May 6, 1969 J. LANGLET ET AL 3,442,005

METHOD OF FORMING BELLOWS

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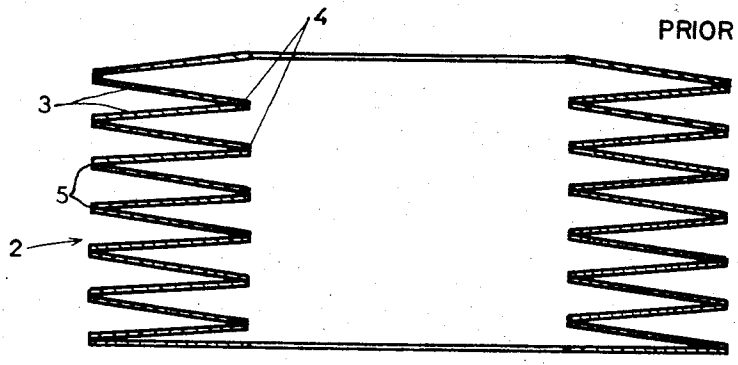
FIG.2

PRIOR ART



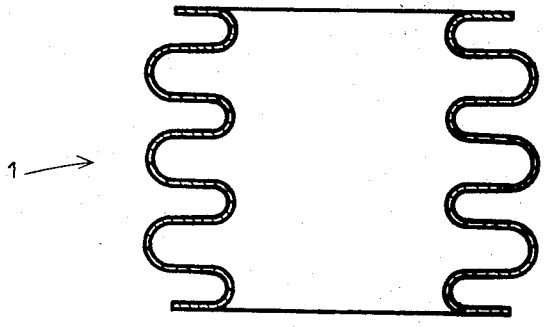


FIG.1

PRIOR ART

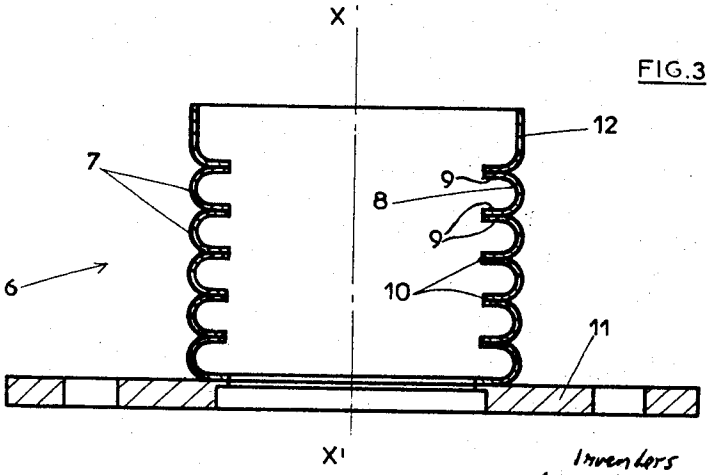


FIG.3

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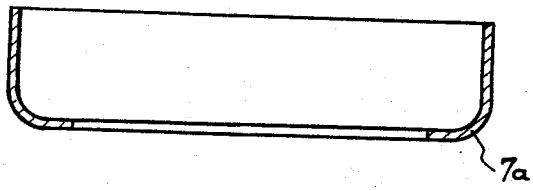

FIG.4a

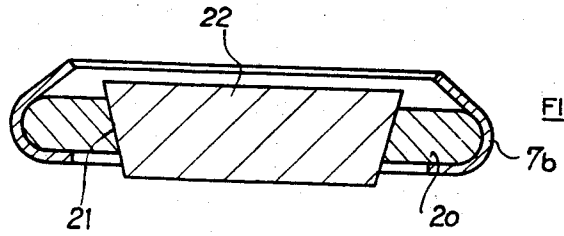

FIG.4b

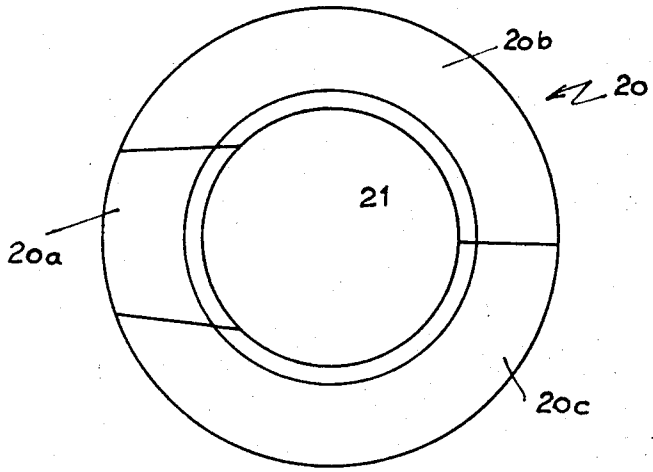

FIG. 5

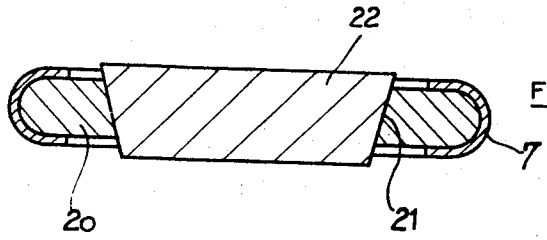

FIG. 4c

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United States Patent Office 3,442,005 Patented May 6, 1969

