

United States Patent

[11] 3,581,546

[72]	Inventor	Christain Ragettli Gockhausen near Zurich, Switzerland
[21]	Appl. No.	822,614
[22]	Filed	May 7, 1969
[45]	Patented	June 1, 1971
[73]	Assignee	Inland Steel Company Chicago, Ill.
[32]	Priority	May 14, 1968
[33]		Great Britain
[31]		22931/68

[56]

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Primary Examiner—Lowell A. Larson

Attorney—Wolfe, Hubbard, Leydig, Voit & Osann

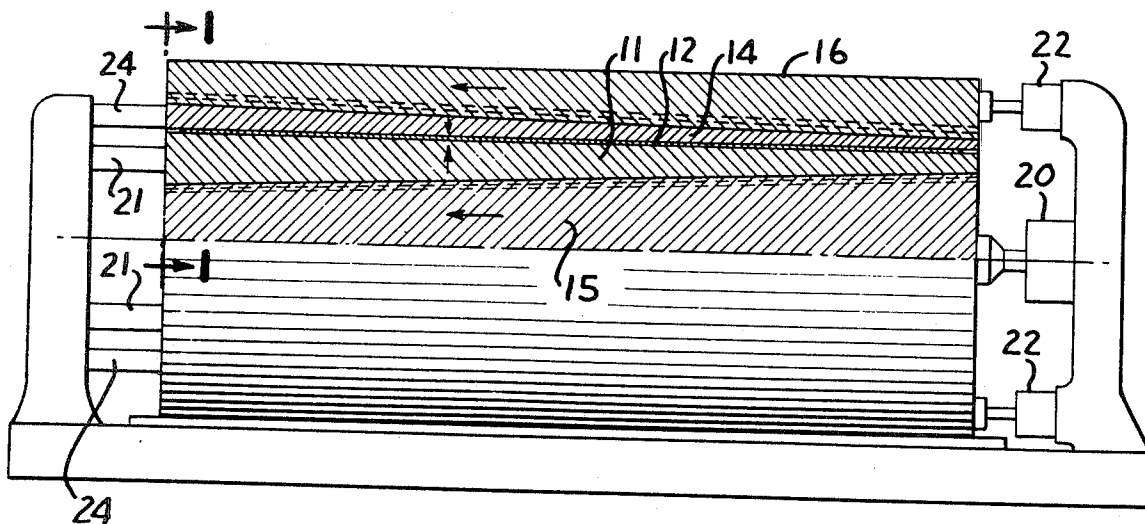
[54] DEDENTING CONTAINERS AND THE LIKE
11 Claims, 4 Drawing Figs.

