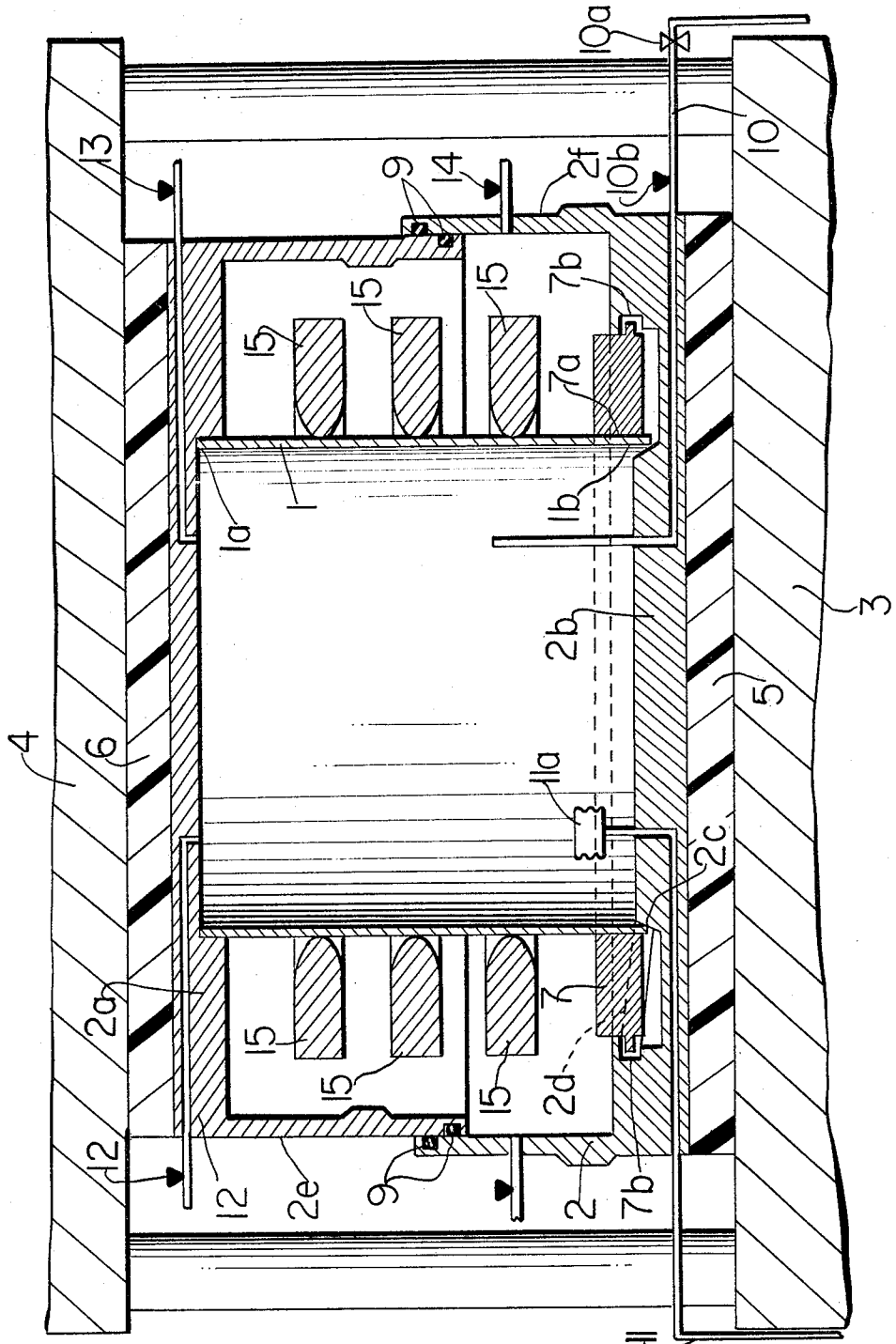
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METHODS OF SHAPING METAL EXPANSION BELLOWS

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METHODS OF SHAPING METAL EXPANSION BELLOWS

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1 Claim. (Cl. 148—11.5)

It is well known that the ultimate strength and the yield strength of certain metals or alloys, such as austenitic steels and aluminum and magnesium based alloys, are greatly improved when, prior to being subjected to a tensile strength test, they are brought to a very low temperature of the order of —200° C., for instance, and maintained at that temperature for the entire duration of the test.

