United States Patent

Bradley et al.

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[54] **INTERNAL LINE-UP CLAMP FOR PIPE LINES**

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[52] **U.S. Cl.** **29/252,** 29/272, 269/17, 269/34, 269/48.1

[51] **Int. Cl.**.....**B23p 19/04,** B23q 3/18, B25b 1/18

[58] **Field of Search** ...269/17, 34, 48.1; 29/252, 272, 29/282, 200 P

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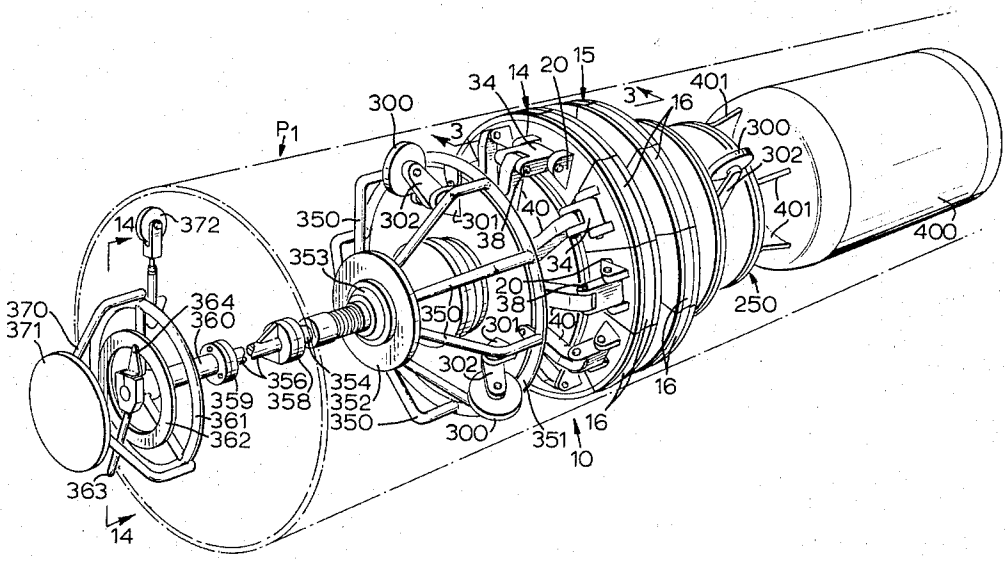
Primary Examiner—Wayne A. Morse, Jr.

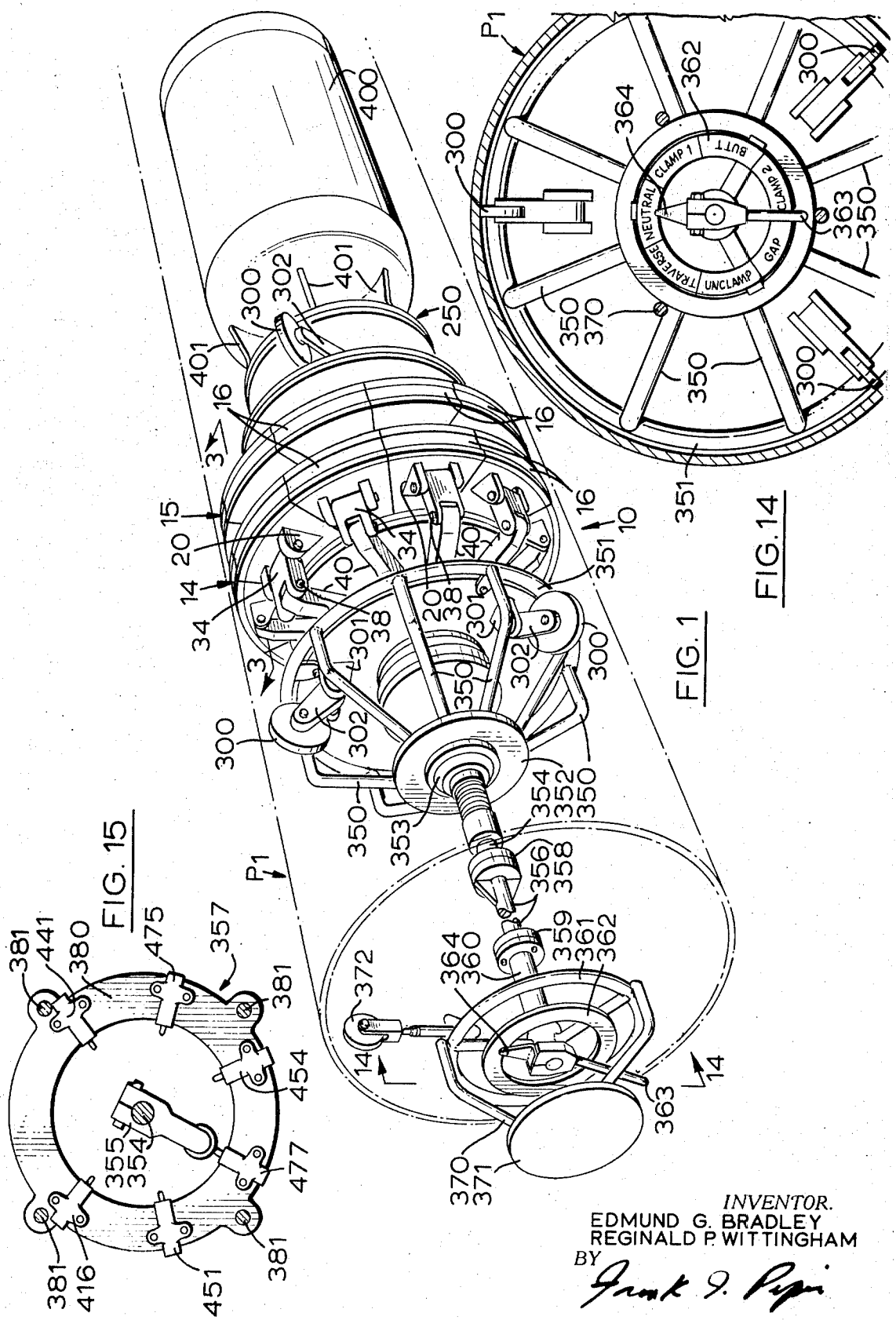
Attorney—Frank I. Piper and Arne I. Fors

[57] **ABSTRACT**

An internal line-up clamp which incorporates a pair of interconnected but independently operable clamping assemblies, each of which includes a set of radially movable pipe engaging shoes adapted to clampingly engage the inner circumferences of a pair of pipe sections in the zones adjacent their ends. At least two axially movable pneumatic actuators are operatively associated with each set of clamping shoes in a manner such that axial movement of the actuators effects radial movement of the shoe set with which they are associated. The clamping assemblies are interconnected by a plurality of axially extending rods which are adapted to maintain the assemblies in axial alignment while permitting them to be moved axially with respect to each other a limited distance. A fifth pneumatic actuator means is provided for effecting such reciprocal axial movement of the clamp assemblies.

12 Claims, 22 Drawing Figures





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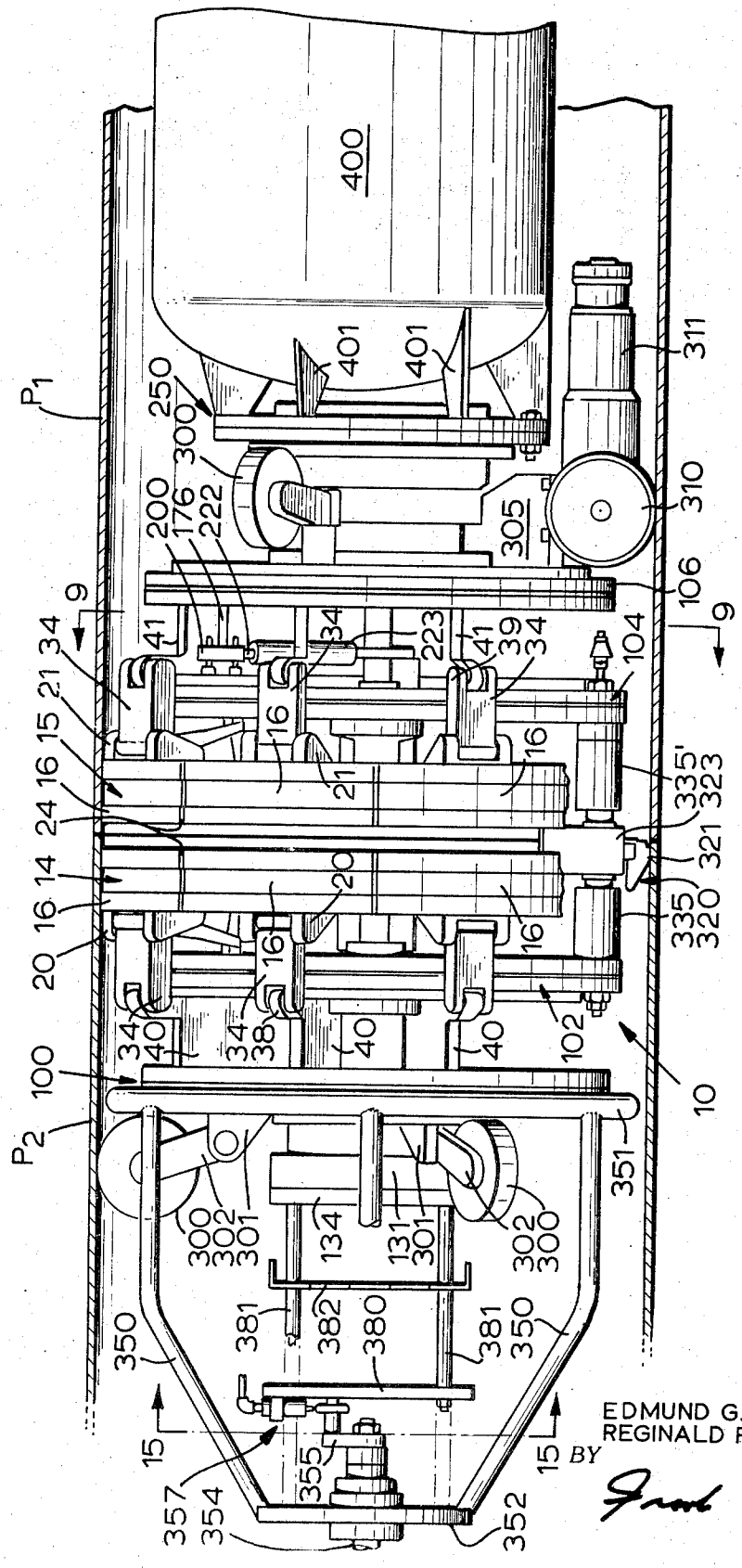


