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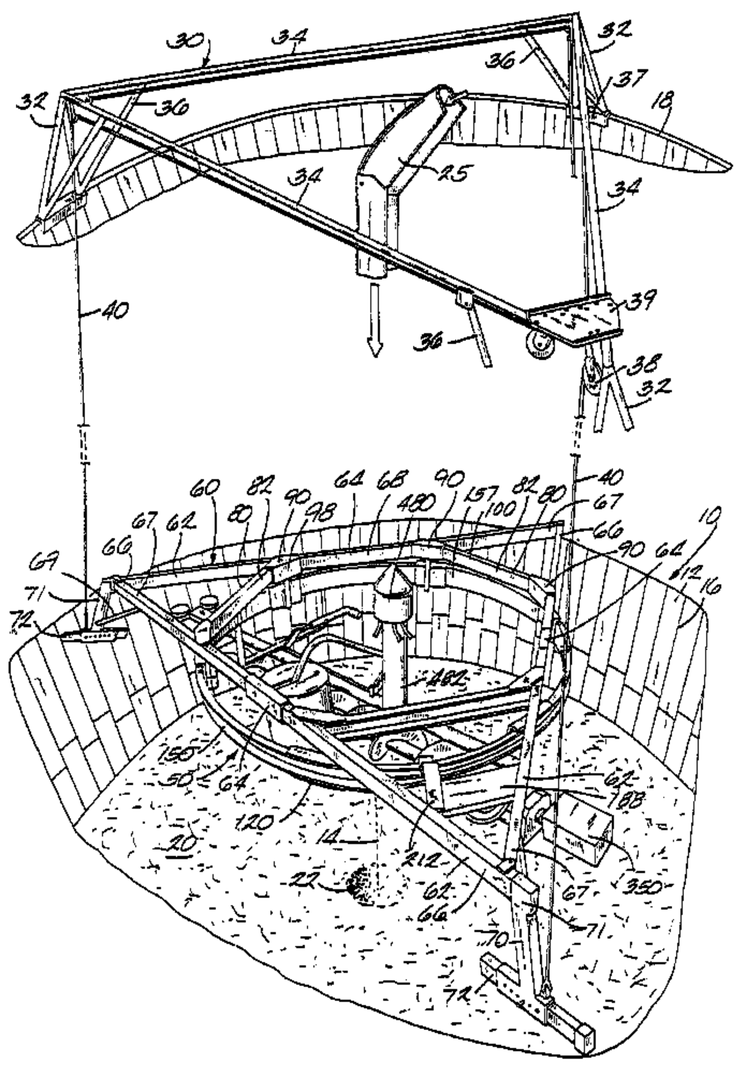
(54) **DESILEUR A DECHARGE PAR LE BAS ET A ANNEAU TOURNANT ET DISPOSITIF DE FORAGE MONTE SUR UN CHASSIS**

(54) **BOTTOM DISCHARGE, ROTATING RING DRIVE SILO UNLOADER AND FRAME MOUNTED DRILLING APPARATUS**



(57) A top loading, top unloading bottom discharge, ring drive silo unloader that is adapted for use with a hexapod suspension, and methods of its use are provided. The unloader features a stationary support frame with an open center concept. Suspended from the support frame is a rotating drive ring, and a telescoping tubular support and auger for distributing and gathering silage. The telescoping tubular support is designed to permit installation adjustment so that the silo unloader can fit into a range of silo diameters and accommodate warpage in the wall of a round shaped silo. A hole former is also secured to the tubular support. A winch assembly may be provided to raise and lower the silo unloader within the silo. Also provided is a drilling apparatus adapted for use with the suspension of the silo unloader. Where the silo unloader is already installed in the silo, the drilling apparatus can be mounted on the suspension in conjunction with the tubular support and auger of the silo unloader, and used to dislodge blockages or enlarge an existing hole through the silage. Where the silo unloader has not been installed, a drilling apparatus can be mounted on a suspension installed in a bottom unloading silo and used to drill a hole through the center of the silage, and a silo unloader with tubular support and auger, can then be mounted onto the suspension within the silo to unload the silage through the newly formed hole.

ABSTRACT

A top loading, top unloading bottom discharge, ring drive silo unloader that is adapted for use with a hexapod suspension, and methods of its use are provided. The unloader features a stationary support frame with an open center concept. Suspended from the support frame is a rotating drive ring, and a telescoping tubular support and auger for distributing and gathering silage. The telescoping tubular support is designed to permit installation adjustment so that the silo unloader can fit into a range of silo diameters and accommodate warpage in the wall of a round shaped silo. A hole former is also secured to the tubular support. A winch assembly may be provided to raise and lower the silo unloader within the silo.

Also provided is a drilling apparatus adapted for use with the suspension of the silo unloader. Where the silo unloader is already installed in the silo, the drilling apparatus can be mounted on the suspension in conjunction with the tubular support and auger of the silo unloader, and used to dislodge blockages or enlarge an existing hole through the silage. Where the silo unloader has not been installed, a drilling apparatus can be mounted on a suspension installed in a bottom unloading silo and used to drill a hole through the center of the silage, and a silo unloader with tubular support and auger, can then be mounted onto the suspension within the silo to unload the silage through the newly formed hole.

BOTTOM DISCHARGE, ROTATING RING DRIVE SILO UNLOADER AND FRAME MOUNTED DRILLING APPARATUS

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation-in-part of U.S. Patent Application Serial No. 08/997,128, now U.S. Patent No. _____.

TECHNICAL FIELD

This invention relates to a ring drive silo unloader for top loading, and top unloading bottom discharge applications.

BACKGROUND OF THE INVENTION

A main problem with silo unloaders is obtaining even distribution of silage over the top layer of the silo during filling. Silage is not a free-flowing material, and does not move easily from the center to the silo walls. In addition, the silo unloader itself is typically positioned in the center of the silo and interferes with a centrally positioned fill chute. This results in either the fill chute being positioned off center - increasing unevenness of distribution - or the need to fill under the suspended unloader from the side of the silo with a "splitter" pipe, which also gives uneven distribution.

Another problem is that the uneven distributor of silage impacts the stability of the unloader during the loading and unloading process. A greater quantity of silage may be packed into one area due to an uneven distribution or there may be an uneven distribution in the moisture content of the silage during the filing process. One side of the silo may also be exposed to more freezing and thawing which can affect the density of the silage in that area. When the auger encounters dense or hardened silage, the auger may become unstable by bouncing or raising up in the silage so that the auger cuts through the silage in an uneven manner. This poor stability also increases the need for maintenance on the machine.

Ease of operation is also a problem in bottom-discharge, ring-drive silo unloader design. The silo unloader should be easily raised and lowered in the silo and the hole former should be easily centered into the silage opening or removed from the silage

opening. The more a farmer has to enter the silo to adjust the operation of the unloader, the greater the safety risk to the farmer.

A further problem is that the silo unloader should be adaptable for use with a conventional hexapod suspension. Unloaders frequently wear out more quickly than their hexapod suspension. Installation costs naturally increase if both an unloader and the hexapod suspension need to be replaced even though the suspension is in good condition.

Manufacturing costs are also of importance in bottom unloading ring drive silo unloader design. Minimization of parts and ease of assembly are important factors to produce a productive cost effective machine. This invention is intended to solve these and other problems.

SUMMARY OF THE INVENTION

This invention relates to a top loading, top unloading bottom discharge, ring drive silo unloader that is adapted for use with a hexapod suspension.

The unloader features a stationary support frame with an open center concept. The support frame includes three main support members joined together to form a triangular frame. Three bracing members are added to the support frame to form an interior perimeter with a generally hexagon shape that delineates the open central area. A rotating drive ring is suspended from the support frame. An electric motor drives a chain loop that engages the exterior surface of the drive ring and causes it to rotate. Optionally, the unloader can also include a mechanism for variably controlling the speed of rotation of the drive ring during filling and discharge of the silage. The variable speed control can be installed or retrofitted onto the support frame of the unloader.

A gathering mechanism that includes a sub-frame with a telescoping tubular support is suspended from the rotating drive ring. An auger is suspended from the tubular support. The telescoping tubular support is designed to permit installation adjustment so that the silo unloader can fit into a range of silo diameters and accommodate warpage in the round shape of the silo wall. The tubular support and auger are pitched at an angle of about six degrees to facilitate the distribution and gathering of silage across the top layer of the silage. Optionally, the auger can include auger knives or cutting blades mounted to the flighting which help cut through the silage as the auger

rotates. The action of the cutting blades can be especially useful in hard-packed silage toward the bottom of the silo. Preferably, the cutting blades are oriented at an about perpendicular angle to the longitudinal axis of the auger.

The auger is driven by an electric motor having a drive shaft in line with the auger shaft. Power is supplied to the auger motor via a collector ring. The collector ring is mounted on a tower extending from the tubular support. A double pivoting wall wheel is secured to the end of the tubular support. A hole former is also secured to the tubular support and can be automatically power driven from a central loading position to an offset storage or unloading position. An on-board winch assembly may also be provided to raise and lower the silo unloader.

A main advantage of the rotating drive ring unloader is its substantially open center area, which permits an even flow of silage onto the top layer of silage in the silo. This enables the auger to distribute and gather the silage evenly across the top surface of the silage. The even distribution of silage promotes optimum performance of the silo unloader both during loading and unloading operations. The even distribution also improves the quality of the silage and maximizes the quantity of silage that can be stored in a given silo. The open center area design spreads the stationary support frame outwardly towards the periphery of the drive ring, and eliminates much of the sub-frame or auger support framework below the open central areas of the stationary support frame. Many components of the support frame, drive ring and sub-frame that would otherwise be in the path of travel of the silage during filling are omitted or replaced by the single telescoping tubular support.

Another advantage of the rotating ring drive silo unloader is that the telescoping tubular support and auger may be adjusted to fit the exact dimensions of the silo. During installation, a U-bolt may be loosened to permit movement of the auger towards the wall of the silo to accommodate a range of silo diameters and variances in the cylindrical shape of the silo wall.

Another advantage of the rotating ring drive silo unloader is the automation of the hole forming mechanism that moves the hole former into its hole forming position during the filling or loading operation, or into its offset or storage position during the unloading operation. This advantage is significant given the bulkiness of the hole former. The

automated hole forming mechanism also provides a means for storing the hole former during the unloading operation.

A further advantage of the rotating ring drive silo unloader is its stability during operation. The rotating ring drive system and open central area concept provides for smooth operation of the machine and reduced maintenance.

A still further advantage of the rotating ring drive silo unloader is its simplicity of design and ease of installation. A minimum number of components are necessary in this design. This reduces both manufacturing costs and installation costs.

A still further advantage of the invention is the double pivoting wall wheel. This design permits smooth operation during the loading and unloading processes and when raising and lowering the unloader in the silo.

A still further advantage of the invention is the on-board winch assembly for raising and lowering the silo unloader to facilitate ease of operation. The on-board winch can be used in a silo with either a rounded or flat roof. The on-board winch is particularly advantageous when installed in a silo with a flat roof. The on-board winch eliminates the need for a hexapod, which would have to be mounted above the roof and would detract from the appearance of the silo.

In another embodiment, the silo unloader can be modified to include a drill assembly to dislodge blockages or enlarge an existing hole through the silage. Such an unloader includes a support frame supported by cables and with an open central area, a rotatable drive ring supported by the support frame, a drive mechanism to rotate the drive ring; and a rotatable auger to move the silage relative to the center of the silo, supported by a frame connected to the drive ring. The drill assembly is releasably attached to a mount connected to the auger support frame adjacent to the auger, and hangs vertically in the silo. The auger is slid horizontally along the support frame to position the drill in the center of the silo, and the drill assembly is attached to the mount.

Where the silo unloader has not been installed, a drilling assembly can be mounted on the suspension of the unloader that is installed in a bottom unloading silo, and used to drill a hole through the center of the silage. A silo unloader with tubular support and auger can be subsequently mounted onto the suspension within the silo to unload the silage through the newly formed hole. The drilling assembly includes a

support frame supported by a plurality of cables and with an open central area, a mount attached to the support frame for releasably connecting a drill in a vertical orientation within the silo, and a drill composed of a power drive unit releasably connected to a rotatable auger drilling section.

Various auger drilling sections can be releasably attached to the drive unit of the drilling assemblies. For example, a starter section composed of an about 6-inch long auger tube with an attached 10-inch diameter, double flighting and a pointed lead portion to dislodge silage clumps, and a blade or cutting member on a leading edge of the flighting to cut an initial circular groove through the silage to help maintain the auger positioned in a straight direction through the silage. A second drilling section can be attached to the starter section, which is preferably about 10 feet long with an about 10-inch diameter double flighting mounted on at least a portion of its length. Additional auger drilling sections can be attached as needed to accomplish a hole that is open to the bottom of the silage. Such drilling sections are preferably about 6 feet long with an about a 10-inch diameter flighting.