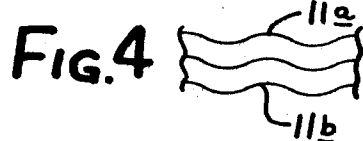
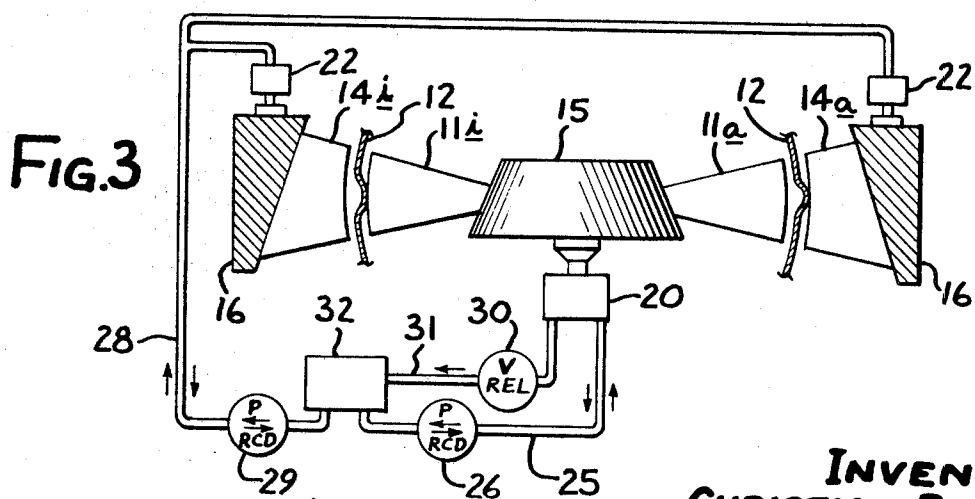
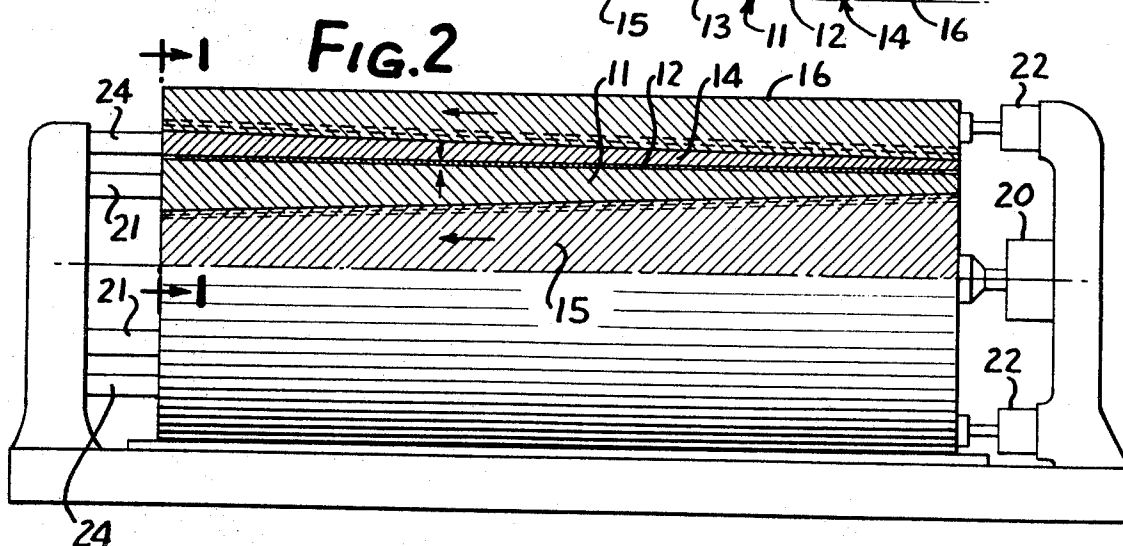
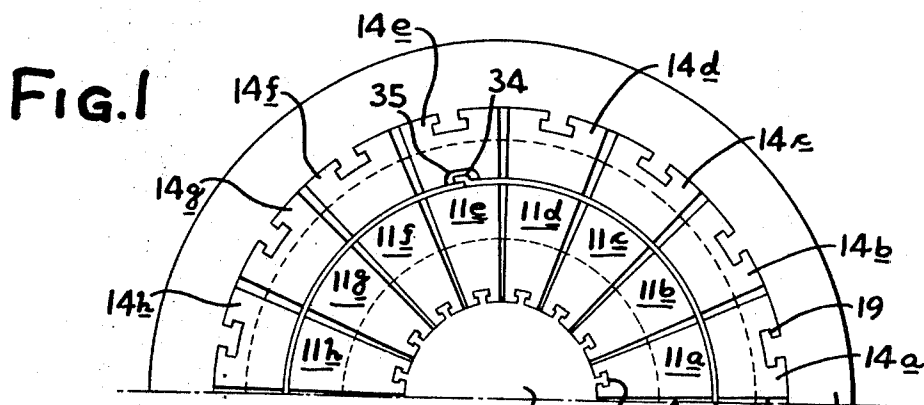
[52] U.S. Cl..... 72/355,
72/370 113/120

[51] Int. Cl. 72/370, 113/120
[50] Field of Search B21d 39/08

[50] **Field of Search**..... B21d 39/08
72/355,
370, 393; 113/120

ABSTRACT: Method and apparatus are provided for removing dents and for reducing asymmetrical stresses in thin wall metal cylinders of the types used in containers or the like. The cylinder is expanded radially to an extent sufficient to exceed the yield point of the metal in tension so as to plastically deform the metal to remove dents, and thereafter the cylinder is compressed radially, while confining the cylinder wall to avoid buckling, to an extent sufficient to exceed the yield point of the metal in compression. By regulating the extent of compression, resilient expansion when the compressive force is withdrawn restores the diameter to substantially the diameter of the original cylinder.





