrugations which are initially formed in the tube before the rolling commences.

The opposite ends of flexible guide members 11 (the right-hand ends as viewed in the drawings) are likewise supported on a bar or bolt 19 which passes freely through enlarged openings 20 formed in said guide members, said openings being of such size as to permit lateral movement of the ends of guide members 11 when the latter are flexed. Bar or bolt 19 may be suitably supported as in brackets 13 projecting upwardly from a base member 14 which is in turn mounted on an inverted U supporting member 15, similarly to the construction used to support the front end of the bed. In order that guide members 11 may be prevented from diverging beyond their normal parallel positions, bar or bolt 19 may, if desired, be provided with a pair of stop members 21 adjustably secured to bar 19 as by set screws 22, said stop members limiting the outward movement of the ends of the two outside guide members 11.

The rolling bed thus formed is adapted to support, and to cooperate with, rolling mechanism later to be described in forming corrugations in the tube 23 from which the bellows is to be formed. As shown in the drawings, while tube 23 may be smooth-walled when placed on the rolling mechanism, it is preferable that it should have been previously provided with a plurality of comparatively shallow, widely spaced corrugations 24, corresponding in number to those which it is desired the bellows should possess when in final form. These initial corrugations may be formed in any desired manner, but, as previously mentioned, the width of or the distance between them should be substantially equal to the spacing between guide members 11 at their front, or left-hand, ends.

After the initial corrugations are formed in tube 23, and said tube is placed on the front end of the rolling bed provided by guide members 11, novel means are provided for rolling the tube along the bed, which means, in cooperation with the flexible guide members 11, progressively deepen and narrow the initial corrugations to final form in a single, continuous rolling operation. In the embodiment disclosed, a shaft 25 on which are mounted a plurality of corrugating

rollers 26 is placed within tube 23 with each roller 26 engaging the interior of one of the initial corrugations 24. Rollers 26 are slidably mounted on shaft 25 so as to be capable of free axial movement therealong when the spaces or distances between the corrugations are narrowed during the rolling operation.

The ends of shaft 25 extend well beyond the ends of tube 23 and the outermost guide members 11, and any suitable means are provided for exerting a downward or radially outward force upon said shaft so as to cause the corrugating rollers 26 to deepen the corrugations. In the form shown, weights 27 are detachably connected in any suitable manner, as by hooked suspension members 28, to the ends of shaft 25. As shown best in Figs. 4 and 5, due to the fact that corrugating rollers 26 are of smaller diameter than the interior of tube 23, weights 27 maintain said rollers in engagement with only the lowermost portions of the corrugations and hence exert a deepening effect upon those particular portions with which these rollers are in engagement, the intermediate portions of the corrugation being supported by the rounded upper edges of guide members 11.

In carrying out the method of the present invention, as by means of the mechanism just described, the first step is preferably that of forming a plurality of initial, comparatively shallow and widely spaced corrugations 24 in the tube 23 which is to be rolled to final form in one continuous rolling operation. Tube 23 is then placed upon the rolling bed formed by guide members 11, and shaft 25 and its associated corrugating rollers 26 are placed within tube 23, each roller being in engagement with the interior or one of corrugations 24 and the rounded upper edge of each guide member 11 being in engagement with the exterior of an adjacent inwardly directed portion of said tube. It will be noted that the number of guide members 11 preferably exceeds that of corrugating rollers 26 by one so that each roller lies between two guide members. Weights 27 are then suspended from the ends of shaft 25 and the mechanism is ready for the rolling operation.

