United States Patent

Vercoglio

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[54] TENSILE BENDING OF METAL PANELS OR STRIP HAVING INFLATABLE PASSAGEWAYS

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[73] Assignee: **Olin Corporation**

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[52] **U.S. Cl.**.....**72/318**, 72/378, 72/151, 29/157.3 V, 113/118 R

[51] **Int. Cl.**.....**B21d 11/04**

[58] **Field of Search**.....113/1 C, 116 U, 118 R, 118 C, 113/118 D; 29/157.3, 157.3 A, 157.3 C, 455 R, 455 LM, 157.4, 157.3 V, 202 R, 202 D; 72/205, 151, 378, 296, 298, 318, 319, 321

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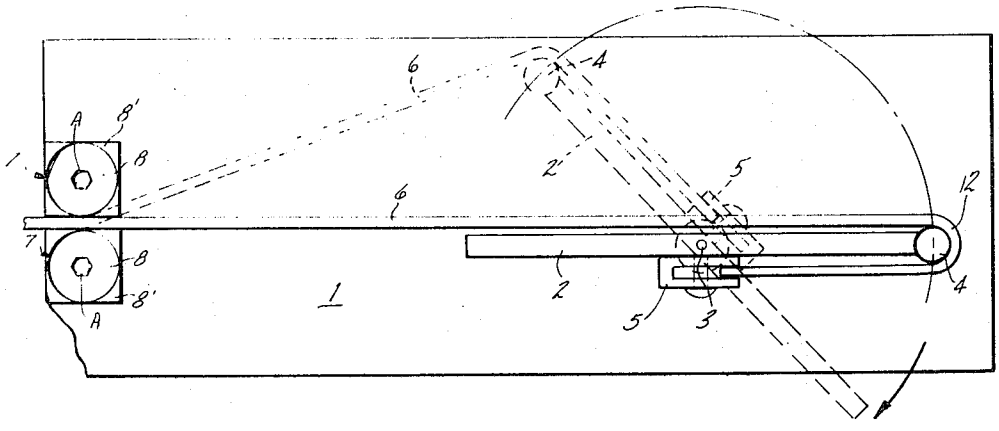
[57] **ABSTRACT**

A process for bonding metal strip or panels containing inflatable passageways, wherein the passageway may be uninflated, partially inflated, preformed, or fully inflated. The strip or panels are eventually fully inflated to form one or more fluid passageways. The strip or panel is maintained under tension and is bent by contacting it with a die spindle while it is under tension. The strip or panel will be forced ahead and around the die spindle, thus creating elongation. Upon completion of the bend, the strip or panel may be inflated using air, water, or any other inflation medium. The inflation can be accomplished while the strip or panel is still under tension, or they may be freely inflated after removal of the tension. An apparatus for carrying out the process comprises a die spindle shaped to substantially mate with the strip or panel which is to be bent. The die spindle is secured to a rotatable bending arm, which is adapted to traverse the die spindle through an arc, which intercepts the strip or panel, forcing the strip or panel ahead and around the die spindle. The apparatus also contains means for 4879888X tension to the strip or panel while it is being bent. The tension is preferably slightly less than the yield strength at 0.2 percent offset of the strip or panel. The apparatus is also capable of automatic and continuous operation and is ideally suited to the formation of serpentine-like configurations for use in heat exchangers.