INVENTOR
CHRISTIAN RAGETTLI

by: Wolfe, Hubbard, Voit & Osann
ATTYS.

DEDENTING CONTAINERS AND THE LIKE

CROSS-REFERENCE TO RELATED APPLICATIONS

Priority is claimed with respect to British Provisional application, Ser. No. 22,931/68, filed May 14, 1968.

BACKGROUNDS AND OBJECTS

This invention relates to the removal of dents and the reduction of asymmetrical stresses in thin wall metal cylinders, and more particularly concerns an apparatus and method for dedenting cylinders of the type used in thin wall containers and the like.

Thin wall metal containers are widely used by reason of the protection they afford to their contents. This protection, however, is frequently achieved at the cost of a dented container, and one that cannot be reused. Methods and apparatus have been proposed for dedenting, or removing dents from, these containers, but in many respects these are unable to restore a badly dented container to its original condition. Local hammering, die forming, expanding, compressing, or rolling the dented area have each been proposed and used, but the restored area has invariably been cold worked. As a result, the restored area has stress concentrations that can and do afford a weakened container and one which is susceptible to stress corrosion cracking. It is accordingly a primary object of the invention to provide a method and apparatus for removing dents from thin wall metal cylinders whereby the adverse affects of local restoration are avoided or minimized.

In addition, techniques for dedenting cylindrical containers or vessels which involve local reworking of the dented area establish reworked areas of reduced thickness. This further impairs the usefulness of a dedented container. An additional object of the invention is to provide a system for dedenting cylinders wherein the final cylinder exhibits no local areas of reduced wall thickness.

The limitations of locally reworking a dented container area have been recognized, and attempts have been made to provide methods or apparatus for reworking the entire cylinder. In general, these involve expanding or shrinking the entire cylinder, and as a result the final cylinder diameter—and capacity—differ from that of the original. Yet another object of the invention is to provide a dedenting method and apparatus for thin wall metal cylinders wherein the final cylinder is substantially the original diameter, and accordingly the capacity remains unchanged.

Additionally, the problem of dent removal from thin wall metal cylinders even before the cylinders have been fabricated into containers is an especially troublesome one. While the purchaser or user of a reconditioned container expects and is willing to tolerate an unsightly appearance, the purchaser of a new container can properly object if the container walls look as though they had been straightened. Yet the cylinders, before they are fabricated into containers, are particularly vulnerable to denting, and the container manufacturer accordingly requires a dedenting system which produces containers that do not appear as though they had been either dedented or manufactured from dedented cylinders. It is therefore a major object of the invention to provide a method and apparatus for removing dents from thin wall metal cylinders without leaving an unsightly cylinder wall; in other words, a method of dedenting cylinders without having them visibly appear dedented.

An overall object is to provide a method and apparatus for removing dents and for reducing asymmetrical stresses from thin wall metal cylinders, either before or after fabrication into containers, which method and apparatus are rapid, effective, and compatible with high quality, mass production, techniques. Yet other and more particular objects, aims, and advantages of the invention will become apparent as the description of the invention proceeds.

BRIEF DESCRIPTION OF DRAWINGS

The invention will be more fully described in conjunction with the annexed drawings, wherein:

FIG. 1 depicts an end view of an apparatus according to the invention, showing only the upper half of the inventive apparatus;

FIG. 2 is a side view, partly in section, of the apparatus of FIG. 1;

FIG. 3 is a schematic drawing depicting the operation of the apparatus of FIG. 1 and FIG. 2; and

FIG. 4 is a partial top view of two expanding (or contracting) sectors as used in the inventive apparatus.

While the invention is susceptible of various modifications and alternative forms, a specific embodiment thereof has been shown by way of example in the drawings and will herein be described in detail. It should be understood, however, that it is not intended to limit the invention to the particular form disclosed, but, on the contrary, the intention is to cover all modifications, equivalents, and alternatives falling within the spirit and scope of the invention as expressed in the appended claims.