When the first auger section reaches the bottom of the silage, the starter section can be removed and replaced by a hole widening auger drilling section, which is preferably about 16 inches long with an about 16-inch diameter flighting. The hole widening section is pulled upward to enlarge the previously bored hole, preferably to about 16 inches in width.

In another embodiment, the auger drilling section can be light-weight and abbreviated in length, and used for dislodging silage that is blocking an existing hole or for enlarging the diameter of a hole that has become too narrow. The light-weight drilling section includes a forward portion composed of an auger shaft, a short flighting about 6 inches in length with an about 6-inch diameter flighting, a removable, pointed lead portion for breaking apart and dislodging silage clogs from the hole, and retractable arms or flails that can extend perpendicular to the auger shaft to cut away silage within the hole.

As the auger drilling sections are pulled upward and out of the newly formed or enlarged hole in the silage, a drilling section is uncoupled from the drive unit and the adjacent drilling section, and removed. The drive unit is then attached to the next auger

drilling section, which is drawn up out of the hole and removed. Similarly, as the drill assembly drills downward into the silage, additional drilling sections can be added by uncoupling a drilling section from the drive unit and sandwiching in and coupling the new section to the present drilling section and the power unit.

To assist in attaching and removing drilling sections from the power drive unit, the auger tubes can include an aperture through which a rod can be inserted at an about perpendicular angle to the longitudinal axis of the auger tube. To mount additional drilling sections to the drill, the rod is inserted through the auger tube of the section connected to the power drive unit, and the auger drilling section is disconnected from the power drive unit and lowered into the hole until the rod rests on the surface of the silage. To remove drilling sections, the rod is inserted through the auger tube of a (first) drilling section hanging down into the hole, which is disconnected from the second drilling section (connected to the power drive unit) and lowered onto the surface of the silage. The second drilling section is then detached from the power drive unit and removed. The drive unit is then moved downward into the silo, attached to the (first) drilling section, and then activated to pull the first drilling section up and out of the hole. Advantageously, the rod prevents the auger drilling sections from falling downward through the hole in the silage during removal and attachment of additional drilling sections.

Other aspects and advantages of the invention will become apparent upon making reference to the specification, claims and drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of the rotating ring drive silo unloader suspended from a hexapod suspension in a silo with the hole former in a raised or offset position.

FIG. 2 is a perspective view of the silo unloader having a stationary support frame, a rotating drive ring, a telescoping tubular support and an auger.

FIG. 3 is a top view of the rotating ring drive silo unloader in a silo with the hole former in a central hole forming position.

FIG. 4 is a side plan view of the rotating ring drive silo unloader with the hole former in its central hole forming position.

FIG. 5 is a top view showing a main support member joined to a brace by a coupling, and the drive ring supported from the coupling via a drive ring support.

FIG. 6 is a sectional view of FIG. 4 taken along line 6-6 showing a coupling and a drive ring support with its associated support bracket engaging the drive ring.

FIG. 7 is a sectional view of FIG. 4 taken along line 7-7 showing the rotating drive ring, a first mount supporting the telescoping tube and a first mount supporting one end of the auger.

FIG. 8 is a side view showing a gripping finger projecting from the exterior surface of the rotating drive ring and engaging a link in the chain of the chain loop drive system.

FIG. 9 is a sectional view of FIG. 4 taken along line 9-9 showing a second mount supporting the telescoping tube.

FIG. 10 is a sectional view of FIG. 4 taken along line 10-10 showing a third mount supporting the telescoping tube, a second mount supporting a second end of the auger, and a double pivoting wall wheel assembly.

FIG. 11 is a perspective view showing a first embodiment of the stationary support frame for a 24 to 28 foot diameter silo.

FIG. 12 is an exploded, perspective view of the stationary support frame of FIG. 11.

FIG. 13 is an exploded, perspective view showing a second embodiment of the stationary support frame for a 20 to 22 foot diameter silo.

FIG. 14 is a perspective view showing the stationary support frame of FIG. 11 with high-lift legs and an on-board winch assembly.

FIG. 15 is a partial, exploded, perspective view showing a portion of the stationary support frame of FIG. 13 with high-lift legs and the on-board winch.

FIG. 16 is an elevated, cutaway view showing the automated mechanism for raising and lowering the hole former when the hole former is in its central hole forming position.

FIG. 17 is an elevated view showing the automated hole forming mechanism with the hole former in its central hole forming position when the silo unloader has been raised.

FIG. 18 is an elevated view showing the automated hole forming mechanism raised into an offset position.

FIG. 19 is a top cutaway view showing the automated hole forming mechanism with the hole former and its central hole forming position, and the linear actuator secured to the second mount for the telescoping tube.

FIG. 20 is a perspective view of an embodiment of the silo unloader having a variable speed ring drive control box attached to a support member.

FIG. 21 is an exploded view of the mounting of the variable speed ring drive control box shown in FIG. 20.

FIG. 22 is a side view of the variable speed ring drive control box shown in FIG. 20, attached to a support member.

FIG. 23 is front view of an embodiment of a flighting having knife blades attached thereto.

FIG. 24 is a side view of a portion of the flighting and knife blades as shown in FIG. 23.

FIG. 25 is a side view of an embodiment of an auger with the flighting and knife blades as shown in FIG. 24, inserted into silage.

FIG. 26 is a perspective view of the silo unloader, without an attached auger assembly, with a drilling apparatus mounted to the support frame.

FIG. 27 is an exploded view of the drilling apparatus of FIG. 26.

FIG. 28 is a side elevational view of the drilling apparatus of FIG. 26, installed in a bottom unloading silo, with the end of the drilling auger at the bottom portion of the silo feed in a hole-forming operation.

FIG. 29 is an elevational view of a portion of the drilling apparatus of FIG. 28.

FIG. 30 is a side view of the drilling apparatus of FIG. 28, with a hole widening attachment mounted to the drilling apparatus to enlarge the hole as the drilling apparatus is drawn upward.

FIG. 31 is a side view of a drilling apparatus with a drill rod inserted through the auger tube of an auger section.

FIG. 32 is a side view of the drilling apparatus of FIG. 31, with the drill rod resting on the surface of the silage.

FIG. 33 is a perspective view of a silo unloader with an attached auger assembly, and a drilling apparatus mounted to the auger support tube.

FIG. 34 is a top view of the silo unloader of FIG. 33, having the auger support tube mounted in its center position.

FIG. 35 is a top view of the silo unloader of FIG. 33, with the auger support tube mounted in an offset position.

FIG. 36 is partial perspective view of the drilling apparatus of FIG. 33, mounted to the auger support tube.

FIG. 37 is a side view of a portion of the drilling apparatus of FIG. 36, taken along line 37-37.

FIG. 38 is an elevational view of an embodiment of the drilling apparatus having moveable flails and an abbreviated starter portion.

FIG. 39 is a top view of the flails of the drilling apparatus of FIG. 38 taken along line 39-39.

DETAILED DESCRIPTION

While this invention is susceptible of embodiments in many different forms, the drawings show and the specification describes in detail a preferred embodiment of the invention. It should be understood that the disclosure is to be considered an exemplification of the principles of the invention. It is not intended to limit the broad aspects of the invention to the embodiment illustrated.

FIGS. 1-4 show a silo 10 having a substantially cylindrical wall 12 with an interior surface 16 and a top end 18. The silo has a center or center line denoted by reference number 14. Silage 20 partially fills the silo 10 to a top layer. A hole 22 is formed in the center 14 of the silage 20. The silage 20 enters the silo via a fill chute 25 which is positioned to distribute the silage over the center 14 of the silo 10. A preferred embodiment of the rotating ring drive silo unloader is denoted by reference number 50. During the loading process, the silo unloader 50 distributes the silage 20 evenly over its top layer. During the unloading process, the silo unloader 50 removes the top layer of silage 20, draws it toward the center 14 of the silo 10, and discharges it through the hole 22 to the bottom of the silo.

A commercially available hexapod suspension pod 30 is mounted to the top end 18 of the silo 10 as shown in **FIG. 1**. The hexapod 30 includes three sets of risers 32. Each riser comprises two upwardly projecting legs spaced apart at their base ends and joined together at their top ends. The hexapod 30 includes three main suspension arms 34 joined together in a triangular shape. Each riser 32 supports a corner of the triangle formed by one end of two separate main suspension arms 34. A brace 36 connects each of the main suspension arms 34 to a base plate 37 of each of the risers 32. The base plate 37 joins the base ends of the legs of its respective riser 32, and mounts the riser to the top end 18 of the silo wall 12. The main suspension arms 34 form an equilateral triangle that is substantially horizontally aligned in the silo 10. The hexapod suspension includes three sheaves 38. Each sheave 38 is located proximal one of the risers 32 near the silo wall 12. A stiffening plate 39 is located near the main riser or main leg. A separate cable 40 is trained over each of the sheaves 38 to raise and lower the silo unloader 50. The three cables 40 may be joined to form a 3 to 1 cable system (not shown) for raising and lowing the silo unloader 50 via an external winch assembly (not shown) that is mounted on the outside surface of the silo wall 12. While the silo unloader 50 is shown and described to be supported by cables 40, it would be obvious to one of ordinary skill in the art to substitute chains, ropes, etc. for the cables.

The silo unloader 50 includes a substantially stationary support frame 60 having three main support members 62. Each main support member 62 includes a middle portion 64, and first and second ends 66 and 67. The middle portion 64 of each main support member 62 has a rectangular cross-sectional shape. As best shown in FIGS. 12 and 13, the first and second ends 66 and 67 are preferably channels having inwardly facing U-shaped cross-sectional shapes. Each end 66 and 67 has a tubular portion 66a or 67a at its inner end. The tubular portions 66a and 67a form the middle portion 64. The first and second ends 66 and 67 are rigidly fixed to their respective middle portion 64 by a solid connector. The middle portion 64 formed by tubular ends 66a and 67a have an interior surface 68. The three main support members 62 form a triangular configuration that is of substantially the same size as the triangle formed by the main suspension arms 34 of the hexapod suspension 30. The triangle formed by the main support members 62 is substantially horizontally aligned in the silo. While the support frame 60 is referred to

as being "substantially stationary" or "substantially rotationally stationary," it should be understood that the support frame is selectively raised and lowered in the silo 10 by the cables 40, and that the support frame may rotate a small amount about the center 14 of the silo given that the support frame is slightly smaller in overall size than the diameter of the silo wall 12. This smaller overall size helps prevent the support frame 60 from binding against the silo wall 12 when it is raised or lowered in the silo 10.

FIGS. 11 and 12 show the support frame 60 for a silo unloader intended for a 24 to 28 foot diameter silo 10. The support frame 60 has high-lift legs 70 secured directly to the first end 66 of each main support member 62. The high-lift legs 70 include telescoping arms or extendible members 71 and 72, and an offset leg 73. The extendible members 71 and 72 can be extended or retracted to accommodate a range of silo diameters or warpage in the silo wall 12. Arm 72 has a bumper 74 at its distal end for engaging the interior surface 16 of the silo wall 12 to help prevent rotation of the stationary support frame 60 during use. The upper telescoping member 71 is sized to be matingly received by the first end 66 of main support member. The lower telescoping member 72 is sized to be matingly received in a horizontal, tubular portion of offset leg 73. The telescoping members 71 and 72 are extended to accommodate the particular diameter and shape of a given silo 10. The second end 67 of each main support member 62 is secured near the first end 66 of an adjacent support member. A brace 69 joins each high-lift leg 70 of one main support member 62 with the second end 67 of its adjacent main support member. As shown in **FIG. 1**, the main support members 62 of the stationary support frame 60 are aligned substantially directly beneath the main suspension arms 34 of the hexapod suspension 30. Similarly, the corners of the triangle formed by the main support members 62 are aligned substantially directly beneath the corners of the triangle formed by the main suspension arms 34 of the hexapod suspension 30.

FIGS. 13 and 15 show the support frame 60 for a silo unloader intended for a 20 to 22 foot diameter silo 10. The support frame 60 has main support members 62 with shorter first and second ends 66 and 67 so that adjacent ends do not directly connect to each other. Upper and lower brackets 76 and 77 join adjacent ends 66 and 67 together. A sleeve 78 is secured between upper and lower brackets 76 and 77 for receiving the

upper telescoping member 71 of the high-lift leg 70. In spite of the shortening of the first and second ends 66 and 67, the three main support members 62 form a partial triangular configuration that is of substantially the same size as the triangular configuration formed by the main suspension arms 34 of the hexapod suspension 30.