35 Claims, 9 Drawing Figures



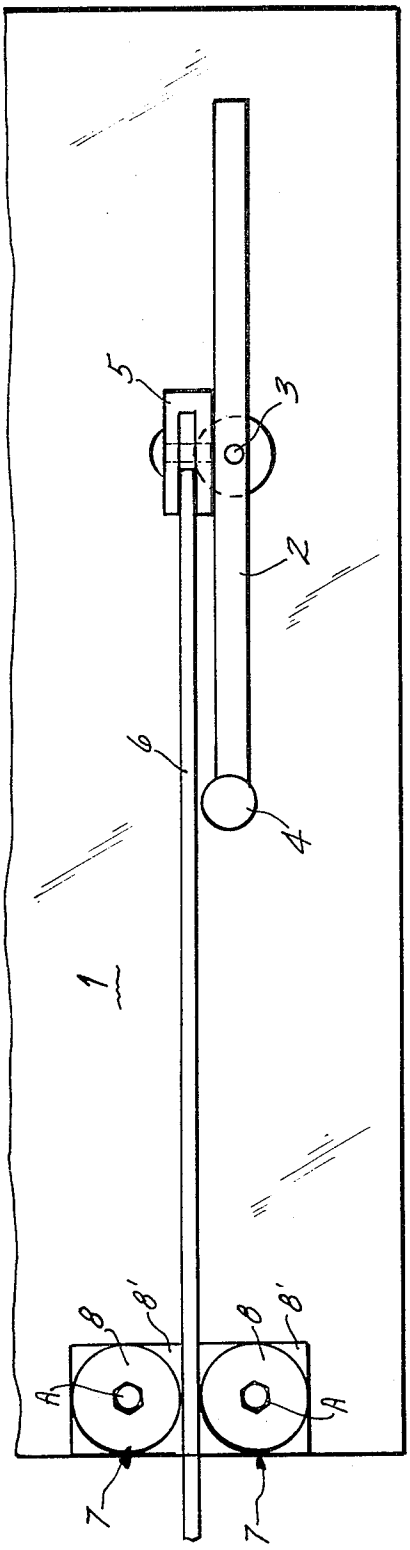


FIG-1

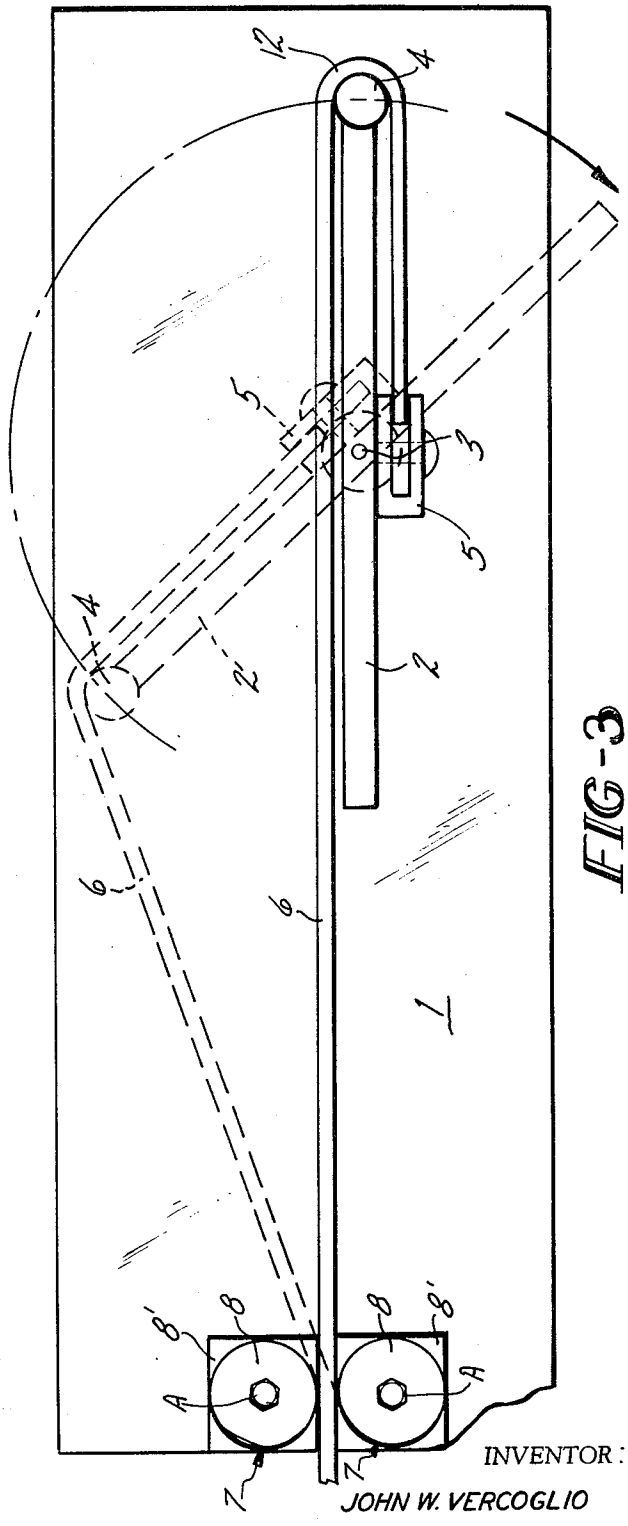


FIG-3

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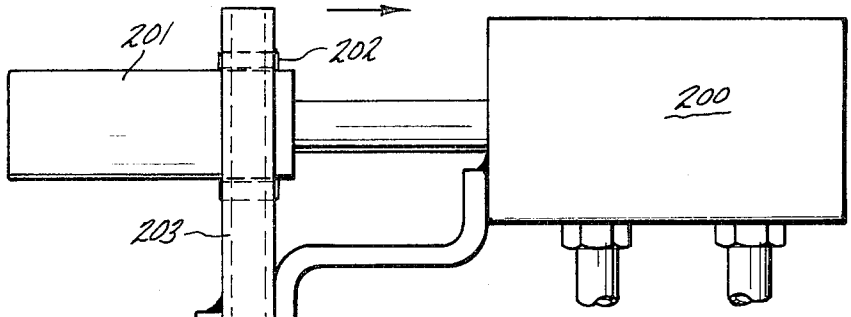

