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(71) Applicant : **MCDERMOTT INTERNATIONAL,
INC.
1010 Common Street PO Box 60035
New Orleans Louisiana 70160 (US)**

(72) Inventor : **Illakowicz, Jan
444 Easy Drive
Thibodaux, Louisiana 70301 (US)**

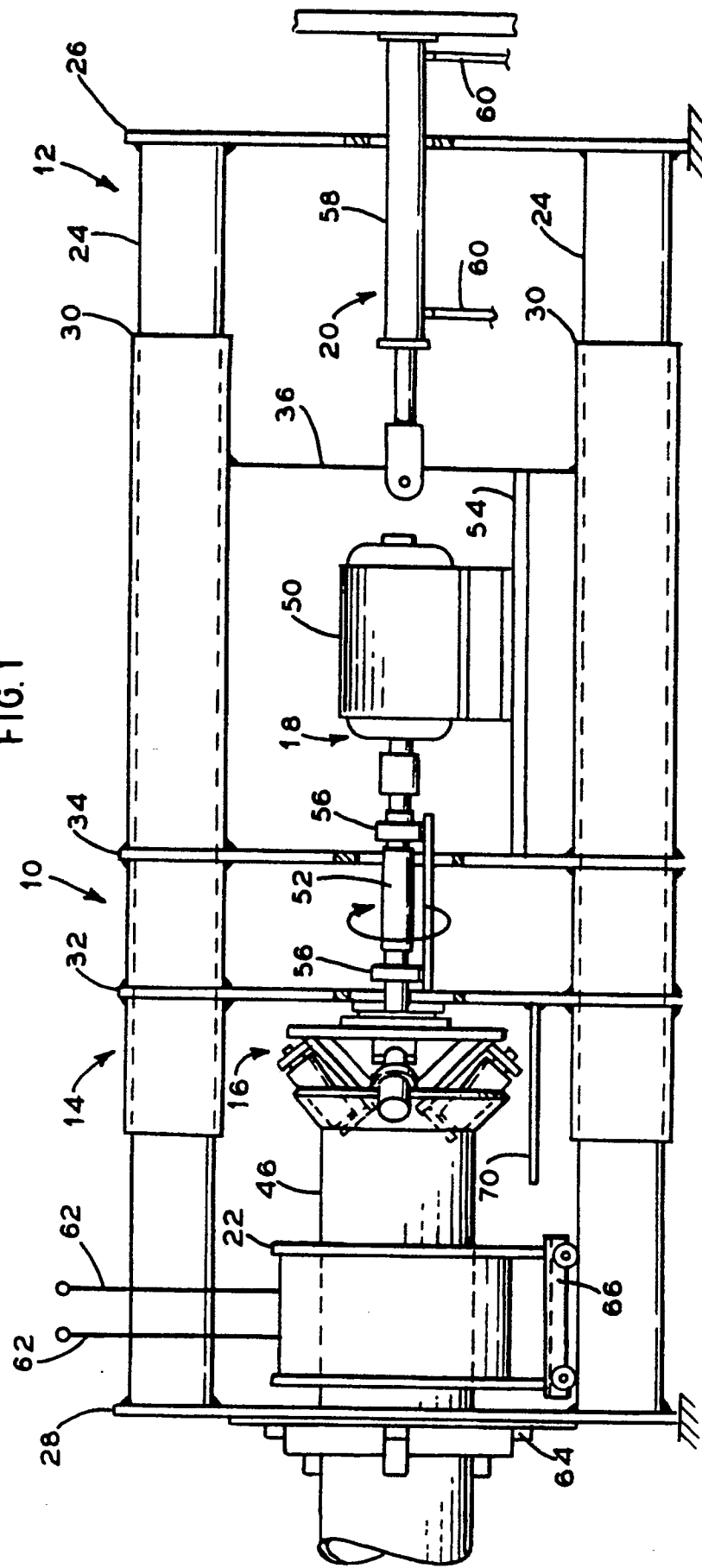
(74) Representative : **Purvis, William Michael
Cameron et al
D. Young & Co. 10 Staple Inn
London WC1V 7RD (GB)**

(54) **Conductor guide forming machine.**

(57) A conductor guide forming machine to flare the end of a pipe (46) outwardly to form a conductor guide has a heating device (22) movably mounted on a base (12) to cause induction heating of the end of the pipe (46) to be flared outwardly. A tool carriage (14) having a forming tool (16) rotatably mounted thereon is moved by a hydraulic cylinder (58) mounted on the base (12) and attached to the tool carriage (14) to insert angled rollers of the forming tool (16) into and against the end of the pipe (46) to be flared. A drive motor (50) mounted on the tool carriage (14) rotates the forming tool (16) simultaneously with movement of the rollers into the pipe (46) to flare the end thereof.