FIG. 2

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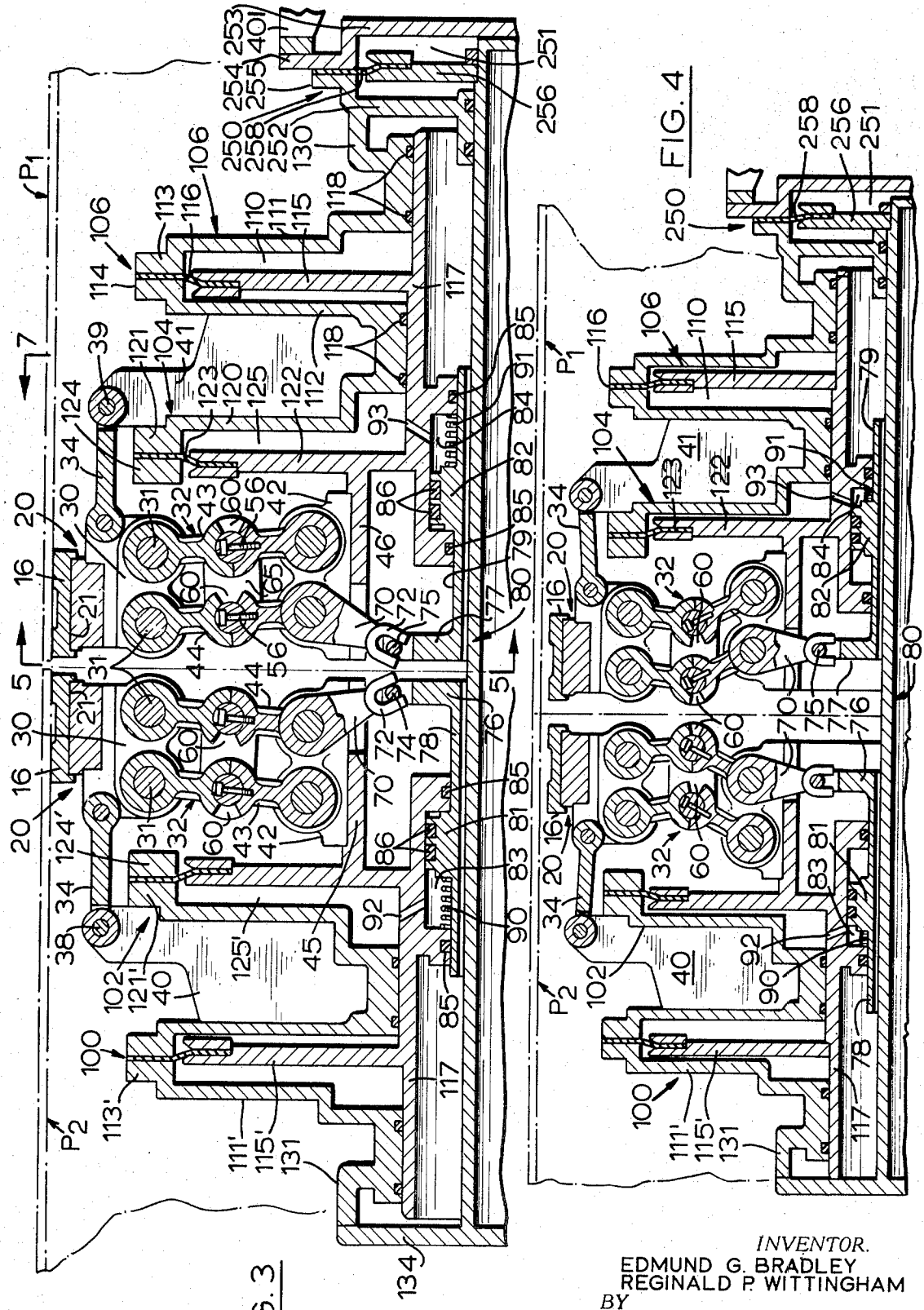


FIG. 3

FIG. 4

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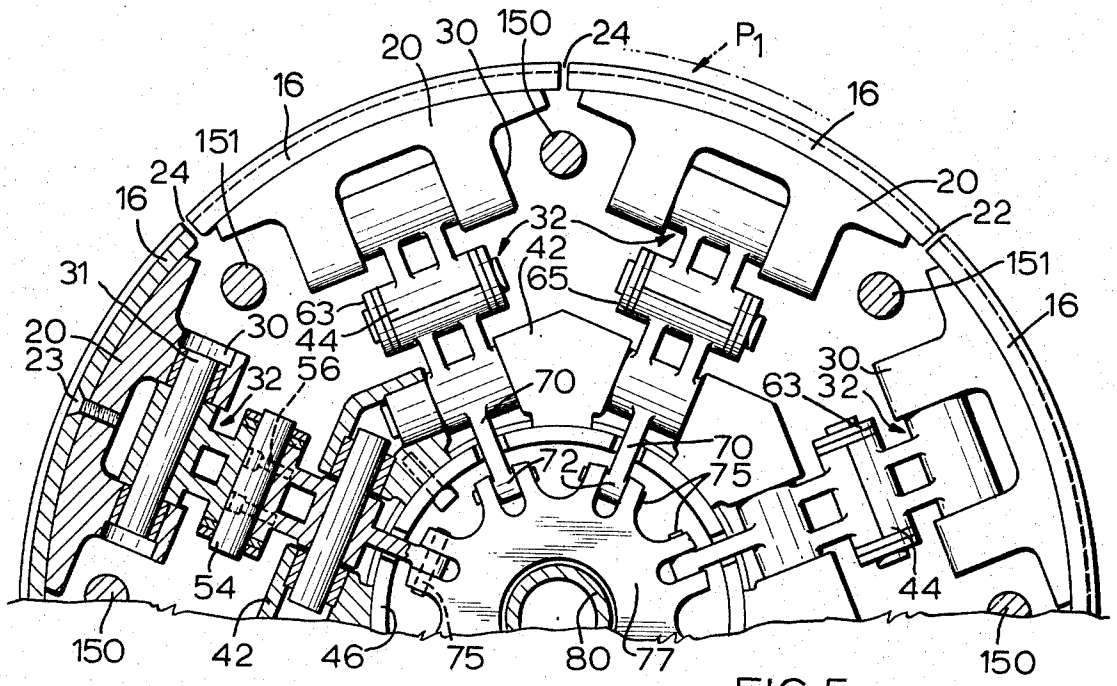


FIG.5

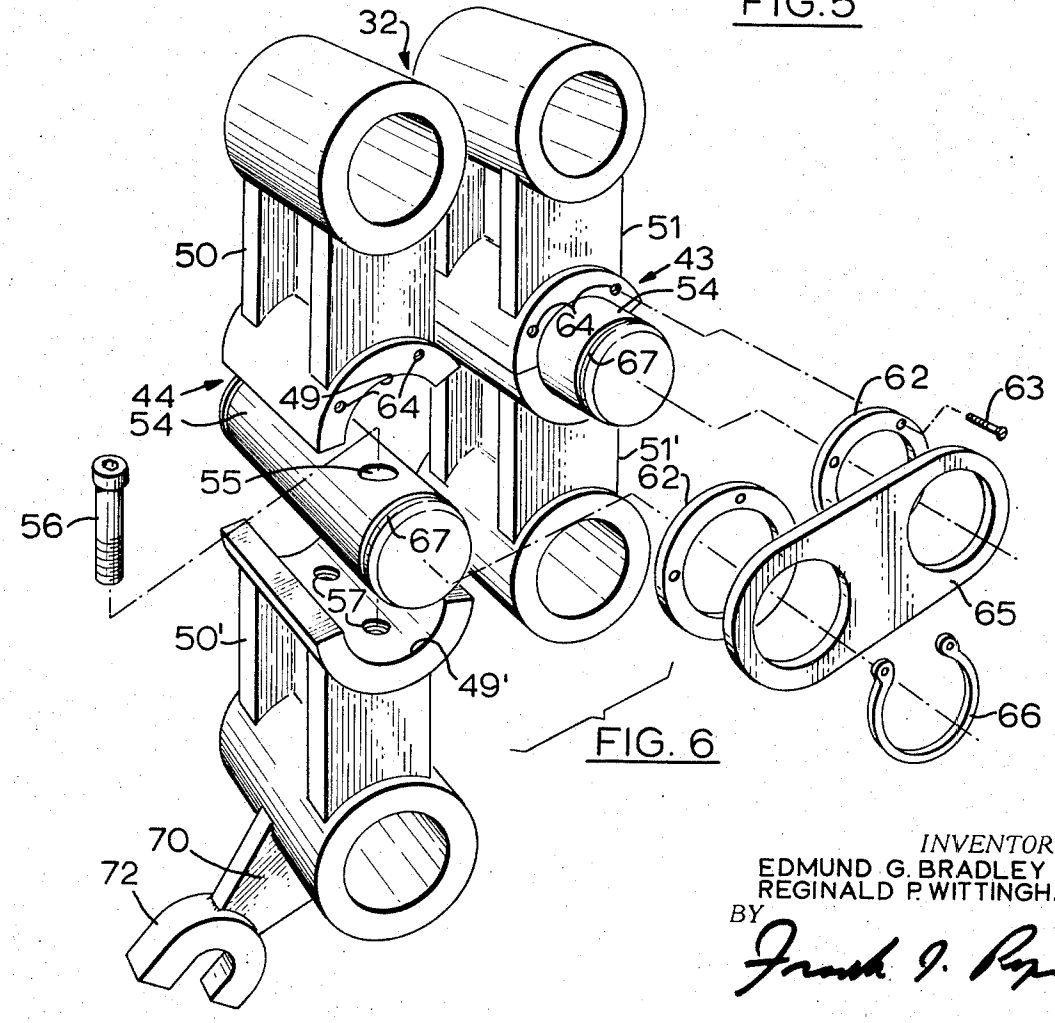
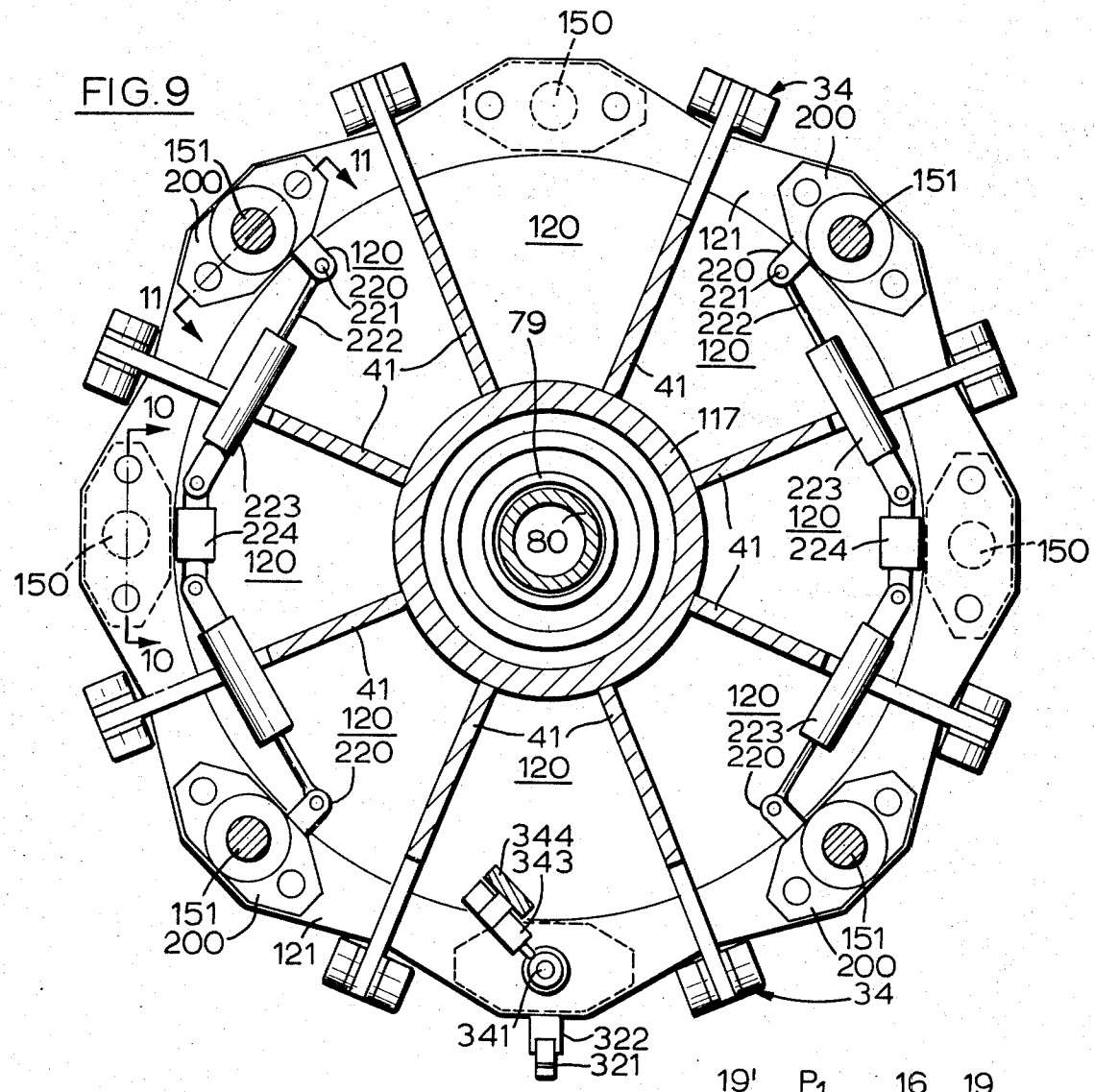


