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(54) **METHOD OF PRODUCING HELICALLY CORRUGATED METAL PIPE AND RELATED PIPE CONSTRUCTION**

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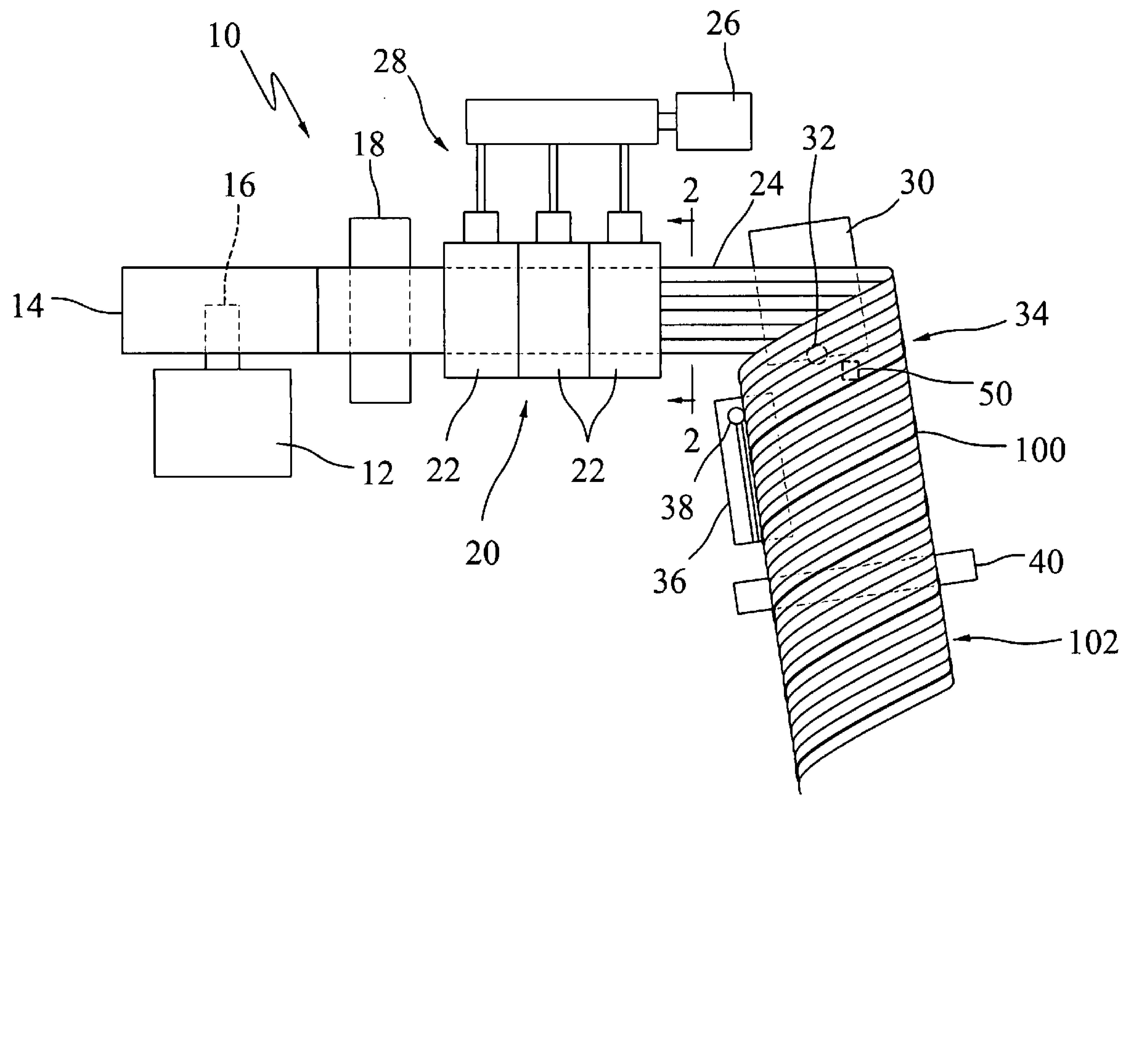
(57) **ABSTRACT**

A pipe manufacturing device and method provides for pipe diameter monitoring and responsive pipe diameter control. Various pipe configurations and pipe assemblies adapted for ease of in the field connection are also provided.