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FIG. 1



The invention relates to a machine for forming conductor guides.

Conductor guides are used in offshore Jackets in the drilling industry.

In the offshore drilling industry a structure commonly referred to as a Jacket is used to support a platform on which drilling equipment, associated equipment and living and working quarters are placed. The jacket is usually formed by at least four legs connected together by a framework of horizontal and diagonal support members such that the base of the structure that rests on the sea bottom is wider than the top of the structure that extends above the normal water level. A jacket and platform may accommodate equipment for drilling one or more wells. When drilling, the drill string for a well extends through the structure between the legs and into the sea bed. When lowering the drill bit to begin drilling and during drilling operations it is necessary to guide and support the drill bit and drill string against wave action and currents normally encountered in open water. This is accomplished by the use of conductors extending vertically along the length of the structure. Conductor guides are used to guide the conductors into place in the jacket. The conductor guides are formed from hollow tubular steel having an inner diameter larger than the outer diameter of the conductor guide. The upper portion of the conductor guide is preferably formed in a cone shape with its upper edge having a larger inner diameter than the lower tubular portion of the conductor guide. This flared shape that extends upward and outward allows for a greater margin of error when lowering the conductor. Depending on water depth and the number of wells, one hundred or more conductor guides may be required on a structure.

Conductor guides have normally been manufactured in two ways, by segment fabrication or pressing. Segment fabrication is accomplished by cutting three separate metal pieces out to size and then forming them into the proper cone shape one at a time by the use of a press. The three pieces are then welded to a conductor guides tubular portion to form a cone-shaped part of the guide. Pressing is performed by heating the tubular section in an oven and then moving it into a press where a tool and die are used to form the guide. During this operation, forces of two thousand to three thousand tons may be required. Both methods are time consuming, labour intensive, and require extra materials and tooling to form conductors in a variety of sizes. Segment fabrication commonly requires as much as twenty man-hours of work per conductor. The use of a press is limited to certain cone sizes due to wrinkling of the cone. A press must also be permanently installed and supported by a proper foundation since such equipment may weight as much as three hundred tons.

According to one aspect of the invention there is provided a conductor guide forming machine, com-

prising:

- a. a base;
- b. a tool carriage mounted on the base so as to be movable between a first retracted position and a second conductor guide forming position;
- c. a forming tool rotatably mounted on the tool carriage;
- d. drive means mounted on the tool carriage to rotate the forming tool;
- e. movement means mounted on the base and attached to the tool carriage to move the tool carriage between the first and second positions; and
- f. a heating device movably mounted on the base.

According to another aspect of the invention there is provided a conductor guide forming machine, comprising:

- a. a base formed from four horizontal support members attached at their ends to first and second plates to define a substantially rectangular frame;
- b. a tool carriage mounted on the base so as to be movable between a first retracted position and a second conductor guide forming position;
- c. a forming tool rotatably mounted on the tool carriage and comprising a substantially circular plate with conical guide forming rollers rotatably attached thereto;
- d. drive means mounted on the tool carriage to rotate the forming tool;
- e. movement means mounted on the base and attached to the tool carriage to move the tool carriage between the first and second positions; and
- f. a heating device movably mounted on the base.

Such a machine can advantageously accommodate a variety of cone angles and sizes, need not require permanent installation, and can reduce the time, labour and materials required in manufacturing conductor guides.

According to a further aspect of the invention there is provided a method of flaring the end of a pipe outwardly to form a conductor guide, comprising:

- a. heating a portion of the pipe to be flared; and
- b. inserting rollers rotatably mounted on a forming tool into and against the heated interior end of the pipe while simultaneously rotating the forming tool.

Thus, after the pipe is heated to the desired temperature the drive motors are actuated to cause rotation of the forming tool. A hydraulic cylinder attached to the base can be used to cause the tool carriage to move on the base toward the pipe. A pair of the rollers rotatably mounted on the forming tool can contact the inside of the pipe and cause the heated end of the pipe to flare outwardly as the tool carriage and forming tool continue moving in the direction of the pipe. A second set of rollers may be used to contact and compress the edge of the flared end to compensate for the minimal thinning of the pipe wall that occurs during form-

ing. After the formed pipe has been cooled, it is removed from the machine and another section of pipe is put into position for forming. The forming tool can be water cooled to prevent damage to the bearings and rollers during the forming process when it is in contact with the pipe.