The rolling of the tube along the rolling bed may be accomplished in any one of a number of ways, either by hand or by suitable mechanical means, the specific character of which forms no part of the present invention. Since no mechanical means have been illustrated, it will be assumed, by way of example, that the operator of the rolling machine simply forces shaft 25 to the right, as viewed in the drawings, by hand. Movement of shaft 25 to the right in turn causes rotation of tube 23 and rollers 26, and as the rolling progresses, the downward force exerted on rollers 26 by weights 27 tends to gradually deepen corrugations 24. At the same time, as these corrugations tend to deepen there is also a tendency, in order to avoid undue stretching of the material of the tube, for them to draw closer together so as to decrease the spaces therebetween, and since guide members 11 are flexible or resilient, this tendency results in a movement or drawing together of said members and a gradual narrowing of the corrugations, this movement of guide members 11 being also possible in the construction illustrated due to the manner in which they are supported at their right-hand ends.

The rolling continues until the corrugations have been deepened and narrowed to the desired final form and size, at which time weights 27

may be removed from the ends of shaft 25, and shaft 25 and rollers 26 removed from the now completely corrugated tube or bellows, it being understood that the length of the rolling bed formed by guide members 11 is suitably designed so that the rolling of the bellows to the desired final form may be completed in one single, continuous rolling operation.

Another mechanism for carrying out the method of the present invention is disclosed in Figs. 6-10, inclusive, the principal variation from the embodiment of Figs. 1-5 being the provision of fixed, gradually converging guide members and associated mechanism for narrowing or decreasing the spaces between the corrugations in a predetermined manner instead of the flexible construction previously disclosed.

As shown, the rolling bed is formed by a plurality of laterally spaced, elongated guide members 29 fixed in any suitable manner to a base plate 30 and gradually converging from the front or left-hand end of the bed to the rear or right-hand end thereof. The spacing between fixed guide members 29, their length and the degree of their convergence, are suitably determined so that in cooperation with the mechanism next to be described the corrugations may be progressively deepened and narrowed from their initial condition to final form during the time that the tube is rolled the length of the bed.

Resting on top of fixed guide members 29 is a shaft 31 on which are mounted a plurality of grooved rollers 32, said rollers being slidable axially of shaft 31 and being positioned axially thereof by virtue of the engagement of a boss 33 formed on the outer face of each of said rollers with the inner vertical face of one of fixed guide members 29. Supported on the upper surface of each of grooved rollers 32 is an elongated, rounded guide bar 34, the left-hand ends of all of said bars being anchored to a suitable ring 35 in any desired manner, as by flexible cables 36, such that longitudinal movement of said bars is prevented but lateral movement thereof permitted. The right-hand ends of guide bars 34 are free so that said bars may take up positions parallel to one another and spaced apart by distances determined by the cooperation of grooved rollers 32 and fixed guide members 29.

The tube 23 in which the corrugations are to be formed is supported on the upper surfaces of rounded guide bars 34, the latter preferably engaging inwardly directed portions of said tube similarly to guide strips 11 of the embodiment of Figs. 1-5. The means for rolling tube 23 are substantially the same as those described in connection with the preceding embodiment, comprising a shaft 25 on which corrugating rollers 26 are slidably mounted and weights 27 adapted to be detachably connected to the ends of shaft 25 by hooked suspension members 28. In the present form, however, shaft 25 also supports a pair of side links or frame members 37 which depend downwardly therefrom adjacent the ends thereof and are provided with vertically elongated slots 38 into which the ends of shaft 31 extend. This construction maintains both shafts 25 and 31 in proper vertical alignment during the rolling operation, regardless of the height of shaft 25 which is dependent upon the depth of the corrugations at any particular point.

The method of the present invention as practiced by the mechanism disclosed in Figs. 6-10 is substantially the same as that previously described in connection with Figs. 1-5, the principal

difference in this second embodiment being that the narrowing of the spaces between the corrugations is positively effected in a predetermined manner by the closing in of the grooved rollers 32 due to their engagement with the inner vertical surfaces of fixed guide members 29, said inward movement of rollers 32 in turn moving rounded guide bars 34 and corrugating rollers 26 closer together simultaneously with a deepening of said corrugations by the action of weighted rollers 26.