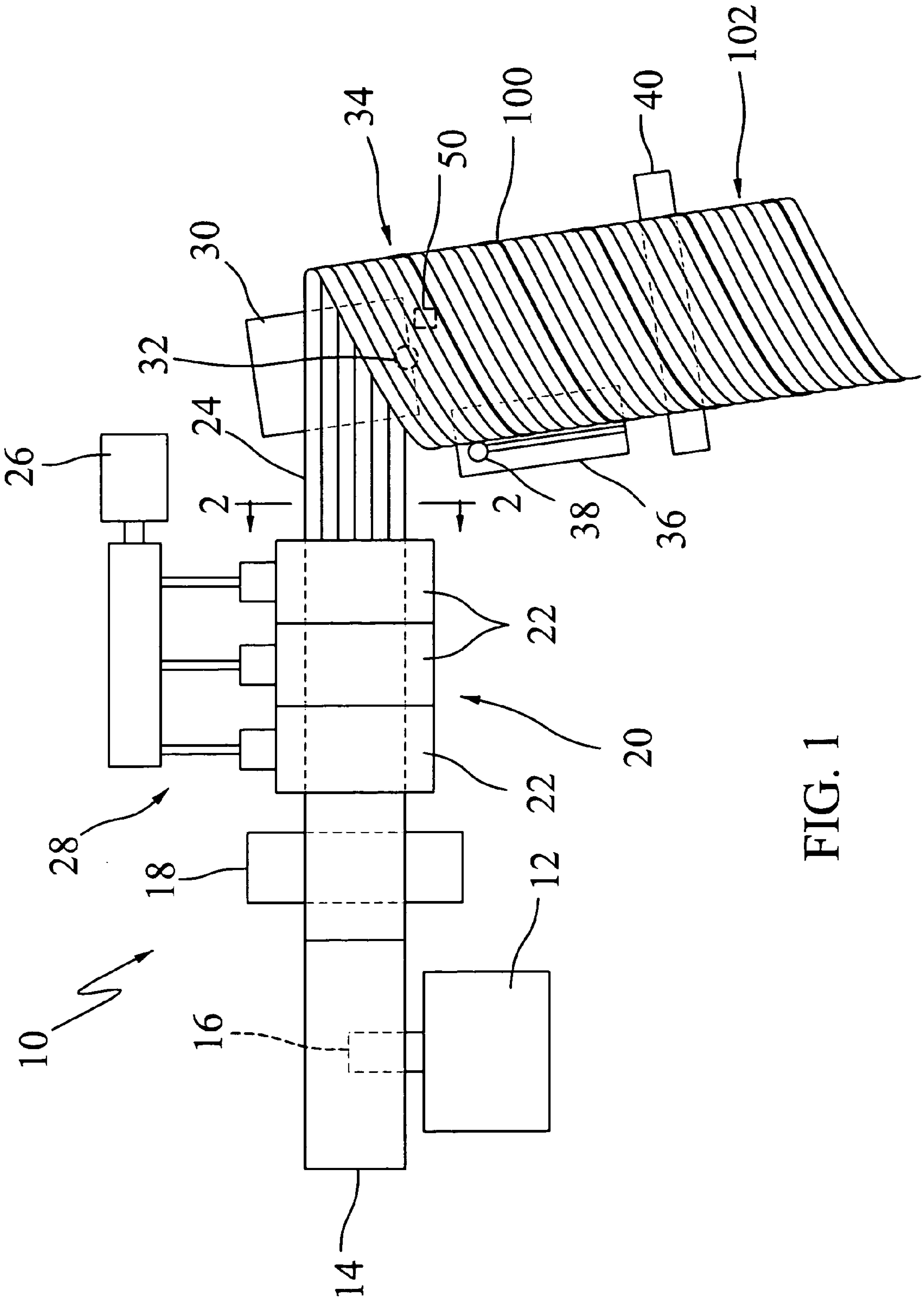



FIG. 1

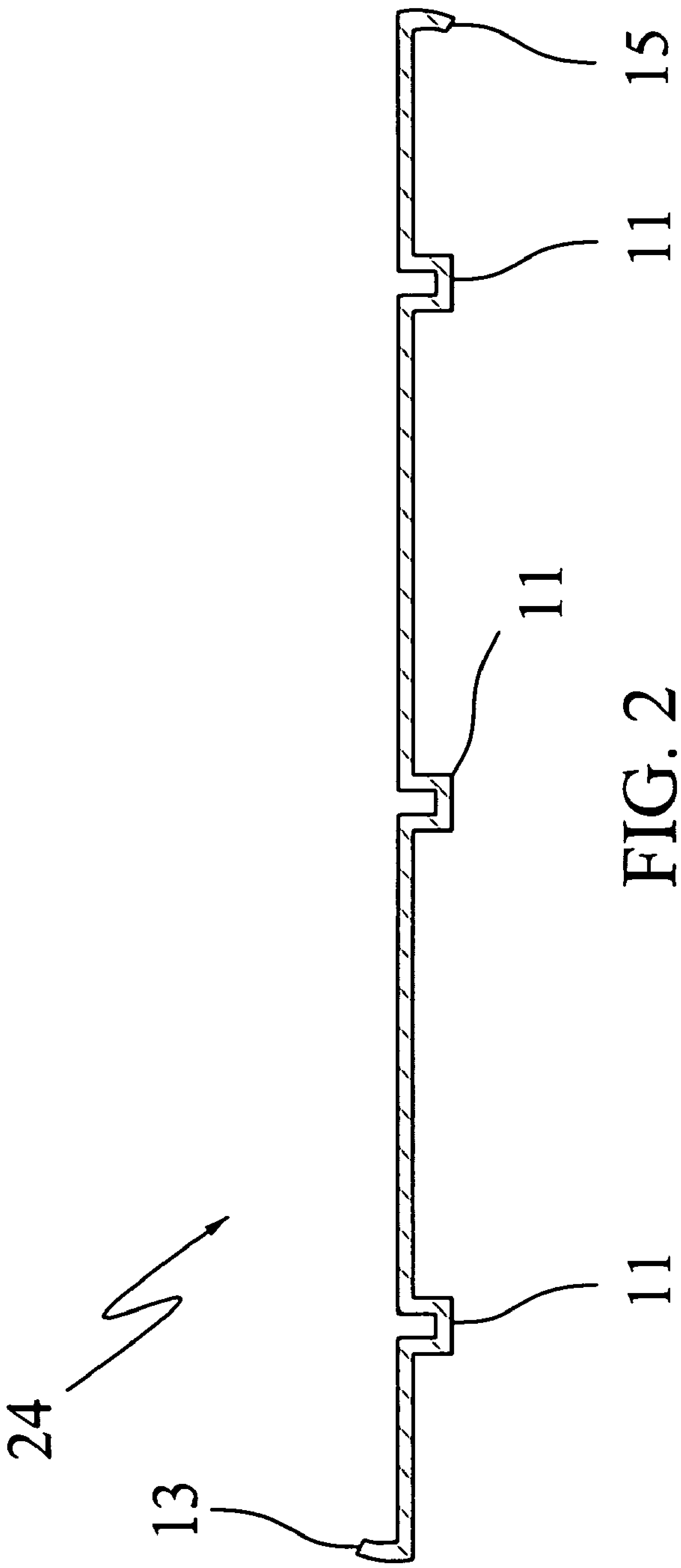



FIG. 2

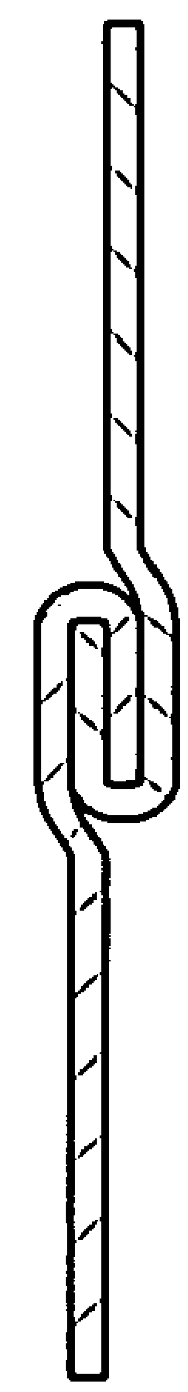


FIG. 3

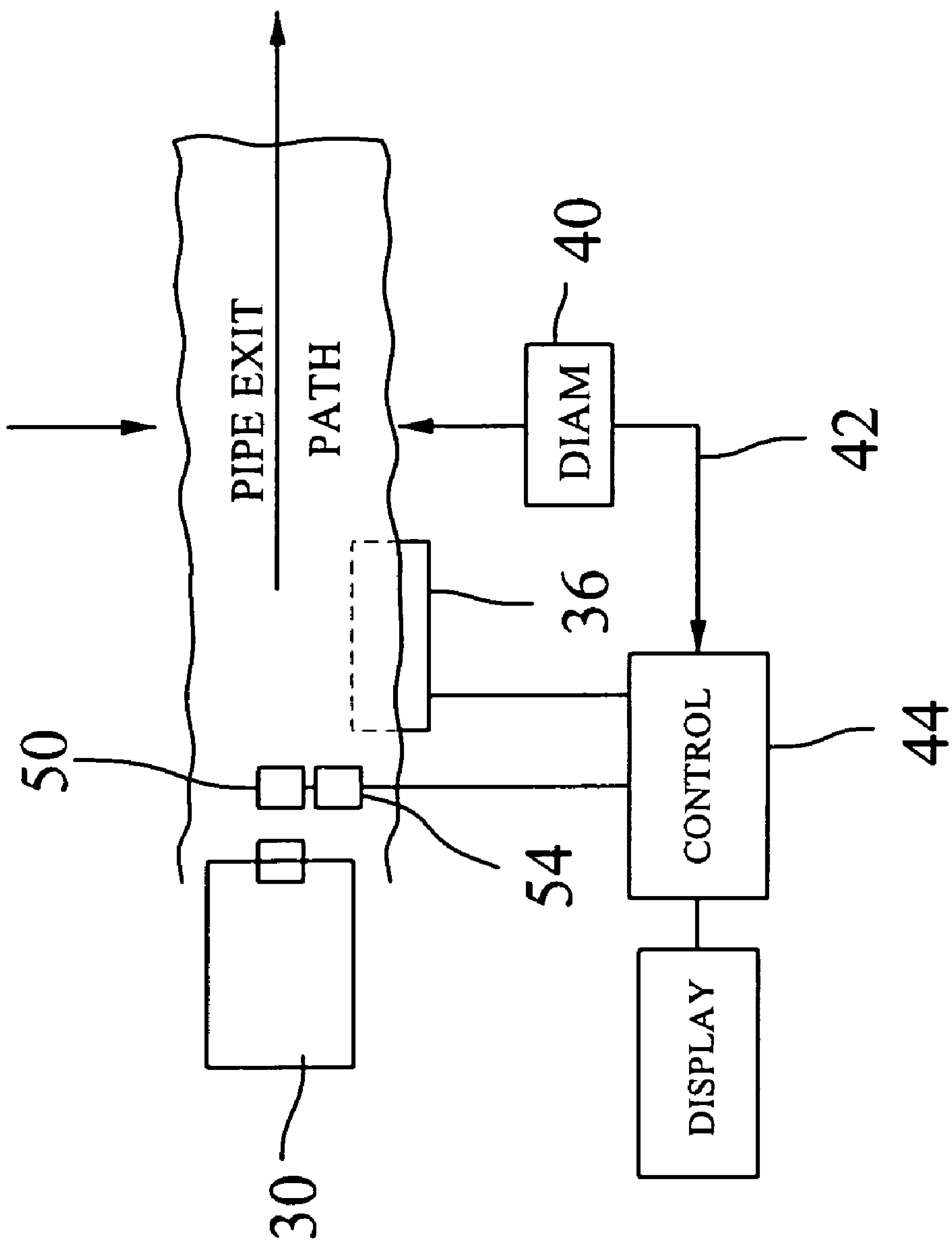



FIG. 4

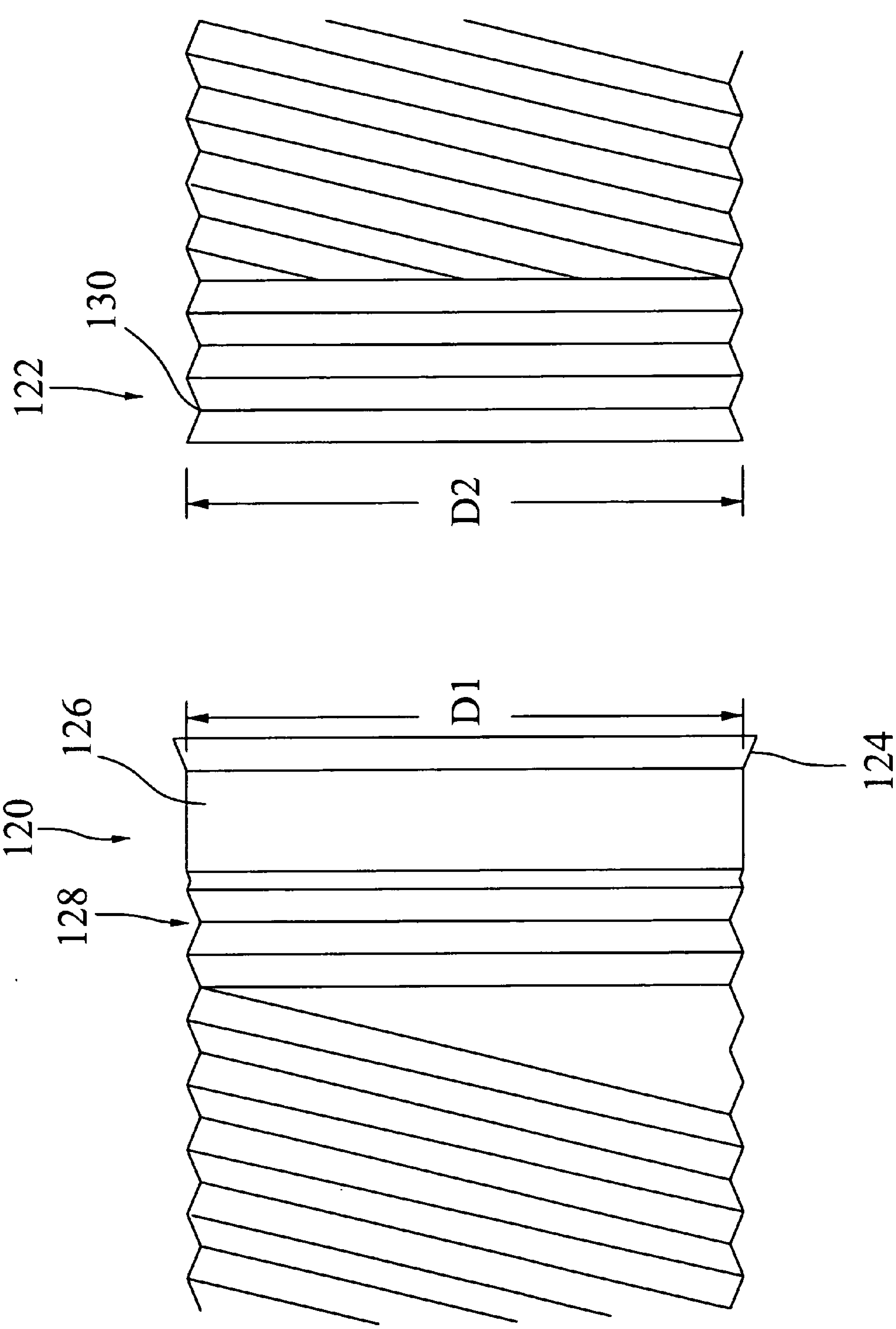



FIG. 5