The stationary support frame 60 includes three braces 80 as shown in **FIGS. 11-15**. Each brace 80 has one end secured between the middle 64 and an end 66 or 67 of one main support member 62, and another end secured between the middle and an end of an adjacent main support member. A coupling 90 is used to form the connection between the end of each brace 80 and the main support member 62. Each brace 80 has an interior surface 82. As best shown in **FIGS. 5, 6, 12 and 13**, each coupling 90 has a middle web 92, an upper flange 94, and a lower flange 96. The middle web 92 includes an interior surface 98. The interior surfaces 68, 82 and 98 of the main support members, braces, and couplings, form an interior perimeter 100 of the stationary support frame 60. The interior perimeter 100 forms or delineates an open central area 102 through which silage 20 can pass in a substantial unobstructed manner.

An on-board winch assembly 45 can be included as in **FIGS. 14 and 15**. The on-board winch assembly 45 includes a hoist with a drum 46 secured to one of the braces 80 of the stationary support frame 60. The winch assembly 45 also includes a pulley system having a number of sheaves 47 and 75 for guiding the cables 40 from the hexapod suspension 30 to the drum 46 of the hoist. The pulley system includes directional sheaves 47 positioned to guide the cables 40 from the end and along the length of the main support members 62 to the drum 46. The directional sheaves 47 are secured to the main support members 62 or an additional mounting plate 48. When the support frame 60 includes high-lift legs 70, the pulley system includes several sets of upper and lower sheaves 75 secured to the upper and lower ends or brackets of each high-lift leg 70. The upper and lower sheaves 75 are position to guide the cables 40 along the contours of the high-lift legs 70. A clean-off brush (not shown) may be located just prior to the drum 46 of the hoist. The on-board winch assembly 45 is used to receive and deploy the cables 40 to and from the drum to raise and lower the silo unloader 50 in the silo 10. Each cable 40 is deployed near an end 66 of one of the main support members 62. Although the on-board winch assembly 45 can be used in conjunction with a hexapod suspension 30, it

should be understood that the on-board winch assembly can also be used without a hexapod suspension by anchoring the cables 40 to the interior surface 16 near the top end 18 of the silo wall 12.

As best shown in **FIGS. 5 and 6,** a separate drive ring support 120 is suspended from each of the six couplings 90. Each drive ring support 120 includes a mounting tube 122 having a first end 124 and a second end 126. The first end 124 of each mounting tube 122 is rigidly secured to the interior surface 98 of each coupling 90. Upper and lower mounting plates 128 and 129 are rigidly secured to and project outwardly from support a bracket 130. Each support bracket 130 is formed by a U-shaped channel having a middle web 132, an upper flange 134 and a lower flange 135. The upper flange 134 is rigidly secured to the upper mounting plate 128, and the lower flange 135 is rigidly secured to the lower mounting plate 129. The middle web 132 has an arcuate shape with a radius similar to that of the drive ring 150. Upper and lower plates 128 and 129 have a hole for pivotally securing the bracket 130 to the second end 126 of mounting tube 122. Upper and lower pins are used to hold plates 128 and 129 and bracket 130 in place.

Upper and lower friction reducing liners 140 are bolted inside each U-shaped support bracket 130. Each friction reducing liner 140 is L-shaped and sized to be matingly received inside its respective bracket 130. Each friction reducing liner 140 can be formed by two separate pieces of friction reducing material. Each friction reducing liner 140 includes a middle portion 142, an upper portion 144 or a lower portion 145. The middle portion 142 is secured against the middle web 132 of the support bracket 130. The lower portion 145 of the lower liner 140 abuts the lower flange 135 of the support bracket 130. The upper portion 144 of the upper liner 140 abuts the upper flange 134 of the support bracket 130.

The drive ring 150 rests on the lower portion 145 of the friction reducing liner 140 inside each support bracket 130. The drive ring 150 is formed by an outwardly facing U-shaped channel having a middle web 152 with an out surface 153, an upper flange 154 and a lower flange 155 projecting from the outer surface 153. The middle web 152 of the drive ring 150 has an interior surface 156. The interior surface 156 of the drive ring 150 combines with other components such as the drive ring supports 120 and support brackets 130 to form an interior periphery 157 of the drive ring. The inside

surface 156 of the drive ring 150 forms the majority of the interior periphery 157. The interior periphery 157 forms or delineates an open middle area 159 through which silage 20 can pass in a substantially unobstructed manner. The drive ring 150 has a normal axis 158 about which it rotates via sliding engagement with friction liner 140. The normal axis 158 passes through the open middle area 159 delineated by the interior surface 156 of the drive ring 150. The drive ring 150 is aligned in substantially horizontal relationship to the stationary support frame 60, and the open middle area 159 of the drive ring is aligned substantially directly beneath the open central area 102 of the stationary support frame. As best shown in **FIG. 2**, the ring 150 may be divided into several segments and joined together via splicing plates. The drive ring 150 also includes a number of gripping fingers 160 shown in **FIG. 8** for gripping a drive chain 200 as discussed below. The drive ring 150 is formed from a seven gauge steel channel with a middle web 152 having a height of nine inches, and upper and lower flanges 154 and 155 having a length of one and three quarter inches. The inside diameter of the ring on a 20 to 28 foot unloader is ten feet ten inches. The inside diameter of the ring of a 30 foot unloader is sixteen feet six inches.

A drive ring motor 180 is suspended from support frames 60. The drive ring motor 180 includes a gearbox 182 and a drive shaft 184. A sprocket 186 is secured to the end of the drive shaft 184. The motor 180 and gear box 182 are secured to a platform 188 mounted to a portion of the support frame 60 located outside of the interior perimeter 100 and open central area 102. The drive ring motor 180 is one-half horsepower. The gear box 182 has a 500 to 1 gear reduction ratio with an oil level sight glass, a one inch diameter output shaft, cast iron construction, and double oil seals on input and output shafts. The sprocket is sized to accommodate seventeen teeth. As shown in **FIG. 15**, the platform 188 for the drive ring motor 180 also serves as the lower bracket 77 of the high-lift leg assembly on 20 to 22 foot silo unloaders.

In an alternative embodiment as shown in **FIG. 20**, a variable speed control 600 can be installed or retrofitted onto the support frame 60 to control the speed of the drive ring 150 during filling and discharge of the silage. This feature allows the user, for example, to speed up the drive ring 150 when filling the silo with silage, and to slow

down the drive ring 150 when unloading the packed silage. For ease of operation, the range of speed can be indicated on the control knob 614.

The control box 602 for the variable speed control 600 can be mounted on the support frame 60, as shown in **FIG. 20**. As shown in **FIGS. 21 and 22**, the control box 602 can be installed by mounting the box 602 to a support bracket 604 with nut and bolt assemblies 606, as shown, and mounting the support bracket 604 to the suspension arm 62 with bolt and nut assemblies 607 through apertures 608, 609 in the return portion 610 of the support bracket 604 and the first side of the suspension arm 62, respectively. The control box 602 is equipped with a heater (not shown) to facilitate operation under cold weather conditions.

In use, the speed of the variable speed control 600 can be adjusted for optimum performance. If the silage is hard-packed or frozen, a lower speed is desired to prevent stressing and bouncing of the auger 400 on the surface of the silage. If the silage is building up above the auger main tubular support 300 and the auger 400 is continuously advancing, a higher speed is desired to increase the speed of the drive ring 150 within the filling range and complete the filling process on a more efficient and timely basis. In the case where the filling process is slower and the auger 400 is being advanced a short distance (i.e., about three feet), then stopped for the addition of more silage, then a lower speed is desired to accommodate the slower rate of fill.

Referring now to **FIGS. 3 and 4**, the chain 200 forms a loop that engages the exterior surface of the middle web portion 152 of drive ring 150. The chain loop 200 is of sufficient length to encompass the outer surface 153 of the drive ring 150 and engage the sprocket 186 of the drive ring motor 180. The chain 200 is formed by a plurality of links 202 having open interiors 204. The chain 200 is preferably a CA550 implement roller chain, having an average ultimate strength of 11,250 pounds pull. The drive ring motor 180 turns sprocket 186 to move the chain 200 in a clockwise path of travel 205, as shown in FIG. 4. The open interior 204 of the chain links 202 engage the gripping fingers 160 of the drive ring 150. This engagement transmits the force necessary to move the drive ring in the path of travel 205 of the chain 200, thereby rotating the drive ring around its normal axis 158.

As best shown in **FIG. 3**, a compression spring and roller type chain tightener 210 is provided to provide tension to and eliminate slack from the chain 200. The chain tightener 210 is supported from platform 212, as shown in **FIG. 1**. A pair of cone shaped guides 162 are rigidly secured to the drive ring for guiding the chain 200 into engagement with the gripping fingers 160 of the drive ring 150, as shown in **FIGS. 8 and 9**. One guide 162 is positioned above and one guide is positioned below the gripping fingers 160.

The rotating ring drive silo unloader 50 supports a gathering mechanism 240 having a gathering mechanism support frame 245, as shown in **FIG. 4**. The support frame 245 includes first, second and third tube mounts 250, 260 and 270 for supporting a telescoping tubular support 300. **FIG. 7** shows the first tube mount 250 secured to the exterior surface of the middle web 152 of the rotating drive ring 150. The first mount 250 includes two spaced-apart brackets 252 secured to the drive ring 150. Each bracket includes an outwardly extending portion 253 and a downwardly extending portion 254. The downwardly extending portions 254 are joined by a channel 256. Mounting plates 258 are secured to the middle of channel 256.

FIG. 9 shows the second tube mount 260 secured to the rotating drive ring 150. The second tube mount 260 is positioned diametrically opposite from the first tube mount 250. Again, the second tube mount is secured to the exterior surface of middle web 152. The second tube mount 260 includes two spaced apart brackets 262. Each bracket 262 includes an outwardly extending portion 263 and a downwardly extending portion 264. The downwardly extending portions 264 are joined by a channel 266. Mounting plates 268 are secured to the middle portion of channel 266.

FIG. 10 shows a third tube mount supporting the telescoping tubular support 300. The third tube mount 270 includes a mounting bracket 272 secured to the tubular support 300. A pair of end braces 275 join bracket 272 to the downwardly extending portions 264 of second tube mount 260.

Telescoping tubular support or main tubular support 300 is composed of a fixed tubular member 302 and a telescoping tubular member 312. The fixed tube 302 has an outside diameter of about six inches. The telescoping tube 312 has an outside diameter of about five and a half inches. The fixed tubular member 302 includes a first end 303, a

second end 304 and an exterior surface 307. The telescoping tubular member 312 includes a first end 314, a second end 316 and an exterior surface 318. The first end 314 of the telescoping tubular member 312 is matingly received into the second end 304 of the fixed tubular member 302. As shown in **FIGS. 2 and 4**, the first end 303 of the fixed tube 302 is supported by the first tube mount 250. The middle of fixed tube 302 is supported by the second tube mount 260. The second end 304 of fixed tube 302 is supported by third tube mount 270. The telescoping tubular member 312 is cantilevered from and supported by the second end 304 of the fixed tubular member 302. However, it should be understood that it is possible to support the telescoping tubular portion 312 by the third tube mount 270 as shown in **FIG. 3**. In this embodiment, the third tube mount 270 is positioned at the second end 316 of the telescoping tubular portion 312. The telescoping tubular support 300 is pitched a predetermined angle of about six degrees 320 so that the first end 303 of the tubular support is above the second end 316. This is accomplished by lengthening the downwardly extending portions 264 of second tube mount 260 and the end braces 275 of the third tube mount 270.

An auger support frame including first and second auger mounts 330 and 370 is used to rotatably support auger 400. As shown in **FIG. 7**, the first auger mount 330 is located substantially directly beneath the first tube mount 250. The first auger mount 330 includes a plate 332 clamped to the lower side of the first end 303 of tubular support 300. A motor support frame 336 abuts plate 332. The motor support frame 336 includes an upper portion 338 with an upper plate 340, and a lower portion 342 with a lower plate 344. The upper and lower portions 338 and 342 are pivotally joined to allow adjustment of auger motor 350. A clamp or U-bolt 346 is secured around the first end 303 of tubular support 300 with its legs extending through plate 332 and the upper plate 340 of motor support frame 336. Locking nuts 348 securely fasten the motor support frame 336 to the tubular support 300. The locking nuts 348 can be loosened to release the clamping engagement of mount 330 and plate 332 to the first end 303 of the fixed tubular support 302.