DETAILED DESCRIPTION

As indicated, the invention is particularly applicable to thin wall metal cylinders, whether the cylinder is employed as such or whether it is previously provided with one or two end walls, chimes, circumferential beads, or the like, as are commonly used in thin wall metal container construction. The terminology "thin wall" as used herein is generally although not exclusively applicable to those containers made of sheet metal, conventionally iron, whose external diameters are at least about 20 times the thickness of the wall.

Referring to FIGS. 1 and 2 in conjunction, the apparatus of the invention essentially includes a set of radially expandable cylindrical internal dies 11 which are disposed within a thin wall metal cylinder 12, and a concentrically disposed, radially compressible, set of cylindrical dies 14 disposed externally of the cylinder 12. Internal die 11 is expanded radially outward by axial movement of the expander plug 15, and similarly the external die 14 is compressed inwardly by an axial relative movement of the shrink ring 16.

As shown in the drawings, the internal die 11 comprises a plurality of truncated sectorlike elements 11a, 11b, respectively connected via the gib, generally shown at 18, to the expander plug 15. The gib 18, an end view of which is shown in FIG. 1, is a T-shaped tongue and groove extending conically along the intersection of the internal die elements 11a, 11b, etc. and the expander plug 15. A similar gib 19 connects the external die segments 14a, 14b, etc. with the shrink ring 16.

In keeping with the invention, a thin wall cylinder 12 is positioned between the expandable internal cylindrical die 11 and the compressible external cylindrical die 14, and expanding pressure is applied to the internal die 11. The expansion of the die elements 11a, 11b, etc. uniformly in a radial outward direction causes the effective diameter of the internal die 11 to increase, initially until it equals the internal diameter of the cylinder 12.

As the internal die 11 continues to expand, its outer diameter begins to exceed the original inner diameter of the cylinder 12. When this occurs, the thin metal wall constituting the cylinder 12 is placed under tension in a circumferential direction. (The tensile stress is equal to the product of the radial expansive pressure times the radius, divided by the cylinder 12 wall thickness). Consequently, the cylinder 12 itself begins to expand under the radial pressure of the internal die 11.

Initially, the expansion of the cylinder 12 follows Hooke's law, and the tensile stress in a circumferential direction is proportional to the radial expansion of the internal die 11. This continues over the initial proportion of the stress-strain curve for the particular metal used for the container 12 walls.

As expansion of the internal die 11 is continued, the expansion of the cylinder 12 continues beyond the linear, or elastic, relationship dictated by Hooke's law. An elastic limit is reached, corresponding to the stress up to which the metal can be subjected without causing a permanent, or plastic, set. In

other words, beyond the elastic limit, or yield point, further stress produces a permanent set in the diameter of the tube 12, and whenever the stress is removed the diameter does not return to that of the original cylinder 12. The yield point, proximately corresponding to the elastic limit, depends on the nature of the metal constituting the cylinder 12 walls as well as on the rate of stress application, temperature, etc. These variables are, for the most part, available in standard mechanical engineering handbooks. For present purposes, the yield point is best considered that point of stress beyond with further deformation produces a permanent set in the cylinder 12 material or, in other words, the point on a stress-strain curve where the cylinder 12 diameter will not—once stress is removed—return to its initial value.

Expanding the cylinder 12 beyond its yield point or elastic limit causes plastic deformation of the cylinder 12 wall metal. In other words, it stretches the cylinder 12 uniformly in a radial direction, so that dents, deformations, and other non-homogeneities are removed. Since the stress applied to the cylinder 12 is essentially uniform about all portions of its diameter, the cylinder 12 is consequently stretched uniformly at all points around its circumference, and as a result there are no local stress concentrations in the region of dents or other imperfections.

Further in keeping with the invention, once the internal die 11 has expanded sufficiently to exceed the yield point of the cylinder 12 metal in tension and also to plastically deform the metal by a predetermined amount, further expansion of the internal die 11 is terminated, and a radially inward or compressing force is applied to the external die 14 to constrict the cylinder 12. While the internal die 11 is expanding, the external die 14 is advantageously spaced slightly away from the ultimate expansion of the cylinder 12. However, as the external die segments 14a, 14b, etc. are compressed radially and uniformly inward, they begin to engage the outer surface of the cylinder 12.

