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 [21] Appl. No. **804,906**
 [22] Filed **Mar. 6, 1969**
 [45] Patented **Feb. 23, 1971**
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 [32] Priority **Mar. 7, 1968**
 [33] **Japan**
 [31] **43/14351**

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[54] **AUGER-TYPE BORING MACHINES**
12 Claims, 9 Drawing Figs.

[52] U.S. Cl. **175/171,**
 175/173, 175/323
 [51] Int. Cl. **E21b 3/02,**
 E21b 17/00
 [50] Field of Search 175/102,
 171, 173, 323

ABSTRACT: Auger-type boring machines for drilling cylindrical holes in order to make pile foundations in the earth, comprising a double auger consisting of an outside auger and an inside auger, with oppositely twisted threads, the latter being rotatably passed through the inside of the former, whereby efficiently to produce holes of large diameters, by rotating the augers in opposite directions.

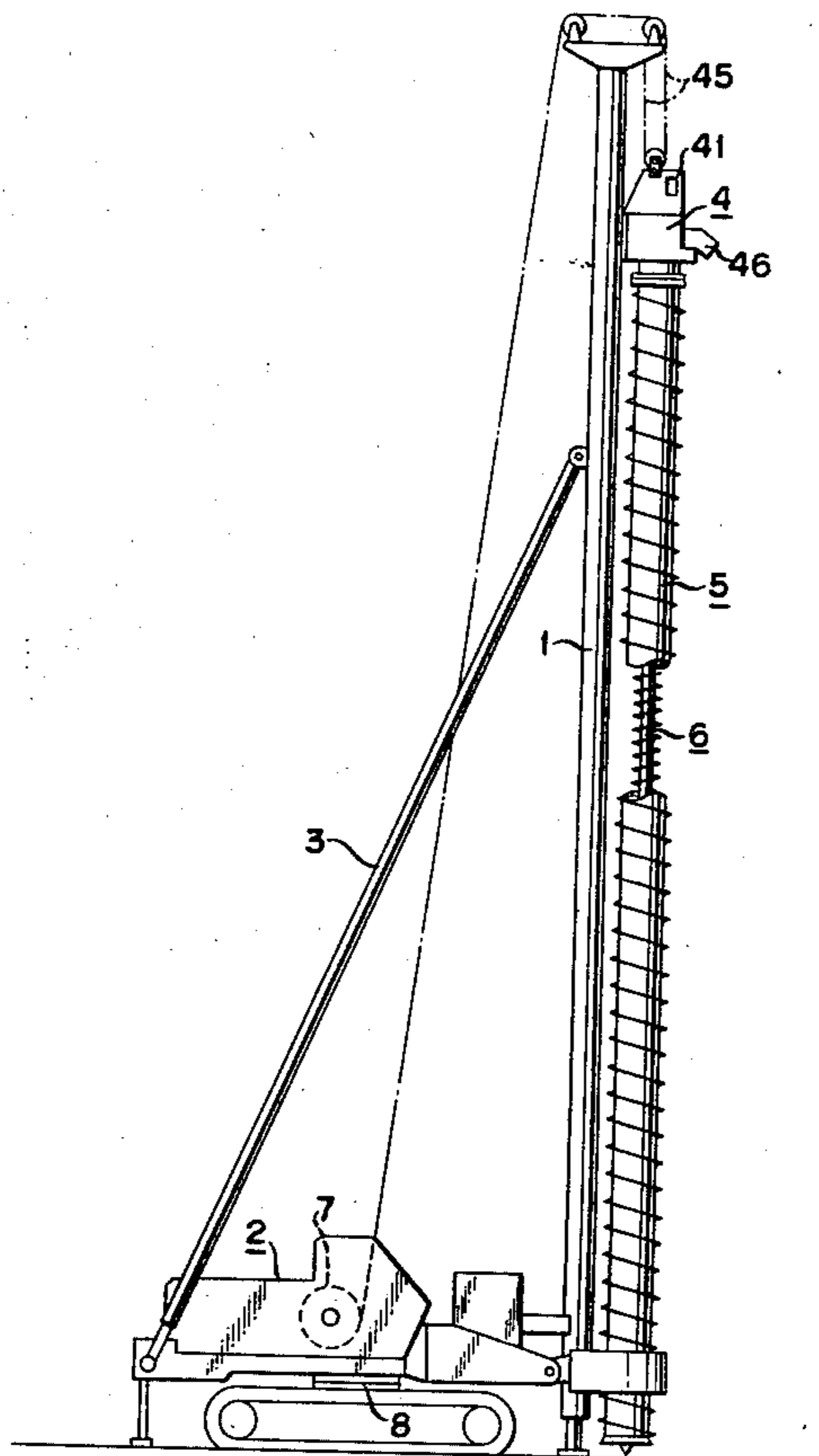
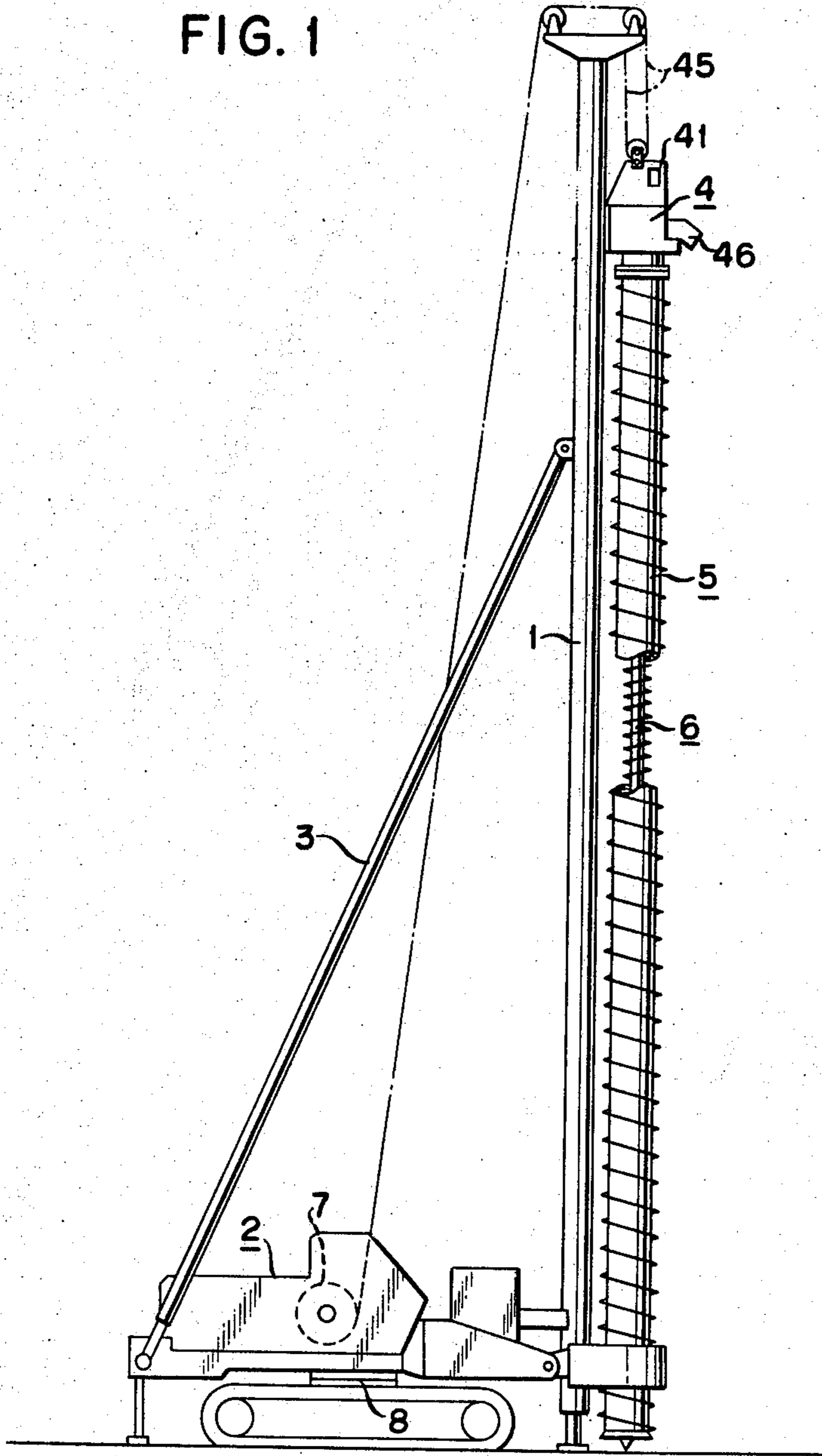