FIG. 6

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FIG. 9



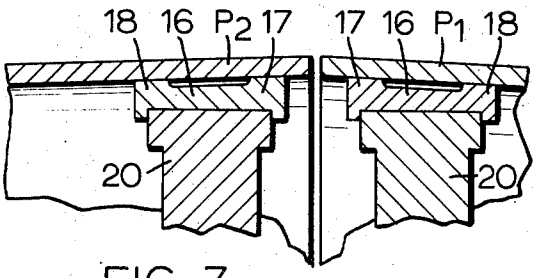


FIG. 7

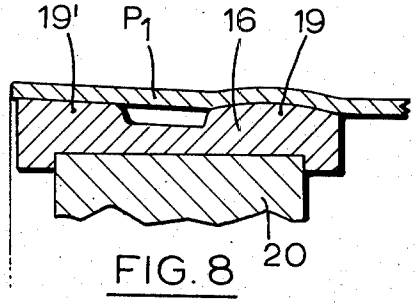


FIG. 8

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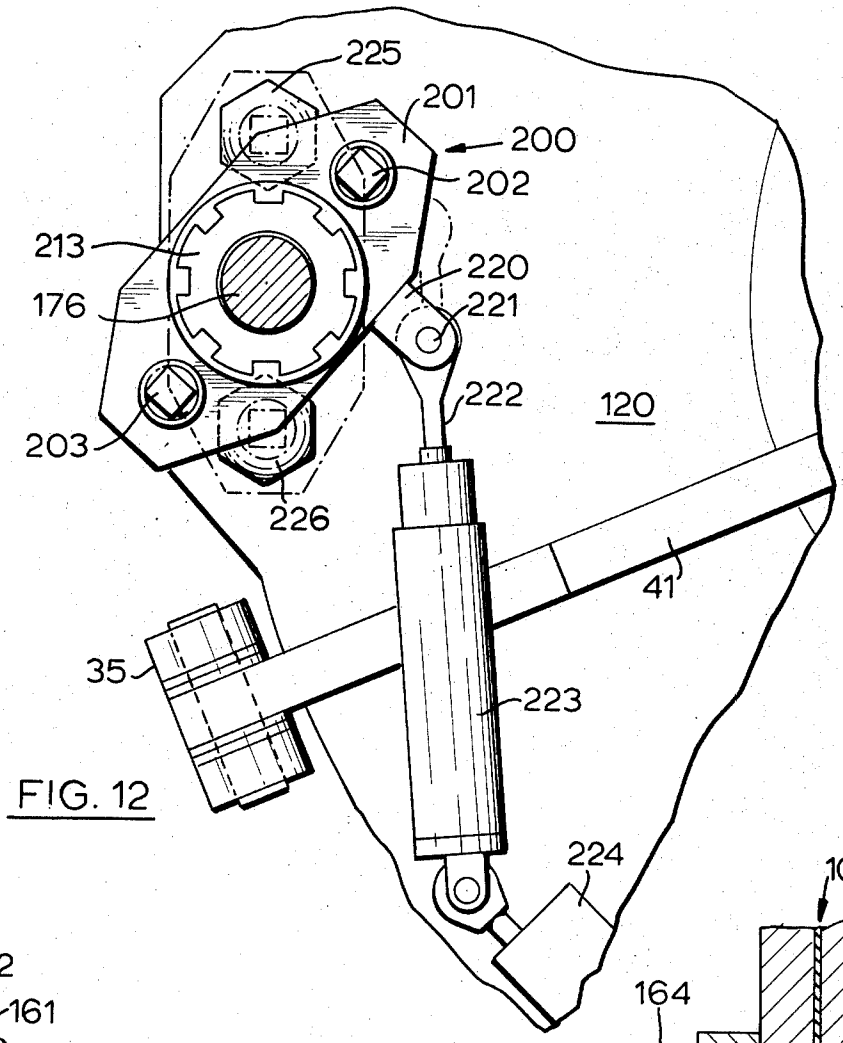


FIG. 12

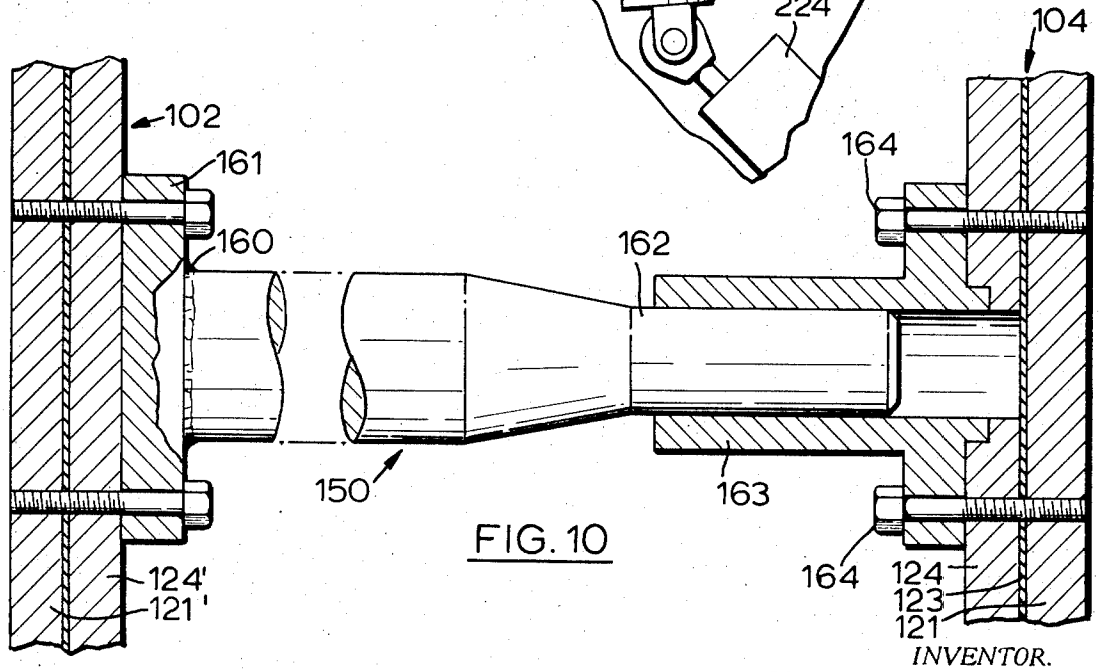


FIG. 10

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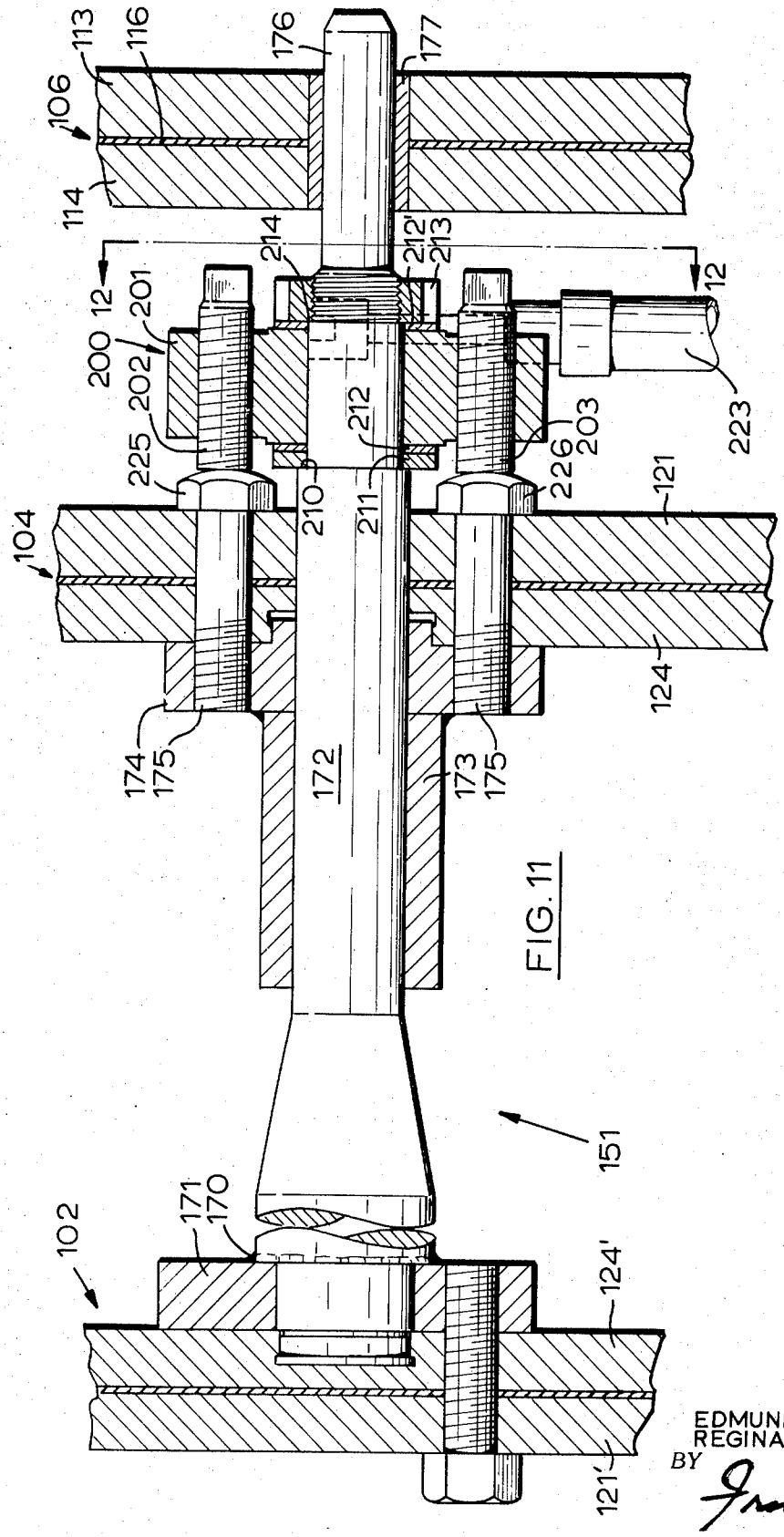


