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Schwartz

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[54] **METHOD AND APPARATUS FOR BENDING A TUBULAR MEMBER**

[75] Inventor: **Walter Schwartz,** Winnipeg, Manitoba, Canada

[73] Assignee: **Dominion Bridge Company Limited,** Montreal, Quebec, Canada

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[52] **U.S. Cl.** **72/383,** 72/301, 72/DIG. 16

[51] **Int. Cl.** **B21d 11/07**

[58] **Field of Search** ..... 72/383, 384, 385, 301, 72/308, 381, 382, DIG. 16; 29/155; 140/105

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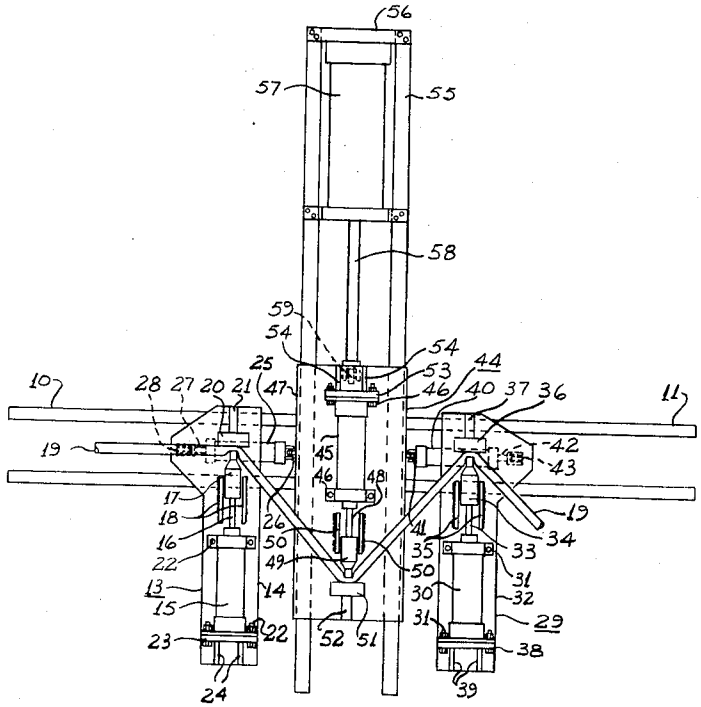
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Primary Examiner—Lowell A. Larson
Attorney, Agent, or Firm—Fetherstonhaugh & Co.; Larson, Taylor & Hinds

[57] **ABSTRACT**

An apparatus and method is disclosed for bending a tubular member into a zig-zag configuration, so that the tubular member is suitable for assembling into an open web joist. The method includes the steps of flattening one section of the tubular member, maintaining a grip on the flattened section and simultaneously bending the tubular member at either side of the flattened section. The apparatus provides a central flattening means adapted to flatten and grip a section of the tubular member, two outer flattening means each adapted to flatten and grip a section of the tubular member, the two outer flattening means being spaced equally apart from the central flattening means. Each of the flattening means are located on a separate movable carriage which are mounted on separate guide members. The carriages for the outer flattening means have their guide members in the same plane and in line and the carriage for the central flattening means has its guide members in the same plane and perpendicular to the guide members for the two outer flattening means carriages. Power means are provided for moving the central flattening means carriage along its guide members so that the central flattening means is out of line with the two outer flattening means.