The invention is diagrammatically illustrated by way of example in the accompanying drawings, in which:

Figure 1 is a side view of a conductor guide forming machine according to the invention;

Figure 2 is a detail view of a forming tool of the machine of Figure 1 before it has contacted a pipe end to be flared; and

Figure 3 is a detail view of the forming tool of Figure 2 after it has contacted and flared a pipe end.

Referring to the drawings, a conductor guide forming machine 10 generally comprises a base 12, a tool carriage 14, a forming tool 16, drive means 18 for the forming tool 16, movement means 20 for moving the tool carriage 14 along the base 12 and a heating device 22.

The base 12 is formed from four support members 24 of which two are shown in Figure 1. Each support member 24 is attached at its ends to first and second plates 26, 28 by any suitable means such as welding to form a substantially rectangular frame. As can be seen in Figure 1, the plates 26, 28 rest on their edges so that the support members 24 are horizontal. The support members 24 are tubular shaped in the preferred embodiment but may be of any other suitable shape such as in the form of I-beams.

The tool carriage 14 is formed from four hollow support legs 30 having an inner diameter larger than the outer diameter of the support members 24 of the base 12. This allows sliding movement of the tool carriage 14 on the base 12 between a first retracted position and a second conductor guide forming position. The first retracted position is illustrated in Figure 2 while the second conductor guide forming position is illustrated in Figures 1 and 3. For ease of movement, wheels may be attached to the support legs 30 so that the tool carriage 14 is rollably supported on the base 12. Vertical plates 32, 34, 36 are rigidly attached between the support legs 30 by any suitable means such as welding. The first and second vertical plates 32, 34 extend across the width of the tool carriage 14 and the third vertical plate 36 extends along the longitudinal axis thereof and is rigidly attached to the second plate 34 and the support legs 30.

The forming tool 16 is carried by the tool carriage 14 and is rotatably mounted on the first vertical plate 32. The forming tool 16 is formed from a substantially circular plate 38, conical guide forming rollers 40, and edge forming rollers 42. As can be seen in Figures 2 and 3, the rollers 40, 42 are rotatably mounted on a framework 44 that is rigidly attached to the circular plate 38. The framework 44 positions the guide form-

ing rollers 40 at approximately a forty-five degree angle to the circular plate 38 such that the leading edges of the rollers 40 extend into a conductor guide 46 to flare out the edge thereof and form a cone portion 48 as seen in Figure 3 as the tool carriage 14 and the forming tool 16 are moved into the second conductor guide forming position. The guide forming rollers 40 are preferably conical in shape as seen in the drawings. The conical shape is preferred because it results in the velocity of the roller at the inside edge of the flared portion of the conductor guide being equal to the velocity of the roller at the outside edge of the flared portion of the conductor guide. This minimises friction and prevents skidding of the rollers on the wall of the pipe which would cause galling of the pipe. The conical shape of the rollers 40 may be determined by the formula $\frac{R_1}{R_2} = \frac{r_1}{r_2}$ where R_1 = the radius

of the inside edge of the flared portion of the conductor guide, R_2 = the radius of the outer edge of the flared portion of the conductor guide, r_1 = the radius of the roller at its point of contact with the inside edge of the flared portion, and r_2 = the radius of the roller at its point of contact with the outer edge of the flared portion. Although rollers of a non-conical shape can be used, this requires more power and results in increased wear of the rollers. Edge forming rollers 42 contact the outer edge of the cone portion 48 slightly to compress it. This counteracts the minimal thinning of the wall that occurs at the outermost edge.

The drive means 18 for the forming tool 16 is provided in the form of electric motor 50 and a spindle or drive shaft 52. As can be seen in Figure 1, the electric motor 50 is mounted on a horizontal plate 54 extending from the third vertical plate 36. The electric motor 50 is operatively engaged with the forming tool 16 by means of the drive shaft 52 that is supported by bearings 56 adjacent the plates 32 and 34.

The movement means 20 to move the tool carriage 14 between its first and second positions is provided in the preferred embodiment by a hydraulic cylinder 58 mounted on the base 12 and attached to the tool carriage 14. Hydraulic fluid is supplied to the hydraulic cylinder 58 from a source not shown through hydraulic fluid lines 60.