FIG. 1



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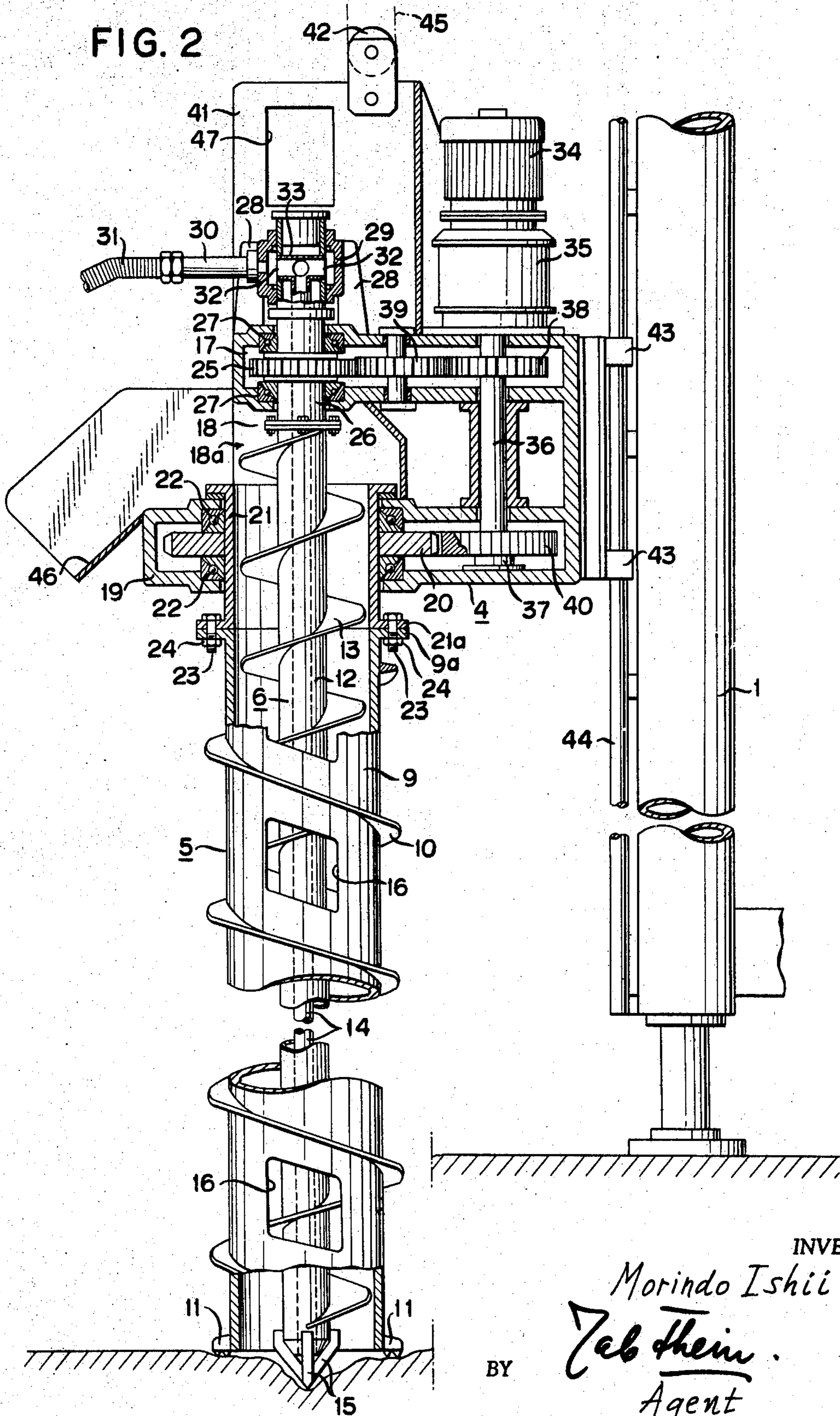
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FIG. 2