9 Claims, 4 Drawing Figures



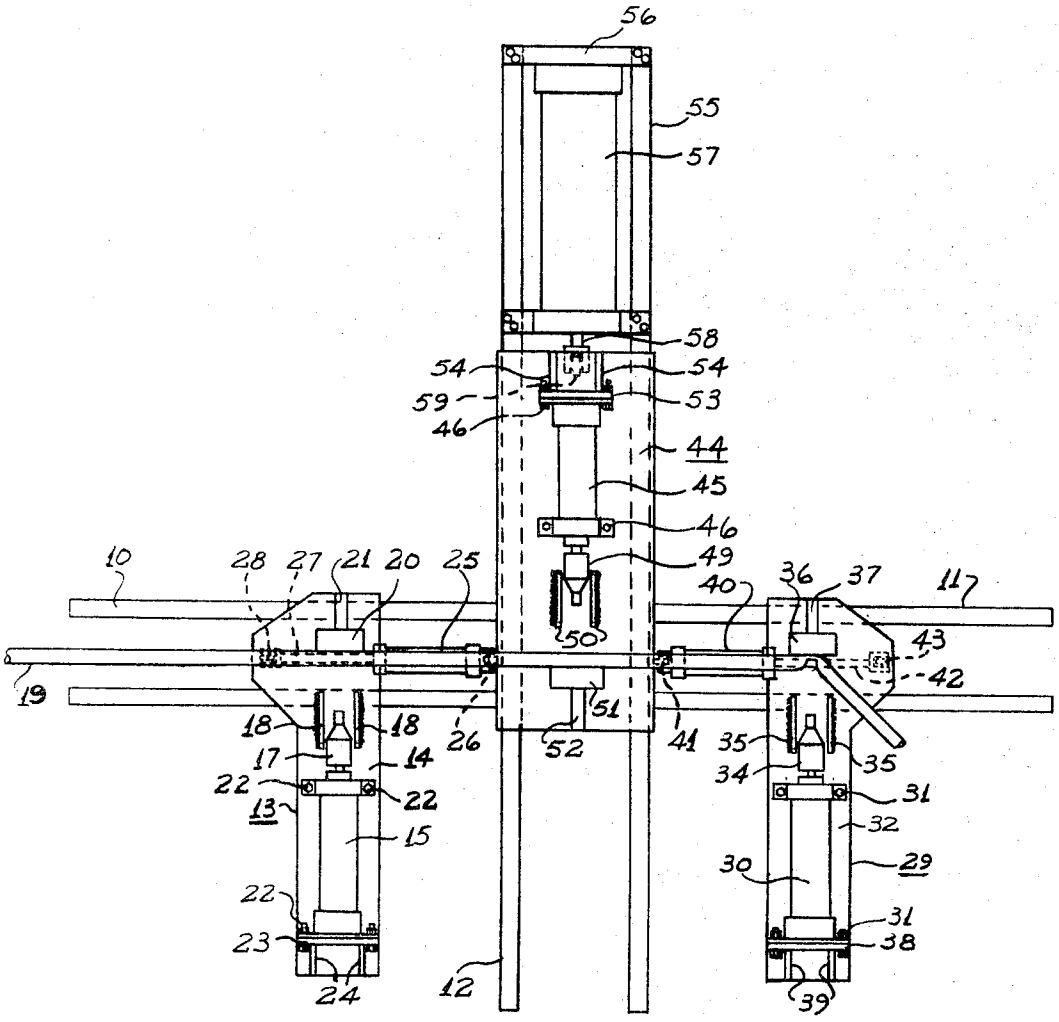

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FIG. 1

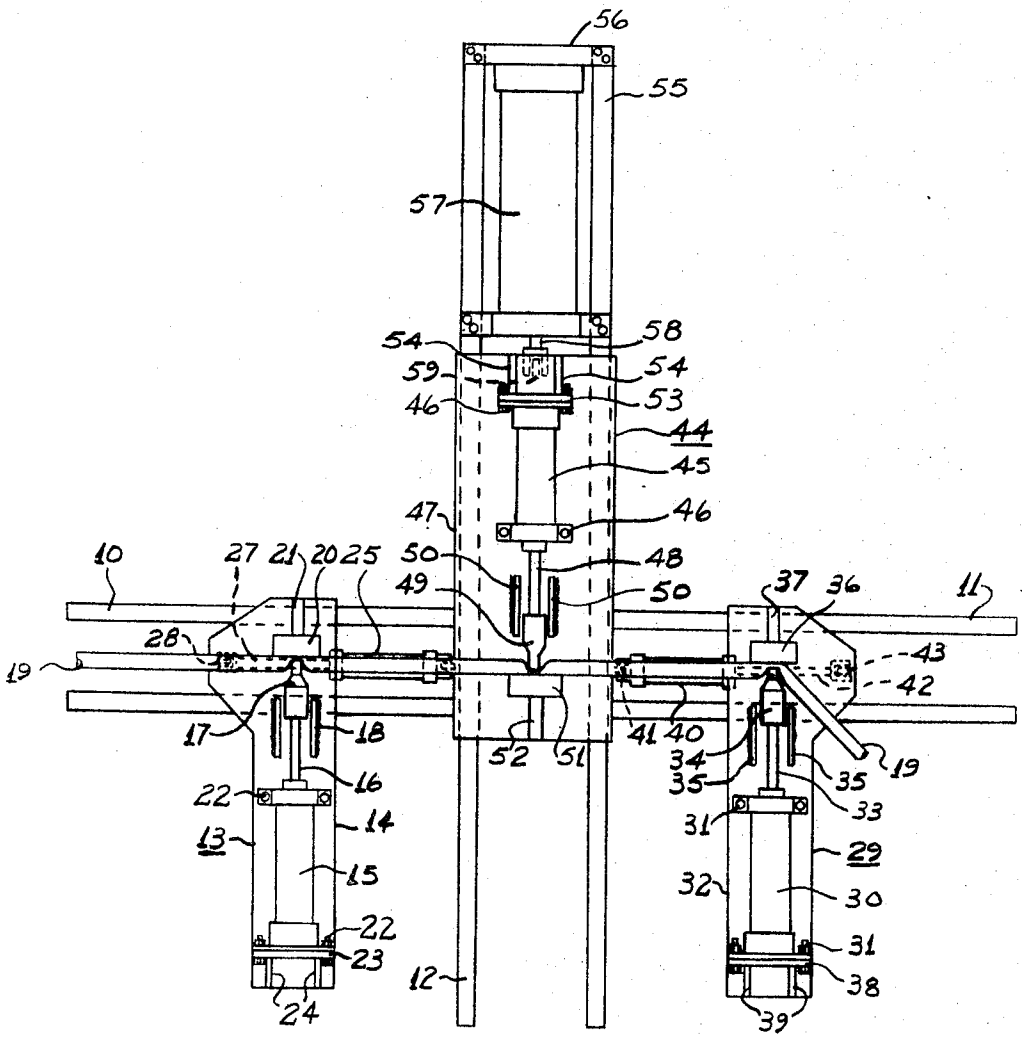

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FIG. 2

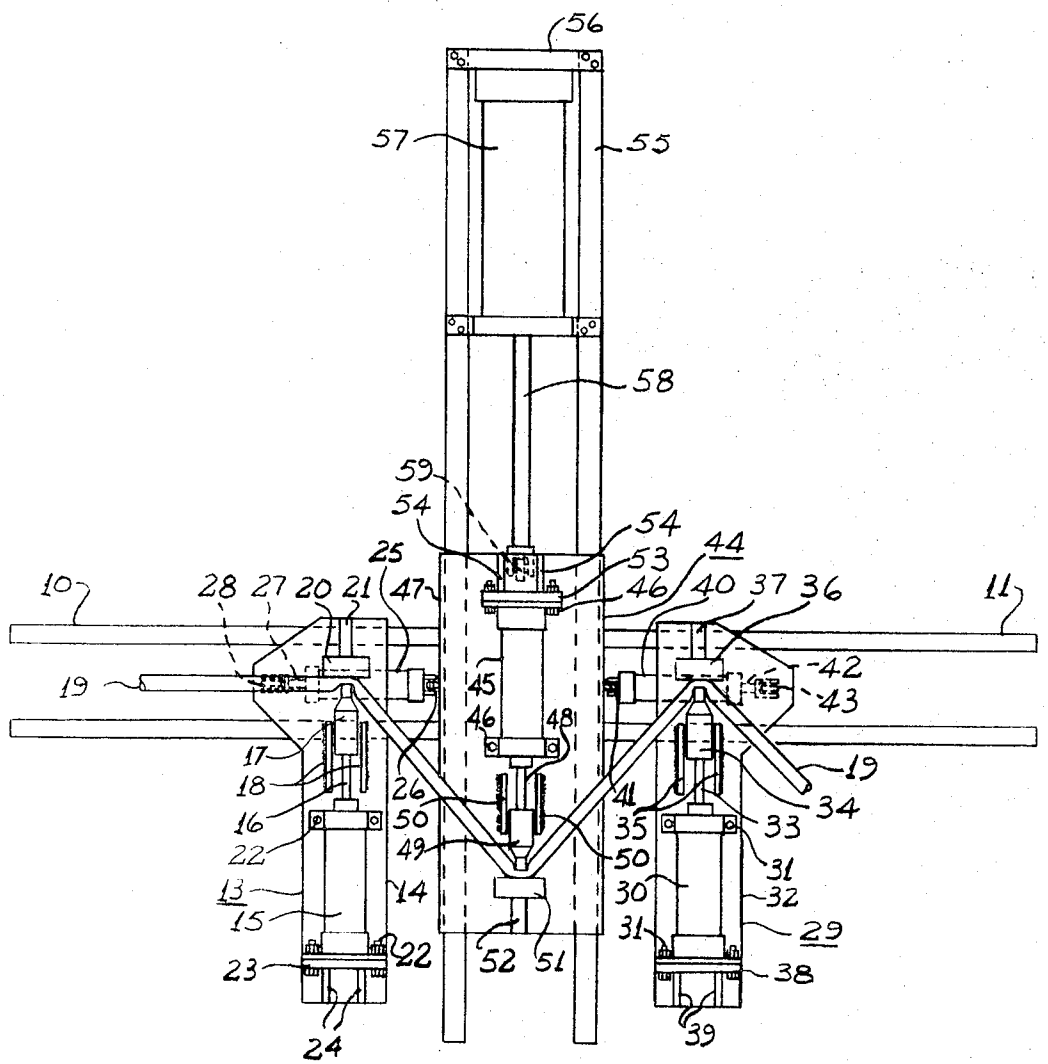

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FIG. 3

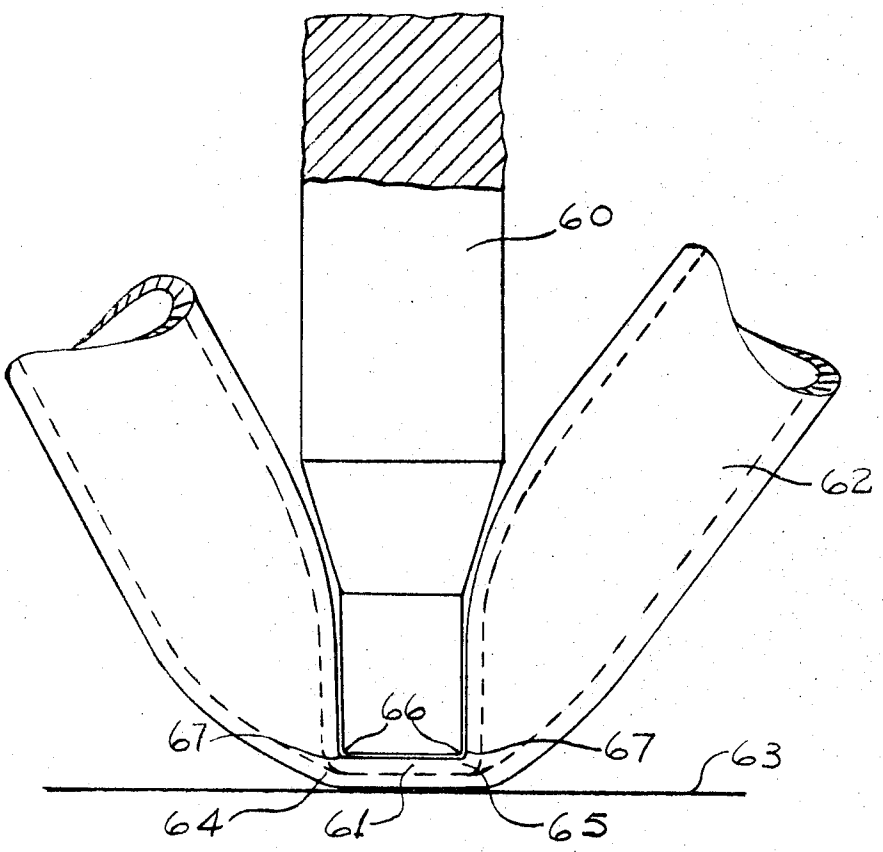


FIG. 4

METHOD AND APPARATUS FOR BENDING A TUBULAR MEMBER

This invention relates to a bending apparatus and more particularly to a machine for bending a tubular member into at least one V-shaped configuration.

In the past open web joists have been made from rods which are first bent into a zig-zag configuration before being welded to top and bottom chords. In larger spans, where a higher strength to weight ratio is required, the zig-zag rod is replaced with short straight sections of a structural angle or a tubular member. These sections require more time for fitting and assembly as each section end must be joined preferably by welding to the chords.

Devices presently used for bending tubular members, generally do so in one operation, and do not provide a flattened section suitable for resistance welding.