FIG. 11

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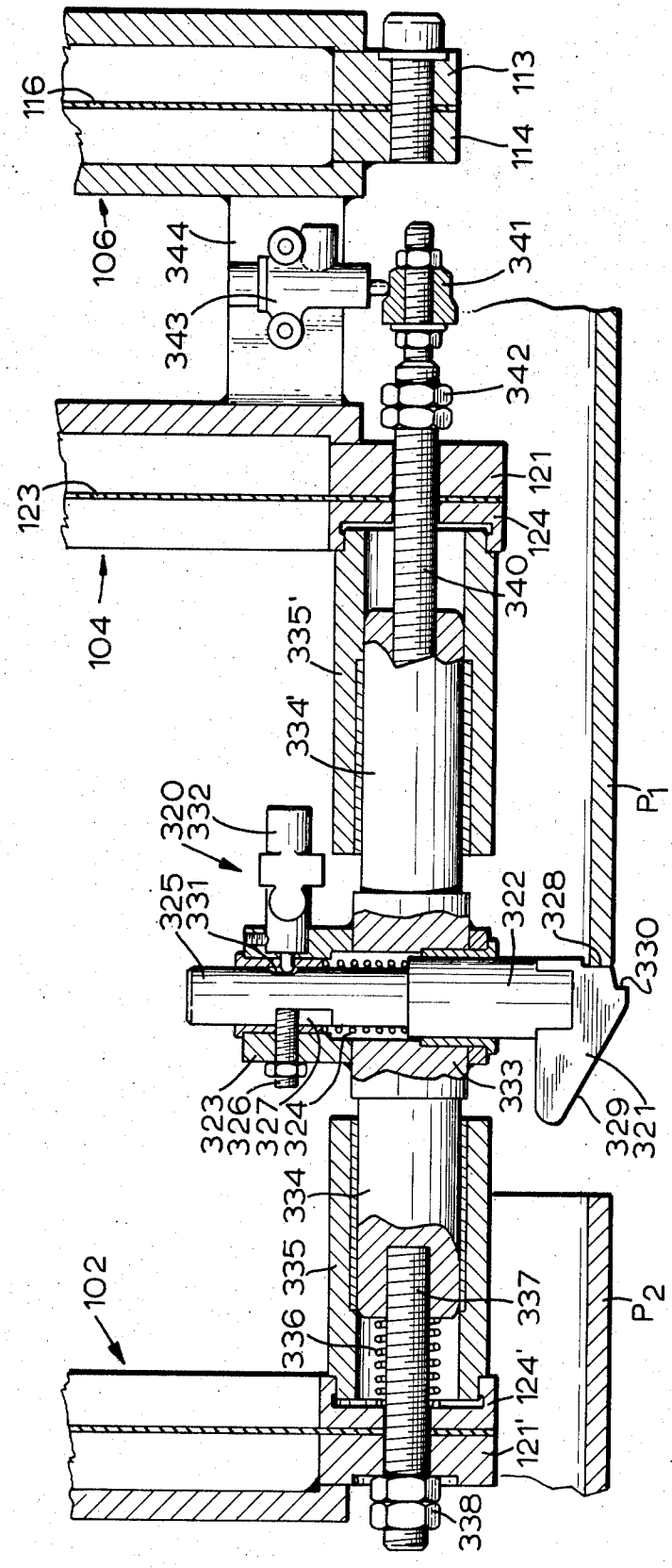


FIG. 13

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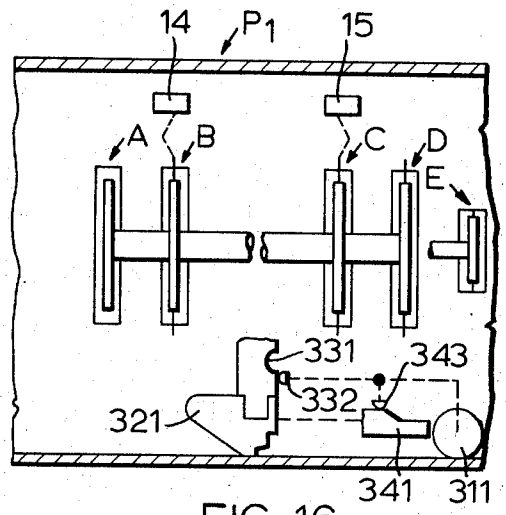


FIG. 16

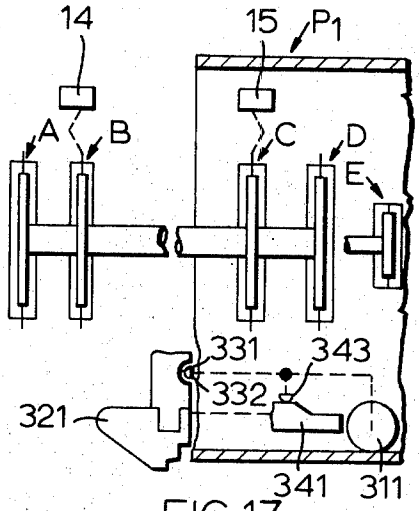


FIG. 17

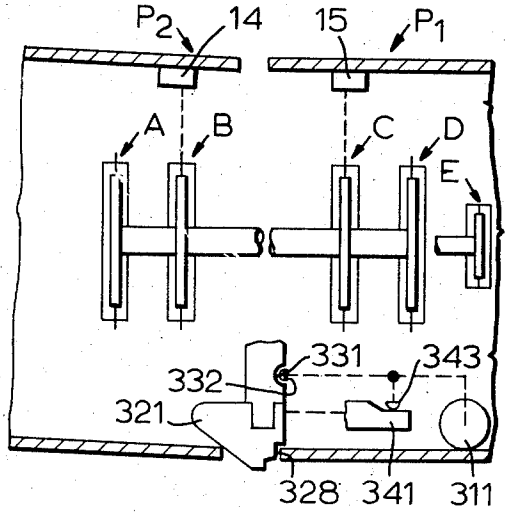


FIG. 18

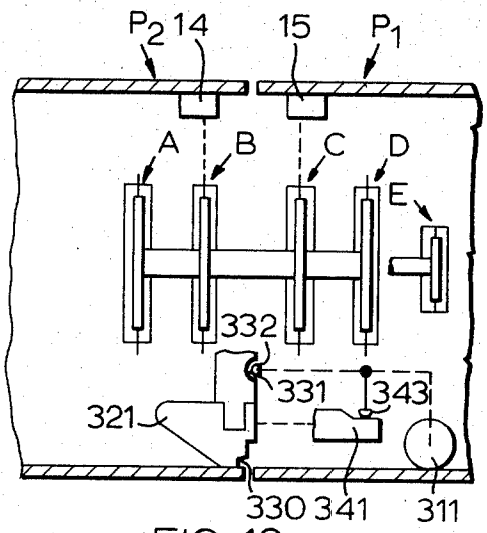


FIG. 19

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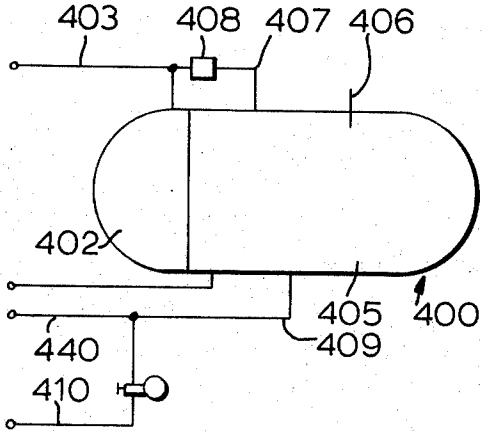


FIG. 20

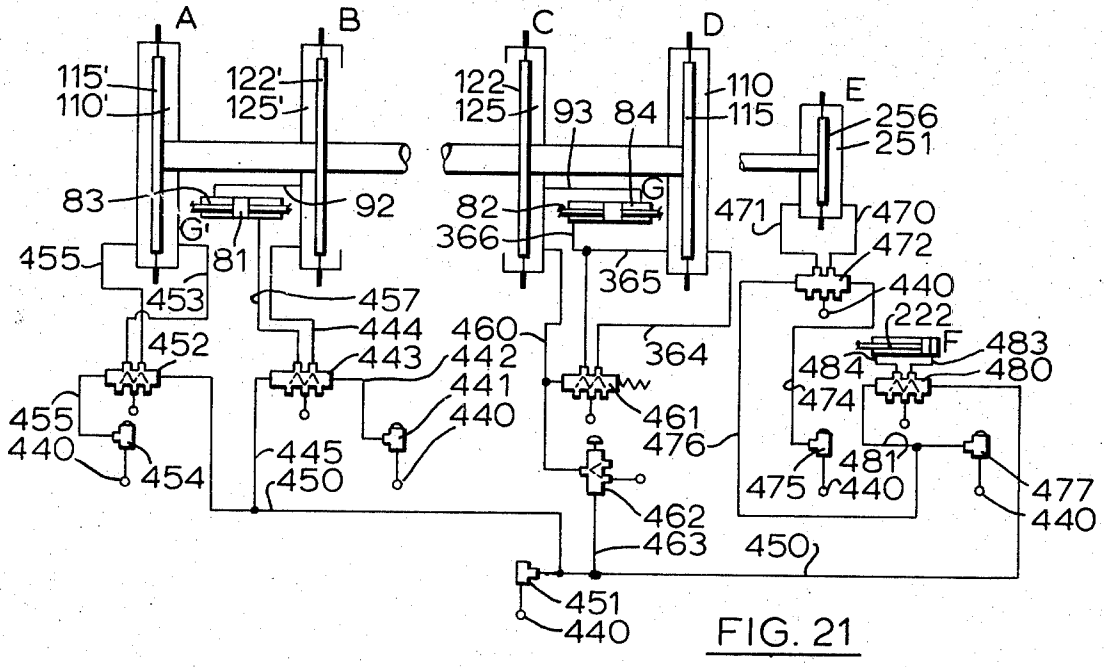


FIG. 21

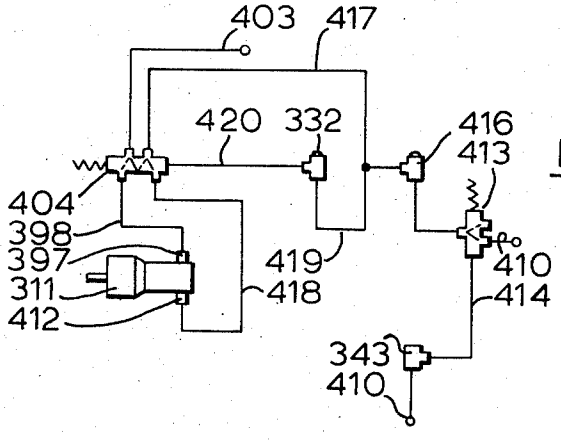


FIG. 22

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INTERNAL LINE-UP CLAMP FOR PIPE LINES

This invention relates to a line-up clamp for use in the welding of pipelines and, more particularly, to a pipe line-up clamp for clamping the internal surfaces of a pair of adjacent pipe ends and positioning and maintaining the pipe ends in precisely aligned relationship for welding by either manual or automatic welding means.