As best shown in **FIGS. 4 and 7**, the auger motor 350 is secured inside motor support frame 336. The auger motor 350 includes a drive shaft 351 and gearbox 354. The gearbox is fastened to the lower plate 344 of motor support frame 336. Auger motor

350 is preferably a ten-horse power "C" face motor. The motor 350 is directly coupled to the 16 to 1 ratio in line helical gear box 354. The gearbox 354 is directly coupled to the auger by 4 five-eighths diameter inch bolts. The output shaft 352 of the gearbox 354 is preferably one and three quarter inches in diameter. A pressure wheel 360 may be secured to the first auger mount 330, as shown in **FIG. 3**. This is accomplished by securing a pressure wheel support 362 to the upper portion 338 of motor support frame 336, as shown in **FIG.** 7.

Second auger mount 370 is best shown in **FIG. 10**. Second auger mount 370 is formed by a mounting bracket 372 welded to the lower exterior portion of telescoping tubular member 312 near end 304. A bearing support flange 374 is bolted to mounting bracket 372. Bearing support flange 374 supports a bearing (not shown) that supports auger 400. The bearing is preferably a one and three eighths diameter inch greasable sleeve bearing.

As shown in **FIGS. 4 and 10**, auger 400 includes a tubular auger shaft 402 having a longitudinal axis 403 about which the auger rotates. The auger 400 has a first end 404, a second end 406 and an exterior surface 407. The first end 404 of auger 400 is secured to the drive shaft 352 of the gearbox 354 of auger motor 350. The second end 406 of auger 400 includes a mounting shaft (not shown). The mounting shaft is secured in the bearing supported by bearing support flange 374. The auger mounts 330 and 370 support the ends of the auger 400 about the same distance from the telescoping tubular support 300 so that the auger shaft 402 is substantially parallel to the tubular support 300. Accordingly, the auger 400 is also pitched downwardly a predetermined angle of about six degrees so that the first end 404 of the auger is above the second end 406.

The auger has helical flighting 410 for moving the silage relative to the center 14 of the silo 10. The auger flighting 410 can include auger knives, as discussed in greater detail below, such as those made of ten-gauge 1045 hardened steel. The auger has a total diameter of twenty inches. Auger shaft 402 has a diameter of six inches on 20 to 30 foot diameter silos. Sectional helical flighting 410 is one quarter inch thick near the silo wall 12, and five sixteenths inch thick helicoid flighting for the remainder of the auger. It should be noted that auger mounts 330 and 370 may be constructed to offset the longitudinal axis 403 of the auger shaft 402 in front of the longitudinal axis 301 of the

tubular support 300. This offset positions the auger 400 in front of the tubular support 300, and prevents the tubular support from coming in contact with the silage 20 before the auger as the gathering mechanism 240 rotates clockwise around the normal axis 158 of the drive ring 150. As shown in **FIGS. 2-4**, chipper wheel 430 is secured to the second end 406 of auger 400. Chipper wheel 430 includes six blades 432. The chipper wheel 430 has a ten-inch diameter and is mounted on a one and three eighth inches diameter shaft.

As the auger rotates, it digs out portions of silage 20, but this cutting action can be difficult in hard-packed silage. In that case, it is desirable to employ an auger 630 such as that shown in **FIG. 23**, having auger knives or cutting blades 640 that are mounted to the flighting 410. The cutting blades 640 facilitate an effective cutting action through silage 20 that is hard-packed, particularly silage in the lower portion and bottom of the silo.

As shown in **FIG. 23**, the cutting blades 640 include a triangular main portion 650 that extends from a rectangular-shaped attachment leg 642 having bores 644. The triangular main portion 650 includes a flat head portion 652 for structural strength, and the edges 653 are sharpened to provide ease of cutting through hard-packed silage. The attachment leg 642 can be mounted to the auger flighting 410 by attachment means such as bolt and nut assemblies 646, onto corresponding holes 649 punched in the auger flighting 410. The cutting blades 640 can be easily unbolted during filling if desired.

As depicted in **FIG. 25**, the cutting blades 640 are mounted with the triangular main portion 650 of the blade 640 positioned at a perpendicular angle to the longitudinal axis 403 of the auger shaft 402. As shown in **FIG. 24**, blade 640 includes an extension portion 654, from the attachment leg 642 to a base portion 656 of the triangular main portion 650. The extension portion 654 positions the cutting blade 640 on the flighting 410 such that the cutting action of the blade 640 is maintained perpendicular to the longitudinal axis 403 of the auger shaft 402. Preferably, four cutting blades 640 are positioned per pitch, or approximately every five inches laterally along the auger shaft 402.

With the use of cutting blades 640, the blades 640 will enter the silage 20 at an approximately 90° angle to the longitudinal axis 403 of the auger shaft 402 **(FIG. 25)**.

The cutting blades 640, rather than the auger blade flighting 410, cut into the hard-packed silage 20 first and, as the auger shaft 402 rotates, the adjacent section of flighting 410 can then push the chopped-up silage along toward the hole 22. This cutting action of the blades 640 helps control bouncing of the auger as it moves along the surface of the silage, and also helps prevent the silage 20 from carrying over the auger 400 as the auger rotates.

Referring now to **FIGS. 2, 4 and 10**, a double pivoting wall wheel assembly 450 is mounted to the second end 316 of telescoping tubular member 312. A mounting bracket 452 is welded to the upper exterior surface of second end 316. A pivot bar 454 is secured to mounting bracket 452. Pivot bar 454 includes a middle 455, a first end 456 and a second end 457. The middle portion 455 is pivotally secured to the mounting bracket 452 via a pivot pin 458. A right pivot block 460 is pivotally secured to the first end 456 of pivot bar 454. A left pivot block 462 is pivotally secured to the second end 457. Wall wheels 465 and 466 are located on opposed sides of and rotatably secured to right pivot block 460 via an axle. Wall wheels 467 and 468 are located on opposite sides of and rotatably secured to left pivot block 462 via a separate axle.

As shown in **FIGS. 1-4**, a collector ring 480 is secured to fixed tubular member 302. The collector ring 480 is mounted atop a tower 482, which is bolted to fixed tubular member 302 of the main tubular support 300. The collector ring 480 is surrounded by a housing 484 having a cone shaped hood. The collector ring 480 is offset from the center 14 of silo 10 a distance of about nine inches to permit a more even distribution of the silage 20 during filling of the silo. The collector ring 480 is positioned at an elevation approximately even with the main support members 62 of the stationary support frame 60. The collector ring 480 is further supported by telescoping support 490. One end of the telescoping support 490 is secured to a brace 80 of stationary support frame 60. Electrical power is received by the collector ring 480 from non-rotating electrical input line 492. Electrical power is transmitted to the auger motor 350 via electrical output line 494. Although the collector ring 480 is shown and described to be mounted atop the tower 482, it should be understood that the collector ring can take the form of a conductive ring (not shown) attached to and extending around the drive ring 150. Electrical power could then be supplied to the auger motor 350 via electrical contacts mounted on the drive ring supports 120.

As shown in **FIGS. 16-19**, the silo unloader 50 includes a hole forming assembly 500. This assembly includes hole former 502 which is secured to one end of a rotating arm 504. Rotating arm 504 is robustly sized to support hole former 502 and is arcuately shaped to avoid contacting or interfering with the auger 400. The hole former 502 is secured to rotating arm 504 by first pivoting joint 506. The opposite end of rotating arm 504 is secured to the upper portion of fixed tubular member 302 via mount 508. Rotating arm 504 is secured to a spacing axle 516 via a second pivoting joint 510. Spacing axle 516 is secured to a torque arm 518. A ball screw linear actuator 520 engages torque arm 518 such that electric motor 522 can cause rotation of torque arm 518 and spacing axle 516. Rotation of spacing axle 516 in turn causes rotating arm 504 and hole former 502 to move along a path of travel 515 from a central hole forming position 512 to an offset position 514. Pivoting joints 506 and 510 enable the hole former 502 to hang substantially vertically when in the hole forming and offset positions 512 and 514.

In the use of the silo unloader 50 to unload silage 20 (**FIG. 1**), the auger 150 pushes the chopped-up silage along the surface and into the vertically formed hole 22 through the center 14 of the silage 20, the hole 22 having been formed by the hole former 502 as the silo is filled with silage. Thus, the use of the silo unloader 50 to unload silage requires it to be initially installed in an empty silo, and then the silage loaded into the silo.

In silos that do not have the silo unloader 50 installed, and are full or partially full of silage, a drilling apparatus 700, as shown in **FIGS. 26-30**, can be used to drill a hole through the center of the silage. To install drilling apparatus 700 in the silo, access to the center area of the packed silage at the base 730 of the silo is required. Such access is typically found in a bottom unloading silo, but can also be provided, for example, by drilling a horizontal tunnel through the bottom portion of the packed silage near the base of the silo (not shown).

The drilling apparatus 700 utilizing auger drilling sections 701, can be used to drill a vertical hole 22 through the center 14 of the silage 20, and the silo unloader 50 can then be installed in the silo to unload the packed silage through the newly formed hole 22. Referring to **FIGS. 26 and 28**, the framework of the silo unloader (50) including the support frame 60 is installed in the silo, and the drilling apparatus 700 is then mounted to

that framework such that the drilling apparatus 700 is in a vertical orientation with the silo.

As shown in **FIGS. 26 and 27**, an assembly 703 composed of suspension arms 704 are used to mount the drilling apparatus 700 to the braces 80 of the support frame 60. The suspension arms 704 are preferably made from rectangular steel tubing about 2 inches wide by 5 inches high by 78 inches long, that are bolted together to form a triangular area 705, preferably about 28 inches on each side. The remaining length of each suspension arm 704 extends to and is mounted on a brace 80 of the support frame 60. A steel plate 706 having a center aperture 707 is fastened onto the suspension arms 704 within the triangular area 705. The power drive unit 702, which includes a motor 708 and gearbox 710, are mounted onto the plate 706, as best seen in **FIG. 27**. The support frame 60 positions the drive unit 702 on or about the vertical center 14 of the silo, and also serves to raise and lower the drive unit 702 by means of the silo unloader winch assembly 45 (**FIGS. 14 and 15**).

In use of the drilling apparatus 700, with the power drive unit 702 mounted, the support frame 60 is raised and the auger drilling sections are attached. Preferably, a first auger section 726, as best depicted in **FIG. 29**, is attached to an auger section 727, which is, in turn, attached to the power drive unit 702. The drive unit 702 is started and, as the silo unloader support frame 60 is lowered, the first auger section 726 bores an initial hole 22 through the silage 20. When the support frame 60 is lowered about five feet, the drive unit 702 is uncoupled from the auger sections 726/727, the support frame 60 is raised, and one end of an auger drilling section 701 is coupled to the auger section 727, and the other end to the drive unit 702. The drive unit 702 is again started, and boring of the hole 22 recommences. This operation is continued and additional auger sections 701 are added as needed to provide a hole 22 that is open to the bottom 728 of the silage 20, as depicted in **FIG. 28**.

As shown in **FIG. 29**, the first auger section 726 is removably attached to the auger drilling section 727 through a coupling member 746. The starter section 726 is preferably about 6 inches in diameter and about 3 feet long, and composed of an auger tube 732, preferably with an about 2 3/8-inch outer diameter, with a double, 6-inch diameter flighting 734. The starter section 726 preferably includes pointed lead portion

735, and side-cutting, triangular-shaped members 736 mounted to the leading edge of the flighting 734. The pointed lead portion 735 guides and starts the auger in a straight line into the silage and, as the first auger section 726 rotates, the side-cutting members 736 cut a circular groove through the silage around the center point of the lead portion 735, and the auger section 726 follows. This helps the first auger section 726 to go straight through the silage and cut the hole 22 through the center 14. This, in turn, helps maintain the auger sections 727, 701 in a vertical position to drill a vertical and straight hole 22.

The auger drilling section 727 is preferably about 10 feet long, with an about 4-inch diameter auger tube 737 and an about 10-inch diameter flighting 738. As shown, the first portion 739 of the auger section 727 is double-flighted. Holes (not shown) can be punched in the flighting 734, 738 of the starter section 726 and the drilling section 727, respectively, to allow the addition of cutting blades 740, which preferably extend about one inch beyond the edge of the flighting. The use of cutting blades 740 helps dig out hard-packed silage while enlarging the drilling hole 22 to a diameter that is larger than the diameter of the auger sections 701 that are added to the drilling apparatus 700, so that the auger drilling sections 701 do not bind in the hole.

Additional auger drilling sections 701 that are attached to the drilling apparatus, are preferably about 6 feet long with an auger tube 742 of an about 4-inch diameter and about an 8-10 inch diameter flighting 744. Inserted into an end of each auger section 701, 726, 727, is a coupling member 746. The coupling members 746 are generally constructed to closely fit the inside diameter of the auger tube. The coupling member 746 is connected to the auger tube by bolts or other connecting member to provide a rigid connection between adjacent auger sections to ensure that the auger sections drill a straight hole 22 through the silage 20.