FIG-6

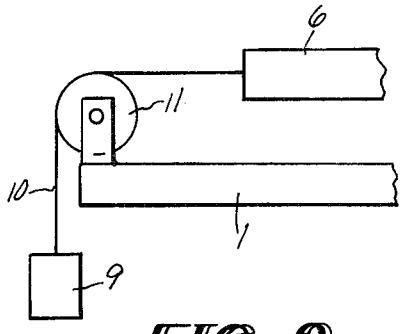

FIG-2

FIG-5

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FIG-4A

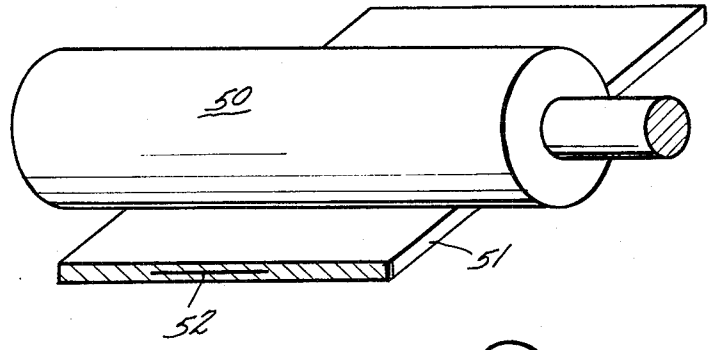


FIG-4B

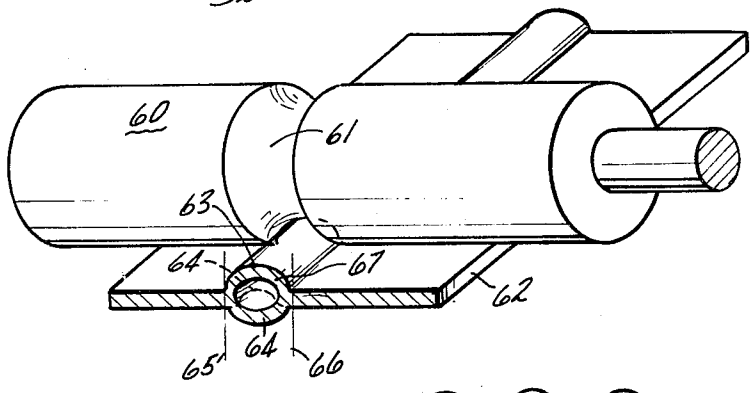


FIG-4C

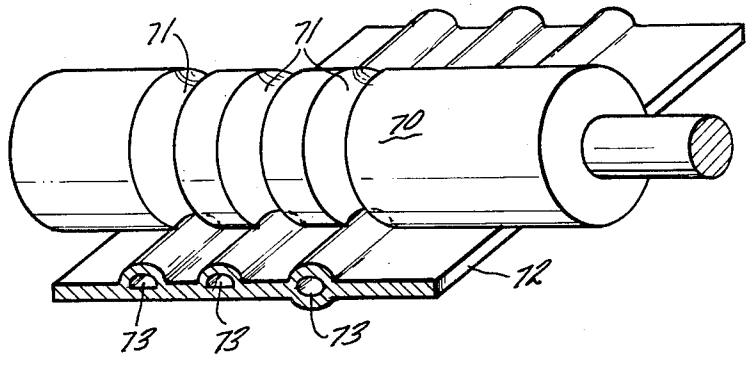
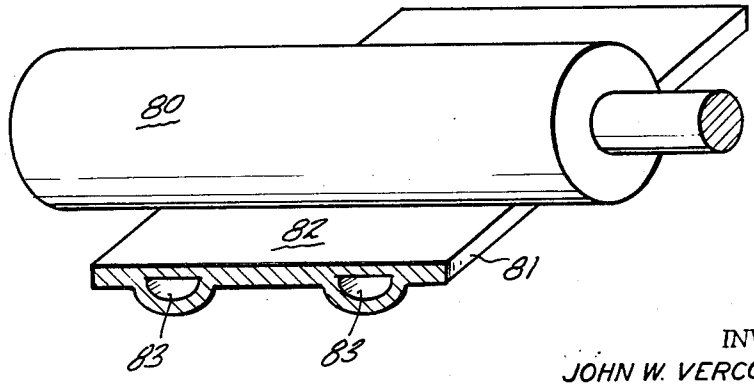


FIG-4D



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TENSILE BENDING OF METAL PANELS OR STRIP HAVING INFLATABLE PASSAGEWAYS

This invention relates to the bending of metal strip or panels containing inflatable passageways, wherein the passageways may be uninflated, partially inflated, preformed, or fully inflated. The strip or panels are eventually fully inflated to form one or more fluid passageways. However, this invention could be practiced on flat seam welded passageways or flattened seam or seamless tubing, in coil form which may be either uninflated or inflated.