It is an object of the present invention to provide an apparatus and a process for forming a tubular member into a V-shaped configuration with the tip of the V being flattened suitable for welding to another structural member.

A further object is to provide an apparatus for flattening a plurality of sections of a tubular member and bending the tubular member into a zig-zag configuration.

With these and other objects in view there is provided a method of bending a tubular member into at least one V-shaped configuration comprising the steps of flattening at least one section of the tubular member, maintaining a pressure grip on the flattened section and simultaneously bending the tubular member at either side of the flattened section.

Furthermore there is provided an apparatus for forming a tubular member into a zig-zag configuration comprising a central flattening means adapted to flatten and grip a section of the tubular member, two outer flattening means each adapted to flatten and grip a section of the tubular member, the three flattening means being in the same plane and in line, the two outer flattening means spaced equally apart from the central flattening means, each flattening means located on a separate movable carriage mounted on separate guide members, the two carriages for the outer flattening means having their guide members in the same plane and in line, the carriage for the central flattening means having its guide members in the same plane and perpendicular to the guide members for the two outer flattening means carriages and located between the two, and power means for moving the central flattening means carriage along its guide members so that the central flattening means is out of line with the two outer flattening means.

In drawings which illustrate embodiments of the invention,

FIGS. **1, 2** and **3** represent top plan views showing the sequence of operation of the apparatus according to the present invention.

FIG. **4** shows an enlarged detail of a flattened section of tube under pressure with bends at either side of the flattened section.

Referring now to FIGS. **1, 2** and **3,** a left hand guide member **10** and a right hand guide member **11** each comprising two rails or guides parallel to each other. The left hand guide member **10** and right hand guide member **11** are in line and in the same horizontal plane.

In between the left hand guide member **10** and the right hand guide member **11** is a central guide member **12.** The central guide member **12** is perpendicular to the left hand guide member **10** and right hand guide member **11,** but in the same horizontal plane as these two members. The central guide member **12,** like the other two members, has two rails or guides parallel to each other. On the left hand guide member **10** is slideably located a movable carriage or slide **13** preferably formed from a steel plate **14** and having mounted thereon a hydraulic cylinder **15.** A movable piston arm **16** from the hydraulic cylinder **15** is connected to a crushing jaw **17** which slides between two guides **18** to flatten and hold a section of a tubular member **19** against a back plate **20,** which is supported by a support gusset **21** attached to the steel plate **14.** The hydraulic cylinder **15** is connected to the steel plate **14** by bolts **22** and has a support plate **23** immediately behind the cylinder **15** with two support gussets **24** behind the support plate **23** attached to the steel plate **14.**