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FIG. 3

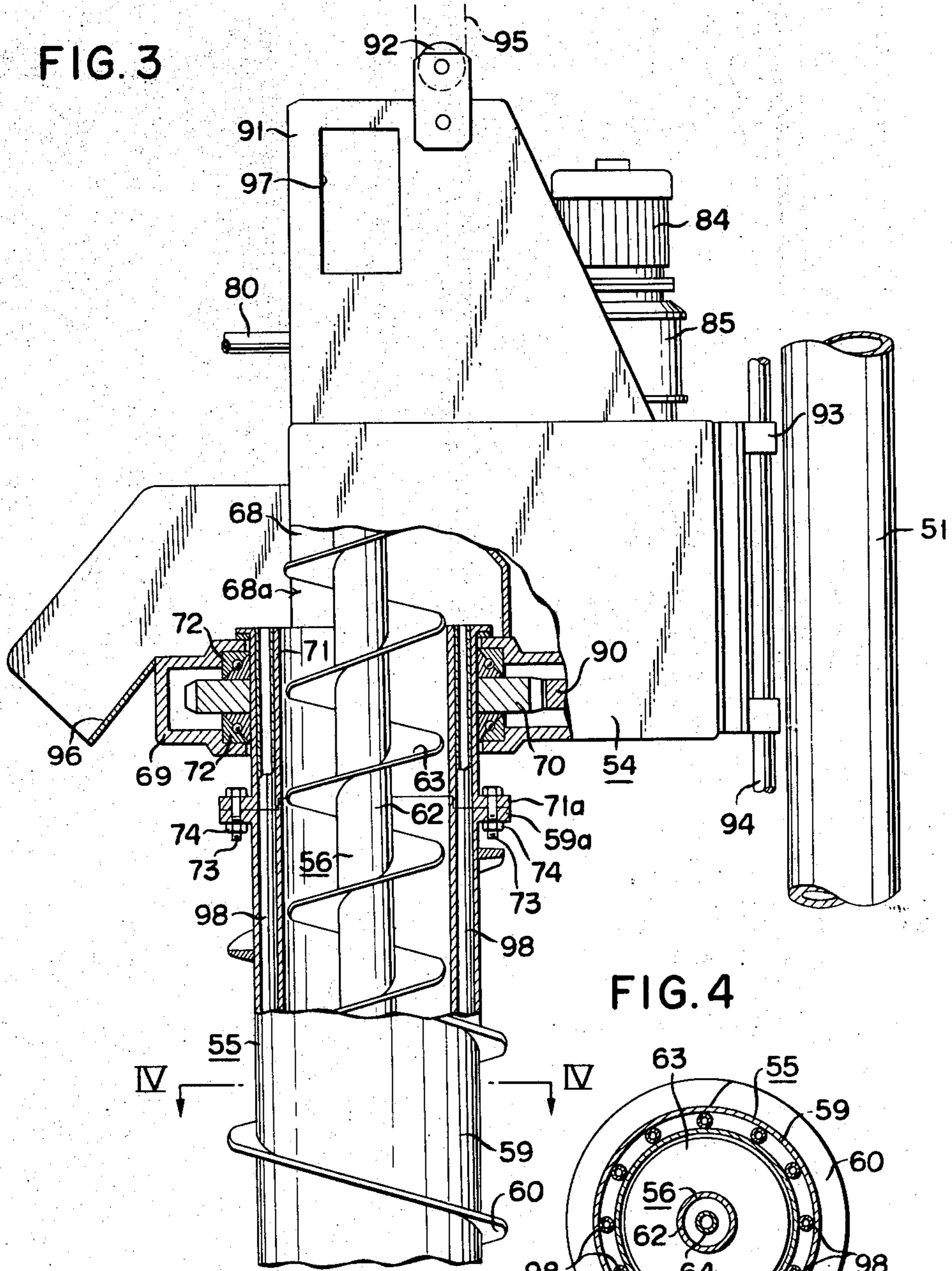
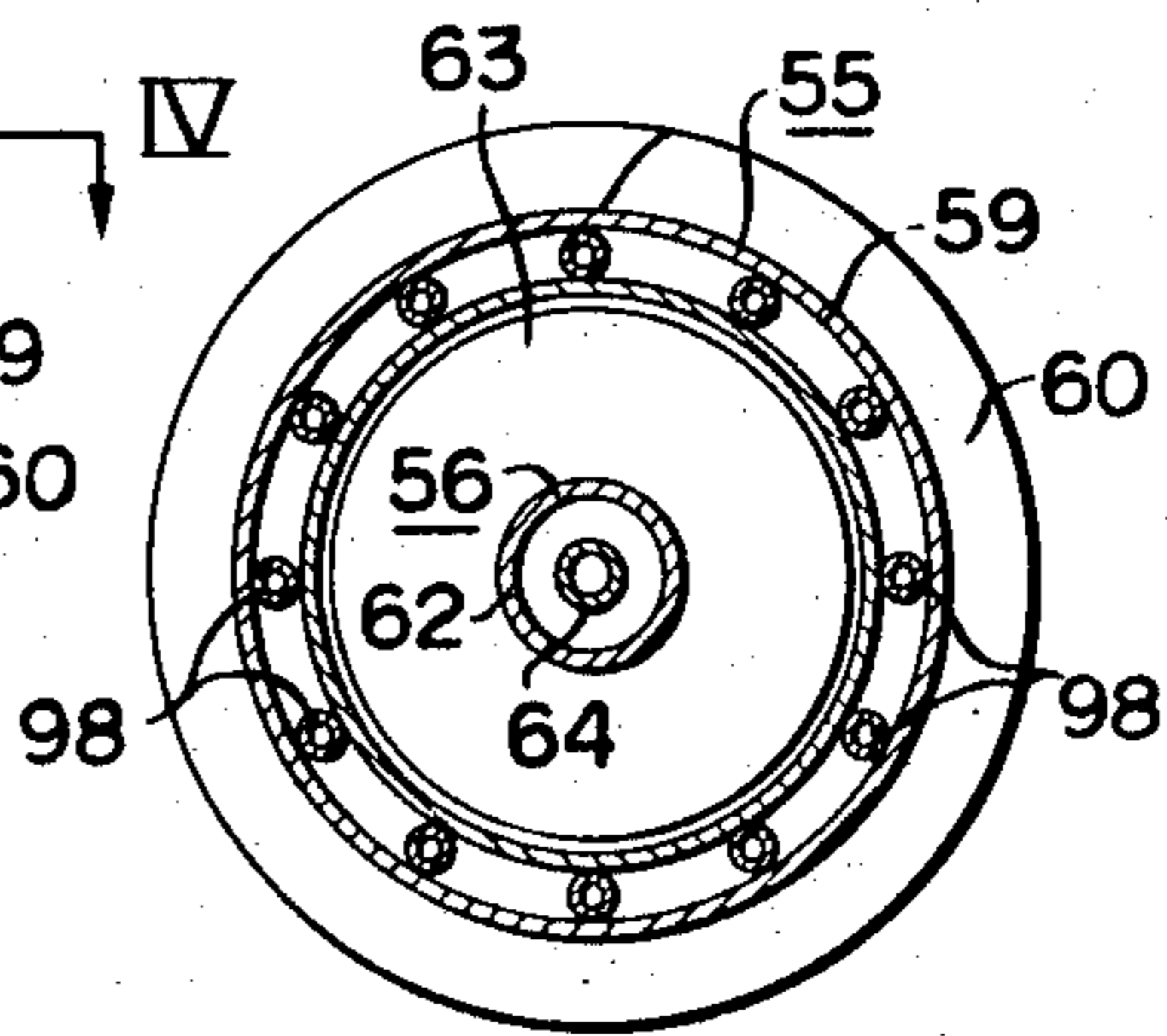


FIG. 4



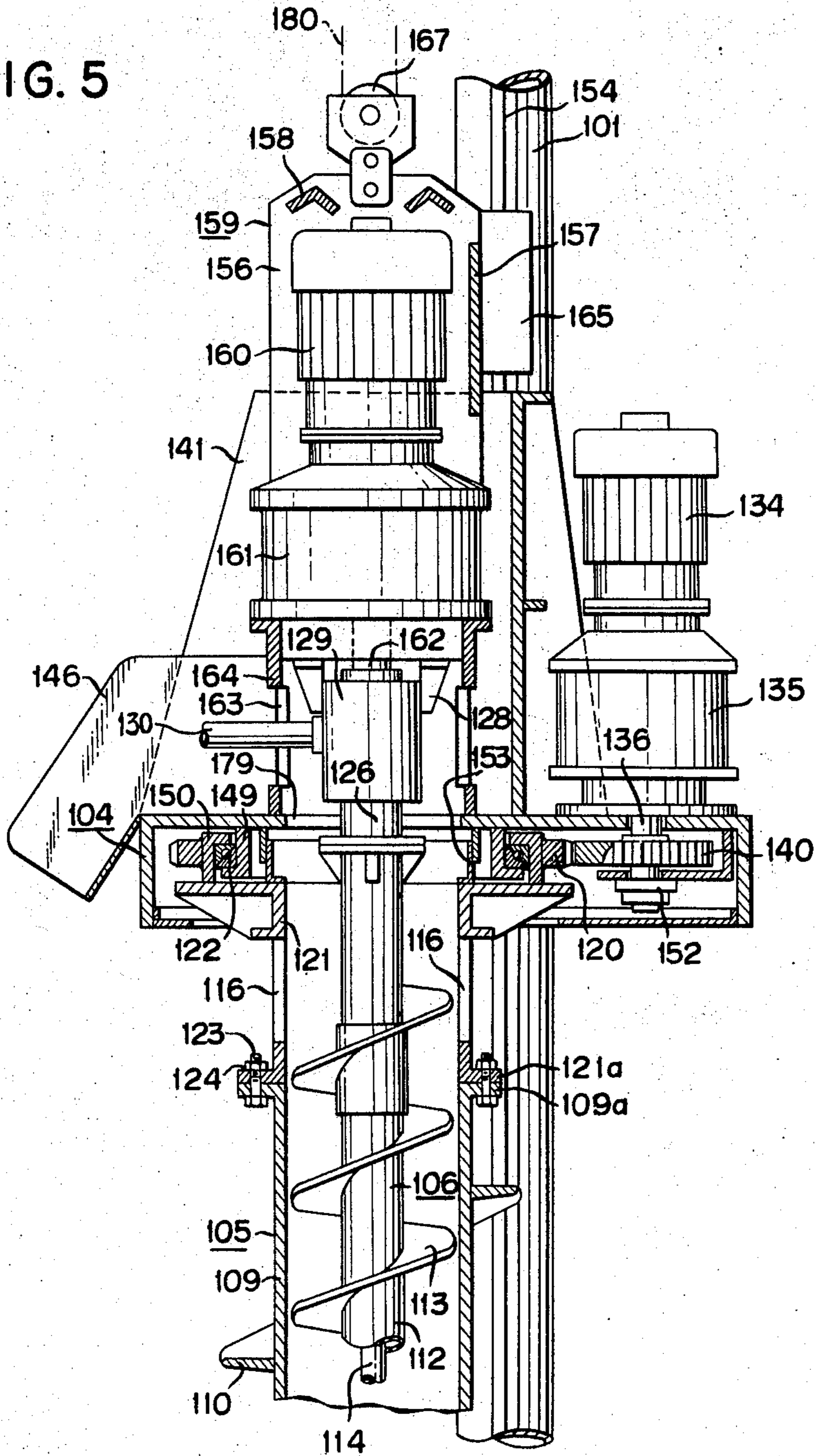
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FIG. 5