At this point, and while the external die 14 is in compression, it is necessary that an opposing internal or expansive pressure be applied by the internal die 11 in a radially outward direction. Simultaneously, a substantially higher pressure is applied by the external die 14 so that there is a net compressive force on the cylinder 12. The radially outward or expansive force from internal die 11 is necessary to confine the thin walls of the cylinder 12 so as to avoid wall buckling, which otherwise would occur if the internal surface of the cylinder 12 were unconfined during compression.

As stated above, the net compressive force is applied to the cylinder 12 by imposing a higher pressure on the external die 14 than on the internal die 11. This force is continued, first through the elastic deformation region of the stress-strain curve of the metal of the cylinder 12, and then beyond the compressive yield point to where the wall metal constricts in plastic compression.

Compression of the cylinder 12 need be continued only until the cylinder 12 walls are compressed to an extent sufficient to exceed the yield point of the metal or, in other words, to deform the metal plastically by compression. Plastic compression quite effectively reduces asymmetric stresses in the cylinder 12 so long as there is at least some measurable plastic deformation beyond the lower yield point.

It is advantageous, however, to continue plastic compression beyond the yield point in order to resize the cylinder 12. Otherwise stated, the cylinder 12 is compressed to a diameter smaller than that of the original cylinder diameter, so that when compression is finally released, the cylinder expands slightly by elastic expansion to substantially its original diameter. The necessary extent of elastic compression is best determined by actual trial and is a function of the cylinder 12 dimensions, the metal composition and history, the rate of compressive stress application, temperature, etc., all of which are generally too complex for calculation in advance. Additionally, the closeness to which the diameter is to be restored to that of the original cylinder diameter depends also on the

use to which the cylinder is to be put; that is, if the cylinder is to be part of a container, the volume constancy of the container will dictate the tolerance of the cylinder diameter.

With respect to the expansive and compressive pressures applied to the cylinder 12 during first the expansion and then the compression or contraction under confined wall conditions, these likewise are best determined experimentally for the particular conditions. In general, the previously stated formula is a first approximation of the relationship between radial outward pressure and circumferential tensile stress, while essentially the same equation is applicable to relate net radial inward or contractive pressure to circumferential compressive stress. Handbook values for the particular cylinder 12 metal composition give approximate values for the yield points in tension, and these are essentially the same as the yield points in compression provided the cylinder 12 walls are confined so as to avoid wall buckling.

The final operation of the apparatus depicted in FIGS. 1 and 2 is the withdrawal or retraction of the outwardly expanding internal die 11 and the inwardly contracting external die 14. These actions separate the die walls from the walls of the cylinder 12, and permit the cylinder to be extracted from the region between the respective dies.

As shown in FIGS. 1 and 2, an exemplary apparatus or device for performing the previous operations is described. The specific interactions of the components may more clearly be appreciated with reference to FIG. 3, and in the ensuing discussion all three FIGS. will be referred to.

As indicated earlier, the internal die segments 11a, 11b, etc. are urged radially outward by relative axial movement of the conical expander plug 15 with respect to the ramplike inner camming surfaces of the die elements or sectors 11a, etc. Axial movement between the two is established by applying pressure from hydraulic cylinder 20 (FIG. 2) to the expander plug 15, which is opposed by an abutment 21 contacting the distal end of each of the inner die elements 11a, 11b, etc. The abutments 21 are advantageously removably secured to the respective elements by connections, not shown, so that opposed hydraulic pressure may be applied to the hydraulic cylinder 20 at the conclusion of the cylinder expansion-compression cycle to thereby retract the inner die elements 11a, 11b, etc.

By substantially the same arrangement of a conical shrinking ring 16 and a set of cam or ramplike wedge surfaces on the external die elements 14a, 14b, etc., relative longitudinal movement between the shrinking ring 16 and the external die 14 is converted to radial inward movement of the external die elements 14a, 14b, etc. This, as was described previously, effects a compressive force on the cylinder 12.