The strip material is often bent, so as to form long serpentined shaped structures for heat exchange applications. However, if the diameter of the bend is small, then conventional methods of bending result in kinking or wrinkling of the inside circumference of the inflated passageway. The kinking is disadvantageous, because if the expanded passageway contains kinks, a higher pressure drop occurs. In come instances, the kinking may be sufficiently severe to cause failures in the material. This is especially the case in condenser applications, where pressures up to 3,000 p.s.i. must be tolerated in the passageways, and for evaporator applications where pressures up to 1,200 p.s.i. must be tolerated.

Conventionally, compression bending is used to bend materials of the type enumerated above. In this process, the strip or panel is pushed around a fixed mandrel or pivot by means of a wiping roller or block. This method tends to result in bends wherein the inside circumference is wrinkled or kinked. Further, the equipment and set up time for practicing compression bending, does not provide for high production rates.

According to the instant invention, it has been found that the above noted disadvantages may be overcome by bending the strip or panel while they are under a tensile stress, preferably slightly less than the yield strength.

It is an object of this invention to bend strip or panels having uninflated, partially inflated, preformed, or fully inflated passageways, without the formation of kinks or wrinkles on the inside circumference of the bend.

It is a further object of this invention to provide a method for bending the strips or panels while they are under tension.

It is a further object of this invention to provide an apparatus for bending strips or panels having uninflated, partially inflated, preformed, or fully inflated passageways while the strips or panels are under tension.

It is a further object of this invention to provide an apparatus for bending the strip while under tension to form a serpentine configuration for use in a heat exchanger.

Other objects will become apparent to those skilled in the art as a detailed discussion of particular embodiments proceeds with reference to the drawings, which form a part hereof, in which:

FIG. 1 is a top view of a simplified apparatus for carrying out the process of this invention, in an operative position prior to bending.

FIG. 2 shows a weight arrangement for applying tension to the panel or strip.

FIG. 3 is a top view of the simplified apparatus shown in FIG. 1 with the operative parts positioned to show completion of a 180° bend.

FIG. 4 gives perspective views of typical die spindles in accordance with this invention as they contact strips which are exemplary of those employed herein.

FIG. 5 is a side view of an apparatus in accordance with this invention for producing strip bent to form a serpentine configuration.

FIG. 6 is a side view of a die spindle actuator, for moving the spindle out of the way of the bent strip.

The process of this invention comprises maintaining under tension, a panel or strip containing at least one inflatable passageway, such that when the panel or strip is inflated, a fluid passageway results, and bending the panel or strip by contacting it with a die spindle, while it is under tension. The panel or strip will be forced ahead and around the die spindle, thus creating elongation. Upon completion of the bend, the panel or strip may be inflated using air, water, or any other inflation medium. The inflation can be accomplished while the panel or strip is still under tension, or they may be freely inflated after removal of the tension.

This method of bending can be applied to panel or strip that has been previously inflated, partially inflated, preformed in the flat condition, or which is uninflated. The preformed panels or strip are obtained by shaping of the uninflated passageways by means of a suitable die so that the flat panel or strip take on the shape of approximately one-half of the inflated passageway. This process of preforming is amply described in the copending application Ser. No. 709,636, assigned to the assignee of the instant invention.

The preferred starting material for the process of this invention may be obtained in accordance with the process disclosed in U.S. Pat. No. 2,690,002 by L. H. Grenell. This starting material comprises panels or strips made of at least two sheets of metal pressure welded together. A suitable pattern of stop-weld is sandwiched between the sheets prior to pressure welding. The stop-weld pattern provides an unbonded region after welding, which may be inflated to form at least one fluid passageway. The sheets may be made of any suitable metal, as for example, copper, steel or preferably aluminum.

Referring now to the drawings and especially to FIG. 1, there is illustrated an apparatus according to this invention. The apparatus comprises a table 1 to which is mounted a bending arm 2. The bending arm 2 is rotatable about a pivot point 3. A die spindle 4 is secured to one end of the bending arm 2, preferably in rotatable engagement with the arm 2. A clamp 5 is secured at an appropriate position along the bending arm 2, determined by the length of the straight section desired. A panel or strip 6 in accordance with the invention, is clamped to the bending arm 2 by means of the clamp 5. As shown in FIG. 1, the die spindle 4 in the starting position is adjacent to the panel or strip 6 to be bent. The panel or strip 6 is maintained in tension by means of a weight 9, as shown in FIG. 2, or a drag 7. The use of a drag 7 is preferred because it provides for more continuous operation.