In the preferred embodiment, the heating device 22 is an induction heating device that causes heating of the conductor guide 46 without touching it. An electric current directed through an electric coil in the heating device 22 via power lines 62 results in the generation of a magnetic field around the coil. The magnetic field induces an electric current in the conductor guide 46 that generates heat due to the high resistance of the steel pipe that the conductor guide 46 is formed from. The design of the heating device 22 provides a specific heat pattern for ease of forming where the end of the conductor guide to be flared is

the hottest. In the preferred embodiment, the heating pattern is as follows. Approximately 114mm (four and a half inches) of the conductor guide inward from the end being flared are heated to about 1260°C (2300°F). Approximately the next 140mm (five and a half inches) are heated to about 982°C (1800°F). Approximately the next 25.4mm (one inch) is heated to about 760° (1400°F). Approximately the next 25.4mm (one inch) is heated to about 260°C (500°F). The flaring takes place in the first 267mm (ten and a half inches) heated.

As can be seen in Figure 1, the second plate 28 is provided with an aperture that allows passage of the pipe therethrough and through the open centre of the heating device 22. A clamp 64, which may be attached to the second plate 28 or to a separate piece of equipment is used to hold the pipe in position during forming operations.

In operation, a section of pipe that will be used as conductor guide 46 is held rigidly in position by the clamp 64 such that it extends through the second plate 28 and the heating device 22. The heating device 22 is rolled into position on a movable platform 66 on the lower support members 24 and is then used to cause induction heating of the end of conductor guide 46 to approximately 1260°C (2300°F).

For a conductor guide that is formed from 12.7mm (half inch) steel and has an outer diameter of 711mm (twenty-eight inches), this heating takes approximately four minutes. When the desired temperature and heat pattern has been reached, the electric motor 50 is actuated to cause rotation of the forming tool 16. The hydraulic cylinder 58 is then actuated to cause the tool carriage 14, the forming tool 16, the electric motor 50 and, the drive shaft 52 to move from their first retracted position away from the conductor guide 46 towards the conductor guide 46. The guide forming rollers 40 contact the inner surface of the conductor guide 46 as they move forward toward the conductor guide and cause the heated end of the conductor guide 46 to flare outwardly to form the cone portion 48 of the conductor guide 46. The forming rollers 42 contact the edge of the cone portion 48 and cause slight compression of the edge radially inwardly along the same axis as the flare to compensate for the minimal thinning that occurs during the forming process. The forming process takes approximately five seconds with the heated end portion of the conductor guide 46 being in a plastic state and with approximately forty tons of pressure provided by the hydraulic cylinder 58. In the preferred embodiment, the forming tool 16 is rotated at approximately 550 RPM. The rollers 40 and 42, being of smaller diameter relative to the inside of conductor guide 46, rotate at approximately 2500 RPM. In the preferred embodiment, a heat shield 68 is positioned on the framework 44 as to extend in front of the rollers 40, 42 to help protect their bearings from the heat. The bearings for the rollers 40, 42 may also

be water cooled. After forming, the pressure from the hydraulic cylinder 58 is reversed to move the tool carriage 14 back to its first retracted position so that the forming tool 16 does not stay in contact with the hot conductor guide 46. After cooling, which may be accomplished by running water over the conductor guide 46 and the cone portion 48, the conductor guide 46 is cut at the appropriate length away from the cone portion 48. The completed and combined one-piece conductor guide is removed, the clamp 64 is loosened, an appropriate length of conductor guide pipe is moved into position and the process is repeated. During the forming operation, a rod 70 mounted on the tool carriage 14 contacts the heating device 22 and causes it to move away from the end of the conductor being flared to prevent interference between the heating device 22, the flared end and the forming tool 16. The angular arrangement of the rollers 40 and 42 allows operation for forming conductor guides in a variety of sizes without altering the equipment. Although only one drive motor is illustrated, two drive motors connected to the drive shaft by drive belts or chains may be used if desired.

Claims

1. A conductor guide forming machine, comprising:
 - a. a base (12);
 - b. a tool carriage (14) mounted on the base (12) so as to be movable between a first retracted position and a second conductor guide forming position;
 - c. a forming tool (16) rotatably mounted on the tool carriage (14);
 - d. drive means (18) mounted on the tool carriage (14) to rotate the forming tool (16);
 - e. movement means (20) mounted on the base (12) and attached to the tool carriage (14) to move the tool carriage (14) between the first and second positions; and
 - f. a heating device (22) movably mounted on the base (12).
2. A conductor guide forming machine according to claim 1, wherein the base comprises four support members (24) attached at their ends to first and second plates (26, 28), defining a substantially rectangular frame.
3. A conductor guide forming machine according to claim 1, wherein the forming tool comprises a substantially circular plate (38) having guide forming rollers (40) rotatably attached thereto.
4. A conductor guide forming machine according to claim 1, wherein the drive (18) means comprises an electric motor (50) operatively engaged with

the forming tool (16).