There are thus provided by the present invention a new and improved method and apparatus for corrugating tubes and forming flexible bellows members which are extremely simple in structure and efficient in operation, and more rapid and economical than processes and mechanisms heretofore known. By utilizing the method and apparatus herein disclosed a tube, preferably one in which a plurality of comparatively shallow, widely spaced corrugations have been initially formed, may be rolled to its final form in a single, continuous operation, the corrugations being progressively deepened and narrowed during continuous rolling of the tube. The method and apparatus of the present invention are especially well adapted for commercial operations because of their simplicity.

It will be obvious that the invention is not limited to the specific structures shown in the drawings, but is capable of a variety of mechanical embodiments. For example, the weights shown for exerting a downward force on shaft 25 may be replaced by any other suitable device for attaining the same result, such as springs or an inclined cam or other guide surface with which shaft 25 may be engaged and by means of which the progressive deepening of the corrugations may be positively predetermined in a somewhat similar manner to that in which the width of the corrugations is governed in the embodiment of Figs. 6-10. It will also be apparent that any desired mechanism may be employed for acting upon interior rollers to carry out the rolling operation instead of the manual operation described. Also, it is obvious that any desired number of guide members or guide bars may be utilized dependent upon the number of corrugations which it is desired to form in the tube at one time, said members need not be rectilinear in form, and the spaces between said guide members may be varied dependent upon the desired width of said corrugations. Various other changes, which will now appear to those skilled in the art, may be made in the form, details of construction or operation, and arrangement of the parts without departing from the spirit of the invention. Reference is therefore to be had to the appended claims for a definition of the limits of the invention.

What is claimed is:

1. In a method of forming a bellows from a tube having a plurality of initially formed, comparatively shallow and widely spaced corrugations in the periphery thereof, the steps of engaging the interiors of said initial corrugations by a plurality of rollers, engaging the exterior portions of the tube between said corrugations by a plurality of elongated guide members, and continuously rolling said tube along said guide members while exerting a force upon said rollers and simultaneously positively moving said guide members closer together, whereby said corrugations are progressively deepened and narrowed.

2. In a tube corrugating machine, a plurality of rollers adapted to engage the interior of a tube

at axially spaced points therewithin, a shaft on which said rollers are mounted, a plurality of elongated guide members upon which the tube is adapted to roll, said guide members being adapted to engage the exterior of said tube at points intermediate the positions of said rollers, means for applying a force to said shaft, and means for mounting said guide members whereby they are free to move closer together during progressive rolling of the tube therealong, said movement being accompanied by corresponding axial movement of the rollers along said shaft, whereby the corrugations in the tube are gradually deepened and narrowed during continuous rolling.

3. In a tube corrugating machine, a plurality of rollers adapted to engage the interior of a tube at axially spaced points therewithin, a shaft on which said rollers are mounted for movement axially therealong, a plurality of elongated guide members upon which the tube is adapted to roll, means for predeterminately spacing said guide members adjacent one end thereof, said guide members being substantially perpendicular to the shaft of said rollers and adapted to engage the exterior of said tube at points intermediate the positions of said rollers, means for applying a downward force to said shaft, and means for mounting said guide members so constructed and arranged as to permit said members to move closer together during progressive rolling of the tube therealong, said movement being accompanied by corresponding axial movement of the rollers along said shaft, whereby the corrugations in the tube are gradually deepened and narrowed during continuous rolling.

4. In a tube corrugating machine, a plurality of rollers adapted to engage the interior of a tube at axially spaced points therewithin, a shaft on which said rollers are mounted for movement axially therealong, a plurality of longitudinal guide members upon which the tube is adapted to roll, said guide members being anchored at one end to prevent longitudinal movement thereof and adapted to engage the exterior of said tube at points intermediate the positions of said rollers, means for applying a force to the ends of said shaft whereby a rolling of the tube tends to deepen the corrugations therein, and means for mounting said guide members so constructed and arranged as to permit said members to move closer together during progressive rolling of the tube therealong, said movement being accompanied by corresponding movement of the rollers along said shaft, whereby the corrugations in the tube are gradually deepened and narrowed during a continuous rolling.