As shown in **FIG. 28**, at the base 730 of a typical bottom-unloading silo, an access tunnel 747 extends to the center 14 of the silo. When the first auger section 726 reaches the access tunnel 747 at the bottom section 728 of the silage, the first auger section 726 can be removed and replaced by a hole widening section 750, as depicted in **FIG. 30**. Preferably, the hole widening section 750 is composed of an about 16-20 inch long and 4-inch diameter auger tube 752 with an attached 16-20 inch diameter flighting 754. Once attached, the drive unit 702 is started, and the silo unloader support frame 60

is raised in the direction of arrow "X", which pulls the hole widening section 750 upward through the previously bored hole 22, enlarging the hole from about 10 inches to the desired diameter, preferably about 16 inches.

As the auger drilling sections 701 are pulled upward and out of the hole 22, the sections are uncoupled from the drive unit 702 and the adjacent drilling section 701, and removed. The drive unit 702 is then attached to the next auger drilling section which is drawn up out of the hole 22 and likewise removed. As depicted in **FIGS. 31 and 32**, to facilitate removal of the auger sections, a drill or holding rod 950 is inserted through an aperture 952 in the auger tube 742 and the coupling member 746 of the auger drilling section 701b remaining in the hole 22, such that the rod 950 is at an about perpendicular angle to the longitudinal axis 703 of the auger tube 742. The auger drilling section 701b is then lowered until the drill rod 950 rests on the top of the silage layer 20, as shown in **FIG. 32**, and the preceding auger drilling section 701a is uncoupled from both drilling section 701b and the power drive unit (not shown), and removed. The insertion of the drill rod 950 prevents the auger drilling sections 701b from sliding back down the hole 22 as the preceding drilling section 701a is uncoupled and removed. Preferably, the drill rod 950 is about 4 feet in length, and the aperture 952 in the auger tube 742 is about 1-inch in diameter and about 30-36 inches from the splice.

Upon pulling the auger drilling sections 701 and hole widening section 750 upward through the bored hole 22, when the last auger section is removed, an about 16-inch diameter hole 22 is formed at the center 14 of the silage 20, such that the silage can readily drop through the hole 22 to a conveyor (not shown) installed in the access area 747 below. If the drilling apparatus 700 has been mounted with suspension arms 704, the drilling apparatus 700 and suspension arms 704 can be removed, and the remainder of the silo unloader 50 can be installed onto the support frame 60. The user can then proceed to empty the silo using the silo unloader 50.

In another embodiment, a drilling apparatus 800 can be used to unplug silage from a clogged hole in a silo in which the silo unloader 50 has already been installed. In such an application, the silo unloader 50 can be adapted as depicted in **FIGS. 33-37**, with the drilling apparatus 800 mounted to the auger main tubular support 300. As shown in **FIGS. 36 and 37**, a mounting member 812 is bolted to the main auger tubular support

300, and the power drive unit 802, which includes a motor 808 and gearbox 810, is attached to the mount 812. An auger drilling section, such as section 900 (**FIG. 38**), can then be attached to the gearbox 810 of the power drive unit 802, so as to extend down alongside the auger 400 with enough clearance for drilling. As shown, the gearbox 810 includes an output shaft 811 that is inserted into a gearbox coupling member 813. An auger shaft coupling member 815 is bolted to the gearbox coupling member 813. In turn, the gearbox coupling member 815 is inserted into a drill shaft 816, preferably about 60 inches in length, to which the auger drilling section can then be attached. The use of the coupling members 813, 815 facilitates quick attachment and removal of the auger drilling section.

The auger main tubular support 300 is slidably mounted to the first tube mount 250 and second tube mount 260, as shown in **FIG. 36**. First and second tube mounts 250, 260 include insertion holes 814 along a top face corresponding to holes in attached brackets 818, 820. This allows brackets 818, 820, and the main auger tubular support 300, to be positioned in a horizontal plane 823 along the length of the tube mounts 250, 260 in the desired location with the easy removal and insertion of pins 822 into the holes of brackets 818, 820, and corresponding holes 814 of the tube mounts 250, and 260. When repositioning the main auger tubular support 300 along its horizontal plane 823, end braces 275 (**FIG. 33**) can be removed from the third tube mount 270 to allow easy movement.

During normal filling or unloading, the auger 400 is centered as shown in **FIG. 34**, and the auger drilling section of the drilling apparatus 800 is not yet mounted onto the mounting member 812. During the unloading operation, if the center hole 22 should become clogged, the auger main tubular support 300 can be slid horizontally in the direction of arrow "Y" so as to be off-center, as shown in **FIG. 35**, and the power unit 802 and the auger drilling section can then be attached to the mounting member 812 of drilling apparatus 800. The auger drilling section extends down alongside the auger 400, and into the center 14 of the silo where the hole 22 was originally formed. The drilling apparatus 800 is now positioned to drill and unclog and/or reform the hole 22, preferably to a diameter of about 15 inches.

In a preferred embodiment of a drilling apparatus 800, an auger drilling section 900, as shown in **FIG. 38**, is used to remove relatively small amounts of silage clogging an existing hole 22, and/or to loosen hard-packed silage from the inside surface so as to enlarge the diameter of a hole that has become too narrow. The relatively lightweight and abbreviated drill assembly 900 includes a forward portion 902, which is connected by means of a coupling member 903 to the drill shaft 816. A shaft coupling member 815 is inserted into the drill shaft 816 and connected. The shaft coupling member 815 is also attached to the gearbox-coupling member 813, which is connected to the output shaft 811 of the gearbox 810.

The auger drilling section 900 extends vertically downward from the power drive unit 802 for insertion into the hole 22. The forward portion 902 includes an auger shaft 910, a short flighting 912, and a removable, pointed lead portion 914 for breaking apart and dislodging silage clogs from the hole 22. The flighting 912 is preferably about 6 inches in diameter, and about 6 inches in length. Preferably, the pointed lead member 914 is about 2 1/8 inch in diameter with an angle 916 of about 20°. Mounted on the forward portion 902 of the drill assembly 900 are moveable flails or arms 918 that are extendible at a perpendicular angle to the longitudinal axis 920 of the drill assembly 900, and retractable against the auger shaft 910. The flail arms 918 are each preferably about 6-7 inches long with a pointed cutting blade portion 922, and an aperture 924 through which the pivot arm 926 mounted to the auger shaft 910, is inserted.

As the drilling assembly 900 is lowered into the hole 22, the flighting 912 and/or the pointed lead portion 914 drill through the plug (not shown) in the hole 22. The flail arms 918 fold up against the auger shaft 910 to allow the auger drilling section 900 to pass through the plug. Once below the plug, the flail arms 918 extend outward due to the rotation of the auger drilling section 900 of the drilling apparatus. Silage dislodged by the flail arms 918 falls through the hole 22 to the conveyor below as the auger drilling section 900 is pulled upward, and the hole 22 is widened to an about 15 inch diameter.

As with the drilling apparatus 700, if the hole 22 is not wide enough, a hole widening section 750 (**FIG. 30**) can replace the auger drilling section 900 to enlarge the hole 22. Preferably, the hole widening section 750 has an about 16-inch diameter flighting to widen the hole to an about 16-inch diameter.

The auger drilling section and drill shaft 816 can then be removed from the drilling apparatus 800, and the auger tubular support 300 repositioned along the horizontal plane 823 in the opposite direction of arrow "Y" **(FIG. 35)**, and centered over the unplugged and/or newly formed hole 22 **(FIG. 34)**. The unloading operation can then be reconvened.

Preferably, a three-phase 10-horsepower "C" face electric motor 708 attached to a 16:1 in-line helical speed reducer is used to power the drill of the drilling apparatus 700, and a three-phase 3-hp "C" face motor and 30:1 worm drive gearbox is used with the drilling apparatus 800. A variable speed motor controller controls speed of the auger drilling sections. Preferably, the motor 708 and gearbox 710 are mounted in a vertical direction to power the auger drilling sections. In general, the auger drilling sections will turn approximately 50 rpm while drilling downward, and about 25 rpm when enlarging the hole on the way up through the hole 22.

The invention has been described by reference to detailed examples and methodologies. These examples are not meant to limit the scope of the invention. Variation within the concepts of the invention is apparent to those skilled in the art. The disclosures of the cited patents, patent applications, and other references are incorporated by reference herein.

WHAT IS CLAIMED:

1. An apparatus for loading and unloading silage into and out of a silo, comprising:

a support frame supported by a plurality of cables, and defining an open central area through which the silage can pass in a substantially unobstructed manner when being loaded into the silo;

a drive ring being rotatably supported by the support frame;

a drive mechanism that rotates the drive ring; and

an auger for moving the silage relative to the center of the silo, the auger being supported from the drive ring and rotatable about a longitudinal axis.

2. The apparatus according to claim 1, wherein the drive ring has an interior periphery that delineates an open middle area aligned beneath the open central area of the support frame.

3. The apparatus according to claim 1, wherein the support frame is triangular shaped, and composed of a plurality of support members.

4. The apparatus according to claim 1, wherein the auger is rotably supported by a frame, and

the apparatus further comprises an assembly for forming a hole in the silage during loading of the silage to allow silage to pass therethrough during unloading; the hole forming assembly supported from the auger support frame.

5. The apparatus according to claim 4, wherein the auger support frame includes a main tubular support, the auger has a shaft aligned substantially parallel to and beneath the main tubular support, and the main tubular support spans the length of the auger shaft.

6. The apparatus according to claim 5, wherein the hole former assembly includes a rotating arm secured to the main tubular support and operable to selectively move the hole former from a position in the center of the silo to an offset position, and the auger is operable to move silage into the hole when the hole former is in the offset position.

7. The apparatus according to claim 1, wherein the auger support frame includes a telescoping main support having a fixed member and a telescoping member; the fixed member rigidly secured to the rotating drive ring, and the telescoping member adapted to telescopingly engage a second end of the fixed member;

a first end of the shaft of the auger being releasably secured to the first end of the fixed member, the second end of the shaft of the auger being rigidly secured to the telescoping member,

wherein the telescoping member and the auger shaft can be selectively extended such that the silo unloader can be mounted in a silo over a range of diameters.

8. The apparatus according to claim 1, wherein the auger is pitched at an angle to facilitate distribution and gather of silage across a top layer of the silage.

9. The apparatus according to claim 1, further comprising a winch assembly for raising and lowering the silo unloader in the silo.

10. The apparatus according to claim 1, further comprising a wall wheel assembly operable to move along a wall of the silo as the silo is raised or lowered.

11. The apparatus according to claim 1, wherein the auger comprises a flighting with cutting members mounted thereto to effect cutting through silage in a top layer of the silage as the auger rotates.

12. The apparatus according to claim 11, wherein the cutting members comprise a triangular main portion having edges effective to cut through the silage.

13. The apparatus according to claim 12, wherein the cutting members are mounted with the triangular main portions of the cutting members oriented at an about perpendicular angle to the longitudinal axis of the auger.

14. The apparatus according to claim 1, further comprising a mechanism for variably controlling the speed of the drive ring, and operable to slow down and speed up the rotation of the drive ring.

15. The apparatus according to claim 1, wherein the auger is rotatably supported by and slidable on a support frame in a horizontal direction within the silo; and

the apparatus further comprises a member mounted on the auger support frame for releasably mounting a hole drilling assembly adjacent to the auger and in a vertical orientation within the silo.

16. The apparatus according to claim 15, wherein when the auger is slid in a first direction on the auger support frame, the drill mounting member is aligned in about the center of the silo.

17. The apparatus according to claim 15, further comprising a drill mounted in the drill mounting member;

the drill comprising a power drive unit being mounted on the drill mounting member and releasably connected to an auger drilling section having a longitudinal axis and extending in a vertical orientation within the silo and adjacent to the auger;

the power drive unit operable to rotate the auger drilling section about said longitudinal axis.

18. The apparatus according to claim 17, wherein the auger drilling section comprises:

a forward portion having a first end and a second end, an auger shaft having a longitudinal axis and a flighting attached thereto, and at least one moveable flail attached to the auger shaft, the flail being extendible at an about perpendicular angle to the longitudinal axis of the auger shaft and retractable against the auger shaft.

19. The apparatus according to claim 18, further comprising:

a drill shaft having a first end and a second end, and a longitudinal axis; and the first end of the drill shaft is releasably connected to the power drive unit, and the second end of the drill shaft is releasably connected to the second end of the forward portion of the auger drilling section.

20. The apparatus according to claim 18, wherein the flail arm has a length of about 6-7 inches.

21. The apparatus according to claim 18, wherein the auger drilling section further comprises a lead portion having a pointed first end, and a second end being releasably connected to the first end of the forward portion.