Thus experiments have shown that in the case of aluminum alloys the tensile strength is increased by some 50% and the yield strength by 25%, and that the elongation prior to failure, i.e. the capability of accepting a markedly bigger permanent set before failure occurs, is correspondingly improved. In the specific case of an aluminum-magnesium alloy containing about 3% of magnesium, it was even found that the elongation at temperatures of the order of —200° C., was doubled and rose from 25% to 50%, for example.

In addition, it is well known that in the case of certain stainless steels a degree of cold working at very low temperatures leads to a permanent improvement in their mechanical properties. More particularly, weld areas having greatly weakened mechanical properties find the latter restored and raised to the level of those of the basic metal.

This invention accordingly aims at providing metal expansion bellows endowed with improved mechanical qualities, and to this end has for its object a method of forming (hydraulically or otherwise) expansion bellows, characterized in that the ferrule designed to constitute the bellows, and possibly also the forming tools, are lowered and maintained at a temperature of the order of —200° C. during the forming operation.

In specific applications of this invention to stainless steel bellows, since the forming process constitutes considerable cold-working in itself it imparts excellent properties to the metal and to the weld areas. In the case of light-alloy bellows, a single forming operation could suffice to obtain undulations the depth of which would be practically double that obtainable at ambient temperature.

In industrial terms, these advantages are reflected in many different ways, to wit:

(a) Substantial gains in lightness for a given required yield strength;

(b) Substantial gains in yield strength for a given weight and, in the case of light alloy, the possibility of producing in a single hydraulic forming operation, bellows having an outer diameter equal to 150% of the inner diameter, i.e. with a 50% elongation giving twice the undulation depth with correspondingly amplified movement of enhanced resiliency;

(c) Combined gains in yield strength and lightness intermediate between the maximum possibilities just cited.

Heretofore such super, or so-called cryogenic, cold-working at very low temperatures has been applied in the case of stainless steels only for producing industrial objects of simple shape, such as pressurized-fluid-containing receptacles or bottles and the like, having cylindro-spherical shapes and relatively narrow openings. In such cases, liquid nitrogen is introduced into the container, the opening of which is connected to a source of nitrogen under pressure. On occasion also, the container being processed is first inserted into a mold the internal void of which has the final desired container dimensions, which container is then preformed at ambient temperature but generally underdimensioned externally to an extent dependent upon the results obtained from prior tests made on specimens of the same metal, whereby to remain within the ultimate strength of the metal in the cryogenic phase.

However, the constantly evolving needs of industry make it necessary to envisage the production of industrial-type metal objects endowed with the improved mechanical properties hereinbefore described but having more complex shapes than those of cylindro-spherical receptacles and embodying one or more openings which preclude joining their internal void to a source of fluid under pressure, a specific example being tubular metal bellows adapted to be interposed between and interconnect two tubular conduits liable, by reason of their function, to be subjected to large and possibly rapid variations in length.

The description which follows with reference to the accompanying schematic drawing will give a clear understanding of how the method according to this invention can be performed. This description is given solely by way of example, for the specific case where bellows cooling before and during the forming operation is carried out by means of a liquefied gas, an example being liquid nitrogen. The device illustrated in section is a device for shaping a bellows with liquid nitrogen cooling.

In this particular example of application of the method, the elemental cylindrical ferrule **1** constituting the bellows blank is mounted inside a deformable metal chamber **2**, which chamber is in turn clamped between the faces **3** and **4** of a press, there being two insulating plates **5** and **6**, made for instance of fiberglass-reinforced plastic material resin-impregnated wood, or like substance. The upper peripheral edge **1***a* and the lower peripheral edge **1***b* of ferrule **1** are respectively mounted in leaktight fashion against the top **2***a* and bottom **2***b* of chamber **2**. Such leaktight joints can be made as illustrated, say, by jamming edge **1***b* between a frusto-conical shoulder **2***c* embodied in the bottom **2***b* of chamber **2** and the edge **7***a* of a ring **7** bearing fixing pegs **7***b* which engage into helical ramps **2***d*. Although not illustrated, it goes without saying that the leaktight joint between the upper peripheral edge **1***a* of the ferrule and the upper wall **2***a* of chamber **2** can be provided in like manner. Thus, the interior of ferrule **1**, the upper wall **2***a* and the lower wall **2***b* of chamber **2** jointly form a sealed chamber **8**.