5. In a tube corrugating machine, a rolling bed along which the tube to be corrugated is rolled comprising a plurality of laterally spaced elongated guide members, means for anchoring all of said members at one end to prevent longitudinal movement thereof, said means being so constructed and arranged as to permit said members to move laterally relatively to one another, and means for rolling along said bed a tube in which a plurality of comparatively shallow, widely spaced corrugations have been previously formed comprising a weighted shaft adapted to extend through the tube, and a plurality of corrugating rollers mounted on said shaft and adapted to engage the interiors of the corrugations, each of the latter lying between two of said guide members, said rollers and guide members gradually moving inwardly during continuous rolling of the tube and

cooperating to produce a progressive deepening and narrowing of the corrugations.

6. In a tube corrugating machine, a rolling bed along which the tube to be corrugated is rolled comprising a plurality of laterally spaced guide members, means for anchoring all of said members at one end to prevent longitudinal movement thereof, said means being so constructed and arranged as to permit lateral movement of said members toward and away from each other, a shaft, means for applying a pressure to said shaft, a plurality of corrugating rollers mounted on said shaft, said shaft and rollers being adapted to be placed within the tube to be corrugated with said rollers engaging portions of the tube intermediate said guiding members, and means for rolling said tube substantially the length of said guide members during which rolling said members and rollers cooperate to progressively deepen and narrow the corrugations in the tube.

7. In a machine for making bellows of the type wherein a tube having a plurality of initially formed, comparatively shallow and widely spaced corrugations is worked to final form by a continuous rolling operation, a rolling bed comprising a plurality of laterally spaced flexible guide members, means for anchoring all of said members at one end at fixed distances apart corresponding to the spaces between the initial corrugations in the tube to be rolled, the tops of said members being adapted to engage the exterior of the tube at points intermediate said initial corrugations, means for supporting the opposite ends of said guide members but permitting flexure thereof, and means for rolling the tube along said bed including a shaft adapted to extend through said tube, a plurality of corrugating rollers rotatably and slidably mounted on said shaft and adapted to engage the interiors of the initial corrugations of said tube and to lie between said guide members, and means for exerting a downward force upon said shaft whereby when said tube is rolled along said bed the initial corrugations therein are progressively deepened by the action of the downwardly forced rollers and the spaces therebetween are progressively narrowed by the drawing together of the flexible guide members and the rollers, said elements cooperating to work the tube to its final form in a single continuous rolling operation.

8. In a machine for making bellows of the type wherein a tube having a plurality of initially formed, comparatively shallow and widely spaced corrugations is worked to final form by a continuous rolling operation, a rolling bed comprising a plurality of laterally spaced flexible guide members having rounded upper edges, means for anchoring all of said members at one end at fixed distances apart corresponding to the spaces between the initial corrugations in the tube to be rolled, the rounded upper edges of said members being adapted to engage the tube at points intermediate said initial corrugations, a fixed supporting member passing freely through the opposite ends of said members so as to permit flexure thereof, and means for rolling the tube along said bed including a shaft adapted to extend through said tube, a plurality of corrugating rollers rotatably and slidably mounted on said shaft and adapted to engage the interiors of the initial corrugations of said tube, each of said rollers lying between a pair of said guide members during the rolling operation, and means for exerting a downward force upon said shaft

whereby when said tube is rolled along said bed the initial corrugations therein are progressively deepened by the action of the downwardly forced rollers and the spaces therebetween are progressively narrowed by the drawing together of the flexible guide members and the rollers, said elements cooperating to work the tube to its final form in a single, continuous rolling operation.

ments cooperating to work the tube to its final form in a single, continuous rolling operation.