22. The apparatus according to claim 17, wherein the auger drilling section comprises a hole widening section including an auger tube having a length of about 16-20 inches with an about 16-20 inch diameter flighting mounted thereon, for enlarging a hole formed in the silage.

23. An apparatus for loading and unloading silage into and out of a silo, and for drilling a hole through silage contained within a silo, comprising:

a support frame supported by a plurality of cables, and defining an open central area through which the silage can pass in a substantially unobstructed manner when being loaded into the silo;

a drive ring being rotatably supported by the support frame;

a drive mechanism that rotates the drive ring;

an auger for moving the silage relative to the center of the silo, the auger being supported by a frame connected to the drive ring, rotatable about a longitudinal axis, and slidable on the auger support frame in a horizontal direction within the silo; and

a member mounted on the auger support frame for releasably mounting a hole drilling assembly adjacent to the auger and in a vertical orientation within the silo.

24. The apparatus according to claim 23, further comprising a drill mounted in the drill mounting member; the drill including a power drive unit and an auger drilling section being releasably connected together; the auger drilling section having a longitudinal axis, and the power drive unit operable to rotate the auger drilling section about said longitudinal axis.

25. An apparatus for drilling a hole through silage contained within a silo, comprising:

a support frame supported by a plurality of cables, and defining an open central area; the support frame operable to be raised and lowered within the silo;

an assembly for releasably mounting a drill to the support frame in a vertical orientation within the silo; and

the drill comprising a power drive unit releasably connected to an auger drilling section having a longitudinal axis; the power drive unit operable to rotate the auger drilling section about said longitudinal axis.

26. The drilling apparatus according to claim 25, wherein the mounting assembly comprises multiple suspension arms connected together to form a triangle shape, and mounted to the support frame by multiple bracing members.

27. The drilling apparatus according to claim 25, wherein the auger drilling section comprises a starter section including:

an auger tube having a double flighting mounted thereon, and a longitudinal axis;

a pointed lead portion connected to the auger tube and having a center point; and

a cutting member mounted on a leading edge of the flighting and operable to cut a circular groove through the silage about the center point of the lead portion.

28. The drilling apparatus according to claim 27, wherein the auger drilling starter section is releasably connected to a first end of a second auger drilling section including an auger tube having a longitudinal axis, a length, and a double flighting mounted on at least a portion of said length.

29. The drilling apparatus according to claim 28, wherein a plurality of cutting members are attached to at least one of the flighting of the auger drilling starter section or of the second auger drilling section, the cutting members operable to effect cutting through silage within the hole.

30. The drilling apparatus according to claim 28, wherein the flighting of the auger drilling starter section has a diameter of about 6 inches and the flighting of the second auger drilling section has a diameter of about 8-10 inches.

31. The drilling apparatus according to claim 28, further comprising a third auger drilling section including an auger tube having a flighting mounted thereon and a longitudinal axis; the third auger drilling section being releasably connected at a first end to a second end of the second auger drilling section.

32. The drilling apparatus according to claim 31, wherein a plurality of cutting members are attached to the flighting of the third auger drilling section.

33. The drilling apparatus according to claim 25, wherein the auger drilling section comprises an auger tube having a flighting mounted thereon, a longitudinal axis, and an aperture for removably inserting a rod therethrough such that the rod is oriented at an about perpendicular angle to the longitudinal axis of the auger tube;

wherein when the rod is inserted into the aperture of the auger tube, and the auger drilling section is disconnected from the power drive unit and lowered onto a surface of the silage within the silo, the rod is effective for maintaining the auger drilling section on the surface of the silage.

34. The drilling apparatus according to claim 25, wherein the auger drilling section comprises a hole widening section including an auger tube having a length of about 16-20 inches with an about 16-20 inch diameter flighting mounted thereon for enlarging a hole formed in the silage.

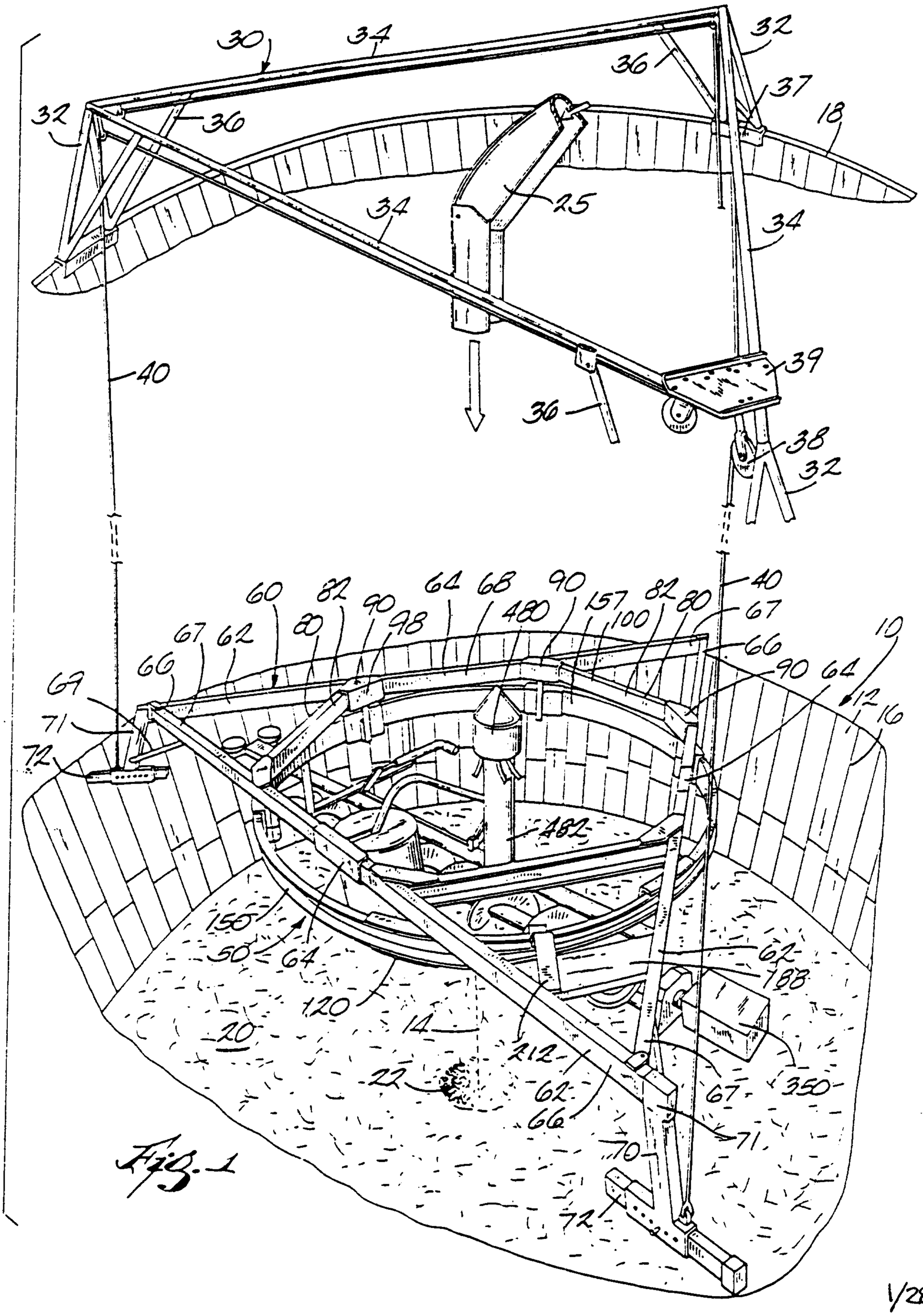

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Fig. 1

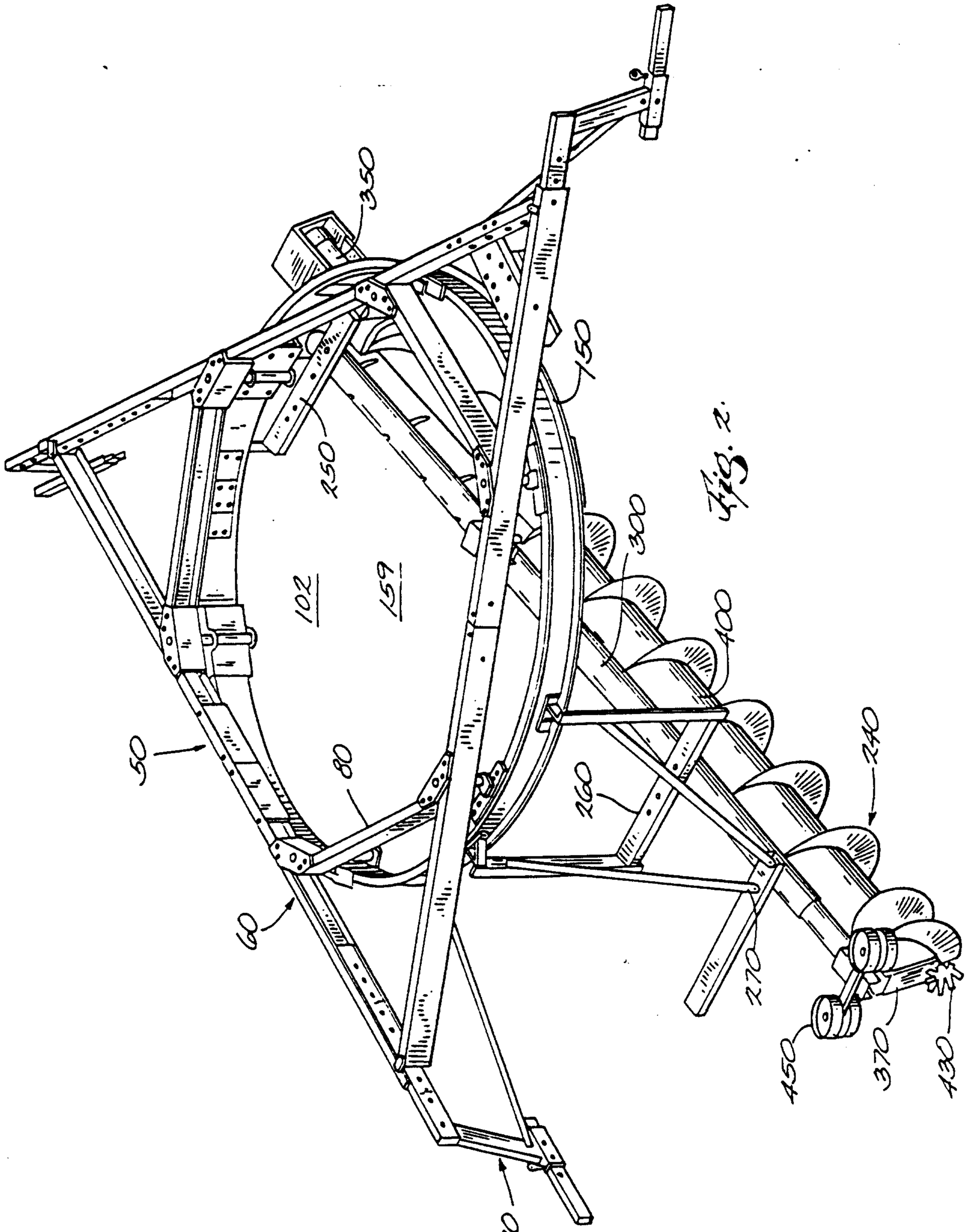

Fig. 2.