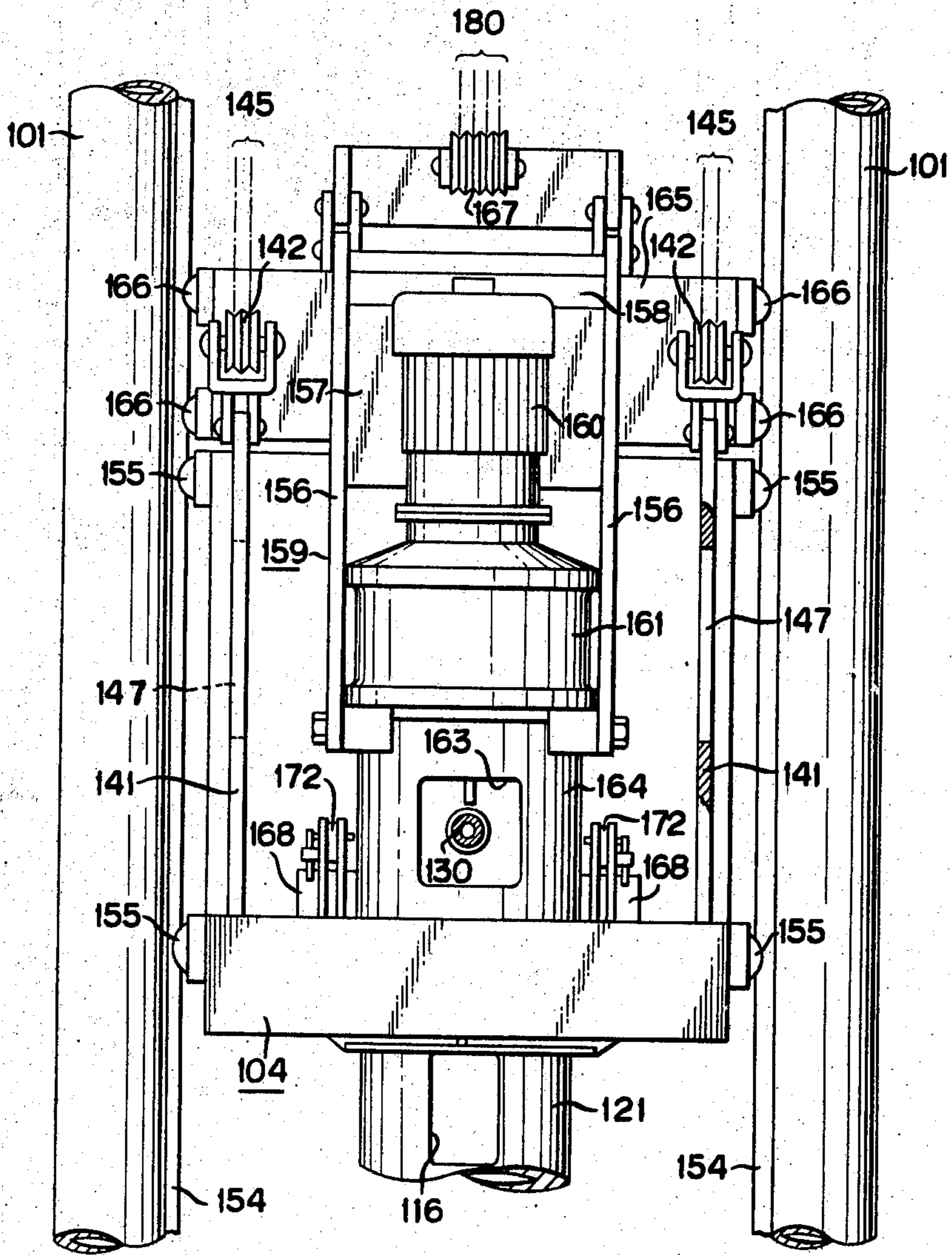


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FIG. 6



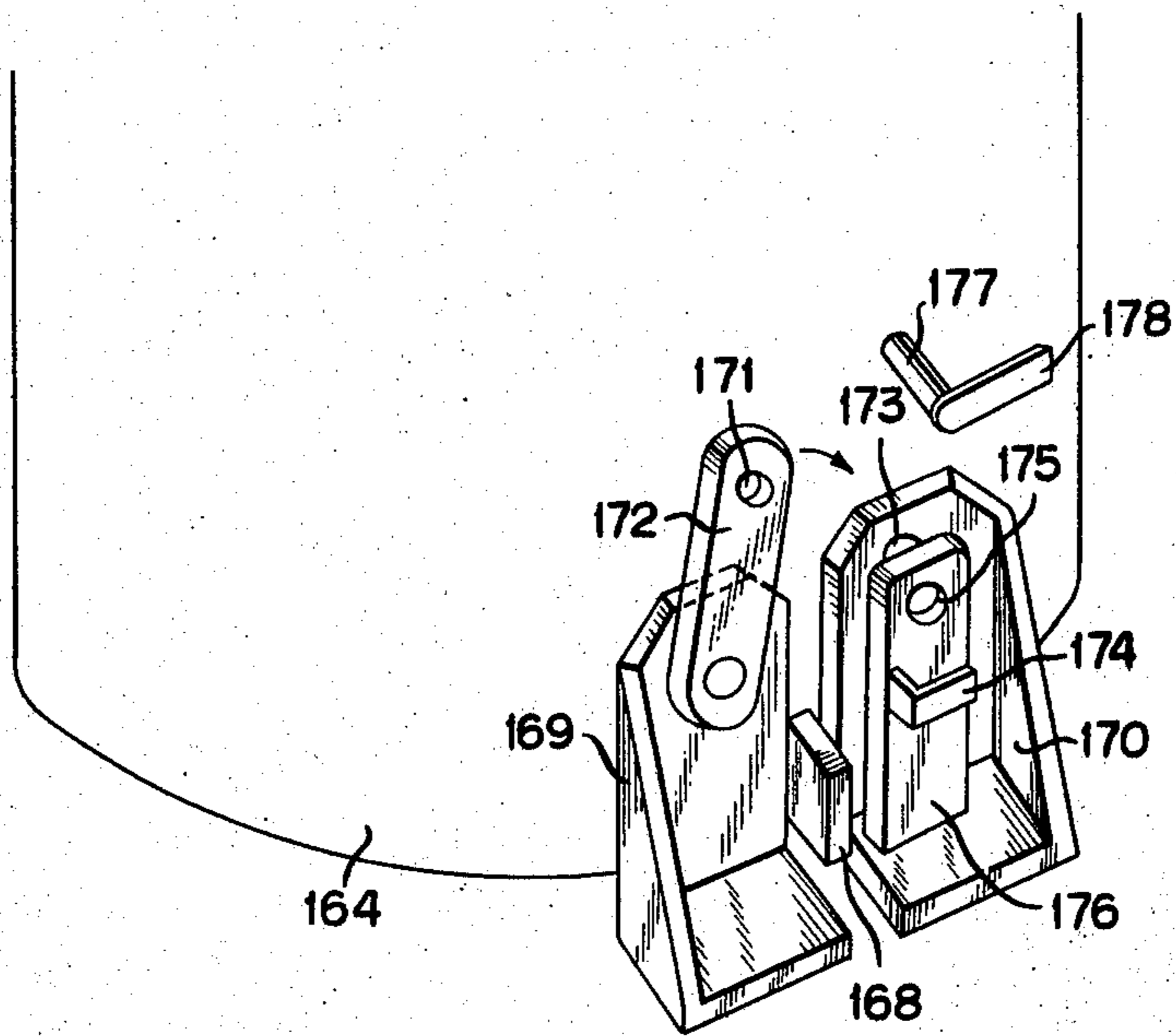
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FIG. 7