In the construction of pipelines, a large number of individual pipe sections are welded together in end-to-end relationship. It is the usual practice to utilize an internal line-up clamp to align adjacent pipe ends prior to welding and maintain them in aligned position during the welding operation. Many such internal pipe line-up clamps are known and in commercial use. However, the known clamps are deficient in many respects.

For effective welding, particularly with automatic welding equipment, the pipe ends must not only be coaxial but the pipe walls must be accurately aligned around their entire circumferences. Steel pipe sections used in the pipeline construction industry are not always exactly cylindrical nor are the ends precisely square. Also, during transportation to and handling on the job site, the pipe sections are often bent out of round. As a result, when a set-in pipe section is positioned in end-to-end relationship with the open end of the welded-in portion of the pipeline, the adjacent pipe ends often exhibit different degrees of roundness and, also, the end faces do not abut even though the pipes may be coaxial.

Conventional line-up clamps are generally not capable of exerting a sufficiently great pressure upon the adjacent ends of out-of-round pipe sections to bring them into precise alignment, particularly in the case of the relatively large diameter pipes which are becoming increasingly common in the pipeline industry. In addition, in using the prior art clamps it is often difficult to bring the end faces of the pipe sections in to proper abutting relationship since the set-in pipe is positioned entirely by mechanical means external to the clamp itself, e.g. by manipulation of the set-in pipe support sling and movement of the side-boom tractor carrying the set-in pipe. This procedure, of course, is tedious and time consuming particularly where the end faces of pipe sections are not exactly square. For these reasons particularly, the prior art line-up clamps are generally unsuitable for use in conjunction with automatic welding equipment which requires extremely precise alignment of the pipe ends and, preferably, accurate spacing between the adjacent surfaces which are to be joined.

The prior clamps also are are generally difficult to manipulate and position within the pipeline section preparatory to clamping each new section in place for welding. Moreover, difficulty is often encountered in moving the prior line-up clamps through curved pipe sections because of the very small clearance normally provided between the pipe engaging clamping shoes and the internal surfaces of the pipe.

Although many attempts have been made to overcome the foregoing and other disadvantages of the prior art clamps, non, as far as is known, has been provided which has been entirely satisfactory in commercial operations.

Accordingly, it is an object of the present invention to provide an apparatus for axially aligning adjacent pipe ends which is capable of exerting very high radial forces on the inner circumference of the pipe ends to force each into a truly circular configuration.

Another object of the invention is the provision of apparatus for aligning pipe ends which is capable of clamping the end of a set-in pipe and drawing it into abutting, axially aligned relationship with the pipe end to which it is to be joined.

Another object of the invention is to provide an internal pipe line-up clamp which may be quickly and automatically positioned and clamped at the end of the welded in-pipe section in position for receiving the set-in pipe section.

Still another object of the present invention is to provide a pipe line-up clamp which functions to (a) securely clamp and round out the open end of the welded-in pipe in an initial clamping action, (b) clamp the set-in pipe end after it is brought into rough end-to-end alignment with the welded-in pipe, (c) draw the set-in pipe towards the welded-in pipe to bring the end faces of the two pipes into engagement, (d) securely clamp and round out the end of the set-in pipe in a secondary clamping action and, finally, (e) back-space the end face of the set-in pipe a predetermined distance of the welded-in pipe end face to provide a uniform gap between the adjacent pipe end faces while still maintaining the pipe walls in accurate alignment.

Yet another object of the present invention is the provision of apparatus for aligning pipe ends which incorporates pipe-engaging clamping elements capable of relatively large retractive radial movement from an operative to a non-operative position thereby permitting the clamp to traverse curved pipe sections without damage to the pipe or clamping elements.

A still further object of the invention is to provide apparatus for positioning and aligning pipe ends which is relatively inexpensive to manufacture, simple to operate and rugged and durable in use.

According to the invention, these and other objects and advantages are obtained by an internal line-up clamp which incorporates a pair of interconnected but independently operable clamping assemblies, each of which includes a set of radially movable pipe engaging shoes adapted to clampingly engage the inner circumferences of a pair of pipe sections in the zones adjacent their ends. At least two axially movable pneumatic actuators are operatively associated with each set of clamping shoes in a manner such that axial movement of the actuators effects radial movement of the shoe set with which they are associated. The clamping assemblies are interconnected by a plurality of axially extending rods which are adapted to maintain the assemblies in axial alignment while permitting them to be moved axially with respect to each other a limited distance. A fifth pneumatic actuator means is provided for effecting such reciprocal axial movement of the clamp assemblies.

The double actuator means associated with each set of pipe engaging shoes enables each shoe set to be actuated independently and it also permits imposition of clamping forces which can be selectively increased through at least two stages to a level sufficiently great to round out large diameter, high strength pipe sections without difficulty. In a preferred embodiment of the clamp, the high clamping force capability of the compound actuator means is transmitted to the pipe engag-

ing clamping shoes by means of a plurality of tandem pivot links which are adapted for retraction radially inwardly when the clamp is in a non-operative or pipe-traversing state, thus ensuring ample clearance between the clamp shoes and the inner wall of the pipe through which it is traversed.

An another preferred aspect, the clamp incorporates pneumatically actuated drive means for propelling the clamp axially forwardly through a pipeline section together with associated control means for automatically stopping, reversing and positioning the clamp at the open end of the welded-in pipe section in position to receive the next set-in pipe section.

The invention is explained in detail hereinbelow by reference to a specific clamp apparatus incorporating the features of the invention. Such apparatus is not meant to be limiting inasmuch as it will be understood that it constitutes but one of the ways in which the principles of the invention may be applied.

In the drawings, wherein like reference numerals indicate line parts in the various views:

FIG. **1** is a perspective view of an embodiment of the clamp apparatus of the invention, with some parts omitted for sake of clarity, showing the clamp traversing a pipe section;

FIG. **2** is a side elevation, with some parts omitted and portions broken away, showing the clamp in operative position in a pair of adjacent pipe sections;

FIG. **3** is a partial longitudinal sectional view taken along the line **3—3** of FIG. **1**;

FIG. **4** is a longitudinal sectional view similar to FIG. **3** but with the pipe clamping shoes and supporting linkages in a retracted position for travel through a pipe section;

FIG. **5** is a transverse sectional view, with portions broken away, taken along the line **5—5** of FIG. **3**.

FIG. **6** is a detail exploded perspective view of a clamp shoe supporting link assembly;

FIG. **7** is a fragmentary longitudinal sectional view showing one form of clamping shoe configuration;

FIG. **8** is a fragmentary longitudinal sectional view showing another form of clamping shoe configuration;

FIG. **9** is a transverse sectional view along the lines **9—9** of FIG. **2**;

FIG. **10** is a longitudinal view along the line **10—10** of FIG. **9**;

FIG. **11** is a longitudinal view along the line **11—11** of FIG. **9**;

FIG. **12** is an end elevation view along the line **12—12** of FIG. **11**;

FIG. **13** is a side elevation detail, with portions broken away, showing the clamp back-stop mechanism;

FIG. **14** is an end elevation along the line **14—14** of FIG. **1** showing elements of the clamp control mechanism;

FIG. **15** is an end elevation along the line **15—15** of FIG. **2** showing the manually actuable pilot valves for controlling the clamp functions;

FIGS. **16**, **17**, **18** and **19** depict schematically the operating sequence of the clamp; and

FIGS. **20**, **21** and **22** are diagrammatic representations of the pneumatic control system for the clamp.

In FIG. **1**, the internal pipe line-up clamp of the invention, indicated generally by the reference numeral **10**, is shown disposed in an intermediate position within a first pipe line section P_1 to which another pipe section P_2 (FIG. **2**) is to be welded in end-to-end relationship. The function of the clamp **10** is to grip the adjacent ends of pipes P_1 and P_2 and position and maintain them securely in a precisely aligned and spaced-apart end-to-end relationship for welding.

The clamp **10** comprises six basic sub-assemblies:

1. The pipe engaging members or clamping shoe sets;
2. the clamping shoe support linkages;
3. the clamping shoe actuation mechanisms;
4. the set-in pipe positioning and back-spacing mechanisms;
5. the clamp drive and conveying mechanisms; and
6. the clamp control mechanisms.

Referring first to FIGS. **1–6**, there are two clamping shoe sets **14**, **15** each comprising a plurality of peripherally spaced clamping shoes **16**. As best shown in FIGS. **3**, **4** and **5**, the shoes **16** are removably secured to mounting blocks **20** by means of tenons **21** and counter-sunk screws shown, for example, at **23** in FIG. **5**. Peripheral spaces **24** are provided between the adjacent shoes **16** in each clamp set **14**, **15** to permit their radial movement in operation. By the use of removable shoes, shoes with different radial thicknesses may be selectively used to adapt the clamp for use with pipe sections of different diameters. Shoes **16** may also be provided with different types of facings such as hard rubber, low friction plastics etc. Also, according to the invention, the shoes **16** may have different peripheral configurations to adapt them for use with thick wall or thin wall pipes. For thick wall pipes, as shown in FIG. **7**, shoes **16** are formed with forward portion **17** of greater radial thickness than the rearward portion **18** so that when the shoes are moved into engagement with pipe sections P_1, P_2, the forward portions **17** contact the pipe surface first. For use with thin wall pipe sections, as shown in FIG. **8**, shoes **16** preferably are formed with slightly curved rearward portion **19** which has a radial diameter slightly greater than that of the forward portion **19'**: this enables imposition of the main clamping pressure at a point back from the pipe end thereby ensuring that the pipe can be firmly clamped without over-stressing it at its outer end.