The movable carriage **13** slides on the left hand guide member **10** and is connected to an air cylinder **25** positioned in the centre of the left hand guide member **10** adjacent the central guide member **12.** The air cylinder **25** has a connection **26** to the frame of the bending device at the central guide member **12** and has a piston arm **27** connected to a bracket **28** on the underside of the steel plate **14** of the movable carriage **13.**

The right hand guide member **11** has a movable carriage **29** with a hydraulic cylinder **30** attached by bolts **31** to a steel plate **32.** A movable piston arm **33** from the hydraulic cylinder **30** is connected to a crushing jaw **34** which slides between two guides **35** to flatten and hold a section of the tubular member **19** against a back plate **36** which is supported by a support gusset **37** attached to the steel plate **32.** A support plate **38** positioned behind the hydraulic cylinder **30** has two support gussets **39** attached to the steel plate **32.** An air cylinder **40** similar to air cylinder **25** is positioned in the centre of the right hand guide member **11** adjacent the central guide member **12,** and has a connection **41** to the frame of the bending device at the central guide member **12.** A piston arm **42** from the air cylinder **40** is connected to a bracket **43** on the underside of the steel plate **32.**

A central movable carriage **44** which slides on the central guide member **12,** moves perpendicular to the movable carriage **13** on the left hand guide member **10** and the movable carriage **29** on the right hand guide member **11.** A hydraulic cylinder **45** is attached by bolts **46** to a steel plate **47.** The hydraulic cylinder **45** has a movable piston arm **48** connected to a crushing jaw **49** which slides between two guides **50** to flatten and hold a section of the tubular member **19** against a back plate **51** which is supported by a support gusset **52** attached to the steel plate **47.** A support plate **53** positioned behind the hydraulic cylinder **45** has two support gussets **54** attached to the steel plate **47.**

The central guide member **12** extends backwards to form an extended frame **55** with a support plate **56** to support a hydraulic cylinder **57.** The cylinder **57** rests between the two rails of the central guide member **12** at the same end as the hydraulic cylinder **45** on the central movable carriage **44.** A piston arm **58** from the hydraulic cylinder **57** is connected to a bracket **59** on the underside of the steel plate **47** of the central movable carriage **44.**

FIG. 1 shows the bending apparatus in the initial position. The tubular member **19** is shown with one side resting against the back plate **20** of the left hand movable carriage **13** and the back plate **36** of the right hand movable carriage **29.** At the same time, the back plate **51** of the central movable carriage **44** touches the other side of the tubular member **19.** The movement of the central movable carriage **44** along the central guide member **12** can be set as required in order to put the desired depth of bend into the tubular member **19.**

FIG. **4** shows a crushing jaw **60** resting against a flattened section **61** of a tubular member **62.** It is seen that in the flattened section both sides of the tube meet thus enabling resistance welding to be performed through the flattened section of the tube. The flattened section **16** is resting up against a back plate **63.** The central movable carriage has been moved in this particular figure, thus a left hand bend **64** and a right hand bend **65** appear on either side of the flattened section **61.** The crushing jaw **60** has a radius **66** at the bottom end thereof such that the tubular member radius **67** is kept within desired limits and is not too great to cause stress or fatigue at that point. The preferred tubular member radius **67** is not less than one-eighth of an inch.

Before commencing operation, the apparatus is first adjusted for the particular diameter of tube to be bent and the desired depth of the V required in the tubular member. If the thickness or gauge of the tube varies, it is not necessary to reset the bending apparatus, as the vertical distance or depth of the zig-zag configuration remains the same being set by the distance from the two outer back plates **20** and **36** to the central back plate **51.** The central movable carriage **44** is located in such a position so that the distance from the left and right hand back plates **20** and **36** to the central back plate **51** is slightly larger than the diameter of the tubular member **19.** Thus, a tubular member **19** is easily placed between the back plates and the crushing jaws of the apparatus. The movement of the central movable carriage **44** along the central guide member **12** is controlled by a stop so that when the hydraulic cylinder **57** pushes this central movable carriage **44** it will only slide as far as the stop thus giving the desired depth of V in the tubular member.