The drag 7 may comprise two rollers 8 which press against opposite sides of the panel or strip 6. The rollers 8 are frictionally engaged to fixed plates 8' such that a tensile force must be applied to the strip or panel 6 to pull or drag it through the rollers 8. The roller 8, plate 8', combination is similar to a friction type clutch. Other suitable means for applying tension to the panel or strip 6 would occur to one skilled in the art, and could be used with the instant invention.

The tensile force is applied in the embodiment shown in FIG. 1, by rotating the bending arm 2 about the pivot point 3 so that the die spindle 4 contacts the panel or strip 6 and begins to pull the strip through the drag 7. Of course, if it were desired to have tension applied to the panel or strip 6 initially one could use a weight 9, as shown in FIG. 2, tied to the panel or strip 6 by a cable 10. The cable 10 would be placed over a pulley 11 so that the weight 9 would hang down, thereby applying the tensile force to the panel or strip 6. Alternatively, tension could initially be applied using the drag 7 by pulling the panel or strip 6 through the drag 7 to the point where it is clamped at 5 or else by pulling back on the panel or strip 6 through the drag 7 after it is clamped at 5.

FIG. 3 shows the operation of the apparatus shown in FIG. 1. As the bending arm 2 is rotated about the pivot point 3, as shown in phantom, the panel or strip 6 is forced ahead and around the die spindle 4, creating elongation. As shown in the figure, the strip or panel 6 is pulled through the drag mechanism 7, which applies a constant tensile force to the strip or panel 6. The tensile force which is applied, may be adjusted by adjusting the amount of pressure between the friction plates 8' and the drag wheels 8 by tightening or loosening nuts A.

The plates 8' and the drag wheels 8 may be made of any suitable material, for example, metal, plastics, ceramics, or a combination of them. The drag wheels 8 or the friction plates

8' or both may be provided with a suitable coating which enhances their frictional qualities. The drag mechanism per se, forms no part of this invention, and numerous suitable mechanisms can be found in the prior art for use with the invention.

The bend **12** is completed as shown in FIG. **3**, by rotating the bending arm **2** through a 180° arc. At this point, the strip or panel **6** may be unclamped and inflated, or it may be inflated while it is under tension. Inflation while the strip is under tension is the preferred approach. To form a further bend, the strip or panel **6** must be unclamped and then suitably reclamped in a position for obtaining the desired bend.

FIG. **4A** shows a typical die spindle **50** as it first contacts a strip **51** in accordance with this invention. The strip is uninflated and has a stop-weld pattern **52** in the middle. The die spindle **50** has a flat cylindrical surface.

In FIG. **4B**, the die spindle **60** has a groove **61** which is contoured to mate with a strip **62** in accordance with this invention, wherein the strip has an inflated passageway **63**. A similar die spindle could be used with strip which has been preformed, in the flat condition. In such case, the bottom sheet **64** between **65** and **66** would be formed to the same contour as the top sheet **67** between **65** and **66**, as shown in phantom. The bottom sheet **64** would then have to be expanded out to form the passageway by inflation.

FIG. **4C** shows a die spindle **70** having a plurality of grooves **71** contoured so as to mate with a strip **72** in accordance with this invention, having a plurality of inflated or preformed passageways **73**.

FIG. **4D** shows a die spindle **80** in accordance with this invention having an essentially cylindrical surface for mating with a strip **81** in accordance with this invention, which may be inflated, but which has one flat side **82** which contacts the die spindle.

Other combinations of panels or strips in accordance with this invention and die spindle configurations are possible. It is necessary that the die spindle be contoured so as to mate with the surface of the panel or strip which it contacts during bending.

It is a preferred aspect of this invention to provide an apparatus that can preform bending in accordance with the technique illustrated in FIGS. **1** and **3** but in a more continuous fashion. FIG. **5** shows an apparatus which will accomplish this object. It is desired for many heat exchange applications to bend the strip so as to form a serpentined configuration as shown at **100**. The apparatus of FIG. **5** accomplishes this in a continuous fashion.

As in the previously described embodiment, bending arms **101**, **102** are provided which are pivoted about fixed points **103**, **104** and which have die spindles **105**, **106** secured at one end, preferably in rotatable engagement. To obtain the serpentine configuration, two bending arms **101**, **102** are employed, which shall be noted as the right bending arm **101** and the left bending arm **102**. In order to provide for automatic and continuous operation, the bending arms **101**, **102** are moved through their respective arcs by means of air cylinder type actuators **107**. Clamps **108**, **109** are provided, one for the right bending arm **108** and one for the left bending arm **109**. They contact the strip **110** at the die spindle **105**, **106** in their down position, so that the strip **110** is clamped between the clamps **108**, **109** and the die spindles **105**, **106**. The clamps **108**, **109** are also actuated by means of air cylinders **111**, the clamping block **108**, **109** being attached to the air cylinder piston rods **112**. The strip **110** is pulled through a drag **113** similar to that described with reference to FIGS. **1** and **3**, which applies the required tensile force in accordance with this invention. The die spindles **105**, **106** which are secured to the bending arms **101**, **102** may be withdrawn from contacting the strip **110** so that the arms **101**, **102** may be raised after the strip **110** has been bent around the respective die spindles **105**, **106**. Suitable means for withdrawing the die spindles **105**, **106** will be discussed later. The apparatus of FIG. **5** operates as follows:

Initially, the strip is pulled through the drag **113** and clamped to the die spindle **106** of the left bending arm **102** while it is in its down position. The right bending arm **101** is then actuated so that the die spindle **105** travels along arc **114** and the strip **110** is forced ahead and around the die spindle **105**. The right bending arm **101** comes down as shown in phantom, and after it is fully down, the strip **110** is clamped to the die spindle **105** by clamping block **108**. The clamping block **109** is then withdrawn so that the strip **110** is no longer clamped to the left bending arm die spindle **106**. The left bending arm die spindle **106** is then moved out of the way of the strip **110**, so that the left bending arm **102** may be raised to its up position. While the left bending arm **102** is in the up position, the die spindle **106** is moved back, after which the left bending arm **102** is pivoted through its arc **115** contacting the strip **110** and bending it, as described above, for the right bending arm **101**. This process can be continued for indefinite lengths of strip **110**, and may be performed in a continuous manner. The strip is clamped to one bending arm die spindle while the other bending arm die spindle is travelling through its arc and bending the strip, the one bending arm spindle is then withdrawn to its original position and the process repeated.

The strip **110** may be inflated while it is under tension, as when it is clamped, or while it is not under tension, after it has passed the clamping point. The inflation pressure depends on the materials being used, and may be up to about 4,000 p.s.i. and preferably between about 100 and 3,000 p.s.i. Inflation is provided by inserting an inflation needle **116** which is connected to an inflation hose **116'** between the layers of the strip **110** and forcing a suitable fluid medium into the strip.

Automatic operation of the apparatus of FIG. **5** is obtained by employing solenoid type valves at **117** for actuating the respective air cylinders **107**, **111** connected to the bending arms **101**, **102** and the clamps **108**, **109**. The sequence can then be controlled by suitable circuitry (not shown) for timing the actuation of the respective air cylinders **107**, **111**. The sequencing may be obtained by employing relays and other timing devices. Similarly, if it is desired to inflate the strip while it is under pressure, the inflation could be sequenced in with other steps of the process.

While the apparatus has been discussed with reference to an uninflated strip, it is obvious that it is equally applicable for use with partially inflated, preformed, or fully inflated strips or panels. It is necessary to employ appropriately contoured die spindles, as discussed above, with reference to FIG. **4**, which will mate with the surface of the strip they contact. It is also necessary to employ clamping blocks which are contoured similar to the die spindles so as to mate with the strip surface. For example, if one were using a strip **62** of the type shown in FIG. **4B**, all of the die spindles and all of the clamping blocks would have to be grooved to mate with the strip surface. However, if one were employing a strip **81**, similar to that shown in FIG. **4D**, then the die spindle secured to one bending arm would have a flat cylindrical surface, as shown in FIG. **4D**, and the die spindle connected to the other bending arm, which would contact the opposing surface, would have a grooved cylindrical surface, as in FIG. **4C**. The clamping blocks would have to be contoured so as to mate with the respective surfaces, one being smooth and the other being grooved.

After the bending arm has reached its bottom position and the strip has been bent around the die spindle, it is necessary to move the die spindle out of the way of the strip in order to raise the arm prior to forming the next bend.

The particular mechanism for moving the die spindle out of the way of the strip, is not shown in FIG. **5**. In FIG. **6**, however, a suitable mechanism is shown. The mechanism is attached to each of the bending arms **101**, **102**, shown in FIG. **5**, at their die spindle **105**, **106** ends.

In the embodiment shown in FIG. **6**, an air cylinder **200** is connected to the die spindle **201** which rides in a ball bushing **202**. The die spindle **201** is shown in its position for contacting the strip to be bent. Upon actuation of the air cylinder **200**, the die spindle **201** is withdrawn in the direction shown by the

arrow, so that it is no longer in the way of the strip when the bending arm **101** is raised to its up position. This approach alone, will work fine where the die spindle **201** has a smooth surface, but where it has a grooved surface, modification of the bending arms **101, 102** is required as shown in FIG. **6**.