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FIG. 8

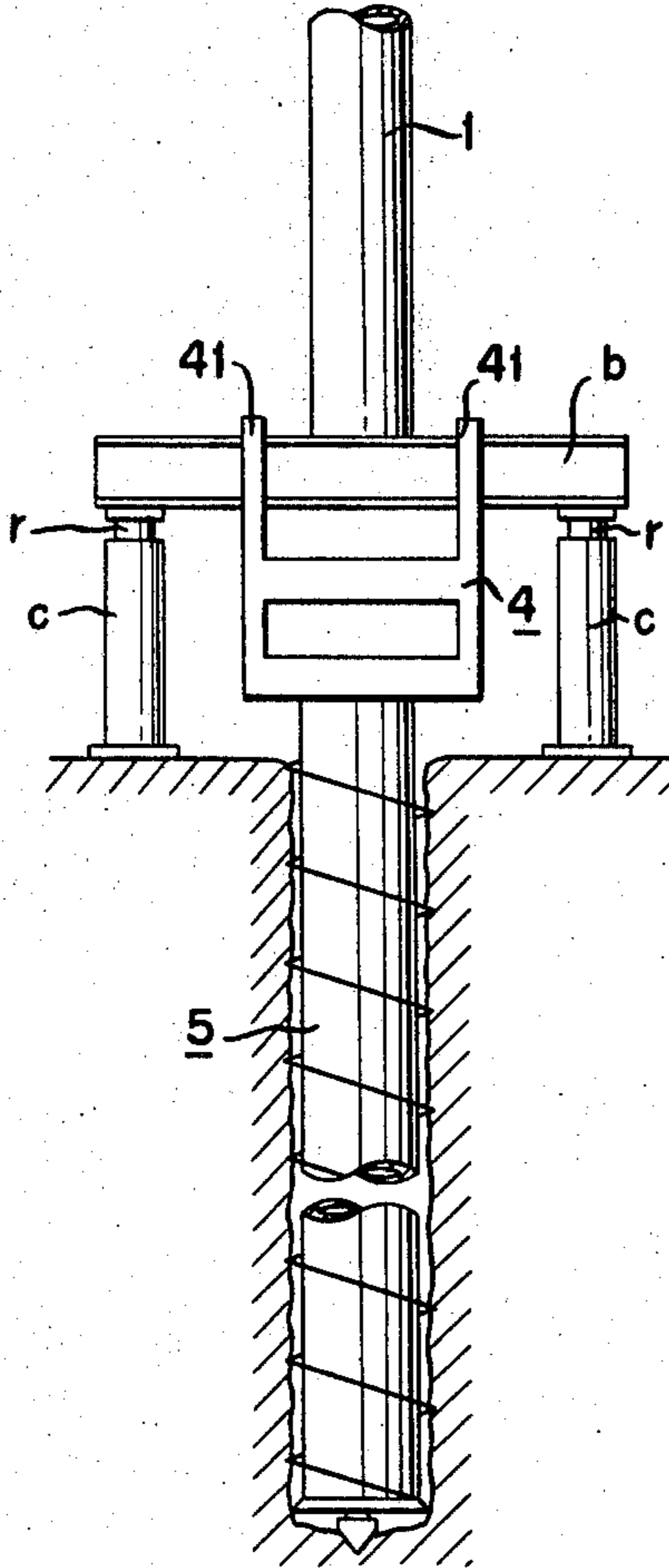
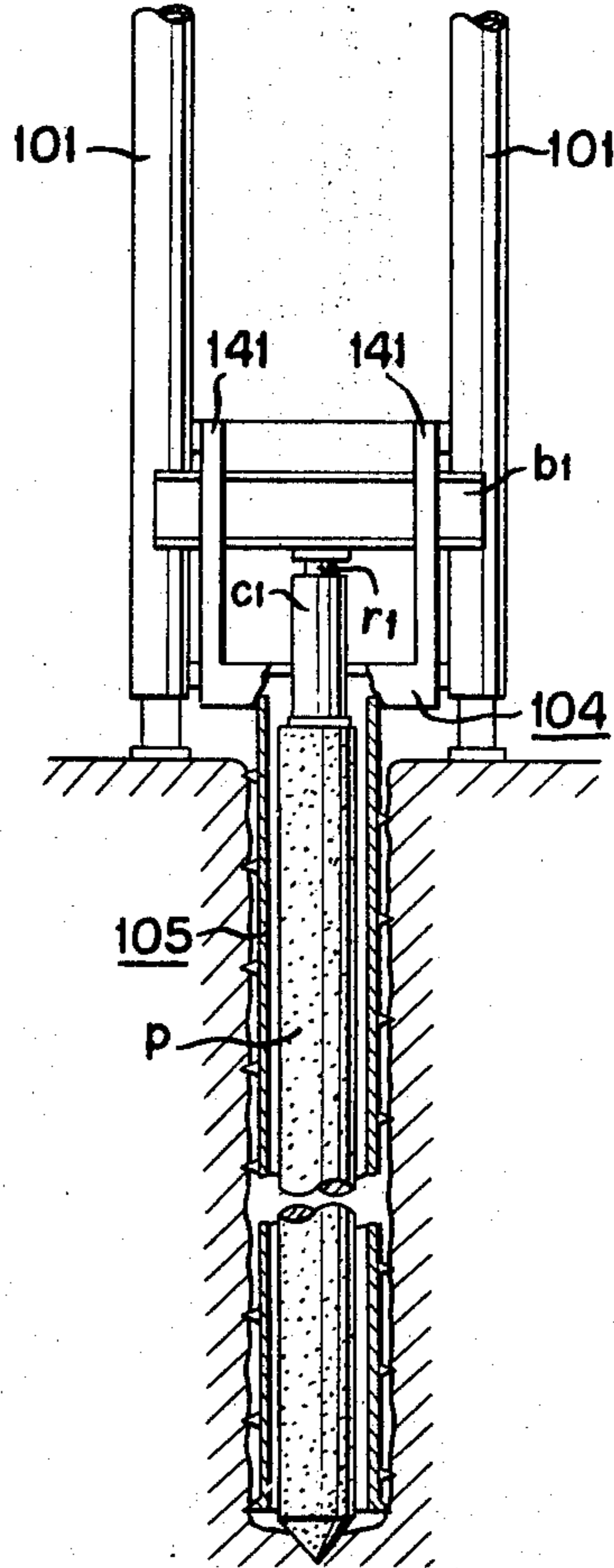


FIG. 9



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AUGER-TYPE BORING MACHINES

This invention relates to double auger-type machines for boring cylindrical holes in order to make pile foundations with prestressed concrete pile (PCP), reinforced concrete pile (RCP), packed-in-place pile, mixed-in-place pile and the like.