5. A conductor guide forming machine according to claim 1, wherein the mount means (20) comprises a hydraulic cylinder (58). 5
6. A conductor guide forming machine according to claim 1, wherein the heating device (22) comprises an induction heating device. 10
7. A conductor guide forming machine, comprising:
 - a. a base (12) formed from four horizontal support members (24) attached at their ends to first and second plates (26, 28) to define a substantially rectangular frame; 15
 - b. a tool carriage (14) mounted on the base (12) so as to be movable between a first retracted position and a second conductor guide forming position; 20
 - c. a forming tool (16) rotatably mounted on the tool carriage (14) and comprising a substantially circular plate (38) with conical guide forming rollers (40) rotatably attached thereto; 25
 - d. drive means (18) mounted on the tool carriage (14) to rotate the forming tool (16); 30
 - e. movement means (20) mounted on the base (12) and attached to the tool carriage (14) to move the tool carriage (14) between the first and second positions; and
 - f. a heating device (22) movably mounted on the base (12). 35
8. A conductor guide forming machine according to claim 7, wherein the drive means (18) comprises an electric motor (50) operatively engaged with the forming tool (16). 40
9. A conductor guide forming machine according to claim 7, wherein the movement means (20) comprises a hydraulic cylinder (58). 45
10. A conductor guide forming machine according to claim 7, wherein the heating device (22) comprises an induction heating device. 50
11. A conductor guide forming machine according to claim 7, further comprising edge forming rollers rotatably attached to the circular plate of the forming tool. 55
12. A method of flaring the end of a pipe outwardly to form a conductor guide, comprising:
 - a. heating a portion of the pipe to be flared; and
 - b. inserting rollers (40,42) rotatably mounted on a forming tool (16) into and against the heated interior end of the pipe while simultaneously rotating the forming tool (16). 6

13. A method according to claim 12, wherein the heating of the pipe is accomplished in a progressive pattern whereby the pipe is heated to progressively higher temperatures toward the end to be flared.