11. In a tube corrugating machine, a plurality of rollers adapted to engage the interior of a tube at axially spaced points therein, a shaft on which said rollers are mounted, a plurality of elongated guide members upon which the tube is adapted to roll, said guide members being adapted to engage the exterior of said tube at points intermediate the positions of said rollers, means for applying force to said shaft, said guide members and rollers being so supported as to move closer together during progressive rolling of the tube therealong, and means for moving said guide members toward each other as said tube rolls therealong, whereby the progressive advance of said tube along said guide members is accompanied by a gradual deepening and narrowing of the corrugations.

12. The method of forming bellows which comprises first forming a plurality of comparatively shallow, widely spaced corrugations in a tube, and then bodily rolling said tube lengthwise of converging corrugation-engaging elements while simultaneously exerting on the corrugations a deepening force to progressively deepen and narrow the corrugations in a single continuous operation.

13. The method of forming bellows which comprises first forming a plurality of comparatively shallow, widely spaced corrugations in a tube, and then bodily rolling said tube lengthwise of corrugation-engaging elements while positively moving said elements toward each other and simultaneously exerting a force on said corrugations to deepen the same as they are narrowed.

14. The method of forming bellows which comprises first forming a plurality of comparatively shallow, widely spaced corrugations in a tube, and then bodily rolling said tube lengthwise of laterally movable corrugation-engaging elements while simultaneously exerting a force on said corrugations to deepen the same as they are narrowed.

15. The method of forming bellows which comprises first forming a plurality of comparatively shallow, widely-spaced corrugations in a tube, and then bodily rolling said tube lengthwise of laterally movable elements engaged in the inwardly directed corrugations of said tube while simultaneously exerting on the outwardly directed corrugations a rolling force to deepen said corrugations and move said elements toward each other.

16. The method of forming bellows which comprises first forming a plurality of comparatively shallow, widely-spaced corrugations in a tube, and then bodily rolling said tube lengthwise of laterally movable elements engaged in the inwardly directed corrugations of said tube while simultaneously exerting on the outwardly directed corrugations a rolling force to deepen said corrugations, and simultaneously moving said elements positively toward each other in proportion to the advance of said tube along said elements.

17. The method of forming bellows which comprises first forming a plurality of comparatively shallow, widely-spaced corrugations in a tube, and then bodily rolling said tube lengthwise of laterally movable elements engaged in the inwardly directed corrugations of said tube while simultaneously exerting on the outwardly directed corrugations the pressure of axially floating rolls to deepen said corrugations and move said elements toward each other.

18. In a tube corrugating machine, a plurality of rollers adapted to engage the interior of a tube

9. In a machine for making bellows of the type wherein a tube having a plurality of initially formed, comparatively shallow and widely spaced corrugations is worked to final form by a continuous rolling operation, a rolling bed comprising a plurality of laterally spaced, rounded guide bars, the upper surfaces of said guide bars being adapted to engage the tube to be rolled at points intermediate the initial corrugations therein, means for anchoring all of said bars at one end to prevent longitudinal movement but permitting lateral movement thereof, means for supporting said guide bars and for decreasing the lateral distances therebetween as the rolling operation progresses, and means for rolling the tube along said bed including a shaft adapted to extend through said tube, a plurality of corrugating rollers rotatably and slidably mounted on said shaft and adapted to engage the interiors of the initial corrugations of said tube, each of said rollers lying between a pair of said guide bars during the rolling operation, and means for exerting a downward force upon said shaft whereby when said tube is rolled along said bed the initial corrugations therein are progressively deepened by the action of the downwardly forced rollers and the spaces therebetween are progressively narrowed by the drawing together of the rounded guide bars, all of said elements cooperating to work the tube to its final form in a single continuous rolling operation.