3,442,005

METHOD OF FORMING BELLOWS

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Filed Apr. 4, 1966, Ser. No. 539,780
Claims priority, application France, Apr. 3, 1965, 11,854
Int. Cl. F16j 3/00
U.S. Cl. 29—454 3 Claims

ABSTRACT OF THE DISCLOSURE

A method of forming a bellows by forming first a plurality of annular sheet metal elements having a pair of spaced substantially parallel flat annular portions integrally connected by a curved portion and having free annular edges opposite the curved portions, superimposing then the elements aligned along a common axis with the flat portions of adjacent elements abutting against each other, and finally welding the abutting flat portions along the annular edges thereof to each other.

The present invention relates to bellows, and more particularly to a bellows composed of a plurality of identical annular parts bonded together in a novel manner to withstand high temperatures and a high pressure.

Two basic types of bellows are known in the art.

One type of bellows is known in which a thin walled tube is corrugated by a hydraulic process into a bellows. The alloys from which the thin walled tubes are formed which are subsequently transformed into a bellows necessarily have to have a ductility and stretchability sufficient to sustain the considerable cold deformation of the tube into a bellows while maintaining after the formation acceptable mechanical characteristics.

Therefore, only certain alloys such as tombac, Monel or stainless steel may be used for this purpose and none of these alloys is structurally hardenable by heat treatment. Therefore the bellows produced from these alloys are not adapted to resist at the same time high temperatures, a high pressure while being subjected to a corrosive atmosphere so as to operate trouble-free for a considerable time under adverse operating conditions. In addition, these bellows usually have a stroke less than 20% of their free length and this stroke is preferably performed by contraction of the bellows.

The second basic type of known bellows comprises a plurality of annular disks welded at the inner and outer peripheral edges to each other. A great number of metal alloys can be used for manufacutring a bellows of this type and especially alloys which can be structurally hardened by heat treatment may be used. The bellows of the second type will therefore have mechanical characteristics improved over the bellows of the first mentioned type and the performance of the bellows of the second type will be superior in many respects with regard to the bellows of the first type. Nevertheless the welded portions of the second type of bellows represent zones of fragility.

For certain applications it is not necessary that the bellows can expand to a considerable extent in longitudinal direction or that they are flexible to a considerable extent in a direction transverse to their axes, but it is necessary that these bellows operate under severe operating conditions, that is at high temperature, for example, at a temperature of 650° C. and that they have to withstand high pressures such as for instance 20 kg. per cm.^{2}. In addition, the bellows in such applications may be subjected to strong internal turbulences and vibrations. The

known bellows of the two constructions above mentioned will go out of service under such operating conditions in a short time either due to rupture of the thin metal wall of the first mentioned type of bellows or due to bursting of the bellows of the second type at the welded edges thereof.

Various attempts have been made to overcome the shortcomings of the two types of bellows mentioned above, but the constructions known in the art to improve these bellows have not worked out satisfactorily in practice.

It is an object of the present invention to provide for a bellows which avoids the shortcomings of the bellows known in the art mentioned above.

It is an additional object of the present invention to provide for a bellows which is composed of a plurality of elements aligned along a common axis, bonded together, and constructed and arranged in such a manner so as to withstand high pressure especially internal pressure without bursting.

It is a further object of the present invention to provide for a method of manufacturing such bellows in a simple and efficient manner.

With these objects in view, the bellows according to the present invention mainly comprises a plurality of superimposed thin walled elements having surfaces of revolution and being aligned along a common axis with each other, each of the elements having in an axial cross section a substantially U-shaped configuration with the concave side of said U-shaped cross section facing the common axis, wherein adjacent elements abut against each other and being bonded to each other along the inner peripheral edges thereof. The plurality of elements above mentioned is preferably formed from sheet metal and the elements are bonded to each other preferably by welding along the inner peripheral edges thereof.

Preferably, the U-shaped cross section comprises a semi-circular portion and a pair of substantially parallel leg portions tangential to said semicircular portion and projecting therefrom toward the axis of the bellows.

In such a construction, high internal pressure will not lead to destruction of the bond between adjacent elements since the higher the internal pressure will be the higher will be the pressure at which the portions of adjacent elements which abut against each other are pressed against each other.