FIG. 1

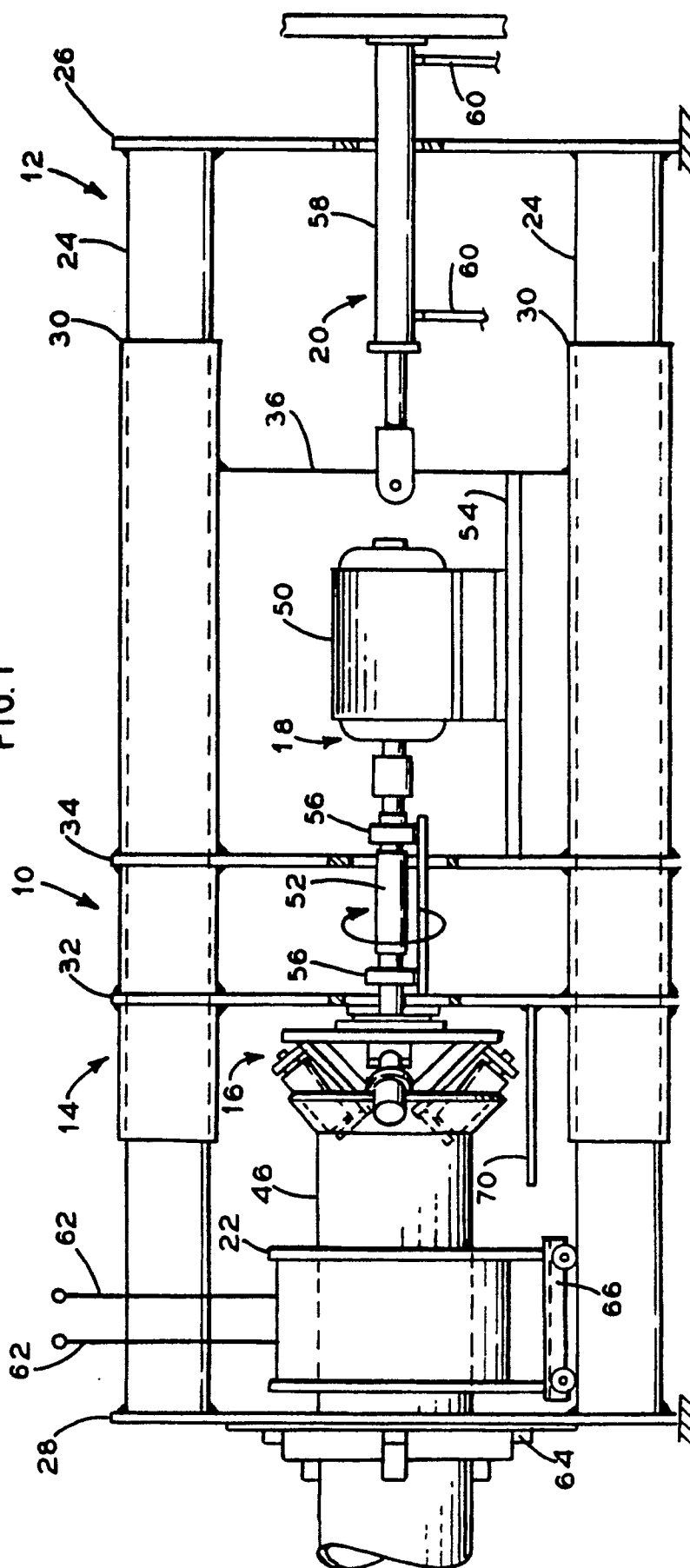


FIG. 2

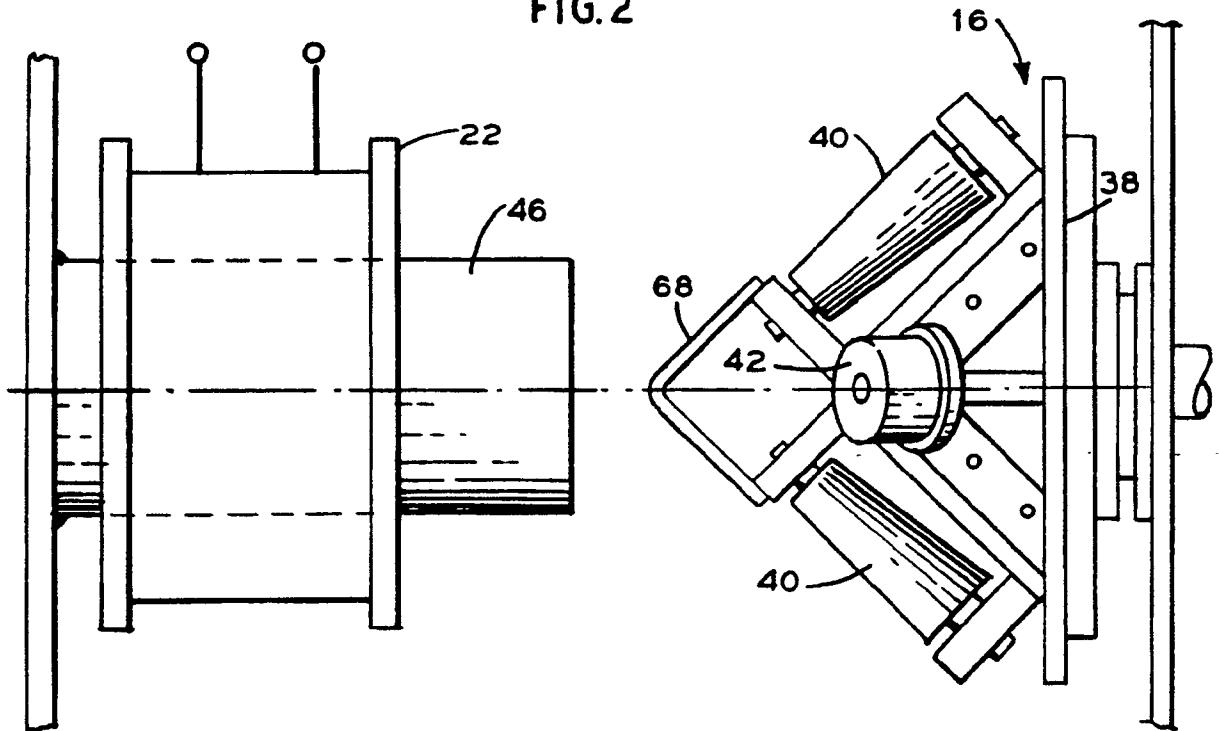


FIG. 3