As further indicated in FIG. 2, the overall apparatus of the invention includes a set of hydraulic cylinders 22 to apply longitudinal, or axial, pressure on the shrinking ring 16, while a set of abutments 24, one each against each of the external die elements 14a, 14b, etc. (FIG. 1) causes longitudinal motion of the shrink ring 16 to be translated into a radially inward movement of the external die 14 to compress the cylinder 12. Again, the abutments 24 are best connected removably to the external die 14 so that retraction of the hydraulic cylinder 22 and its shrinking ring 16 retracts the external die elements 14a, 14b, etc.

FIG. 3 depicts schematically the operation of a pair of opposed internal die elements 11a, 11i, and a pair of opposed external die elements 14a, 14i, together with the associated expander plug 15 and shrinking ring 16. It will be appreciated that these elements are in a concentrically disposed array, as shown in FIG. 1, but only some of the die elements are included for clarity.

Hydraulic pressure is applied to the expander plug 15 via hydraulic cylinder 20, receiving hydraulic fluid from conduit 25 via a reversible continuous volume delivery, or gear, pump 26. Correspondingly, hydraulic cylinders 22 operate to move the shrinking ring 16 axially with respect to the external die elements 14a, 14i, and are supplied with hydraulic fluid via

conduits 28 and a reversible continuous delivery, or gear, pump 29, having a higher ultimate pressure than that of the pump 26.

While pressure is being applied to the hydraulic cylinder 20 to thereby advance the expander plug and, in turn, expand the internal die elements 11a, 11i, suitable pump controls (not shown) either operate on pump 29 so as to retract the shrinking ring 16 and disengage the external die elements 14a, 14i, or else bypass the pump 29 to permit pressure to be released from the hydraulic cylinder 22. Otherwise stated, while the internal die elements 11a, 11i are expanding, no opposing pressure—or at best no interfering opposed pressure—is applied from the external die elements 14a, 14i.

However, when pressure is applied to the external die elements 14a, 14i to compress the cylinder 12, it is advantageous to maintain an opposing pressure on the internal die elements 11a, 11i to prevent wall buckling. This may be effected by maintaining the continuous operation of the pump 26 and permitting a release valve 30 on the return conduit 31 to relieve excessive pressure back to the hydraulic fluid thump 32. This action, it will be appreciated, yieldably supports the inner die elements 11a, 11i against the inward movement of the outer die elements 14a, 14i. Alternatively, the respective inner and outer die elements may be mechanically connected so that as the external elements 14a, 14i move inwardly, the internal elements 11a, 11i move inwardly by the same linear distance.

As described above, the apparatus of the invention is suitable for a variety of generally cylindrical configurations, although only a straight-sided cylinder has been shown and discussed. Where the cylinder is beaded, flanged, provided with one or more chimes, or provided with either longitudinal or circumferential seams, these protuberances may be accommodated by providing a corresponding recess in the die face. Thus, directing attention to FIG. 1, a longitudinal lap seam 34 is accommodated within a recess 35 in the inner cylinder-contacting surface of external die element 14e.

The invention is broadly applicable to virtually any thin wall metal container. Not only does it apply to cylinders having diameter-to-thickness ratios under 20:1, but cylinders having diameter-to-wall thickness ratio of below 200:1 may be dented and stress relieved. Where the ratio is quite high, it is preferable that the longitudinal edges of the die be sinusoidal lines indicated in the partial top view shown in FIG. 4. This nonlinear contact is even better able to resist buckling forces, particularly at the intersecting edges of adjacent die sectors.

Thus, it is apparent that there has been provided, according to the invention, a method and apparatus uniquely capable of satisfying the objects, aims and advantages set forth earlier.

Other modifications will of course be suggested. For example, in lieu of an internal die composed of individually movable rigid segments, the internal die may comprise a pneumatic or hydraulic flexible bag, in which event controlled retraction of the external die 14 governs the elastic expansion of the cylinder 12. Also, while the preferred embodiment described earlier employs no opposing pressure on the external die while the internal die is expanding, to reduce the necessary stroke of the internal die it may be desirable, under some instances, to apply an opposing force on the external die while the internal one is in the expansion phase.