According to a preferred method of forming the bellows according to the present invention, a plurality of annular sheet members are first formed, for instance by stamping and each of the annular sheet members is then formed into a substantially cup-shaped configuration having a bottom portion with a central opening and an annular rim portion projecting to one side of the bottom portion and joined thereto along a curved portion. Subsequently thereto the rim portion is bent towards the bottom portion so as to form from the rim portion a second curved portion forming a continuation of the first mentioned curved portion and having the same radius of curvature as the latter, and a flat portion substantially parallel to the bottom portion and overlapping the latter. The thus-formed elements may be considered as toric shells having flat border portions. After forming a plurality of such toric shells, the same are superimposed upon each other abutting against each other along the flat border portions and subsequently thereto the abutting portions of the elements are welded to each other along the inner peripheries thereof. The welding is preferably performed as an autogenous welding in an inert gas atmosphere, especially in an atmosphere of argon.

End members of appropriate shape may be connected to the opposite ends of the thus formed bellows and

these end members may be connected to the inner periphery of the opposite end elements forming the bellows, or one or both of the end elements forming the bellows may have a free end portion in the form of a cylinder to the outer or inner surface thereof the connecting member may be fixed, for instance likewise by welding.

A bellows of the aforementioned kind can be manufactured from a great veriety of alloys, especially from alloys which may be hardened by heat treating.

The bellows according to the present invention has a great number of advantages over the bellows according to the above discussed prior art. The bellows according to the present invention may be manufactured from the plurality of superimposed toric shells in a very efficient manner and therefore at reasonable cost. The bellows according to the present invention will have a movability in longitudinal and transverse direction which closely approaches that of the bellows of the first mentioned kind. The shape of the bellows according to the present invention is especially adapted for the provision of internal or external guide means and means to prevent turbulence in the exterior of the bellows or vibration thereof. In addition, the bellows according to the present invention has a remarkable resistance against high internal pressures even if applied under additional especially severe conditions such as temperatures higher than 650° C. or maintenance of the bellows in a strongly corrosive atmosphere. Experience has shown that the bellows according to the present invention will withstand such severe operating conditions in a perfect manner.

The novel features which are considered as characteristic for the invention are set forth in particular in the appended claims. The invention itself, however, both as to its construction and its method of operation, together with additional objects and advantages thereof, will be best understood from the following description of specific embodiments when read in connection with the accompanying drawings, in which:

FIGS. 1 and 2 are axial cross sections through bellows according to the prior art;

FIG. 3 is an axial cross section through a bellows according to the present invention;

FIGS. 4*a*, 4*b* and 4*c* are axial cross sections and respectively illustrate successive steps of forming the toric shells from which the bellows according to the present invention are made; and

FIG. 5 is a top view of a multipart form for forming the toric shells.

The bellows **1** shown in FIG. 1 is a bellows according to the prior art in which a thin walled tube is corrugated in a manner known to form the bellows **1** illustrated in FIG. 1 therefrom. FIG. 2 likewise illustrates a bellows according to the prior art and the bellows **2** shown in FIG. 2 is composed of a plurality of substantially frustoconical disks **3** which are welded at the inner and outer peripheral edges **4** and **5** to each other. Internal pressure in the bellows **2** will tend to spread the radially outwardly extending portions of adjacent disks apart so that rupture along the outer edges **5** may easily occur.

FIG. 3 illustrates an axial cross section through a bellows according to the present invention. As can be seen from FIG. 3 the bellows according to the present invention comprises a plurality of elements or shells **7** wherein each of the shells **7** has a surface of revolution about the axis X–X' which in an axial cross section has a substantially U-shaped configuration with the concave side of the U-shaped cross section facing the aforementioned axis. More precisely each U-shaped cross section comprises a semi-circular portion **8** and a pair of substantially parallel leg portions **9** tangential to the aforementioned semicircular portion and projecting therefrom substantially normal to the axis X–X' towards the latter. Each shell **7** is therefore substantially in the form of a semitore having a concave side facing the axis thereof and extending tangentially by two flat annular portions.

The shells **7** are preferably made from annular disks stamped out of sheet metal. The annular disks are then formed for instance in a press into a substantially cup-shaped member as shown in FIG. 4*a* having a substantially flat bottom portion with a central opening and an annular rim portion projecting to one side from the bottom portion and joined thereto along a curved portion so as to present in cross section a configuration of a rounded L **7***a* as shown in FIG. 4*a*. A bending form **20** having three parts **20***a*, **20***b*, and **20***c*, as shown in FIG. 5, is then placed in the interior of the cup-shaped member, and as shown in FIG. 5 the part **20***a* of the form **20** is constructed in such a manner that it can be withdrawn into the central frustoconical opening **21** of the three part form **20**. A frustoconical member **22** is then placed into the central opening **21** of the three part form to hold the outer toric surface thereof in engagement with the inner surface of the cut-shaped member.