FIG. **1** shows a half formed V-shape in the tubular member **19** formed in a previous operation, and this is located at the right hand side of the apparatus so that it lines up between the right hand crushing jaw **34** and back plate **36.** When the tubular member **19** has been lined up in the machine, the hydraulic cylinders **15, 30** and **45** are first activated, and these in turn push the crushing jaws **17, 34** and **49** up against the tubular member **19.** The crushing jaws **17, 34** and **49** each flatten a section of the tubular member so that the two sides of the tubular member are touching. The pressure from the hydraulic cylinders **15, 30** and **45** is maintained on the three crushing jaws **17, 34** and **49** to grip the three flattened sections, and the hydraulic cylinder **57** mounted in the extended frame **55** of the central guide member **12** is next activated to push the central movable carriage **44** along the central guide member **12.** As the piston arm **58** from the hydraulic cylinder **57** slowly moves the central movable carriage **44,** the tubular member **19** commences to bend at the points at the end of each flattened section adjacent to each of the crushing jaws. The section of tubular member **19** held by the central crushing jaw **49** bends on each side in the configuration shown in FIG. **4.** As the central movable carriage **44** slides along the central guide member **12,** both the left hand movable carriage **13** and the right hand movable carriage **29** slide on their guide members in towards the centre of the apparatus. As the carriages **13** and **29** move in towards the centre, the piston arms **27** and **42** move into the air cylinders **25** and **40.** This movement is preferably assisted by stored air in an accumulator (not shown). The air assist is regulated so that it does not provide quite enough power to move the carriages **13** and **29** on their own, but gives an assist as the central movable carriage **44** starts to move commencing the bend in the tubular member. The bending speed is controlled by the flow of hydraulic fluid into the cylinder **57** which moves the central movable carriage **44** along the central guide member **12.** When the central movable carriage **44** reaches the preset stop, the bend configuration is complete. Once the bend configuration has been completed, the hydraulic pressure is released from the hydraulic cylinders **15, 30** and **45,** and the crushing jaws **17, 34** and **49** open. The tubular member **19** may then be lifted and removed from the apparatus. The movable carriages **13, 29** and **44** are then returned to their initial position. The carriages **13** and **29** are returned by compressed air being passed into the low pressure side of the air cylinders **25** and **40.** This forces the air in the opposite side of the cylinder into the accumulator (not shown) which is then held by an electric solenoid valve (not shown) for the next bend operation. The tubular member **19** is moved along and placed such that the section flattened by the crushing jaw **17** on the left hand movable carriage **13** is positioned under the crushing jaw **34** of the right hand movable carriage **29.** The sequence then commences over again to form another V-shaped configuration. This sequence of operation continues until a zig-zag configuration has been made which is suitable for forming a web of an open web joist. Alternatively, only one V-shaped configuration is required suitable for welding, by regular electrode or resistance type to a structural member to form a strong connection suitable for many types of open structural frames.

The three hydraulic cylinders **15, 30** and **45** operating the crushing jaws **17, 34** and **49** are preferably connected to a hydraulic power source by means of flexible tubing (not shown). The motions of the crushing jaws are preferably controlled by a push button which operates an electric solenoid valve controlling the hydraulic fluid flow to the cylinders from a hydraulic power source such as a portable hydraulic power pack. It is not essential to have an electrically powered hydraulic source, a manual hydraulic jack has been found to operate adequately. The power to the hydraulic cylinder **57** in the extended frame **55** of the central guide member **12** is preferably from a hydraulic power source, preferably a portable hydraulic power pack and the motions of the central movable carriage **44** is preferably controlled by push button which operates electric solenoid valves controlling the air flow to the two air cylinders **25** and **40** and hydraulic fluid flow to the individual cylinder **57.** This system may also be operated manually with merely a connection to a compressed air supply.