Earth boring auger machines have been hitherto known, comprising a long auger of about 50 to 60 cm. in diameter, suspended by way of a carrier element reciprocally disposed in a tower resting on the earth. According to this machine, a hole of desired depth can be obtained by boring the earth with said auger, rotating the same by appropriate driving means, and pulling it again out of the earth.

This so-called single-auger machine is found inapplicable for boring holes of large diameters because the carrier element and the tower suffer from the strong reaction forces caused by the rotation of the long and heavy auger so that the structure of the adjacent parts must be tough enough to escape destruction. Furthermore, when using the single-auger machine for depositing piles to be placed in the earth, there is a considerable drawback in that the soil of the inside bore wall, after it was once made up, is subject to spontaneous deformation and to collapse when the auger is pulled out of the earth, so that the piles cannot be embedded in the soil to the desired depth.

To prevent deformations of the inside bore wall, the so-called Benoto boring machine has been proposed which is characterized in pushing under pressure a casing pipe into the earth, and in alternating the operation of boring and soil removal or exhausting by way of hammer grab controlled with a rope, thereby forming bores, the inside walls of which are protected by the casing pipes.

Referring further to another known machine, called the William digger's drilling machine, a bentonite solution is charged in the bores made by an ordinary auger so as to secure the inside bore walls.

Either of those engineering methods, to prevent the bore walls from becoming deformed, needs many hours for the operation. Particularly the former is found defective in respect of having respective installments of dimensions and considerable trouble in pushing the casing pipe in the earth under pressure and in extracting the same after mortar is placed. As for the latter, it has the added defect as to involve additional expenses because of the use of costly bentonite or similar materials.

The object of the present invention is to provide a new double auger-type boring machine efficiently to execute the boring of large-diameter holes in such manner to offset reaction forces caused by the rotation of the augers.

Another object of this invention is to provide a double auger-type boring machine to execute the forming of packed-in-place piles, mixed-in-place piles and the like, simultaneously to prevent deformations in the inside bore walls after they are completed.

Still another object of this invention is to provide a double auger-type boring machine to execute the foundation in the earth of built-up piles such as prestressed concrete piles, reinforced concrete piles, and simultaneously to prevent the inside bore walls from becoming deformed.

According to one of the important features of this invention, the inventive boring machine comprises a double auger consisting of an outside auger and an inside auger, the latter being inserted lengthwise and rotatably through the inside of the former. The outside auger consists of a hollow shaft provided with screws twisted in one direction on the outer periphery while the inside auger consists of a shaft provided with screws twisted in the other direction; on the outer periphery. A tower is also provided for raising and lowering the double auger, and drive means for rotating the augers in the respective opposite directions.

By the use of the double-auger boring machine it is possible alternately to carry out the operations of efficiently boring and of smoothly extracting the digged soil, by way of rotating the two oppositely threaded augers in opposite directions.

It will be moreover appreciated that the outside auger will protect the inside bore wall when built-up piles are founded in the earth, such as in casing pipes as used with the above-mentioned Benoto boring machine. It is further to be noted that, because of carrying out the boring by way of rotating the augers in opposite directions, the specific reaction force caused by the rotation of both augers is canceled out so that the means required for holding the double auger can be made weaker than those of the aforementioned single-auger structures.

The construction of the tower means and the associated means may thus become simpler. By virtue of this advantage, the diameters of the augers can be made considerably larger than was heretofore possible, and thus the boring of large-diameter holes can be carried out. Other objects and many of the attendant advantages of the invention will be readily appreciated as the same becomes better understood by reference to the following detailed description, when considered with the accompanying drawings, wherein:

FIG. 1 is a somewhat simplified side view of a double auger-type boring machine according to the present invention, partly cut away, and referring to a first preferred embodiment thereof, such as shown in FIG. 2; is

FIG. 2 is an enlarged sectional, partial side view of the casing and auger portions, partly cut away, of the first embodiment;

FIG. 3 is a still further enlarged sectional, partial side view of the casing portion, partly cut away, of a second embodiment of the invention;

FIG. 4 is a sectional view taken along line IV-IV of FIG. 3;

FIG. 5 is a partial side view, similar to the upper portion of FIG. 2, but of the casing portion, partly cut away, of a third embodiment;

FIG. 6 is an enlarged front view of the casing portion shown in FIG. 5;

FIG. 7 is an enlarged perspective view of a lock device in the third embodiment of FIGS. 5 and 6;

FIG. 8 is a somewhat schematic front view, partly cut away, showing the extraction of the auger, carried out with the auger-type boring machine according to the invention; and

FIG. 9 is a view similar to that of FIG. 8, showing the load testing of piles.

The following description relates to the first, preferred embodiment of the inventive double auger-type boring machine, as shown in FIGS. 1 and 2, keeping in mind that the former should also be considered with the description of the subsequently described second and third embodiments.

The machine comprises a tower 1 having a lower end portion connected with the end crawler 2 and is erected in a position for boring, supported by a plurality of stems 3 extended from the crawler 2. It should be understood that the underscored numerals (like 2) relate to the entire element or structural part while the nonunderscored numerals relate to parts thereof, for a better understanding of the drawings and the description. A gear casing 4 is supported in a vertically reciprocable manner by tower 1. Details of the gear casing 4 are shown in FIG. 2 in full detail. In casing 4, the tops of an outside auger 5 and an inside auger 6, rotatable in the inside of the casing, are secured, as will be explained in full detail. The tower is thus capable of raising and lowering the augers 5 and 6. The crawler 2 is provided with a winch mechanism 7, a turning mechanism 8, and other necessary devices which are conventional and need not be described herein.

The outside auger 5 has screw-shaped twist blades 10 disposed counterclockwise on the outer periphery of a hollow shaft 9 which is punched so as to provide a plurality of soil-extracting windows 16. A plurality of cutters 11 are fixed around the lower head of the hollow shaft 9.

The inside auger 6 has screw blades 13 twisted clockwise on the outer periphery of a preferably hollow shaft 12, in the latter, a feeding pipe 14 is inserted lengthwise for transporting water or grout. The lower end of pipe 14 is open through bits

15 with which the shaft 12 is headed. It is desirable that the pitch of screw 10 of the outside auger 5 should be larger than that of screw 13 of the inside auger 6.

As further shown in FIG. 2, the gear casing 4 consists of an upper chamber 17, an intermediate chamber 18 having a front opening 18a therebelow, and a lower chamber 19 further therebelow. An annular gear 20 is fixed on the periphery of a cylindrical coupling or flange 21, having the same diameter as that of the outside auger shaft 9, rotatably engaged in the vertical direction with two thrust ball bearings 22 in the front portion of the lower chamber 19.

A flange 9a mounted on the outside auger shaft 9 is connected with a flange 21a extending from the coupling 21, by means of a plurality of bolts 23 and nuts 24. In the opening 18a a chute 46 is provided. In the front portion of the upper chamber 17, a gear 25 is fixed on the periphery of a cylindrical and upright coupling 26, having the same diameter as that of the inside auger shaft 12, being vertically rotatably engaged with two thrust ball bearings 27. The coupling 26 is connected to the upper portion of the inside auger shaft 12.

On the upper and outer periphery of the coupling 26 a swivel case 29 is mounted by means of a bracket 28 on the upper chamber 17. In the front portion of the swivel case 29, an inlet pipe 30 is provided which passes therethrough. This pipe 30 is joined to a flexible pipe 31 extended from conventional means (not shown) for providing water or grout under pressure. On the periphery of the cylindrical coupling 26, within the swivel case 29, a plurality of through holes 32 are punched, each of the holes being placed in connection with the top of the feeding pipe 14 by means of a multibranch pipe 33.