Each of clamping shoe mounting blocks **20** is formed with a tandem clevis **30** on its radially inwardly disposed side. The clevises **30** are pivotally connected by means of transverse pins **31** with the radially outer ends of tandem link pairs **32**. Blocks **20** are also pivotally connected to generally axially and outwardly directed link arms **34**, the other ends of which are pivotally connected as indicated at **38** to the radially outer end of fixed radial brackets **40** in the case of shoe set **14** and as indicated at **39** to the outer end of fixed radial bracket **41** in the case of shoe set **15**. Brackets **40**, **41** are secured to the actuator housings of the clamp. In operation, the link arms **34** permit radial movement of shoe sets **14**, **15** but limit axial movement thereof with respect to brackets **40** and **41**, respectively. It should be noted, however, that shoe sets **14** and **15** are coaxial but mounted independently of each other so that in operation, although they are maintained in axial alignment, they can be moved axially with respect to each other as is explained later.

The radially inner ends of the link pairs **32** of each shoe set are pivotally connected by mounting blocks **42** to axially movable piston rod element, indicated generally **45** for set **14** and at **46** for set **15**, so that the link pairs **32** convert axial movement of the piston rod elements **45, 46** into radial movement of the clamping shoe sets **14** and **15** respectively.

Each link pair **32** is comprised of first link members **43** and second link members **44** pivotally mounted between shoe support blocks **20** and piston rod mounting blocks **42** in a tandem arrangement. Link pairs **32** are constructed with a limited arc pivot joint at their mid-points which permits them to be selectively positioned in an "extended" or operative position as shown in FIG. **3** or in a "retracted" or non-operative position as shown in FIG. **4**. This retractility of the link pairs **32** ensures ample clearance between the clamping shoe sets **14, 15** when the clamp is traversing a pipe section, particularly a curved pipe section, after a weld is completed and the clamp is being moved to a new joint. The structural details of each link pairs **32** can be seen by reference to FIG. **6**. FIG. **6** shows the construction of one link pair **32** associated with shoe set **15**, but it will be appreciated that each of the link pairs **32** (eight for each clamp shoe set in the embodiment illustrated) have an identical construction and that the link pairs associated with shoe set **14** are merely reversed with respect to their axial disposition. Link pairs **32** include tandem links **43, 44** each of which is formed of two half-links **50, 50'** and **51, 51'**. The inwardly disposed ends of the half-links **50, 50'** and **51, 51'** are formed with arcuate saddle portions as indicated at **49, 49'** adapted to seat on central pins **54**. Pins **54** are provided with two holes as shown at **55** through their diameters adapted to receive bolts such as **56** in counterbored relationship. Threaded holes **57** corresponding to holes **55** are provided in half link portions **50', 51'** to receive bolts **56**. The arcuate saddle elements **49, 49'** each is comprised of segments of less than 180° so that there is an open segment, as indicated at **60** in FIGS. **3** and **4**, in the pivot joint between each half link which permits limited pivotal movement of the half links from the extended of "in line" position as shown in FIG. **4**. Half-links **50, 51** are secured together for limited pivotal movement by means of spacer rings **62** which circumscribe pins **54** and are attached to half links **50, 51** by means of screws such as shown at **63** threaded into holes **64**. Links **44, 43** are connected at their central pivot joints by means of link element **65** which, in turn, is secured to pins **54** by means of retainer ring **66** and co-operating grooves **67** formed in pins **54**. It can be noted that central pivot joints are arranged such that the link pairs **32** associated with each shoe set can pivot from the extended position to the retracted position only to the left in the case of link pairs associated with clamp shoe set **14** and, in the case of link pairs associated with shoe set **15**, as shown in FIGS. **3** and **4** only to the right.

In their normal pipe traversing disposition, link pairs **32** are in a retracted condition as shown in FIG. **4** to provide maximum clearance between clamping shoe sets **14, 15** and the inner circumference of the pipe section through which the clamp **10** is moved preparatory to positioning between pipe joints P_1, P_2 for clamping the pipe ends for welding. Means are provided, therefore, for effecting movement of the link pairs **32** from their retracted position to their extended position. This means includes lever arms **70** fixed at a slight angular disposition to the radially inward ends of links **44**. The other ends of levers **70** are provided with saddle elements **72** which are pivotally connected by means of pins **74, 75** to annular axially movable spider members **76** (see FIG. **5**) and **77** which, in turn, are fixed to annular piston rod elements **78, 79** which are adapted for axial reciprocatory movement along cylindrical central rod **80**.

Piston rod elements **78, 79** are fixed to annular pistons **81, 82** respectively which are positioned for axial reciprocal movement within annular cylinders **83, 84**. Suitable piston rod sealing rings **85** and piston sealing rings **86**, are provided to ensure a pressure tight seal between the relatively movable elements. Compression springs **90, 91** between the piston and cylinder end walls bias pistons **81, 82** to the right and left respectively thereby providing a spring assist for the movement of pistons **81, 82** and associated pivot links to the "straight" or extended position, as shown in FIG. **3**. Pressurization of cylinders **83, 84** through conduits **92, 93** respectively will move pistons **81, 82** towards the right and left respectively with accompanying extension of link pairs **32**, as shown in FIG. **3**, with assist springs **90, 91** ensuring that this action will take place with relatively low pressure.

As noted above, axial movement of annular piston rod elements **45** and **46** effects radial movement of shoe sets **14, 15** respectively through the medium of the link pairs **32**. According to the invention, axial movement of piston rod elements **45, 46** is effected by means of a dual actuator arrangement associated with each shoe set **14** and **15**. This permits imposition of staged and large clamping pressures on the inner circumference of the pipe sections P_1, P_2. For the purposes of this description, the four clamp shoe actuators are referred to herein from time to time as actuators A, B, C and D. Actuators A and B are operatively associated with shoe set **14** and actuators C and D with shoe set **15**. Referring particularly to FIGS. **3** and **4**, actuator A is indicated generally by numeral **100**, actuator B by numeral **102**, actuator C by numeral **104** and actuator D by numeral **106**.

The structure and operation of actuators **104** and **106** (C and D) will be described first. Actuator D includes an annular cylinder **110** defined by housing comprising a first casing member **111** and a second casing member **112** secured together, such as by bolts (not shown) through inset peripheral flanges indicated at **113, 114**. Positioned for axial movement within cylinder **110** is an annular piston member **115** in the form of a radially disposed plate peripherally secured in a pressure-tight manner by resilient diaphragm **116** clamped between flanges **113** and **114**. The radially inner end of piston **115** is integral with sleeve member **117** which is axially movable with respect to casing members **111** and **112** and which functions as a piston rod for piston **115**. Suitable pressure-tight seals **118** are provided between sleeve member **117** and casing members **111** and **112** to prevent air loss when cylinder **110** is pressurized.

Actuator **104** (C) includes annular casing member **120** which is integral with casing member **112** and has

an inset peripheral flange **121**. A second piston **122** in the form of a radially extending annular plate is peripherally secured in a pressure-tight relationship to flange **121** by means of a resilient diaphragm **123** clamped to the flange **121** with ring flange **124**. The inner radial end of piston **122** is integral with sleeve **117** and also is fixed to piston rod element **46**. An air-tight annular chamber **125** is defined between wall casing means **120** and piston **122**.

In operation, the introduction of air under pressure into cylinder **110** on the right side of piston **115** will cause piston **115** to move axially to the left as viewed in FIGS. **3** and **4** and this movement will be transmitted by sleeve **117** and piston rod element **46** to link pairs **32** to cause, in turn, the clamping shoe set **15** to move into engagement with the inner circumference of pipe section P_1. Also, application of pneumatic pressure to chamber **125** will cause piston **122** to move axially to the left. This serves to increase the force exerted on line pairs **32** and shoe set **15** by virtue of the increasing of the piston area acted on by air pressure. The force resulting from the pneumatic pressure on piston **122** is transmitted through sleeve **117** and piston rod element **46**, which are common to both piston **122** and piston **115**.

The structure and function of actuators **100** and **102** (A and B) and the mechanism for transmitting the axial movement of these actuators to clamp shoe set **14** for clamping pipe section P_2 is essentially the same as that just described for actuators **104**, **106** (C and D) of clamp shoe set **15**. The mechanisms are, of course, reversed with respect to their axial dispositions. In addition, it should be noted that for purposes which are explained later, the housing of actuators **100** and **102** is fixed to central rod **80** by means of end cover plate **134** which is secured to the end of rod **80** and to portion **131'** of actuator casing member **111'**, whereas the housing of actuator **104** and **106** is not fixed to rod **80**.

The set-in pipe positioning and back-spacing mechanisms of clamp **10** will now be described. In general, according to the invention, this mechanism is provided for the purpose of first clamping and drawing the set-in pipe section P_2 into precise end-to-end abutting relationship with the previously welded pipe section P_1 and then back-spacing the set-in pipe P_2 a predetermined distance while retaining the two sets of clamping shoes **14**, **15** and the ends of pipes P_1 and P_2 in precise axial alignment. Referring particularly to FIGS. **9**, **10**, **11** and **12**, means are provided for retaining the clamp shoe sets **14**, **15** in axial alignment which include a plurality of axially extending rods **150**, **151** arranged around and interconnecting the peripheral flanges **121**, **124** of actuator **104** with peripheral flanges **121'**, **124'** of actuator **102**. As shown in FIG. **10**, rods **150** are of cylindrical configuration and have one end fixed in perpendicular relationship to the flange **124'** of actuator **102** by means of welding, as shown at **160**, and bolted bracket **161**. The other end of rod **150** has a reduced cylindrical portion **162** which is slidably fitted in a cylindrical bearing member **163** which is secured to the peripheral flange of actuator **104** by a suitable means such as bolts **164**.

As shown in detail in FIG. **11**, rods **151** also have one end fixed to peripheral flange **124'** of actuator **102** by means of welding at **170** and bolted bracket **171**. However, the other end of rods **151** passes through the peripheral flanges **121**, **124** of actuator **104** and projects on through the peripheral flanges **114**, **113** of actuator **106** as well. Rod **151** has a first reduced-size portion **172** which is slidably received in a bearing member **173** fixed to peripheral flange **124** by means of bracket **174** and bolts **175**.

A stop block **200** is rotatably mounted on a second reduced portion of each shaft **151** between flanges **121** and **114**. Stop block **200**, together with other elements described later, functions to effect accurate back-spacing of the clamped set-in pipe P_1 a predetermined distance from the clamped welded pipe P_2 after the pipe ends have been brought into precise alignment and abutting relationship. The stop block **200** includes a body portion **201** and a pair of axially extending studs **202**, **203** threaded therethrough. Block **200** is held in an axially fixed position on rod **151** by means of a shoulder **210** on shaft **151**, spacer **211**, a pair of thrust washers **212** and **212'** and a lock nut **213**, threaded on the rod and abutting a second shoulder **214**. A suitable low friction bushing **177** is provided in the peripheral flanges **114**, **113** of actuator **106** to slidably receive the outer end portion **176** of rod **151**.

Rigidly secured to each block **200** is a pivot arm **220** which is pivotally connected by pin **221** to piston rod **222** of a pneumatic actuator **223** (actuator F). Actuators **223** are pivotally secured to anchor blocks **224** fixed to casing member wall **120** of actuator **104**. Two blocks **224** serve to anchor the ends of the four actuators **223** as shown in FIG. **9**.