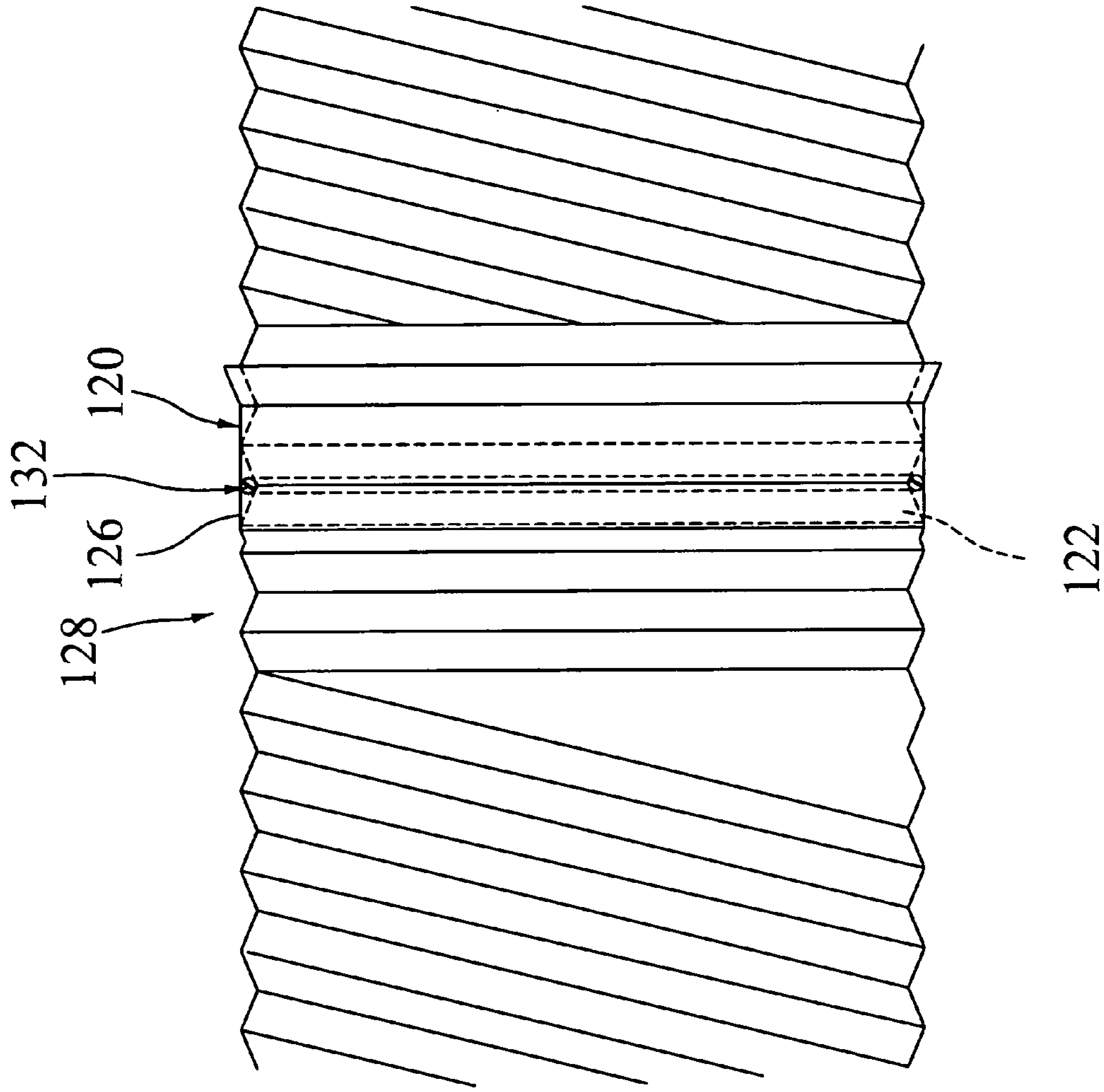



FIG. 6

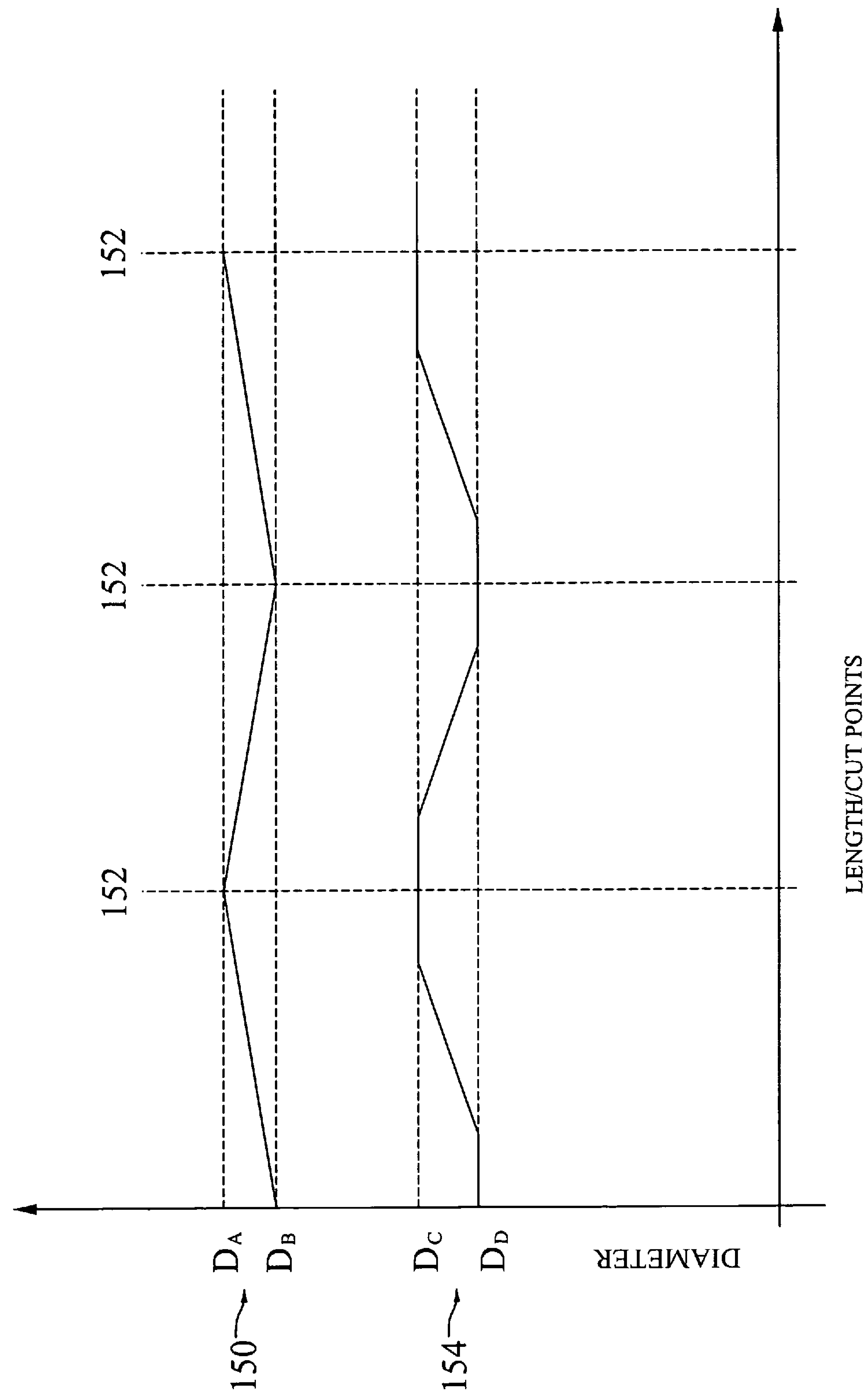



FIG. 7

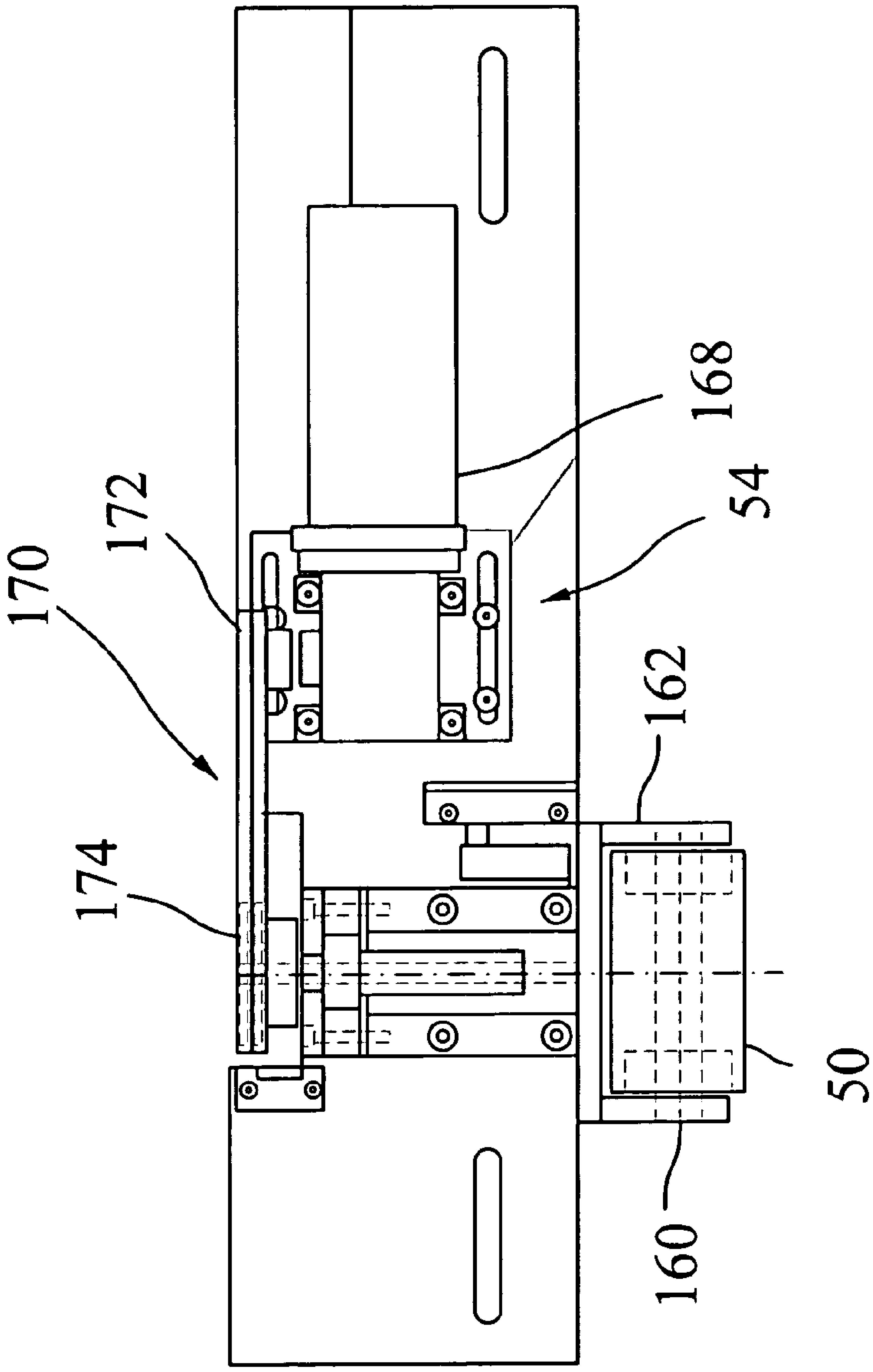



FIG. 9

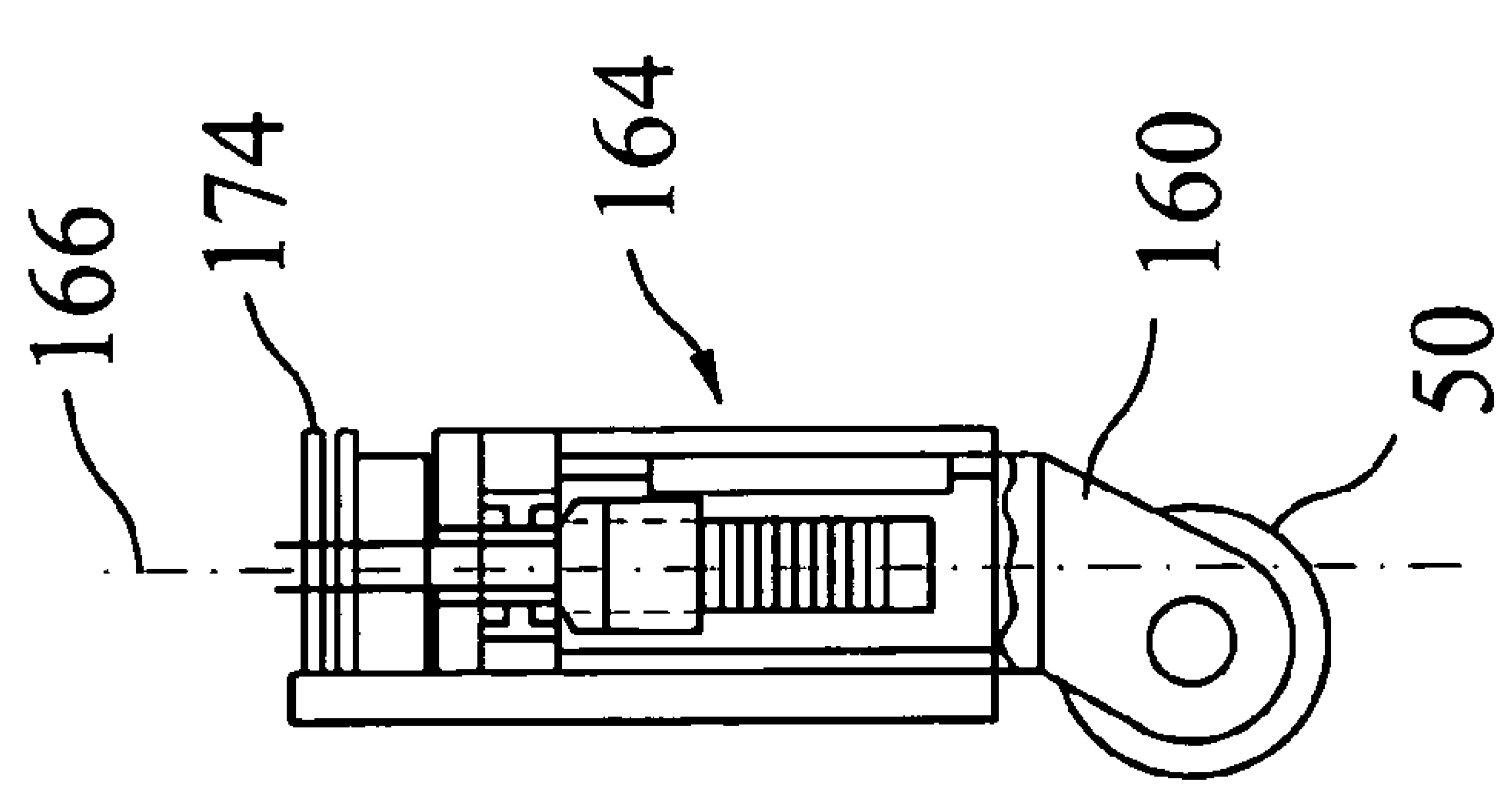
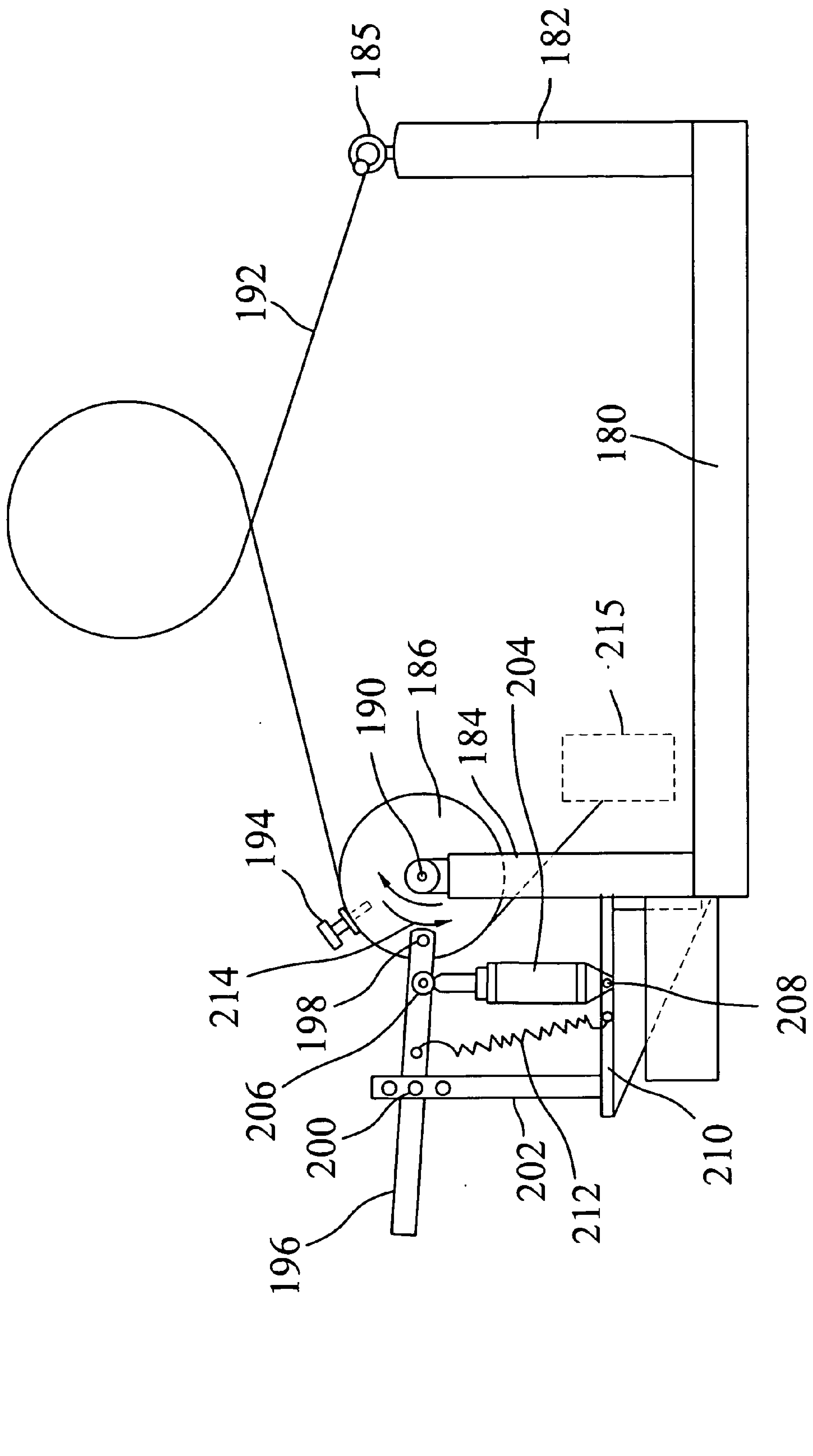



FIG. 8


185
182
192
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215
204
186
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184
194
214
198
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212
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208
196