As for the drive means for rotating the inside and outside augers in opposite directions, this should be described as follows. At the rear portion of the top face of the gear casing 4 a reversible motor 34 and a reduction device 35 are installed. A driving shaft 36 extending from the reduction device 35 passes successively through the chambers 17, 18 and 19, and is fixed at its bottom by way of a bearing 37. A gear 38 fixedly mounted on the shaft 36, located within the upper chamber 17, is engaged with the gear 25 to the inside auger 6 by the intermediary of an idle gear 39. Likewise, a gear 40, secured to the same driving shaft 36 and located within the lower chamber 19, is engaged with the gear 20 of the outside auger 5.

The gear casing 4 has side plates 41 on both sides thereof, and the upper portion of each sideplate is provided with a sheave 42, each having a wire rope 45 therearound which allows the gear casing 4 to be raised and lowered, as can best be seen from the overall view of FIG. 1. On either side of the back of the gear casing 4 a semicircular slider 43 is fixed which is removably engageable at two points with a leader 44 arranged in parallel and lengthwise relation with respect to the tower 1. Besides, the sideplates 41 have holes 47 at appropriate positions, through which beams may be passed for the extraction of augers, as will be explained hereinafter.

In the operation of the boring and subsequently the forming of concrete piles according to the just described first embodiment of the double auger-type boring machine according to the invention, in case the lower end of the double auger approaches the earth, and the motor 34 is actuated for starting, the double auger 5, 6 is driven to gradually descend into the earth by means of the outside auger 5 being twisted counterclockwise, upon rotation, while its inside auger 6 is twisted clockwise when rotated. This procedure is of course aided by gravity and by the pressure of the casing and the other attached elements. Finally a bore is produced which has almost the same diameter as that of the outside auger 5.

Simultaneously, the soil removed by the screw 10 of the outside auger 5 is gradually delivered to the surface of the earth. At the same time, the soil removed by the screw 13 of the inside auger 6 is raised through the hollow shaft 9 of the outside auger 5, and on its way part of the soil is discharged through the windows 16 while the rest of the soil reaches the inter-

mediate chamber 18; it is then removed or discharged through the opening 18a of this chamber.

In case the boring is carried out in clay, for example, it is preferred that water is conveyed under pressure into the flexible pipe 31. The water is introduced to the feeding pipe 14 by passing through the swivel case 29 and the multibranch pipe 33, and then injected into the boring hole through the opening at the lower end of the pipe 14. The clay soil thereby becomes muddy, facilitating the boring, delivering and removal by means of the screws.

When the hole is bored to the desired depth, the motor 34 is made to stop, and grout is made to follow by feeding the same under pressure into the pipe 31, when the double auger is to be pulled out slowly by winding rope 45. The pressurized grout is ejected into the boring hole from the lower end of the feeding pipe 14, and filled thereinto no sooner than the auger is pulled out so that no time is allowed for deforming the inside wall of the hole. When the double auger 5, 6 emerges to the earth surface, the grouting in the resultant hole is completed.

There are some cases in which the auger cannot be pulled out simply by means of the wire rope 45 because of strong earth pressure. In such cases it is better to fit an I-shaped steel beam *b* (see FIG. 8) into the hole 47 of each sideplate 41, and interpose oil-pressure cylinders *c* between the earth and the two ends of the beam *b*. Hereupon pressure oil is supplied to both cylinders *c*, and then the beam *b* is pushed upwards by means of rams *r* so that the auger is pulled up. After having reached the maximum stroke of the rams *r*, the auger can be easily pulled out.

It will be understood that other conventional means may of course be used for raising the double auger-type boring machine or parts thereof from the borehole, and FIG. 8 is intended to illustrate one possible expedient only.

A structural modification of the machine described so far is illustrated in FIGS. 3 and 4, constituting a second preferred embodiment. The reference numerals used for the second embodiment are higher by 50 than those of the first embodiment, with a few exceptions (parts of the first machine which are not needed in the second).

A hollow shaft 59 (the counterpart of the previously described hollow outside auger shaft 9) within an outside auger 55 (similar to auger 5) and a cylindrical coupling or flange 71 (similar to 21) are formed in a double structure consisting of two tubes, each having a different diameter, as will be described hereafter in more detail.

A plurality of guide pipes 98 for guiding reinforced bars are disposed lengthwise at equal distance of the peripheral space between the two diameters.

The remaining structure of the second embodiment is substantially identical to that shown in FIGS. 1 and 2. The elements 51, 54, 56, 59a, 60, 62 to 64, 68 to 74, 68a, 71a, 78 to 80, 84, 85 and 90 to 97 are considered to be counterparts of those of the first embodiment, namely 1, 4, 6, 9a, 10, 12 to 14, 18 to 24, 18a, 21a, 28 to 30, 34, 35 and 40 to 47.

In this modification, the reinforced bars may be inserted from the top of each guide pipe 98 after the boring is completed, and the grouting is finished as well. Insertion of the bars is best carried out by rotating the outside auger 55 gradually and intermittently, and by exposing the upper end of the opening of the guide pipes 98 out of the intermediate chamber 68.

The third embodiment of this invention, illustrated in FIGS. 5 to 7, is mostly suited to found or embed built-up piles in the earth after the boring is completed. Two towers 101 (similar to the respective towers 1 and 51 described for the preceding embodiments) are connected with the crawler and stand on the ground (please refer to FIG. 1 for the overall showing of the crawler 2 and the associated arrangement, not illustrated further in the remaining views). An outside auger 105 is rotatably held by a gear casing 104 which is supported by both towers for reciprocation in a vertical direction, while an inside auger 106 passes through the auger 105, adapted to be removed therefrom. (The elements 104, 105 and 106 are

again similar to the previously described elements 4, 5 and 6, respectively). It will be understood that most of the structural parts of the first embodiment, necessarily apply to and are present in the third embodiment.

In the front portion of the gear casing 104 a round hole 179 is provided, and a sectionally L-shaped annular holder is tightly attached at the periphery of the round hole at the back of the casing 104, while an annular gear 120 and a sectionally L-shaped annular holder 150 therein are secured respectively on the upper end of a cylindrical coupling 121. Thus, holders 149, 150 rotatably engage each other by the intermediary of a thrust ball bearing 122. A flange 109a extends upwards from a hollow shaft 109 in the outside auger 105 and is joined with a flange 121a which extends downward from the coupling 121 by means of bolts 123 and nuts 124. Two windows 116 are provided in the coupling 121. Chutes 146 are disposed at the gear casing 104.

In the rear of the casing 104 a reversible motor 134 and reduction means 135 are installed to rotate the outside auger 105. A driving shaft 136, projecting into the casing 104 out of the reduction means 135, is tightly fitted to a gear 104 engaging the aforementioned annular gear 120. The projecting end of the driving shaft 136 is supported by a pillow block 152. It should also be noted that an annular rubber or synthetic resin-fabricated packing 153 is provided between the hole 179 and the upper end of the coupling 121.

The casing 104 has on both sideplates 141 equipped with a plurality of rollers 155 to touch a guide rail 154 fixed on the towers 101, whereas on the top of both sideplates 141 a sheave 142 is fixed, embracing wire ropes 145. Holes 147 are provided in plates 141, as has been explained before for holes 47.

Next the structure for detachably inserting the inside auger 106 into the outside auger 105 will be explained. A reversible motor 160 and a reduction device 161 are placed on a frame 159 consisting of sideplates 156 facing each other, a backing plate 157 and upper plates 158. A cylindrical coupling 126 is connected with a driving shaft 162 extending from the reduction device 161. A hollow inside auger shaft 112 having screw blades 113 is connected at the upper portion with the coupling 126.