Actuators **223** function to selectively rotate blocks **200** from the position shown in FIG. **11** with studs **202**, **203** in axial alignment with bolt heads **225**, **226** to the position shown in FIG. **12** in which the studs **202**, **203** are not aligned with bolt heads **225**, **226**. As is described later, rotation of blocks **200** from the latter, non-aligned position to the aligned position enables back-spacing of the set-in pipe P_2 a predetermined distance from the end of welded pipe section P_1 to provide a precise, controlled-dimension gap between the adjacent pipe ends which facilitate welding.

From the foregoing description, it can be seen that the sets of shoes **14**, **15** and associated actuators A, B and C, D, respectively, are retained in axial alignment by rods **151** and **150** but are adapted for axial displacement with respect to each other without loss of axial alignment. Axial displacement of the clamp shoe sets and associated actuators with respect to each other is effected by means of actuator mechanism **250** (actuator E). As shown in FIGS. **3** & **4**, actuator **250** consists of an annular cylinder **251** defined by an annular inner end wall **252** which is integral with casing wall **111** of actuator **106** and an outer wall **253** which is secured by means of flange **254** to flange **255** of inner wall **252**. A piston member **256** which is in the form of an annular, radially extending plate, is positioned in cylinder **252** for axial movement. Piston **256** is peripherally secured in a pressure-tight manner by resilient diaphragm **258** which is also clamped between casing flanges **254**,**255**. The radially inner end of piston **256** is fixed to central rod **80** such that the rod **80** functions as a piston rod for piston **256**. Selective introduction of pneumatic pressure to cylinder **251** will axially displace central member **80** either to the left or right in FIG. **4**. Since

member 80 is fixed to casing end cover 134 which is fixed to the casing of actuators 100 and 102, axial movement of member 80 will axially displace clamp shoe set 14 and its associated actuators 100 and 102 with respect to clamp shoe set 15 and its associated actuators 104 and 106.

Referring again to FIG. 11, it can be seen that axial movement of rods 151 to the left in FIG. 12 will be limited by the engagement of studs 202, 203 with bolt heads 225, 226. Thus, the amount of back-displacement of clamp shoe set 14 with respect to clamp shoe set 15 and the amount of back-spacing of set-in pipe section P_2 from pipe section P_1 can be selectively varied by adjustment of studs 202, 203 in stop blocks 200.

The clamp 10 of the invention includes means for conveying the unit through pipe sections and for automatically positioning the clamp at the forward end of the welded pipe line for receiving and clamping a new pipe section. As can be seen in FIGS. 1 and 2, a plurality of rollers 300 are mounted on the housings of actuators 100 and 106 by means of mounting clevises 301 and brackets 302. Mounted on the casing of rear actuator 106 by means of radial bracket 305 is a drive wheel 310 having a rubber tread traction surface and being adapted to engage the interior of the pipe wall beneath the clamp unit in the central region of the pipe section.

Drive wheel 310 is operatively connected with a conventional, instantly reversible air driven motor 311. The motor control mechanism 320 is shown in FIG. 13 and comprises an axially aligned cam 321 mounted on a rod 322 mounted for slidable radial movement in a fixed sleeve 323. A helical compression spring 324 is disposed in sleeve 323 around the upper end 325 of rod 322 such as to normally urge the rod and its cam 321 radially outwardly. A fixed stop 326 and a co-operating keyway 327 in the upper section of rod 322 serve to restrict the extent of radial movement of rod 322.

The cam 321 is provided with a rearwardly directed and radially extending cam face 328 which is provided for end abutment with the end surface of the welded pipe line section P_1 and with a forwardly directed oblique cam surface 329 for engagement with the leading edge of the set-in pipeline section P_2 so that, during the positioning of pipe section P_2 about the clamp shoe set 14, the cam 321 will be urged radially inwardly. The purpose of the notch 330 adjacent cam surface 328 will become apparent when the description of the operation of the line-up clamp is given.

Diametrically opposite the keyway 327, the rod 322 is provided with a cam surface 331 which co-operates with a spring return cam actuated pilot valve 332 for the purpose which will become apparent as the description proceeds.

The sleeve 323 is mounted on a shaft 333 which has opposed reduced-size cylindrical portions 334, 334' slidably fitted for limited axial movement in bushed housings 335 and 335'. Housings 335 and 335' are fixed to the peripheral flanges 124' and 124 of actuators 102 and 104, respectively. A helical compression spring 336 is disposed within housing 335 between the end of shaft portion 334 and the face of flange 124' so that shaft 333 is constantly biased to the right as viewed in FIG. 13. A stud 337 is axially threaded into shaft end portion 334 and projects through an opening in flanges 124', 121' with sufficient clearance to permit free axial movement. Lock nut 338 is provided to adjust and limit axial movement to the right of stud and attached shaft 333. A stud 340 is axially threaded into reduced portion 334' of shaft 333 and projects through an opening in flanges 124 and 121 of actuator 104 with sufficient clearance to permit free axial movement thereof. Stud 340 terminates in a cam member 341 which is operatively associated with spring return, cam operated pilot valve 343 mounted on a bracket 344 secured between the casing walls of actuators 104 and 106. Axial movement of stud 340 is limited by lock nuts 342.

As shown particularly in FIGS. 1, 2, 14 and 15, the clamp handle and control mechanisms comprise a protective frame consisting of tubular frame members 350 fixed to circular frame member 351 which, in turn, is attached by brackets (not shown) to the peripheral flange 113' of actuator 100. Frame elements 350 extend radially forwardly and inwardly and are fixed to a central flange 352 positioned coaxially with central rod 80 of the clamp. Mounted in flange 352 is a bearing member 353 which rotatably supports a stub shaft 354. The inner end of stub shaft 354 projects through bearing 353 and has a crank element 355 mounted thereon in operative relationship with spring return, cam operated pilot valves 416, 441, 451, 454, 475 and 477 which are mounted on a control valve support assembly 357 and which control the flow of pneumatic pressure to the various clamp actuators as will be explained later. As shown particularly in FIGS. 2 and 15, assembly 357 includes annular mounting ring 380 fixed co-axially with respect to shaft 354 by means of axially extending support rods 381 secured to cover plate 134. A bracing element 382 is fixed to rods 381 about midway between ring 380 and plate 134. A connecting rod 356 of a length at least equal to the length of the longest pipe section to be welded is removably connected to stub shaft 354 by means of a first coupler 358. Rod 356 is connected by a second coupler 359 to an outer stub shaft 360 which is journalled for rotation within frame 361.

A control handle 363 is fixed to shaft 360 to permit shaft 360 and the connecting rod 356 to be selectively rotated thereby turning stub shaft 354 and associated crank means 355 to actuate the cam operated pilot valves 416, 441 451, 454, 475 and 477. A pointer 364 is also attached to stub shaft 360 to visually indicate, in conjunction with dial 362, the clamp function which is effected at each position of the control handle. A frame 370 and protective end cover 371 are provided to prevent damage to or accidental actuation of the control mechanisms. The circumferentially spaced support rollers 372 are secured around frame 361 to center the control head in pipe section P_2.

Referring now to FIGS. 20, 21 and 22, the pneumatic control circuit for clamp 10 includes a two-compartment compressed air supply tank 400 which, as shown in FIGS. 1 and 2 for example, is secured by mounting brackets 401 to the casing wall of actuator 250. A high pressure compartment 402 of tank 400 is connected via conduit 403 through air applied, spring return four-way valve 404 (FIG. 22) and conduit 398 to reverse drive inlet port 397 of drive motor 311.

The low pressure compartment 405 of tank 400 is provided with a safety valve 406 and is connected via conduit 407 through non-return valve 408 with conduit

403. Valve 408 permits flow of air from tank compartment 405 to compartment 402 when the pressure in the latter compartment drops below that of 405.

Low pressure compartment 405 is also connected via conduits 409 and main pressure supply line 410 with the forward drive inlet port 412 of drive motor 311 through the circuit shown in FIG. 22. This circuit includes single air operated spring return three-way valve 413 connected by conduit 414 to spring return pilot valve 343 (see also FIG. 13) which, in turn, is connected with the main low pressure air supply line 410. The outlet side of valve 413 is connected through manually operated spring return, pilot valve 416, conduit 417, valve 404 and conduit 418 with the drive motor forward drive inlet port 412. Automatic control pilot valve 332 (see also FIG. 13) is connected via conduit 419 to conduit 417 and via conduit 420 to valve 404 so that actuation of pilot valve 332 actuates valve 404 to shut off the air to conduit 418 and to admit high pressure air through conduit 398 and port 397 to instantly reverse the motor 311.

The pneumatic control circuit for actuators A, B, C, D, E, and F includes main air supply conduit 440 connecting low pressure tank compartment 405 with the actuator cylinders through the circuit shown in FIG. 21. Referring first to actuator B, main air supply line 440 is connected through manually operated pilot valve 441, conduit 442, double air operated four-way valve 443 and conduit 444 with cylinder 135' of actuator B. Valve 443 is also connected via conduit 445 with conduit 450. Conduit 450 is connected to air supply line 440 through cam operated pilot valve 451 and is connected with the right side of cylinder 110' of actuator A through air supply spring return four-way valve 452 and conduit 453. Valve 452 is also connected to cam operated pilot valve 454 through conduit 456. Valve 452 is connected by conduit 455 to the left side of cylinder 110' of actuator A. Valve 443 is also connected through conduit 457 with the right side of cylinder 83 (see also FIG. 3) of actuator G'. The left side of cylinder 83 is connected via conduit 92 with cylinder 125'.

Cylinder 125 of actuator C is connected via conduit 460 with single air operated spring return four-way valve 461 and to manually operated air return three-way valve 462. Valve 462 is also connected to conduit 450 via conduit 463. Valve 461 is connected through conduit 364 with the right side and through conduit 365 with the left side of cylinder 110 of actuator D. Conduit 365 also is connected through conduit 366 with the left side of cylinder 84 of actuator G. The right side of cylinder 84 is connected via conduit 93 with cylinder 125.

Conduite 470 and 471 connect the right and left sides respectively of cylinder 251 of actuator E with double air operated four-way valve 472. Valve 472 is connected through conduit 474 with manual cam operated pilot valve 475 and is also connected via conduit 476 to manual cam operated valve 477 which, in turn, is connected with air supply line 440. Switch 477 is connected to the extend and retract sides of actuator F via conduits 483 and 484 respectively. Finally, valve 480 is also connected to air supply line 440 through conduit 450 and switch 451.

For purposes of explaining the operation of the clamp, it will be assumed that welding of two adjacent pipes has been completed, the clamping pressure has been released and the clamp 10 is ready to be moved to the forward end of the pipe line for clamping a new set-in pipe joint P_2 for welding to the previously welded pipe section P_1. At this point, the pipe clamping shoe sets 14 and 15 will be in a fully retracted position as shown structurally in FIG. 4 and schematically in FIG. 16. The clamp backstop mechanism 320 will be in the retracted position with the cam member 321 abutting the inner surface of the pipe section P_1 also as schematically illustrated in FIG. 16. To initiate operation of the pipe clamp from this point, motor 311 is actuated by turning control handle 363 to actuate pilot valve 416 admitting air through valve 404 to the forward drive inlet 412 of motor 311 thereby driving the clamp forward. When the clamp 10 reaches the front end of pipe section P_1, cam 321 and rod 323 move radially outwardly under the action of spring 324 to the position shown schematically in FIG. 17. This movement actuates pilot valve 332 which admits air through conduit 420 to valve 404 closing conduit 418 and opening conduit 398 to admit high pressure air to motor 311 through reverse drive inlet port 397. The reverse drive of motor 311 continues until surface 328 of cam 321 is forced into engagement with the end of pipe section P_1 as shown in FIG. 18. This causes shaft 333 carrying cam member 341 to be pushed to the left against the bias of spring 336 (FIG. 13). This, in turn, causes actuation of pilot valve 343, also as shown in FIG. 18, which admits air to valve 413 to shut off the high pressure, reverse drive air supply and stop the motor 311.