FIG. 10

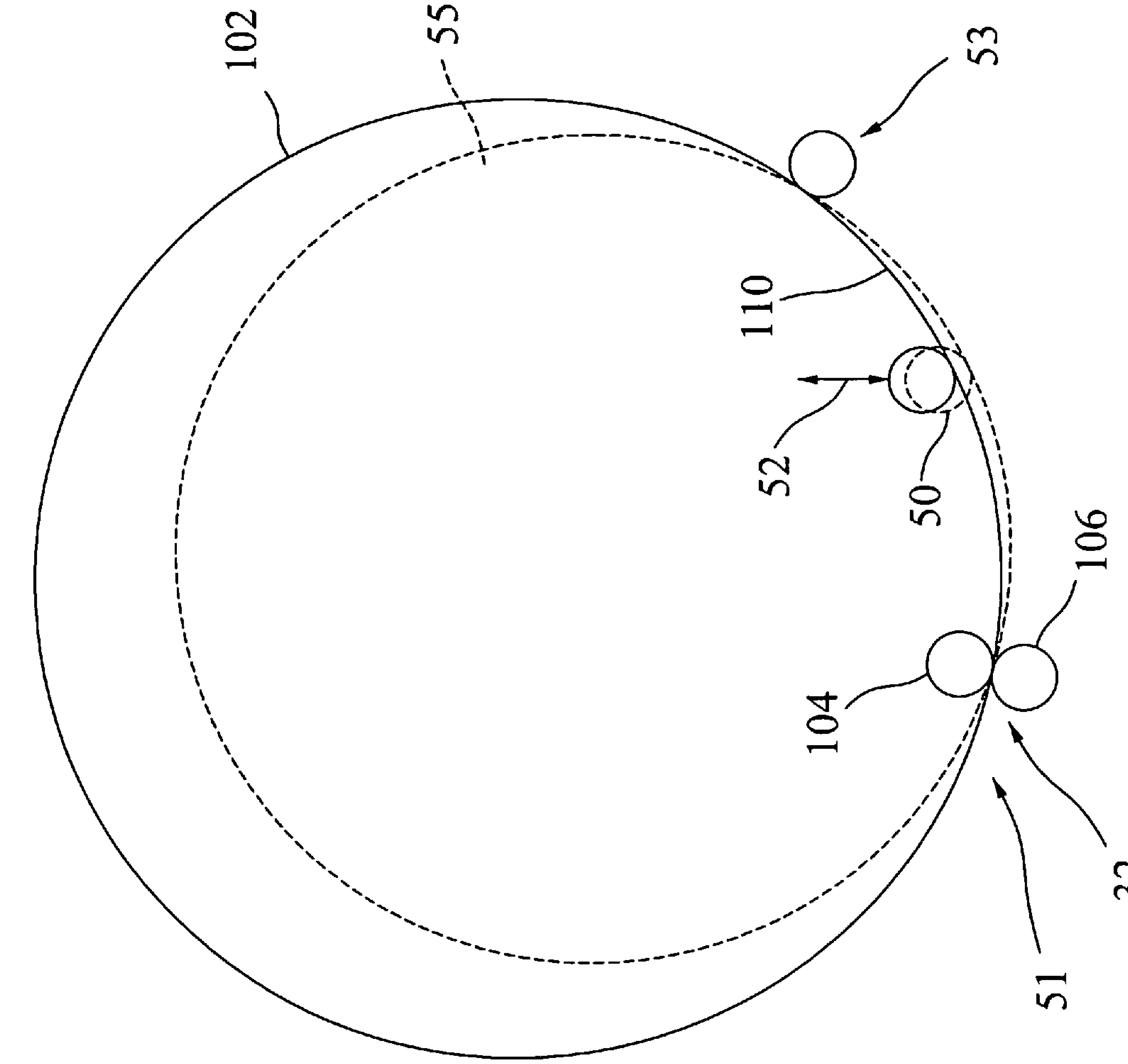


FIG. 11

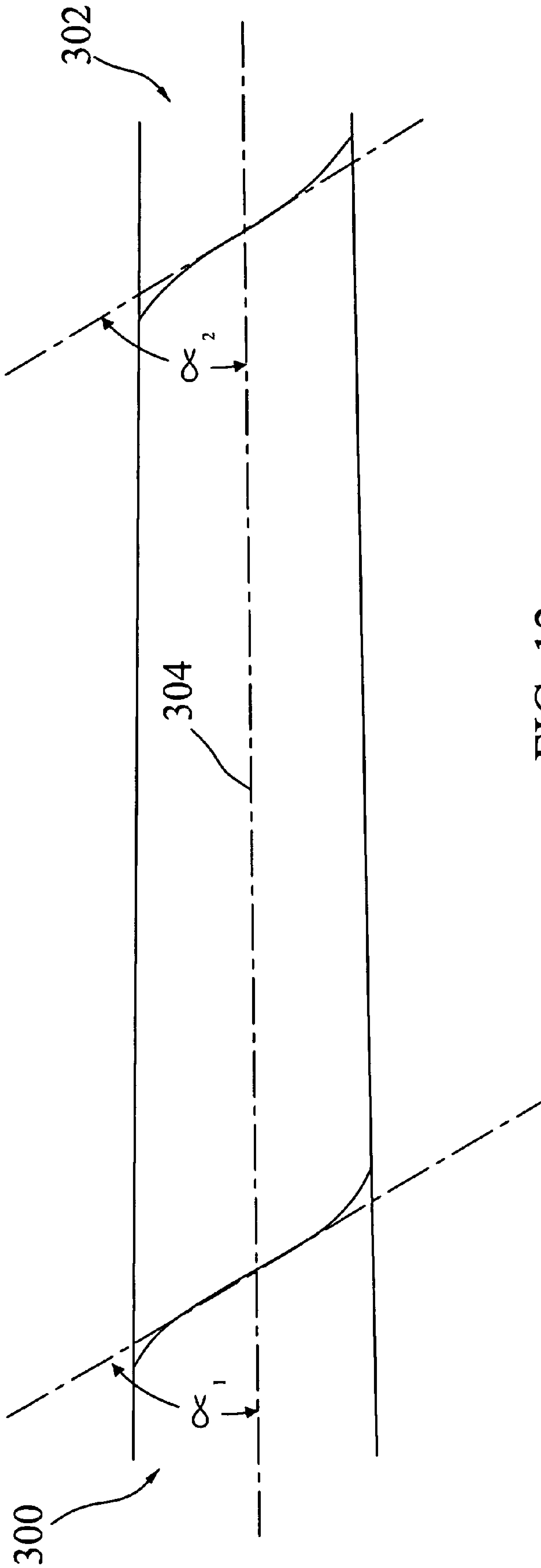


FIG. 12

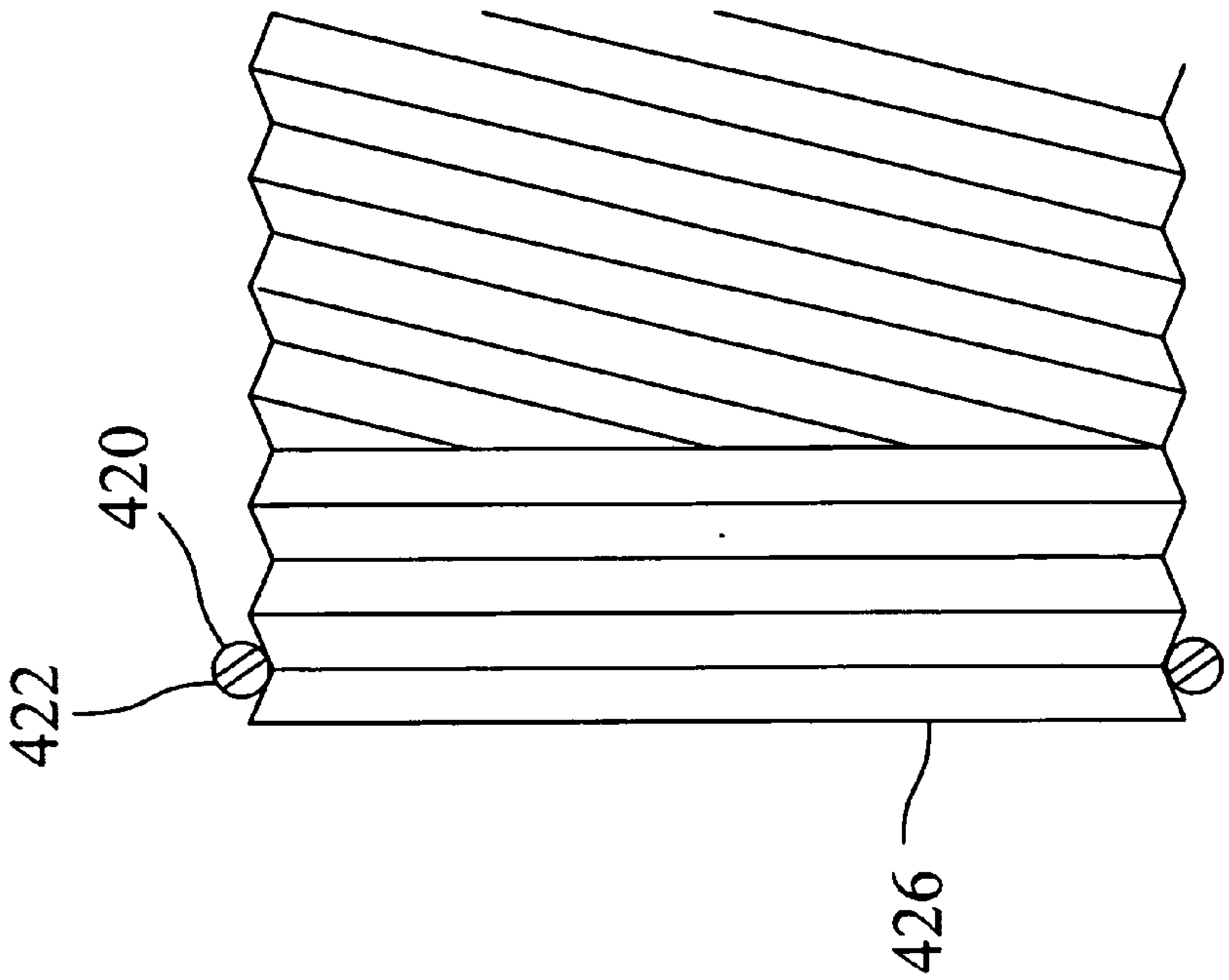


FIG. 13B

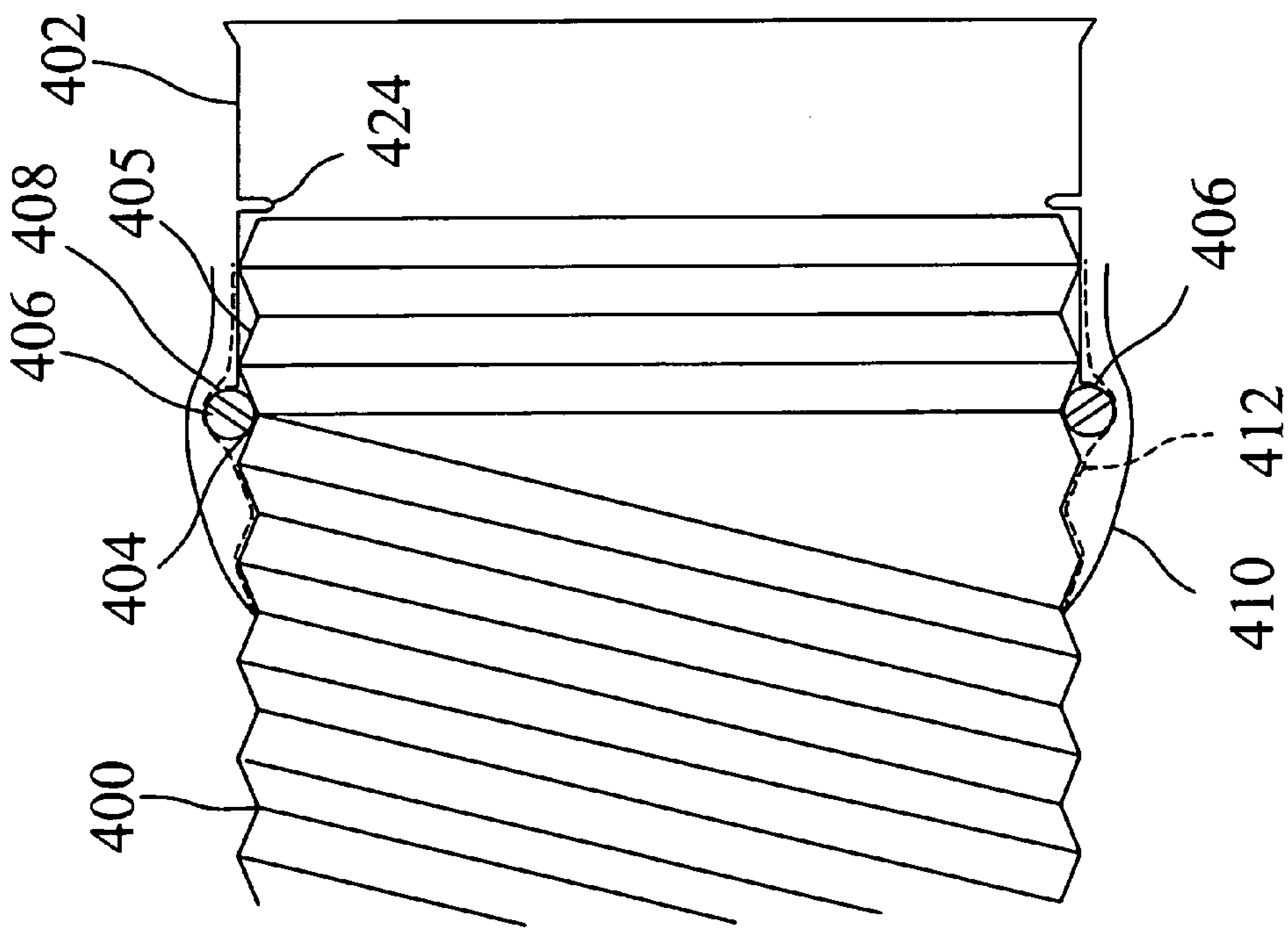


FIG. 13A

# METHOD OF PRODUCING HELICALLY CORRUGATED METAL PIPE AND RELATED PIPE CONSTRUCTION

## TECHNICAL FIELD

[0001] This application relates generally to helically corrugated metal pipe commonly used in drainage applications and, more specifically, to a method of producing such pipe with improved diameter control and/or end connection features.

## BACKGROUND

[0002] The standard production process for producing helically corrugated metal pipe is well known and involves first forming lengthwise corrugations in an elongated strip of sheet metal, with the corrugations extending along the length of the strip. The corrugated strip is then spiraled into a helical form so that opposite edges of the corrugated strip come together and can be either crimped or welded to form a helical lock along the pipe. Diameter control of the resulting pipe is regularly an issue in the manufacturing process and is important to the functionality of the pipe from an installation standpoint when pipes are being connected end to end at a job site in the field. Attempts to address diameter control have been made in the past. U.S. Pat. Nos. 3,940,962, 3,417,587, 4,287,739 and 4,438,643 describe pipe manufacturing techniques and related equipment. Improvements are continually sought.

[0003] Joining lengths of helically corrugated metal pipe creates issues in the field. U.S. Pat. No. 5,842,727 teaches a coupling member that can be used to join the ends of two pipes in a sealed manner. Improvements in the area of pipe coupling would be advantageous as the same could reduce pipe installation costs.

## SUMMARY

[0004] A system and method for pipe size or diameter control in connection with the production if helically corrugated pipe is provided. Advantageous pipe configurations may be achieved. Pipe size monitoring and control may be automated.

## BRIEF DESCRIPTION OF THE DRAWINGS

[0005] FIG. **1** is a top plan schematic of a pipe manufacturing device;

[0006] FIG. **2** is a cross-section of an exemplary corrugated metal strip taken along line **2**-**2** of FIG. **1**;

[0007] FIG. **3** is an exemplary cross-section of a lockseam;

[0008] FIG. **4** is an exemplary control system configuration for the device of FIG. **1**;

[0009] FIG. **5** shows exemplary pipe with unitary bell end and unitary spigot end;

[0010] FIG. **6** shows a spigot end of one pipe within a bell end of another pipe;

[0011] FIG. **7** depicts exemplary pipe diameter profiles;

[0012] FIGS. **8** and **9** illustrate an exemplary pressure roller and drive assembly;

[0013] FIG. **10** illustrates an exemplary pipe diameter monitoring device;

[0014] FIG. **11** is a schematic illustration showing a pair of lockseam rollers and a pressure roller;

[0015] FIG. **12** is a schematic depiction of a pipe having a larger diameter end and a smaller diameter end; and

[0016] FIG. **13** is a schematic depiction of another embodiment of a pipe assembly.