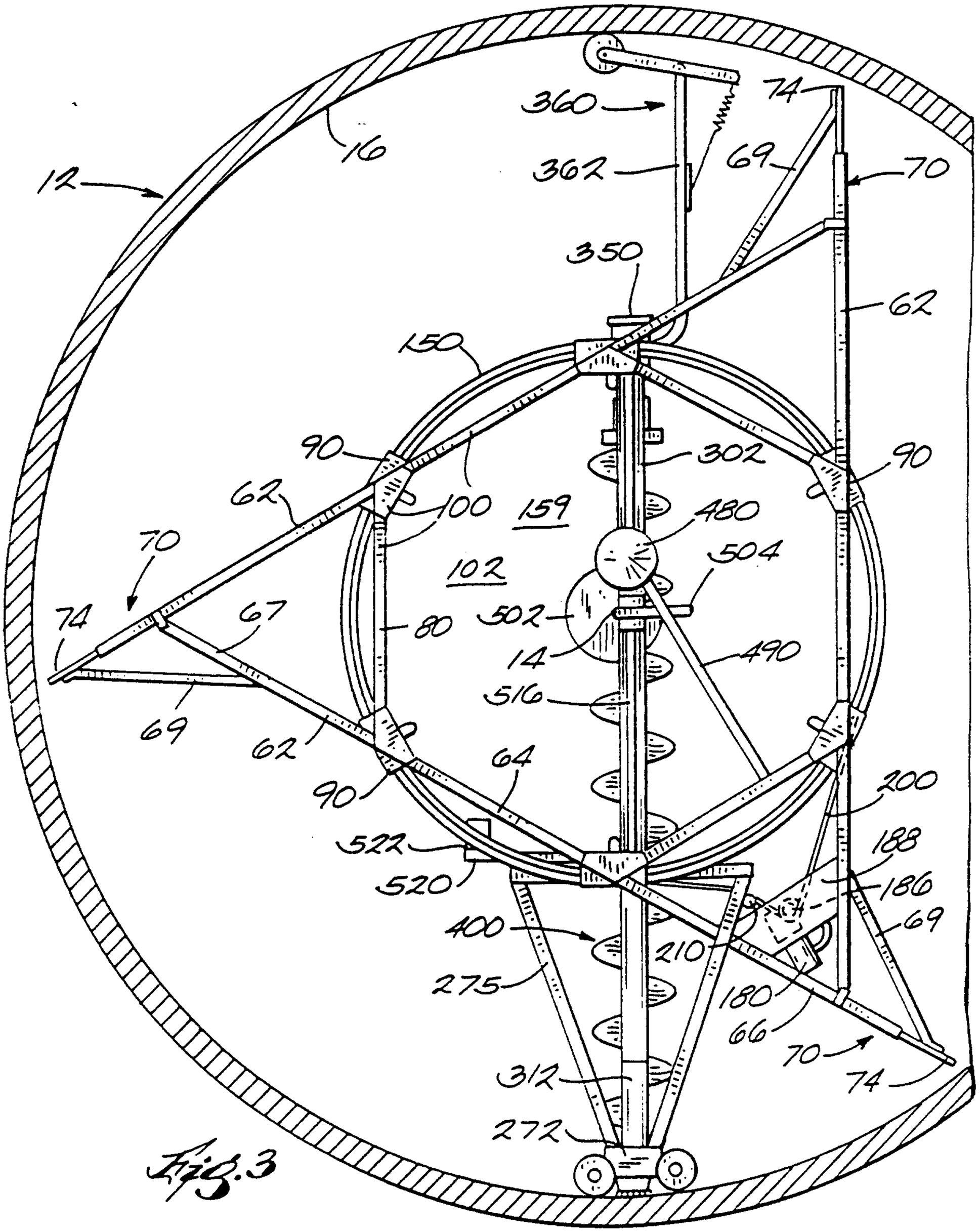
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Fig. 3

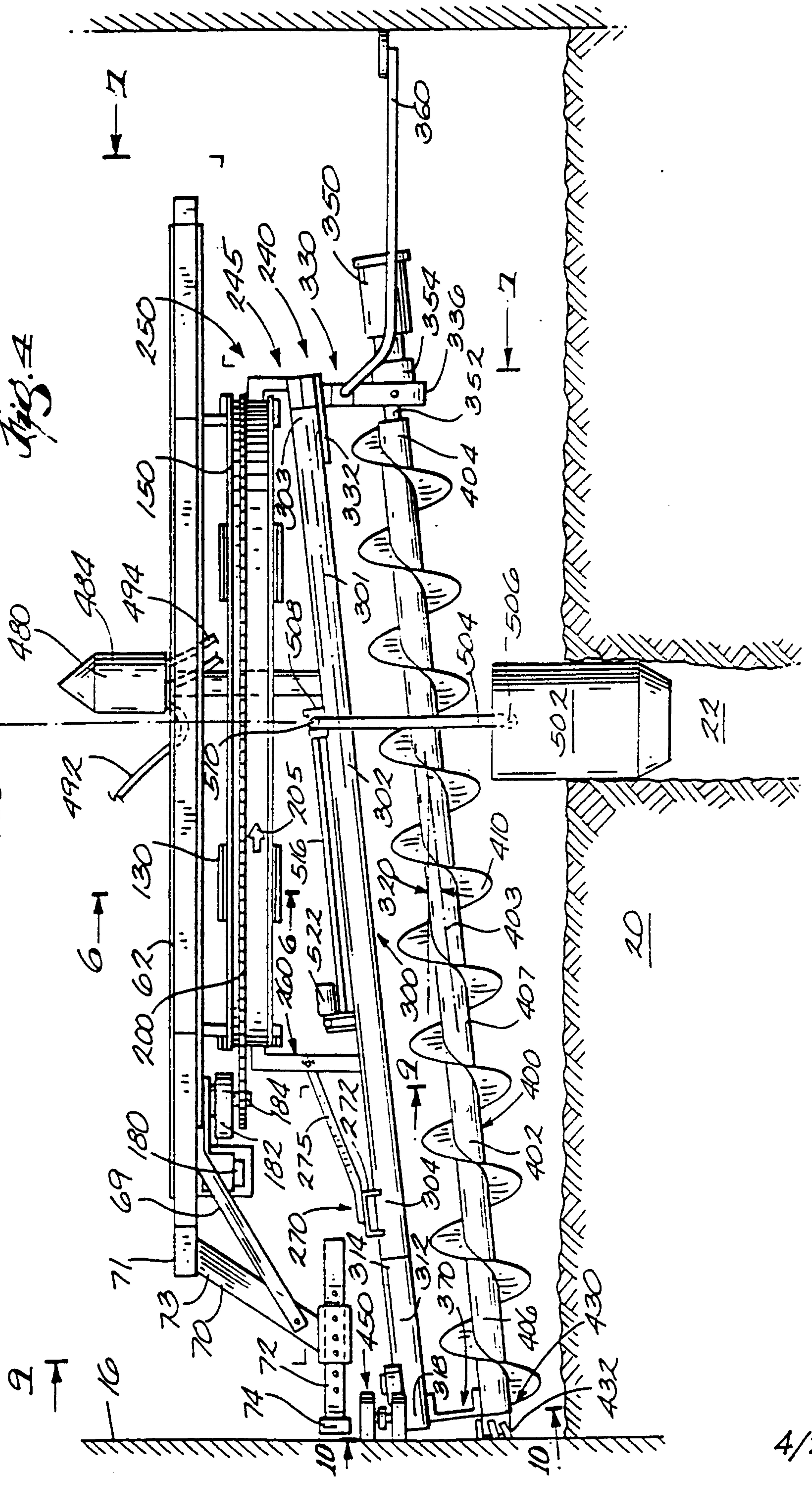
Fig. 4
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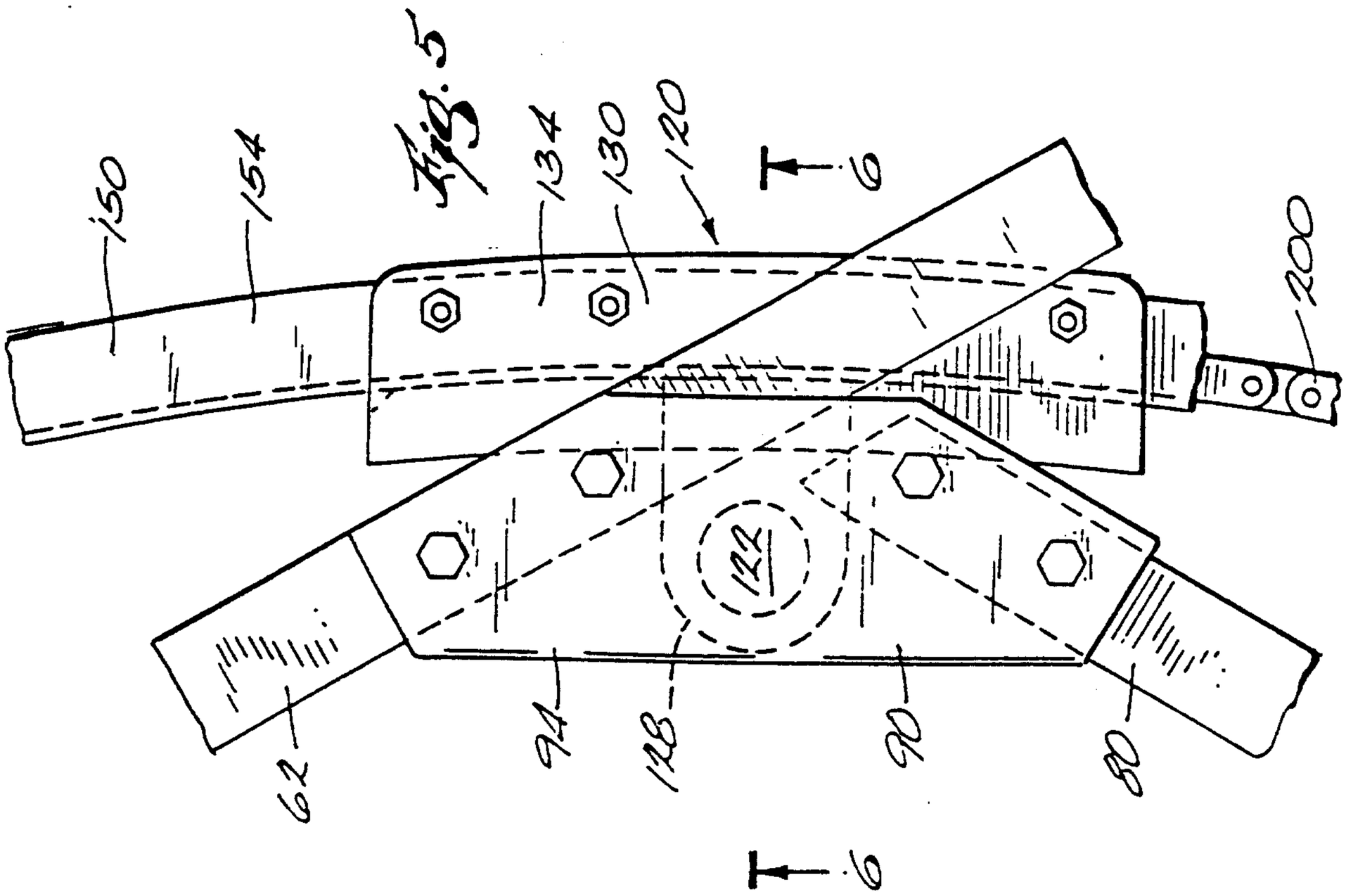
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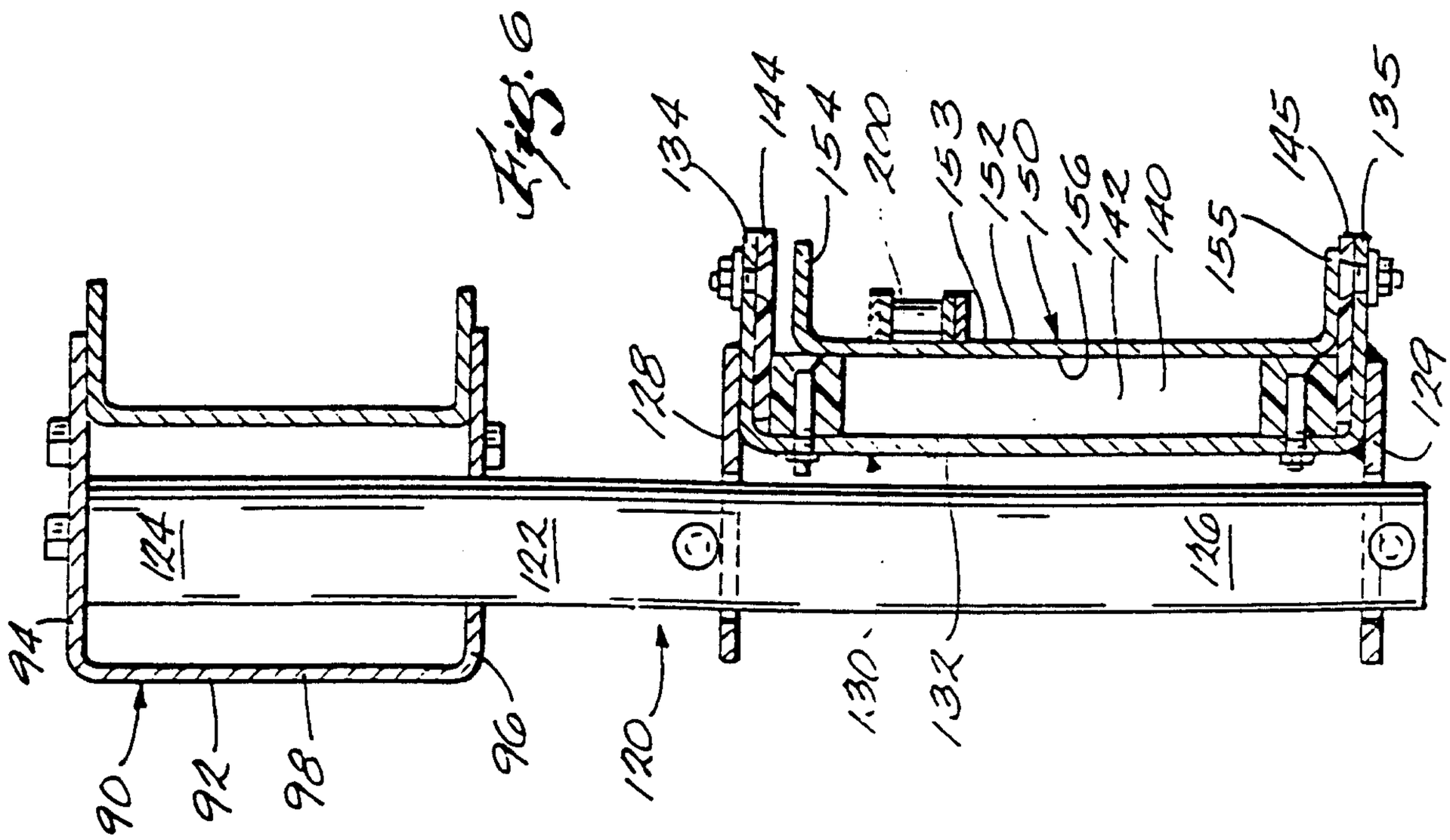
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Fig. 6