Whereas one embodiment of the present invention has been fully described, it will be apparent to those skilled in the art that a number of changes may be made

to this embodiment without detracting from the spirit or scope of the present invention. For instance, where hydraulic cylinders and air cylinders are shown with the operating means of the present embodiment, it will be apparent to those skilled in the art that mechanical bending means may also be used. Furthermore, the air cylinders **25** and **40** for moving the left hand movable carriage **13** and right hand movable carriage **29** may be replaced with hydraulic cylinders.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A method of bending a tubular member into a zig-zag configuration comprising the steps of flattening three sections of the tubular member at two outside locations and one central location with two outside flattening and gripping means and one central flattening and gripping means, respectively, thereby forming two outside flattened sections, said central means being movable in a perpendicular direction to a line through the two outside flattened sections and each said outside means being freely movable in the direction of said line; maintaining a pressure grip on each of the flattened sections with said outside means and said central means; moving said central means perpendicular to said line for a predetermined distance; simultaneously with the moving of the central means, allowing said outside means to be pulled towards each other along said line by said tubular member and controllably assisting the moving of said outside means, and hence the movement of said outside flattened sections, with fluid actuated means by controlling the flow of fluid to said fluid actuated means such that said assistance alone is unable to move the two outside flattened sections, thus forming a v-shaped configuration in the tubular member; releasing the pressure grip from the flattened sections; moving the tubular member to a new location wherein one of the outside flattened sections just formed is positioned in the place of the other outside section just formed and repeating the above steps.

2. A method as claimed in claim **1** wherein said tubular member is flattened by compressing said tube with a jaw means having a radius of curvature at the outer ends thereof, said flattening being such that both sides of said tube are forced into contact with each other and a corresponding radius of curvature is formed on the inner surface of said tubular member in contact with said jaw means at each end of said flattened sections.

3. An apparatus for forming a substantially straight tubular member into a zig-zag configuration comprising:

a central guide member; two outer guide members located in the same plane in line with each other, said central guide member being disposed between said two outer guide members in the same plane therewith and perpendicular thereto;

a movable central carriage and two movable outer carriages respectively mounted for independent movement on said central guide member and said two outer guide members;

a central flattening means mounted on said central carriage for flattening and gripping a section of the tubular member;

two outer flattening means mounted on said two outer carriages, respectively, for flattening and gripping repective sections of the tubular member;

and fluid operated power means for moving said central carriage and said central flattening means a predetermined distance along said central guide member, whereby upon the movement of said central carriage said outer carriages and the corresponding said outer flattening means when in a gripping relationship with the tubular members are pulled towards said central guide member by the tubular member; and fluid operated return means connected to said outer carriages for returning said outer carriages to a starting position after operation, said outer carriages moving independently of each other and of said central carriage.

4. Apparatus as claimed in claim **3** and further including fluid operated assisting means for controllably assisting and dampening the movement of said outer carriages, said assisting means being controllable by controlling the flow of operating fluid thereto.

5. Apparatus as claimed in claim **4** wherein said assisting means is also said power means.

6. Apparatus as claimed in claim **4** wherein said assisting means includes an air cylinder mounted at the adjacent ends of each of the guide members for said two outer carriages, said air cylinder having a piston arm connected to said outer carriage, a compressed air supply for the air cylinder, and a bleed control valve for controlling the air bleeding from said valve air cylinder and thereby controlling the dampening of said piston arm in said air cylinder.

7. Apparatus as claimed in claim **3** wherein each said flattening means includes a flattening jaw, a back plate, cooperating with said jaw for flattening a section of the tubular member, and fluid operated means for moving said jaw, all said jaws and back plates being in the same plane.

8. Apparatus as claimed in claim **7** wherein said flattening jaw has a radius of curvature at the outer ends thereof such that upon the flattening of said tubular member, a corresponding radius of curvature is formed on the inner surface of the tubular member in contact with said jaw means at each end of said flattened sections.

9. Apparatus as claimed in claim **6** wherein said guide members are disposed in a horizontal plane and said flattening means and said carriages are movable in a horizontal plane.

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