## DETAILED DESCRIPTION

[0017] Referring to FIG. **1**, a pipe manufacturing line or device **10** is shown in top plan schematic form. The device **10** includes a decoiler unit **12** for receiving a coil **14** formed by a rolled metal sheet. The illustrated decoiler unit **12** supports the coil **14** on a rotatable expansion mandrel **16**, permitting the coil to rotate during pipe manufacture. A weld table **18** is shown downstream of the decoiler unit **12** and is provided for welding the end of one metal sheet to the end of the metal sheet of a different coil upon coil replacement. A corrugating line **20** includes a number of corrugators **22** for drawing the metal sheet off of the coil **14** and placing corrugations in the metal sheet to produce a corrugated metal strip **24**. The metal sheet passes between upper and lower corrugating rollers in each of the corrugators **22** and the rollers apply pressure to the sheet to form corrugations. By way of example, first corrugator **22** may form a middle corrugation in the strip, next corrugator **22** may form second and third corrugations alongside the previously formed middle corrugation, next corrugator **22** may form fourth and fifth corrugations alongside the previously formed second and third corrugations, and so on, with the number of corrugators varying as necessary. However, variations on the operation of the corrugators are possible. The corrugations may be of any suitable shape and configuration. In one embodiment, the pipe manufacturing device operates to produce hydraulically efficient pipe such as that described in U.S. Pat. No. 4,838,317, in which case the corrugated metal strip may have a cross-section similar to that generally shown in FIG. **2**, where the corrugations **11** are shown with a generally rectangular or box-shape and the side edges of the corrugate metal strip **24** includes respective lips **13** and **15** for use in producing the helical lockseam described below. The exact configuration of locking lips **13** and **15** can vary.

[0018] The rollers of the illustrated corrugators **22** are driven by an electric motor **26** with its output linked to a gearbox/transmission arrangement **28**. A forming head **30** is positioned to receive the corrugated metal strip **24** and includes a lockseam mechanism **32** located at a pipe exit side **34** of the forming head. The forming head **30** may be a well known three-roll forming head configured to spiral the corrugated metal strip **24**. The lockseam mechanism **32** locks adjacent edges of the spiraled corrugated metal strip in a crimped manner to produce a helical lockseam **100** in the resulting pipe **102**. Specifically, as the corrugated metal strip is helically curved back upon itself to form the pipe-shape, the locking lips **13** and **15** come together before passing into the lockseam mechanism **32**, and the lockseam mechanism **32** presses the lips together to produce a lockseam that may, in one example, have the general appearance of that shown in the cross-section of FIG. **3**. Referring to FIG. **11**, in one embodiment the lockseam mechanism **32** is formed by an upper lockseam roller **104** and a lower lockseam roller **106**. The engaged locking lips **13** and **15** of the spiraled strip pass between these rollers where the crimping operation is performed. As an alternative to the lockseam mechanism, a weldseam mechanism could be provided to join adjacent edges of the strip to form a helical weldseam.