Subsequently thereto the rim portion of the cup-shaped member is bent at **7***b*, as shown in FIG. 4*b* over the curved surface of the three part mold and finally the upper portion of the rim of the cup-shaped member is pressed against the upper substantially flat surface of the three part form **20** so as to obtain the toric shell **7** as shown in FIG. 4*c*.

After the shell **7** is thus finished the central core **22** is withdrawn from the three part mold and afterwards the part **20***a* is withdrawn into the central opening of the three part mold **20** whereupon the other two parts **20***b* and **20***c* may also be withdrawn from the interior of the shell **7**.

The above manner of manufacturing the shell **7** is given only by way of an example and obviously the shell may be manufactured in various different other ways.

After a plurality of shells **7** is manufactured, for instance in the above-described manner, the shells are superimposed upon each other, aligned along a common axis, with the bottom portion of one shell abutting against the flat top portion of the shell adjacent thereto. Subsequently thereto the abutting portions of the shells are fixedly connected together for instance by autogenous welding in an inert gas atmosphere, for instance in an atmosphere of argon. The weld seams are produced along the inner peripheries **10** of the shells.

In this way a bellows is produced which is adapted to withstand great interior pressures, since in the thus obtained construction an increased presesure in the interior of the bellows will press the leg portions **9** of adjacent shells **7** with increased pressure against each other so that the weld seams **10** at the inner peripheries of the shells **7** will not be affected by the increased pressure in the interior of the shells and evidently the bellows according to the present invention is adapted to withstand a much greater internal pressure than the bellows according to the prior art as shown in FIG. 2 in which an increased interior pressure will tend to press the outer peripheral portions of the frustoconical disks **3** away from each other so that the weld seams at the outer periphery of these disks are liable to burst as the interior pressure in the bellows increases.

To connect the bellows **6** shown in FIG. 3 to another machine element, an end member **11** as shown in FIG. 3 may be attached to the lowermost of the shells **7**, for instance by welding the bottom portion of the lowermost shell **7** along the inner periphery thereof to the end member **11**. A member **12** having an upper cylindrical portion may be attached in the same manner to the uppermost of the shells **7**, as shown in FIG. 3, and the member **12** may serve to attach thereto in any convenient manner, for instance likewise by welding, a connecting member not shown in FIG. 3 thereto.

It will be understood that each of the elements de-

scribed above, or two or more together, may also find a useful application in other types of bellows differing from the types described above.

While the invention has been illustrated and described as embodied in a bellows formed by a plurality of substantially toric shells welded together, it is not intended to be limited to the details shown, since various modifications and structural changes may be made without departing in any way from the spirit of the present invention.

For instance, if the bellows has to withstand an external pressure the toric shells may be arranged so that the concave sides thereof face away from the axis of the bellows.

Without further analysis, the foregoing will so fully reveal the gist of the present invention that others can by applying current knowledge readily adapt it for various applications without omitting features that, from the standpoint of prior art, fairly constitute essential characteristics of the generic or specific aspects of this invention and, therefore, such adaptations should and are intended to be comprehended within the meaning and range of equivalence of the following claims.

What is claimed as new and desired to be secured by Letters Patent is:

1. A method of forming a bellows composed of a plurality of superimposed thin-walled elements defined by surfaces of revolution and being aligned along a common axis and having each in axial cross-section a substantially U-shaped configuration, said method comprising the steps of forming from bendable but form-retaining sheet metal a plurality of substantially flat annular sheet metal members; bending said substantially flat annular sheet metal members into annular elements of substantially U-shaped cross-section having each a pair of spaced substantially flat portions connected to each other by a curved portion so as to form on each of said flat portions a free annular edge distant from said curved portion, said bending being performed by first deforming each of said substantially flat annular sheet metal members into a cup-shaped member having a bottom portion with a central opening and an annular rim projecting to one side of said bottom portion and joined thereto along a curved portion, and by subsequently bending said rim portion towards said bottom portion so as to form therefrom a second curved portion forming a continuation of said first-mentioned curved portion and having the same radius of curvature as the latter and a flat portion substantially parallel to said bottom portion and overlapping the latter; superimposing said thus bent members along a common axis with said flat portions of adjacent members abutting against each other; and bonding said superimposed bent members along the free edges thereof to each other.

2. A method as defined in claim **1**, wherein said U-shaped annular elements are formed from sheet metal and wherein said step of bonding said elements is performed by welding said elements along said free edges thereof to each other.

3. A method as set forth in claim **2**, and including the step of inserting into said cup-shaped member a multipart form having an outer toric surface, said bending of the rim portion being performed by bending said rim portion onto said outer surface of said form, and subsequently removing said multipart form from the formed sheet metal member.

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U.S. Cl. X.R.

29—472.3, 475; 92—45; 138—173