Valve 462 is then opened, either manually or by pilot valve means which is automatically actuated when the reverse drive air supply is cut off. This admits air to cylinder 125 of actuator C and to the right side of cylinder 110 of actuator D. Pressurization of cylinder 125 also admits air pressure to cylinder 84 via conduit 93 (see FIG. 3). This causes piston 82 of actuator G to move to the left, as viewed in FIGS. 3 and 4, straightening link pairs 32 to their extended or operative positions, as shown in FIG. 3. This straightening action occurs before sufficient pressure is built up in cylinder 125 to cause axial movement of piston 122 because the assistance provided by spring 91 and also because much less pressure is required to actuate piston 82 in cylinder 84 than is required to move piston 122 of actuator C. After links 32 are extended, pressure buildup in actuators C and D continues and causes pistons 115 and 112 to move to the left forcing clamp shoe set 15 into engagement with pipe section P_1.

The set-in pipe section P_2 is then introduced over projecting clamp shoe set 14 as shown in FIG. 18, and actuator B is activated by pilot valve 441 which opens valve 443 to admit air through conduit 444 to cylinder 125'. This results first in the straightening of link pairs 32 by actuation of piston 81 of actuator G' in a similar manner to that just described for link pairs 32 and piston 82 and, second, in the engagement of clamp shoe set 14 against pipe P_2 as shown in FIG. 18. At this point, actuator A has not yet been pressurized and pipes P_1 and P_2 are not necessarily in alignment. Actuator E is next pressurized by actuation of pilot valve 475 which opens valve 472 to admit air through conduit

471 to the left side of cylinder 251. This causes piston 256 to move to the right pulling clamp shoe set 14 and clamp set-in pipe section P_2 into end abutting relationship with pipe section P_1. Pilot valve 454 is then activated to open valve 452 to pressurize the left side of piston 115' of actuator A thereby forcing piston 115' to the right, increasing the pressure of clamp shoe set 14 to round out the end of pipe P_2 and ensure true axial alignment with the end of pipe P_1.

Next, actuator F is pressurized by an activation of pilot valve 477 which opens valve 480 to cause piston rod 222 to extend. This results in rotation of stop blocks 200 such that studs 202, 203 are in axial alignment with bolt heads 225, 226 as shown in FIG. 11. Actuation of pilot valve 477 simultaneously opens valve 472 to effect pressurization of the right side of cylinder 251 of actuator E thereby causing piston 256 to move to the left until studs 202, 203 come into engagement with bolt heads 225, 226 as shown in FIG. 11. By selective adjustment of studs 202, 203, pipe section P_2 will be spaced back from pipe section P_1 as shown in FIG. 19, a distance which provides an optimum gap for welding having regard to the pipe diameters, type of welding system employed, etc. Also, as shown in FIG. 19 and FIG. 2, with the clamp 10 in this position cam 321 is disposed with notch 330 adjacent the gap between the pipes P_1 and P_2 so that cam 321 will not interfere with the welding operation.

The welding operation is then carried out. At completion of the welding operation, pilot valve 451 is activated and actuators A, D, G' and G are pressurized so as to cause pistons 115, 82 and 115', 81 to move to the left and right respectively thereby retracting the clamp shoe sets 14 and 15. At the same time, cylinders 125' and 125 are vented to the atmosphere and piston rod 222 of actuator F is retracted to rotate the stop blocks 200 to the non-aligned position shown in FIG. 12. Also, cylinder 251 is pressurized via conduit 470 to fully extend piston 256 to the left.

The line-up clamp of the invention has numerous important advantages over the clamps heretofore known and used in the pipeline construction industry. Foremost of these advantages is the adaptability of the clamp for use with automatic pipe welding systems. In order to function effectively, automatic welding requires extremely accurate alignment of the adjacent pipe ends as well as a uniform gap between the opposed surfaces which are to be joined. Heretofore, in order to obtain the necessary uniformity of alignment and spacing, it has been necessary to first clamp the pipes then cut or grind the ends to provide the desired gap. This expensive and time-consuming procedure can be eliminated through use of the clamp of the present invention.

What we claim as new and desire to protect by Letters Patent of the United States is:

1. A line-up clamp for aligning a pair of pipeline sections by engagement with their inner surfaces which comprises: a first set of radially movable pipe engaging shoes adapted to engage the inner circumference of the first of said pair of pipeline sections, a second set of radially movable pipe engaging shoes adapted to engage the inner circumference of the second of said pair of pipeline sections, a first housing substantially coaxial with said first set of pipe engaging shoes and a second housing substantially coaxial with said second set of pipe engaging shoes, means interconnecting said first and second housings and maintaining said housings in axial alignment while enabling limited axial movement of said housings with respect to each other; actuator means for effecting reciprocal axial movement of said first and second housings with respect to each other; first and second pairs of fluid driven actuators mounted for reciprocatory movement in said first and second housings, first and second drive members operatively associated with said first and second actuator pairs respectively and adapted for reciprocal axial movement independently of each other, a first set of link members operably interconnecting said first drive means with said first set of clamping shoes such that axial movement of said drive means is converted to radial movement for actuation of said first set of pipe clamping shoes, a second set of link members operably interconnecting said second drive means with said second clamping shoe sets such that axial movement of said drive means is converted to radial movement for actuation of said second set of pipe clamping shoes.

2. An internal line-up clamp as claimed in claim 1 in which said interconnecting means includes a fifth actuator means adapted to effect selective axial displacement of said first housing and associated set of pipe engaging shoes with respect to said second housing and associated set of pipe engaging shoes whereby said pipeline sections may be moved into and away from end abutment with each other.

3. A clamp as claimed in claim 1 in which said links are arranged and constructed for radial retraction and extension to non-operative and operative positions respectively.

4. A clamp as claimed in claim 1 which additionally comprises drive means for driving said clamp axially forward through said pipeline section, control means for controlling the operation of said drive means, backstop means comprising a radially movable cam member adapted to normally abut said inner surface of said pipeline section, means urging said cam member radially outwardly, means sensitive to radial outward movement of said cam member radially outwardly beyond said inner surface of said pipe section and adapted on such movement of said cam member to reverse said drive means to drive said clamp rearwardly a predetermined distance.

5. An internal line-up clamp as claimed in claim 3 in which said links have pivotally connected inner and outer sections, and means being provided to maintain each of said inner sections in radially alignment with their respective outer section and to permit said inner and outer sections to pivot with respect to each other whereby said pipe engaging members may be retracted substantially radially inwardly.

6. An internal line-up clamp as claimed in claim 5 including pneumatic actuator means operatively connected with said links and adapted to selectively pivot said links into radial alignment.

7. An internal line-up clamp for aligning a pair of pipeline sections by engagement with their inner surfaces which comprises an elongated axial cylindrical member, a first set of radially movable pipe engaging members adapted to engage the inner circumference of the first of said pair of pipeline sections, a second set of

radially movable pipe engaging members adapted to engage the inner circumference of the second of said pair of pipeline sections, a first sleeve circumscribing and axially slidable along said axial cylindrical member, first actuator housing means circumscribing said axial cylindrical member in a fixed position with respect thereto, first and second actuator means in said first housing means and connected with said first sleeve for effecting reciprocal axial movement of said first sleeve along said axial cylindrical member, a first set of generally radial linkages interconnecting said first sleeve and said first set of radially movable pipe engaging members such that axial movement of said first sleeve effects radial movement of said first set of pipe engaging members, a second sleeve circumscribing and axially slidable along said axial cylindrical member, second actuator housing means circumscribing said axial cylindrical member and axially movable with respect thereto, third and fourth actuator means in said second housing means and connected with said second sleeve for effecting reciprocal movement of said second sleeve along said axial cylindrical member, a second set of generally radial linkages interconnecting said second sleeve and said second set of radially movable pipe engaging members such that axial movement of said second sleeve effects radial movement of said second set of pipe engaging members, a plurality of circumferentially spaced axially extending rod elements interconnecting said first and second actuator housings and maintaining them in axial alignment while permitting limited axial movement of said housings with respect to each other, and fifth actuator means connected with said axial cylindrical member and adapted to effect reciprocal axial movement of said cylindrical member with respect to said second actuator housing means.

8. The clamp as claimed in claim **7** including adjustable stop-block means associated with said axially extending rod elements and adapted for limiting axial movement of said rod elements such that the first housing and associated first set of clamp engaging members may be backspaced a predetermined distance from the second housing and associated second set of pipe engaging members by extension of said fifth actuator.

9. An internal line-up clamp as claimed in claim **7** in which said first, second, third, fourth and fifth actuator means are independently operable whereby actuation of said first and second actuator means effects secure engagement of said first set of pipe engaging members with said first of said pair of pipe sections, whereby actuation of said third actuator means causes limited frictional engagement of said second set of pipe engaging members with said second of said pair of pipe sections, whereby subsequent actuation of said fifth actuator causes relative axial movement of said first and said second sets of said pipe engaging members until said pair of pipe sections are in at least partial joint end abutment, whereby subsequent relative axial movement of said first and said second sets of pipe engaging members continues until said pair of pipe sections are in substantially peripherally complete end abutment with any necessary sliding movement of said second of said pair of pipe sections with respect to said second set of pipe engaging members and whereby actuation of said fourth actuator means in a final clamping operation effects secure engagement of said second set of pipe engaging members with said second of said pair of pipe sections whereby said second and said first pipe sections are securely held in end-abutting relationship.

10. The internal line-up clamp as claimed in claim **9** in which means are provided whereby actuation of said fifth actuator effects axial separation of said securely held end-abutting section to provide a uniform gap of predetermined width between said pipe sections.

11. An internal line-up clamp as claimed in claim **7** including drive means for driving said clamp axially forwardly through said pipe section, control means for controlling the operation of said drive means and for controlling the operation of said radially movable pipe engaging members, end-sensing means comprising a radially movable member adapted to normally abut the inner surface of said pipeline section, means urging said end-sensing means radially outwardly, means sensitive to radially outward movement of said end-sensing means radially outwardly beyond said inner surface of said pipeline section and adapted, on such movement of said end-sensing means, to actuate said drive means to prevent further forward movement of said clamp axially through said pipeline section.

12. An internal line-up clamp as claimed in claim **11** in which said means sensitive to said radial outward movement of said end-sensing means beyond said inner surface of said pipe section is also adapted, on such movement of said end-sensing means, to actuate said first and second actuators for clampingly engaging said first set of pipe engaging members with said first pipe section.

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