[0019] Referring back to FIG. **1**, a saw unit **36** is positioned along the pipe exit path and includes a saw **38** that is movable into and out of engagement with the pipe **102** and that is also movable along a path parallel to the pipe exit path so that the pipe can be cut even while pipe continues to be produced. Pipes with a variety of diameters can be formed by the device **10**, and large scale diameter control is made by adjusting an entry angle of the corrugated metal strip **24** to the forming head **30**. Such angle adjustment can be achieved by either by rotating the forming head **30** relative to a stationary corrugation line **20** or by rotating the corrugation line **22**, weld table **18** and decoiler unit **12** relative to a stationary forming head **30**. A variety of systems such as that generally described above have long been used and are available from, for example, Pacific Roller Die of Hayward, Calif. and IMW Industries of Chilliwack, British Columbia, Canada.

[0020] The pipe manufacturing device **10** also includes a pipe size monitoring device **40** along the pipe exit path, in this case shown downstream of the saw unit **36**. However, the pipe size monitoring device **40** could also be located upstream of the saw unit **36**. While helically corrugated pipe is generally specified, along with other parameters, by length and diameter, the term "diameter" can be difficult to apply to the pipe with absolute technical accuracy because the pipe may actually be slightly out of round. The term "pipe size" is used herein to broadly refer to any of a perimeter (inner or outer) dimension of the of the pipe, a diameter dimension of the pipe, or some other dimension of the pipe that is reflective of the flow capacity of the pipe, but the term "pipe size" specifically does not include pipe length. As used herein the term "diameter" applies even to pipe that may be out of round, in which case the diameter may be an average radial dimension measured from a generally centrally located axis of the pipe.

[0021] The pipe size monitoring device **40** can be used to provide automated pipe size control for pipe **102** as it is produced. Specifically, the device **10** may include an internal pressure roller **50** located downstream (FIG. **1**) and slightly offset laterally of the lockseam rollers **104** and **106** as shown in FIG. **11**. As demonstrated schematically by FIG. **11**, the pressure roller **50** is located for rolling contact with an inner surface **110** of the pipe **102**. In one example the pressure roller is positioned such that it rolls over the inner side of one of the box-shaped corrugations **11**. The pressure roller **50** is movable along a vertical path **52** so that the radially outward pressure applied to the inner surface **110** can be varied. Due in part to the relative positioning of the pressure roller **50** between the seaming roll location **51** and the buttress roll location **53** (both of which are part of the forming head), when the pressure roller **50** is moved downward (e.g, to position shown by the dashed line circle) the pressure roller **50** causes the "next coil" of pipe to be pulled into the lockseam slighly faster, or in other words with a slightly tighter or smaller curvature (as reflected in an exaggerated sense by dashed line strip **55**), causing the pipe size to decrease. On the other hand, when the pressure roller **50** is moved upwards, the next coil of pipe is pulled into the lockseam slightly slower, or in other words with a slightly looser or larger curvature, causing the pipe size to increase. Tightening or decreasing the curvature of the pipe results in an effective increase in the instantaneous helix angle of the pipe and loosening or enlarging the curvature of the pipe results in an effective decrease in the instantaneous helix angle of the pipe.

[0022] Referring now to FIG. **4**, a schematic representation of an exemplary control system of the pipe manufacturing device **10** is provided. The pipe size monitoring device **40** provides an output **42** that is indicative of the pipe size as the pipe is being produced. The output **42** may vary regularly to reflect pipe size changes as they occur. In one embodiment the output **42** is indicative of pipe size by way of an analog or digital signal that actually contains the pipe size information. In another embodiment the output **42** is indicative of pipe size by reflecting changes from a set point, those changes being convertible to an actual pipe size by suitable processing. Either way, a control unit **44** may receive the output **42** and responsively effect operation of an automated drive mechanism **54** that adjusts the position of the pressure roller **50**. Thus, it is seen that the device **10** provides for automated control of pipe size (e.g., diameter) by providing a feedback arrangement of monitored pipe size. In one example, the pressure roller **50** and related drive **54** may be configured to provide diameter control within a tolerance of about one fourth of one percent (0.25%) or better of total pipe diameter, such as about one sixth of one percent (0.167%) or better of total pipe diameter or about one eighth of one percent (0.125%) or better of total pipe diameter. Thus, it is seen that the device **10** provides advantageous pipe size or diameter control during pipe production.

[0023] In one embodiment the control unit **10** is configured to provide pipe size control of at least two types. Specifically, in a first mode the control unit **44** effects operation of the automated drive **54** so as to maintain a substantially constant pipe size during pipe production (e.g, by comparing a measured pipe size to a desired pipe diameter stored in memory of the control unit and effecting operation of the drive **54** when the measured pipe size moves outside of a certain range about the desired pipe size, or by comparing a monitored pipe size variation to a permissible variation stored in memory and effecting operation of the drive **54** when the monitored pipe size variation exceeds the permissible variation). In a second mode the control unit **44** effects operation of the automated drive **54** so as to intentionally vary pipe size during pipe production (e.g., by comparing the measured pipe size to a desired diameter as indicated by a desired pipe diameter profile stored in memory, or by comparing monitored pipe size variation to a desired variation profiled stored in memory). Selection of either the first mode or the second mode may be made via a user interface associated with the control unit **44**. In one embodiment the user interface may take the form of a touch screen display **46** that displays visual interface keys that an operator can touch and trigger. However, the user interface could also take other forms, such as a standard display in combination with a keypad. In either case, during pipe production the display may **46** provide a continuously updated visual display of measured pipe size or diameter and/or of variance of pipe size or effective diameter from a desired pipe size.

[0024] In one example of the above-mentioned second mode, pipe production is controlled so that a resulting pipe has one end with a larger diameter than its opposite end. Referring to FIG. 12 where the profile of such a pipe is shown schematically, a helix angle $\alpha 1$ toward larger diameter end 300 is larger than a helix angle $\alpha 2$ toward smaller diameter end 302, where the helix angle is taken at instantaneous locations along the lockseam and is reference from a central pipe axis 304. It may be difficult to observe the helix angle difference between opposite pipe ends where the pipe size is large and the diameter difference between the two ends of the pipe is only a couple of inches or less.

[0025] The pipe, with ends of different diameters, can then be worked further to produce a pipe configuration with advantageous bell and spigot connecting ends. Specifically, the larger diameter end of the pipe may be worked so as to produce a substantially corrugation free bell end 120 and the downstream end is worked to produce a spigot end 122, as shown in FIG. 5 where the bell end 120 and spigot end 122 are shown facing each other for ease of relative discussion. The bell end 120 includes an outwardly flared entry lip 124 at the end edge of generally cylindrical portion 126. At the opposite end edge of generally cylindrical portion 126 one or more annular corrugations 128 are also formed. The spigot end 122 is formed with one or more annular corrugations so as to provide an annular gasket seat 130. Notably the very edge of the spigot end 122 flares outwardly. The inner diameter D1 of the bell end 120 is slightly larger than the outer diameter D2 of the spigot end 122, enabling the spigot end 122 of one pipe to be readily inserted into the bell end 120 of another pipe as reflected in FIG. 6. In one example, the inside diameter D1 of the bell end is at least about ⅓" greater than the outside diameter D2 of the spigot end 122. In another example, D1 is at least about ½" greater than D2. Variations are possible. Also shown is a gasket 132 positioned in gasket seat 130 so as to seal with the inside surface of bell end portion 126. The internal portion of annular corrugation 128 provided adjacent the cylindrical portion 126 of bell end 120 serves as an abutment or stop that contacts the outwardly flared spigot end 122 so that entry of the spigot end into the bell end 120 is limited.

[0026] In one example, an axial length of cylindrical portion 126 is at least about four inches, while in another example an axial length of portion 126 is at least about six inches. Variations are possible.

[0027] The working of the end of the pipe to form the spigot end may be achieved using a suitably formed recorrugator, which is a device known in the art. Likewise, the working of the end of the pipe to form the bell end may start by using a recorrugator to form annular corrugations at the pipe end. The resulting annular corrugations at the very end of the pipe are then eliminated to form cylindrical portion 126 by a similar rerolling process. Alternatively, one or more annular corrugations may be formed in position slightly spaced apart from the end of the pipe and the remaining helical corrugations at the end of the pipe may be eliminated by rerolling to form cylindrical portion 126.

[0028] The device 10 can be used in a process to form multiple helically corrugated metal pipe segments of similar length that are readily connectable end to end. Specifically, the method involves: (a) drawing a metal sheet off of a coil; (b) corrugating the metal sheet to produce a corrugated metal strip; spiraling the corrugated metal strip and locking adjacent edges of the spiraled corrugated metal strip in a crimped manner to produce a helical lockseam; (d) automatically monitoring pipe size of pipe being produced; (e) based upon the pipe size monitoring, automatically varying helix angle of the pipe as it is produced in a manner to intentionally vary pipe diameter; (f) producing multiple pipe segments by cutting the helically corrugated metal pipe each time a specified length of pipe is produced; (g) coordinating the pipe diameter variations of step (e) with the cutting operations of step (f) such that pipe segments are produced in the following sequence in a repeating manner: (1) producing a pipe segment having a downstream end and an upstream end, a diameter of the upstream end larger than a diameter of the downstream end, then (2) producing a pipe segment having a downstream end and an upstream end, a diameter of the upstream end smaller than a diameter of the downstream end. As a general rule the diameter of the upstream end of each pipe segment of (g)(1) will be substantially the same as the diameter of the downstream end of each pipe segment of (g)(2). For each pipe segment of (g)(1), the upstream end is rerolled or otherwise worked to produce a substantially corrugation free bell end, and the downstream end is rerolled or otherwise worked to produce a spigot end with at least one annular corrugation. For each pipe segment of (g)(2), the downstream end is rerolled or otherwise worked to produce a substantially corrugation free bell end, and the upstream end is rerolled or otherwise worked to produce a spigot end with at least one annular corrugation.