Chamber **2** is deformable, the peripheral wall **2***e* joined to its upper wall **2***a* being capable of sliding relative to the peripheral wall **2***f* joined to its lower wall **2***b*, and to that end sealing O-rings **9** are provided between walls **2***e* and **2***f*. In this way, chamber **2** can sustain deformations when the two faces of the press, **3** and **4**, move toward each other.

Chamber **8** communicates with the exterior via a liquefied-gas-introducing pipe **10** which is controlled by a cryogenic valve **10***a* and incorporates a non-return valve **10***b*. In addition, a pressure take-off **11** is connected to an aneroid capsule **11***a* capable of withstanding very low temperatures of the order of —200° C. By way of safeguards various calibrated valves equipped with anti-frost devices, **12**, **13** and **14**, prevent overpressures from building up both in chamber **8** and in the space comprised between ferrule **1** and chamber **2**.

Lastly, counterpunches **15** are disposed along the periphery of ferrule **1**. The relative spacing between counterpunches **15** varies with the gradual deformation of chamber **2**, said counterpunches being interconnected in

a manner well-known per se, for instance by pantograph-type devices.

The manner of operation of the device described hereinabove is simple: with valve **10***a* open, liquid nitrogen is introduced into chamber **8** through pipe **10**. As it is introduced thereinto, the nitrogen is unable to escape from chamber **8** due to the provision of non-return valve **10***b*. Such introduction of liquid nitrogen has the dual effect of lowering the temperature in chamber **8** and creating a working pressure therein which is the pressure of the saturated nitrogen vapor at the temperature attained in chamber **8**. As the temperature in chamber **8** of ferrule **1** increases, the pressure therein also increases, being at all times equal to the pressure of the saturating nitrogen vapor at the particular temperature reached, and it is this internal pressure in chamber **8** which is instrumental in forming the bellows out of ferrule **1**, by applying the same against counterpunches **15**, the troughs of the undulations corresponding to the portions in contact with said counterpunches **15**. As the forming proceeds, peripheral edges **1***a* and **1***b* of ferrule **1** move closer to each other under the combined effects of the forming pressure and the pressure exerted by the press. The closing motion of faces **3** and **4** is preferably slaved to the pressure prevailing in chamber **8**. Pressure take-off **11** is utilized for such slaving.

Metal bellows produced thus by forming at low temperatures are greatly superior to bellows made by conventional methods, as explained precedingly. In particular, the mechanical strength of stainless steel bellows is markedly improved, while in the case of light-alloy bellows the depth of the undulations is greater by about 50%, for a given weight of metal, than that obtained by conventional methods. Generally speaking, in comparison with bellows produced by methods resorted to heretofore, bellows obtained by performing the method of this invention possess substantially increased resilience and strength per unit length.

It goes without saying that although nitrogen was used in the operating method hereinbefore described, any other suitable liquefied gas could be employed in lieu thereof.

Similarly, the outer surface of ferrule **1** could be placed in contact with the cryogenic medium if desired.

Lastly, the means used to form the bellows in the foregoing example was described as being the pressure exerted by a liquid and its saturating vapor, but it will of course be understood that recourse could be had to hydraulic shaping with a liquid at very low temperature.

What I claim is:

A method of shaping a bellows of aluminum and magnesium alloys possessing for a given weight, an undulation depth greater than that obtained with conventional methods, including the steps of:

(1) directly contacting a portion of the surface of a cylindrical blank of aluminum and magnesium alloys destined to form said bellows with a liquefied gas cryogenic medium whereby the temperature of said cylindrical blank is lowered to a cryogenic temperature of about −200° C.,

(2) performing the shaping operation on said cylindrical blank while substantially maintaining said cryogenic temperature by maintaining said contacting of said cryogenic medium with a portion of said cylindrical blank being shaped, and

(3) recovering said shaped bellows.

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