The bending arm **101**, for example, is provided with a sleeve portion **203** which slides over the arm portion **204**. The sliding position of the sleeve **203** is controlled by an air cylinder **205**. The die spindle **201**, ball bushing **202**, and air cylinder **200** are all secured to the sliding sleeve **203**. In operation, the arm **101** and die spindle **201** contact and bend the strip. After the bending is completed, the sleeve **203** is retracted by means of air cylinder **205**, thereby moving the die spindle **201** out of contact with the strip. The die spindle **201** is then withdrawn as aforenoted, by actuating air cylinder **200**, and the bending arm **101** is raised to its "up" position.

Obviously, numerous other mechanisms could be thought of which would provide suitable means for moving the die spindle out of the way so that the arm can be raised to the "up" position after the bend has been completed.

In carrying out the process of this invention, the panel or strip should be maintained at a tension less than the yield strength at 0.2 percent offset of the panel or strip. Preferably, the tensile stress should be between about 1,000 p.s.i. and the yield strength at 0.2 percent offset of the panel or strip and preferably just slightly less than the yield strength at 0.2 percent offset of the panel or strip.

The strip or panel may be bent to any desired degree in accordance with the process of this invention. It is possible to make bends greater than 0°, and up to 360°, or the limit imposed by the apparatus being used, preferably between about 15° and 270°. The bend diameter is limited by the die spindle employed, but the invention is most applicable for bend diameters less than 3 inches and especially less than 1 inch.

When bends are made, in accordance with this invention, the circumference of the passageway on the inside of the bend is free of kinks and wrinkles. The theory of this invention appears to be that elongation must occur in the bend area to reduce the compressive loads. This is the apparent explanation for the absence of the kinks or wrinkles when the strip is bent, in accordance with the process herein disclosed, though the invention is not intended to be limited to this explanation.

To further illustrate the process of this invention, the following example is presented.

EXAMPLE I

The strip which was to be bent comprised 0.034 inch gauge 1100 clad 3004 aluminum. The bending equipment used was similar to that shown in FIGS. **1** and **3**. The tensile force used to conduct the tests was 140 lb. for previously inflated strip and 60 lb. for previously preformed strip. As the die spindle was rotated through a 180° arc, the strip took on the shape of the die spindle. Upon completion of the bend, the inside circumference of the bend was pulled completely smooth. An inflation needle was inserted between the sheets and clamped with vice grips having jaws shaped to fit the needle. An inflation hose was attached to this needle by means of an air coupling at the inflation end and to an air valve at the regulator end. The regulator needle valve was opened rather fast allowing air pressure to flow into the passageway of the strip, thus inflating the bend area to a height which is acceptable in refrigeration applications. The air pressure used ranged from 800 to 1,100 p.s.i.g. The final passageway height varied depending upon the inflation pressure. Both the inside and outside circumference areas of the bend after inflation were wrinkle and kink free.

Thus, it can be seen that by following the process of the instant invention, wherein a panel or strip is bent around a die spindle while it is under tension, the resultant bend area will be free of kinks or wrinkles. The process has the further advantage in that it is amenable to high production rates and automatic operation.

Numerous suitable modifications of the process and apparatus of this invention are possible, and it is intended that the invention encompass all modifications which are within the spirit and scope of this invention as set forth herein. Thus, it is understood that the invention is not to be limited to the illustrations described or shown herein, which are deemed to be merely illustrative of the best modes of carrying out the invention, and which are suitable of modification of form, size, arrangement of parts and details of operation.

What is claimed is:

1. A process of bending metal panels or strip having at least one passageway, comprising:
- providing a metal panel or strip having at least one passageway,
- applying a tensile stress to said panel or strip, and then
- bending said panel or strip a given amount about a die spindle while it is under said tensile stress.

2. A process as in claim **1**, wherein said at least one passageway comprises an inflatable fluid passageway and wherein said panel or strip has a plurality of inflatable fluid passageways.

3. A process as in claim **1**, wherein said tensile stress applied is less than the yield strength at 0.2 percent offset of said panel or strip.

4. A process as in claim **1**, wherein said panel or strip is bent between about 15° and 270°.

5. A process as in claim **1**, wherein said panel or strip is bent about 180°.

6. A process as in claim **2**, wherein said panel or strip is inflated subsequent to the bending step.

7. A process as in claim **6**, wherein said panel or strip is inflated while it is under tension.

8. A process of bending metal panels or strip having at least one passageway, comprising:
- providing a panel or strip having at least one passageway, defined by a stop-weld pattern said panel or strip comprising at least two sheets of metal with said stop-weld pattern sandwiched between them, said sheets being pressure welded together except in the regions of the stop-weld pattern,
- applying a tensile stress to said panel or strip, said tensile stress being less than the yield strength at 0.2 percent offset of said panel or strip, and then
- bending said panel or strip a given amount about a die spindle while it is under said tensile stress.

9. A process as in claim **8**, wherein said panel or strip, which is provided, has a plurality of fluid passageways.

10. A process as in claim **8**, wherein the tensile stress which is applied is greater than 1,000 p.s.i. and less than the yield strength at 0.2 percent offset of said panel or strip.