10. In a machine for making bellows of the type wherein a tube having a plurality of initially formed, comparatively shallow and widely spaced corrugations is worked to final form by a continuous rolling operation, a rolling bed comprising a plurality of laterally spaced, gradually converging fixed guide members, a shaft extending transversely to and supported on said guide members, a plurality of grooved rollers rotatably and slidably mounted on said shaft, each of said rollers being positioned axially of said shaft by engagement with the inner vertical face of one of said guide members, and a plurality of rounded guide bars supported on said grooved rollers and anchored at one end to prevent longitudinal movement, the upper surfaces of said rounded guide bars being adapted to engage the tube to be rolled at points intermediate the initial corrugations therein, and means for rolling the tube along said bed including a shaft adapted to extend through said tube, a plurality of corrugating rollers rotatably and slidably mounted on said shaft and adapted to engage the interiors of the initial corrugations of said tube, each of said corrugating rollers lying between a pair of said guide bars during the rolling operation, and means for exerting a downward force upon said shaft, whereby when said tube is rolled along said bed the initial corrugations therein are progressively deepened by the action of the downwardly forced rollers and the spaces therebetween are progressively narrowed by the drawing together of the rounded guide bars by the cooperation of the fixed guide members and the grooved rollers, all of said ele-

at axially spaced points therein, a shaft on which said rollers are mounted to float axially, a plurality of elongated guide members upon which the tube is adapted to roll, said guide members being adapted to engage the exterior of said tube at points intermediate the position of said rollers, and means of applying force to said shaft, said guide members being flexible and mounted so as to be deflected closer together during progressive rolling of the tube therealong, whereby the progressive advance of said tube along said guide members is accompanied by a gradual deepening and narrowing of the corrugations.

19. In a tube corrugating machine, a plurality of rollers adapted to engage the interior of a tube at axially spaced points therein, a shaft on which said rollers are mounted to float axially, a plurality of elongated guide members upon which the tube is adapted to roll, said guide members being adapted to engage the exterior of said tube at points intermediate the position of said rollers, and means for applying force to said shaft, said guide members being so supported as to move closer together during progressive rolling of the tube therealong, whereby progressive advance of said tube along said guide members is accompanied by a gradual deepening and narrowing of the corrugations.

20. In a tube corrugating machine, a plurality of rollers adapted to engage the interior of a tube at axially spaced points therein, a shaft on which said rollers are mounted to float axially, a plurality of elongated guide members upon which the tube is adapted to roll, said guide members being adapted to engage the exterior of said tube at points intermediate the position of said rollers, means for applying force to said shaft, and means for spacing said guide members predeterminately adjacent one end thereof, said guide members converging adjacent their opposite ends, whereby as the tube is progressively rolled along said guide members the corrugations in said tube are gradually deepened and narrowed.

21. In a tube corrugating machine, a plurality

of rollers adapted to engage the interior of a tube at axially spaced points therein, a shaft on which said rollers are mounted to float axially, a plurality of elongated guide members upon which the tube is adapted to roll, said guide members being adapted to engage the exterior of said tube at points intermediate the position of said rollers, and means for applying force to said shaft, said guide members being movable and coacting with said axially movable rollers to deepen and narrow said corrugations as said tube is progressively rolled along said guide members.

22. The method of forming a bellows from a tube which includes the steps of forming a plurality of initial, comparatively shallow and widely spaced corrugations in the periphery thereof and then progressively deepening and narrowing said corrugations to render them axially flexible by rolling the tube between one or more exterior non-rotatable members adapted to form inwardly extending corrugations and one or more interior rotatable members adapted to form outwardly extending corrugations while frictionally rotating said tube by the movement of said rotatable member and exerting a force on one of said forming members to move it radially of the tube to deform the tube with respect to the other forming member.

23. The method of forming a bellows from a tube which includes the steps of forming a plurality of initial, comparatively shallow and widely spaced corrugations in the periphery thereof and then progressively deepening and narrowing said corrugations to render them axially flexible by rolling the tube between a set of axially-spaced exterior non-rotatable members adapted to form inwardly extending corrugations and a set of interior rotatable members adapted to form outwardly extending corrugations while frictionally rotating said tube by the rotation of said rotatable forming members and exerting a force to move one set of forming members radially of the tube with respect to the other set.

PAUL E. CATE.

45

50

55

60

65

70

75

80

85

90

95

100

105

110

115

120

125

130

135

140

145

150