[0029] The diameter control from end to end of each pipe segment may be in accordance with a diameter profile stored in memory of the control unit. Two exemplary diameter profiles are shown in FIG. 7. In profile 150 the pipe diameter is controlled in a substantially linear manner between diameters $D_A$ and $D_B$, with the pipe being cut at points 152 along the profile. In profile 154 the pipe diameter is controlled so that the diameter is temporarily held stable, at either diameter $D_C$ or $D_D$, before and after each of the cut points 152. Other profiles could also be developed and used without departing from the scope of this application.

[0030] Referring now to FIGS. 8 and 9, an exemplary pressure roller assembly and associated automated drive 54 are shown. Pressure roller 50 is rotatably held between end brackets 160 and 162 that extend from a support assembly 164. Support assembly 164 includes at least two members threadedly engaging each other, where one of the members is rotatable but has a fixed position along vertical axis 166 and the other member is non-rotating but is movable along axis 166. A servomotor 168 is provided to effect rotation of the rotatable member via a chain and sprocket arrangement or a belt and pulley arrangement 170. The smaller pulley/sprocket 172 transfers the rotation to a larger pulley/sprocket 174 to effect rotation of the rotatable member of support assembly 164. The size and pitch of the threads of the support assembly members, the relative size of the pulleys/sprockets 172 and 174 and the precision of the servomotor 168 can be selected to provide a desired level of controllability and tolerance for position of the pressure roller 50. The entire pressure roller assembly can be supported off of the end of the pipe forming head 30 (FIG. 1) so as to be located internal of the pipe as it is produced.

[0031] Referring now to FIG. **10**, an exemplary pipe size monitoring device **40** is shown and includes steel frame with a base **180** and upright side supports **182** and **184**. Atop support **182** is a ring member **185** and atop support **184** is a rotatable pulley **186** supported on axis **190**. A tension line **192** (such as a wire, band or rope) has one end fixed to the ring **185** and loops about the pipe that moves along the pipe exit path. The tension wire **192** extends to pulley **186** and is fixed for rotation with the pulley **186** by a wire locking screw **194**. A tensioning arm **196** is pivotably connected with the pulley **186** at axis **198** and is also pivotably connected at a non-moving location **200** along an upright guide bar **202**. A linear transducer **204** includes one end **206** pivotably connected with the tensioning arm **196** and its opposite end **208** pivotably connected to a horizontal support **210**. A spring member **212** extends between the tensioning arm **196** and the horizontal support **210** to bias the pulley **186** in the counterclockwise direction reflected by arrow **214**. A wire source **215**, such as a wire spool, is also shown. During pipe manufacture, increases in the diameter of the pipe are translated into rotation of the pulley **186** in the clockwise direction of the pulley **186** as reflected by arrow **216**, resulting in an extension of the linear transducer **204**. Conversely, decreases in the diameter of the pipe are translated into rotation of the pulley **186** in the counterclockwise direction of the pulley **186** as reflected by arrow **214**, resulting in a retraction or shortening of the linear transducer **204**. The linear transducer **204** outputs an electrical signal that varies with its length. Thus, pipe diameter variations are reflected by signal changes from the transducer **204**, that can be provided to the above-mentioned control unit **44** (FIG. **4**). When it is desired to change from measuring a relatively small diameter pipe to a relatively large diameter pipe, the wire locking screw **194** is released to allow sufficient wire or other line to feed past the pulley **186** for extending about the larger pipe diameter, and the wire locking screw **194** is again rotated to lock the wire in place for movement with the pulley **186**. Other types of pipe size monitoring devices could also be used. As used herein "diameter variations" or "pipe size variations" can be reflected in a signal that contains an absolute diameter or pipe size measurement or in a signal that simply departs from a reference level.

[0032] It is recognized that the position of the pressure roller **50** could also be controlled by operator (e.g., by pushing an up or down button or by rotating a knob) in response to an indication on the operator display indicating that pipe diameter is moving or has moved out of tolerance.

[0033] Referring now to FIG. **13**A, one end of a helically corrugated pipe **400** is shown with a bell end fitting **402** attached thereto. The end of the pipe **400** is rerolled to eliminate the helical corrugations but to leave at least one annular gasket seat **404** into which an annular gasket **406** is placed. The annular gasket **404** might alternatively be located in the annular corrugation **405** located closer to the end of the pipe. One end **408** of the bell fitting **402** is configured to slide onto the end of the pipe **400** and to engage the gasket **406**. In the illustrated embodiment fitting end **408** include an outwardly turned lip or flange. The bell fitting **402** is held on the end of the pipe by a shrink wrap material, the position of which prior to heat shrinking is shown by solid line **410** and the position of which after heat shrinking is shown by dashed line **412**. This pipe assembly can be produced in the plant so as to avoid the need to deal with heating the shrink wrap in the field. Specifically, the helically corrugated pipe **400** is produced and it end is rerolled to form the annular gasket seat **404**. The annular gasket **406** is then positioned in the seat. The bell fitting **402** is typically manufactured with a diameter to assure it can readily slide onto the end of the pipe **400**, but not so large as to have excessive play relative to the end of the pipe. Once the bell fitting is slid onto the end of the pipe into the desired position relative to the gasket **406**, the shrink wrap is wrapped around the pipe as generally shown at **410**. Next, the pipe assembly can be passed by a suitable hot air heating system to cause the shrink wrap to shrink, thereby securely holding the bell fitting on the end of the pipe and assuring a good seal. In some embodiments is may be possible to eliminate the gasket **406** and to rely upon shrink wrap material alone to form a suitable seal, particularly where the shrink wrap material is positioned so as to shrink tightly over at least one annular corrugation crest or other annular formed ring on each of the pipe end and the bell fitting end.

[0034] The opposite end of the pipe **400** may be configured to be a spigot end as generally shown in FIG. **13**B, with the end rerolled to provide an annular gasket seat **420**. In the field, as pipes are being connected end to end, a gasket **422** is placed in the gasket seat **420** of the spigot end of one pipe and the spigot end is then pushed into the bell end (formed by the bell fitting) of the other pipe. The gasket **420** forms a suitable seal between the spigot end and bell end. The bell fitting may include an inwardly extending lip or corrugation **424** against which the end face **426** of the spigot end of a pipe will abut, providing a simple manner of assuring that spigot ends are inserted into bell ends properly.

[0035] It is to be clearly understood that the above description is intended by way of illustration and example only and is not intended to be taken by way of limitation, and that changes and modifications are possible. Accordingly, other embodiments are contemplated.

What is claimed is:

**1-11**. (canceled)

**12**. A method of manufacturing helically corrugated metal pipe, comprising the steps of:

(a) drawing a metal sheet off of a coil;

(b) corrugating the metal sheet to produce a corrugated metal strip;

(c) spiraling the corrugated metal strip and joining adjacent edges of the spiraled corrugated metal strip in a crimped manner to produce a helical seam;

(d) automatically monitoring diameter variations of pipe being produced;

(e) based upon the diameter monitoring, automatically varying pipe diameter in a manner to produce a pipe segment having a first end with a diameter that is larger than a diameter of a second end;

(f) working the first end to produce a substantially corrugation free bell end, and working the second end to produce a spigot end with an annular gasket seat.

**13**. The method of claim 12 wherein step (e) involves varying helix angle of the pipe segment along a length of the pipe.

**14**. The method of claim 12 wherein the bell end is produced with a entry lip that angles outward.

**15**. The method of claim 12 wherein step (f) includes forming one or more annular corrugations adjacent the substantially corrugation free bell end.

**16**. A method of manufacturing helically corrugated metal pipe, comprising the steps of:

(a) drawing a metal sheet off of a coil;

(b) corrugating the metal sheet to produce a corrugated metal strip;

(c) spiraling the corrugated metal strip and joining adjacent edges of the spiraled corrugated metal strip to produce a helical seam;

(d) automatically monitoring diameter of pipe being produced;

(e) based upon the diameter monitoring, automatically varying pipe diameter;

(f) producing multiple pipe segments by cutting the helically corrugated metal pipe each time a specified length of pipe is produced;

(g) coordinating the pipe diameter variations of step (e) with the cutting operations of step (f) such that pipe segments are produced in the following sequence in a repeating manner:

(1) producing a pipe segment having a downstream end and an upstream end, a diameter of the upstream end larger than a diameter of the downstream end, then

(2) producing a pipe segment having a downstream end and an upstream end, a diameter of the upstream end smaller than a diameter of the downstream end.

**17**. The method of claim 16 wherein the diameter of the upstream end of each pipe segment of (g)(1) is substantially the same as the diameter of the downstream end of each pipe segment of (g)(2).

**18**. The method of claim 16 wherein, for each pipe segment of (g)(1), the upstream end is worked to produce a substantially corrugation free bell end, and the downstream end is worked to produce a spigot end with at least one annular corrugation.

**19**. The method of claim 16 wherein, for each pipe segment of (g)(2), the downstream end is worked to produce a substantially corrugation free bell end, and the upstream end is worked to produce a spigot end with annular corrugations.

**20-36**. (canceled)

**37**. A helically corrugated metal pipe assembly adapted for facilitating end-to-end connection in the field, comprising:

a tubular structure in the form of a spiraled corrugated metal strip with opposite side edges adjacent each other and joined together to form a helical seam along a length of the tubular structure, a central region of the tubular structure helically corrugated, a first end of the tubular structure worked to provide an annular structure, a bell fitting positioned on the first end of the tubular structure and having an end portion, shrink wrap material wrapped about the pipe assembly in a region to cover the annular structure and the end portion of the bell fitting, the shrink wrap heated to form fit to the pipe assembly thereby securing the bell fitting on the end of the tubular structure and providing a sealing function between the tubular structure and the bell fitting.

**38**. The helically corrugated metal pipe assembly of claim 37 wherein the annular structure is an annular gasket seat with an annular gasket therein, wherein the end portion of the bell fitting engages the annular gasket.

**39**. The helically corrugated metal pipe assembly of claim 37 wherein a second end of the tubular structure includes an annular gasket seat.

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