A swivel case 129 is supported by brackets 128 attached beneath the bottom or base of the reduction device 161 and is fitted to the outer periphery of the coupling 126 while in the front portion of the swivel case 129 an inlet pipe is fixed, a feeding pipe 114 being in connection with both the swivel case 129 and the pipe 130, disposed lengthwise in the inside auger shaft 112. The internal structure of the swivel case is substantially identical to the embodiment shown in FIG. 2. A screw (twist blades) 110, associated with outside auger 105, also forms part of this embodiment.

It may be recapitulated at this point that the elements of the first embodiment are numbered from 1 through 47; those of the second, from 51 through 98 and of the third, 101 through 147, all substantially correlated in the above-explained scheme of 50 being added to each similar numeral (such as, for example, gear casings 4, 54 and 104, or holes 47, 97 and 147). Certain numerals are not being used, such as 65 to 67, etc. in the second embodiment, or 111, 148, etc. in the third. Numerals 149 through 180 denote additional elements described in connection with the third preferred embodiment only.

Beneath the bottom of the frame 159 there is a cylindrical mounting element or cover 164 having a diameter which is larger than the round hole 179 and a plurality of windows 163. The element 164 is tightly fixed as embracing the swivel case 129 therein, and the inside auger 106 is suspended on the gear casing 104 by means of the mounting element 164 placed on the casing 104 when it is inserted in the outside auger 105.

Other components of the inside and outside augers, not shown in FIGS. 5, 6 and 7, are similar to those of the first embodiment, as shown in FIG. 2 (such as, for example, counterparts of elements 17, 18a, 27, 37, etc.).

A beam 165 is horizontally fixed on the back of the frame 159. At both sides of the beam a plurality of rollers 166 is arranged to touch each guide rail 154 of said towers, and on the upper portion of said frame a sheave 167 is set up to wind wire rope 180.

Next, the locking device for detachably fitting said frame 159 to the gear casing 104 is provided. Referring to FIGS. 6 and 7, a pin 168 horizontally projects at either side of the lower end of said mounting cover 164 while each of two pairs of brackets 169, 170 are arranged to hold each pin on the casing 104. One of the brackets, namely 169, is pivotally fixed with a ratchet 172 having a keyhole 171. The other bracket 170 is punched with a keyhole 173. In addition, besides said bracket 170, a third bracket 176 is used, having a hook 174 and a keyhole 175.

Under such conditions that said pin 168 is placed between the brackets 169, 170, the latch or ratchet 172 is turned, then inserted between the brackets 170, 176; thus a key 177 is made to pass through the keyholes 171 and 173, 175; then a key handle 178 is seized by the hook 174 such that said frame 159 may be locked to the casing 104.

Besides, both side plates 141 correspond to each hole 147, through which a beam is passed for the use of auger extracting, as explained before, and for the use of testing the load tolerated by the built-up piles.

According to the third double auger-type boring machine, and in operation of the boring and the founding of built-up piles, firstly the boring is carried out by rotating the outside auger 105 in the counterclockwise direction and then the inside auger 106 in the clockwise direction, by the starting of motors 134, 160, as in the first embodiment explained above. When the boring proceeds at the desired depth, the outside auger 105 is continued to rotate whereas the inside auger 106 ceases to drive. Next, the inside auger 106 is pulled upwards through the inside of the outside auger 105 by means of releasing the lock device and holding the frame 159 with wire rope 180. Subsequently, the built-up concrete piles are inserted inside of the outside auger 105. The continuous rotation of the outside auger 105 eliminates trouble in the subsequent extraction of the auger, caused by tightly adhering soil surrounding the outside auger 105 to the auger screw 110.

At the time of the foregoing boring, stone and the like in the earth are forced to dig between both the inside auger 106 and the outside auger 105; thereby the augers will sometimes become incapable of rotating. In this case, said stones can be eliminated from the auger head by means of rotating motor 160 in the reverse direction.

There are further some cases when the built-up piles inserted in the boring holes are incapable of the desired loading after their founding, under certain ground conditions to affect the lower ends of said piles. For this reason, a load test is required according to the following explanations. A beam *b1* is passed through each hole 147 of both side plates 141 of the casing as shown in FIG. 9 and an oil-pressure cylinder *c1* is interposed between said beam *b1* and the upper end of the uprightly founded pile.

Next a ram *r1* is forced to proceed, and consequently pile *p* is acted upon with a force equal to the loading power which said pile should have. After the above test, as soon as the beam and the oil-pressure cylinder are taken off, the subsequent operation follows.

By means of reversely rotating the motor 134, and rotating the outside auger clockwise, soil in the boring hole is sent downwards under pressure by the screw (twist blades) 110, then filled on the periphery of the built-up piles in close contact therewith. The outside auger 105 will go up gradually by its reverse rotation. In this case, it is preferable to raise the outside auger slowly with wire rope 145, and then to bring on the screw of the outside auger the soil once extracted on the ground when the boring is carried out. When the outside auger 105 is entirely pulled out of the earth, the soil is set in close contact condition with its surrounding, resulting in the built-up piles being well founded in the earth.

75 I claim:

1. A boring machine comprising, in combination, double auger means including first and second augers, said second auger being inserted lengthwise and rotatably through the inside of said first auger, the latter including a hollow shaft provided with screws twisted in one direction on the outer periphery thereof, said second auger including a shaft provided with screws twisted in the other direction on the outer periphery thereof, tower means for raising and lowering said augers, and drive means for rotating said augers in the respective opposite directions.

2. The boring machine as defined in claim 1, wherein said hollow shaft of the first auger is provided with at least one window for extracting the soil removed during the operation of the boring machine.

3. The boring machine as defined in claim 1, further comprising a casing reciprocable by said tower means, wherein the upper portions of said augers are secured to said casing, and said drive means is disposed on said casing.

4. The boring machine as defined in claim 3, wherein said casing includes an element having a hole through which a beam is allowed to pass, selectively to receive working force added for pulling said augers out of the earth, and to perform therewith load tests on inserted piles.

5. The boring machine as defined in claim 3, wherein said second auger is adapted for being freely inserted in and extracted from said inside of the first auger.

6. The boring machine as defined in claim 5, further comprising a frame supporting said upper portion of the second auger, and lock means for detachably locking said frame to said casing.

7. The boring machine as defined in claim 6, wherein said lock means includes a mounting element fixed to said frame, a plurality of pins projecting from said mounting element, and latch means on said casing for engaging said pins.

8. The boring machine as defined in claim 3, wherein said upper portions of the augers are rotatably secured to said casing, and said drive means includes at least one motor and means for transmitting rotational forces from said motor to said augers.

9. The boring machine as defined in claim 8, wherein said second auger includes a feeding pipe running throughout said shaft thereof for introducing a fluid, the upper end of said pipe being connected to an outwardly projecting pipe to convey said fluid, whereas its lower end is open for injecting said fluid at the lower end of said second auger.

10. The boring machine as defined in claim 9, wherein said first auger includes a plurality of guide pipes for introducing reinforcing bars which are adapted to pass through the wall of said hollow shaft and being spaced equally in the circumferential direction of said wall, the upper end of said guide pipes being open for inserting said bars, and the lower ends of said guide pipes being open at the lower end of said first auger.

11. The boring machine as defined in claim 8, where in drive means includes a first motor mounted on said casing for rotation of said first auger, and a second motor mounted on said frame for rotation of said second auger.

12. The boring machine as defined in claim 11, wherein at least one of said motors is reversible.

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