I claim as my invention:

1. A method for removing dents and for reducing asymmetrical stresses in a thin wall metal cylinder, comprising:

uniformly expanding said cylinder radially to an extent sufficient to exceed the yield point of said metal in tension to thereby plastically deform said metal to remove dents, and

thereafter uniformly compressing said cylinder radially, while confining said cylinder wall to avoid thin wall buckling, to an extent sufficient to exceed the yield point of said metal in compression to thereby plastically deform said metal to reduce asymmetrical stresses.

2. Method of claim 1 wherein said yield points are the lower yield points.

3. A method for removing dents and for reducing asymmetrical stresses in a thin wall metal cylinder while preserving substantially the original diameter of said cylinder, comprising:

uniformly expanding said cylinder radially to an extent sufficient to exceed the yield point of said metal in tension to thereby plastically deform said metal to remove dents, said expansion plastically increasing the diameter of said cylinder, and

thereafter uniformly compressing said cylinder radially, while confining said cylinder wall to avoid thin wall buckling, to an extent sufficient to exceed the yield point of said metal compression, to thereby plastically deform said metal to reduce asymmetrical stresses, and to a diameter smaller than that of the original cylinder so that when said compression is released the elastic deformation of said cylinder restores the diameter substantially to that of the original diameter.

4. A method for removing dents and for reducing asymmetrical stresses in a thin wall metal cylinder, comprising:

disposing said cylinder about a radially expandable cylindrical internal die and within a radially compressible cylindrical external die,

uniformly expanding said internal die radially to expand said cylinder to an extent sufficient to exceed the yield point of said metal in tension to thereby plastically deform said metal to remove dents, and

thereafter uniformly compressing said cylindrical external die radially, while maintaining an expansion force on said internal die less than the compressive force simultaneously applied to said external die to avoid thin wall buckling, the net compressive force being sufficient to exceed the yield point of said metal in compression to thereby plastically deform said metal to reduce asymmetrical stresses.

5. Method of claim 4 including the subsequent step of collapsing said internal and said external dies to their original positions to permit removal of said cylinder.

6. Method of claim 4 wherein said external die is collapsed to constrict said cylinder to a diameter smaller than that of the original cylinder so that when said compression is released the plastic deformation of said cylinder restores said cylinder to substantially the original diameter thereof.

7. Apparatus for removing dents and for reducing asymmetrical stresses in a thin wall metal cylinder comprising:

a radially expandable cylindrical internal die disposable internally of said cylinder,

a radially compressible cylindrical external die disposable externally of said cylinder,

means for applying an expanding force to said internal die sufficient to expand said cylinder beyond the yield point of said metal in tension to thereby plastically deform said metal to remove dents, and

means for thereafter applying a compressive force to said external die, while maintaining an expansion force on said internal die less than the compression force simultaneously applied to said external die to avoid thin wall buckling, the net compressive force being sufficient to exceed the yield point of said metal in compression to thereby plastically deform said metal to reduce asymmetrical stresses.

8. Apparatus for removing dents and for reducing asymmetrical stresses in a thin wall metal cylinder while preserving substantially the original diameter of said cylinder, comprising:

a radially expandable cylinder internal die disposable internally of said cylinder,

a radially compressible cylinder external die disposable externally of said cylinder,

means for applying an expanding force to said internal die sufficient to expand said cylinder beyond the yield point of said metal in tension to thereby plastically deform said metal to remove dents, and

means for thereafter applying a compression force to said external die, while maintaining an expansion force on said

internal die less than the compression force simultaneously applied to said external die to avoid thin wall buckling, the net compression force being sufficient to exceed the yield point of said metal in compression to thereby plastically deform said metal to reduce asymmetrical stresses, the extent of said compression being sufficient to reduce the diameter of said cylinder to a diameter smaller than that of the original cylinder so that when said compression is released the plastic deformation of said cylinder restores the diameter to substantially that of the

original cylinder.

9. Apparatus for claim 8 wherein said radially expansible cylindrical internal die comprises a plurality of radially expansible sectors.

10. Apparatus of claim 8 wherein said radially compressible cylindrical external die comprises a plurality of radially compressible sectors.

11. Apparatus of claims 9 and 10 wherein the peripheral boundaries of said sectors are other than a straight line.

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