11. A process as in claim **10**, wherein the tensile stress which is applied is slightly less than the yield strength at 0.2 percent offset of said panel or strip.

12. A process as in claim **8**, wherein the diameter of the bend is less than 3 inches.

13. A process as in claim **12**, wherein the strip is bent about 180°.

14. A process as in claim **8**, wherein the panel or strip is inflated at said stop-weld pattern subsequent to the bending step, to provide at least one fluid passageway.

15. A process as in claim **14**, wherein the panel or strip is inflated while it is under said tensile force.

16. A process as in claim **15**, wherein said panel or strip is inflated using air pressure ranging from 100 to 3,000 p.s.i.g.

17. A process as in claim **8**, wherein the panel or strip is bent by forcing it around a die spindle which is contoured to substantially mate with said panel or strip.

18. An apparatus for bending a metal panel or strip having at least one inflatable fluid passageway, comprising:
- tensioning means, contacting the panel or strip, being operative to place the panel or strip under tension prior to bending,

bending means, contacting the panel or strip, being operative to bend only a portion of the panel or strip while it is under tension, and

inflation means, contacting the panel or strip, being operative to inflate said fluid passageway.

19. An apparatus as in claim **18**, wherein the tensioning means comprises a clamp attached to one end of the panel or strip and drag means contacting the panel or strip at a point along its length, said drag means being operative to maintain the panel or strip, which is held between said drag means, and said clamp, under tension.

20. An apparatus as in claim **19**, wherein the amount of tension is less than the yield strength at 0.2 percent offset of the panel or strip.

21. An apparatus as in claim **20**, wherein the bending means comprises a die spindle which contacts the panel or strip, said die spindle being operative to force the panel or strip ahead and around said die spindle.

22. An apparatus as in claim **21**, wherein the die spindle is secured to a bending arm which is pivotable about a fixed point, said bending arm being operative when rotated to traverse said die spindle through an arc which intercepts the panel or strip such that the panel or strip is forced ahead and around said die spindle.

23. An apparatus as in claim **22**, wherein said die spindle has a surface which is contoured to substantially mate with the surface of the panel or strip which it contacts.

24. An apparatus as in claim **23** wherein said inflation means is operative to inflate said passageway in the strip while it is under tension.

25. An apparatus for bending a metal strip having at least one inflatable fluid passageway to form a serpentine configuration comprising:

tensioning means, contacting the strip being operative to place the strip under tension less than the yield strength at 0.2 percent offset of the strip prior to bending,

a first bending means contacting the strip, being operative to bend the strip in one direction while it is under tension,

a second bending means, contacting the strip, being operative to bend the strip in an opposite direction while the strip is under tension.

26. An apparatus as in claim **25**, wherein said tensioning means comprises a clamp clamping the strip at one point along its length and drag means contacting the strip at another point along its length, said drag means being operative to maintain the strip which is held between said drag means and said clamp under tension.

27. An apparatus as in claim **26**, wherein the amount of tension is between about 1,000 p.s.i. and the yield strength at 0.2 percent offset of the strip.

28. An apparatus as in claim **27**, wherein the tension is slightly less than the yield strength at 0.2 percent offset of said strip.

29. An apparatus as in claim **27**, wherein said first bending means comprises a first die spindle which contacts the strip, said die spindle being operative to force the strip ahead and around said die spindle.

30. An apparatus as in claim **29**, wherein said second bending means comprises a second die spindle which contacts the strip, said die spindle being operative to force the strip ahead and around said die spindle.

31. An apparatus as in claim **30**, wherein said first die spindle is secured to a first bending arm which is rotatable about a first fixed point in a first direction, said first bending arm being operative when rotated in said first direction to traverse said first die spindle through an arc which intercepts the strip such that the strip is forced ahead and around said first die spindle, and wherein said second die spindle is secured to a second bending arm which is rotatable about a second fixed point in a second direction which opposes said first direction, said second bending arm being operative when rotated in said second direction to traverse said second die spindle through a second arc which intercepts the strip such that the strip is forced ahead and around said second die spindle, so as to form a serpentine configuration.

32. An apparatus as in claim **31**, wherein said first and second die spindles have surfaces which are contoured to substantially mate with the respective surface of the strip which they contact.

33. An apparatus as in claim **32**, further including inflation means contacting the strip, said inflation means being operative to inflate said fluid passageway.

34. An apparatus as in claim **32**, including control means being operative to sequence the operation of the apparatus such that said first bending means and said second bending means are operated alternately whereby the strip may be formed into a serpentine configuration.

35. An apparatus as in claim **33** wherein said inflation means is operative to inflate said passageway in said strip while it is under tension.

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