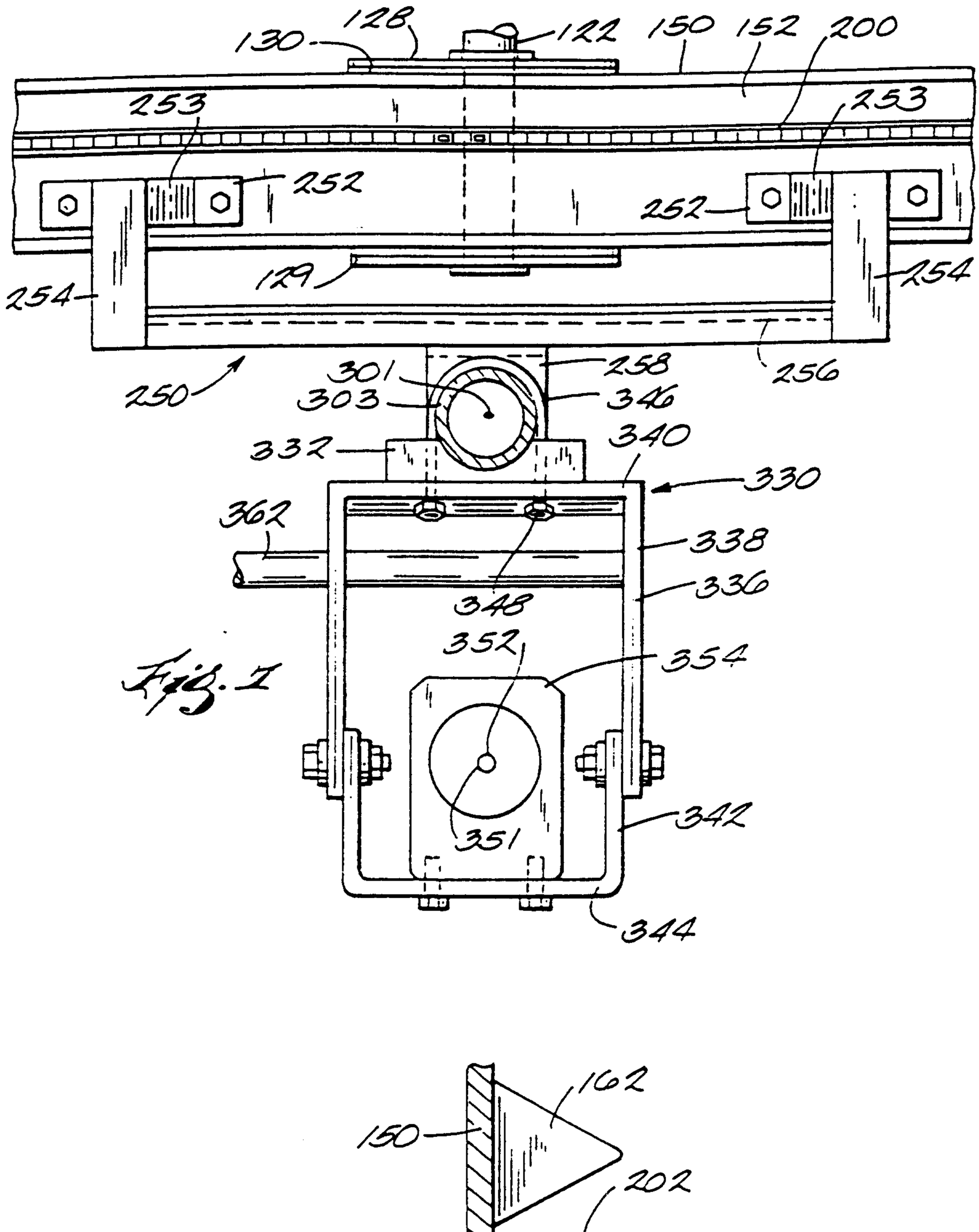
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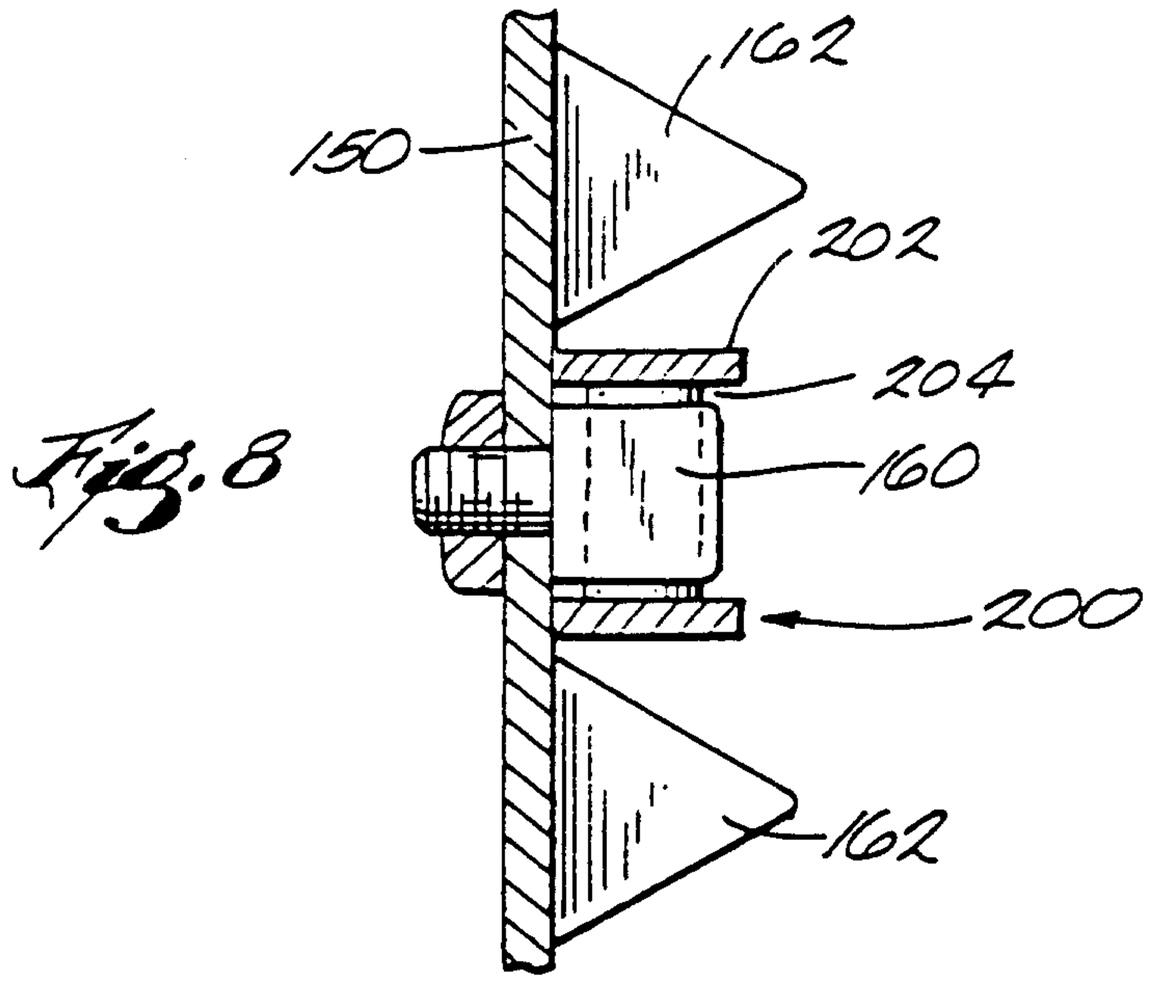
Fig. 1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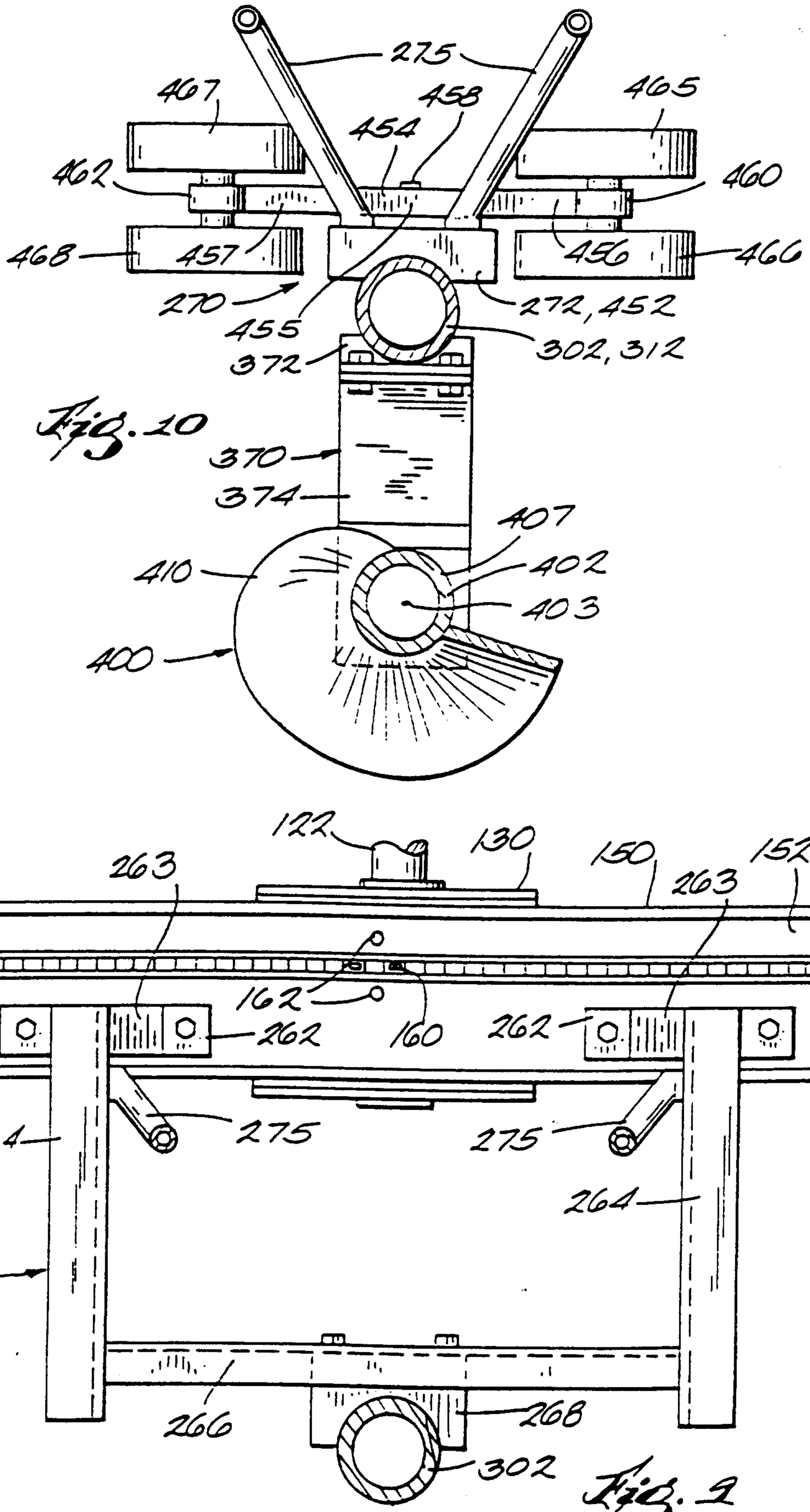
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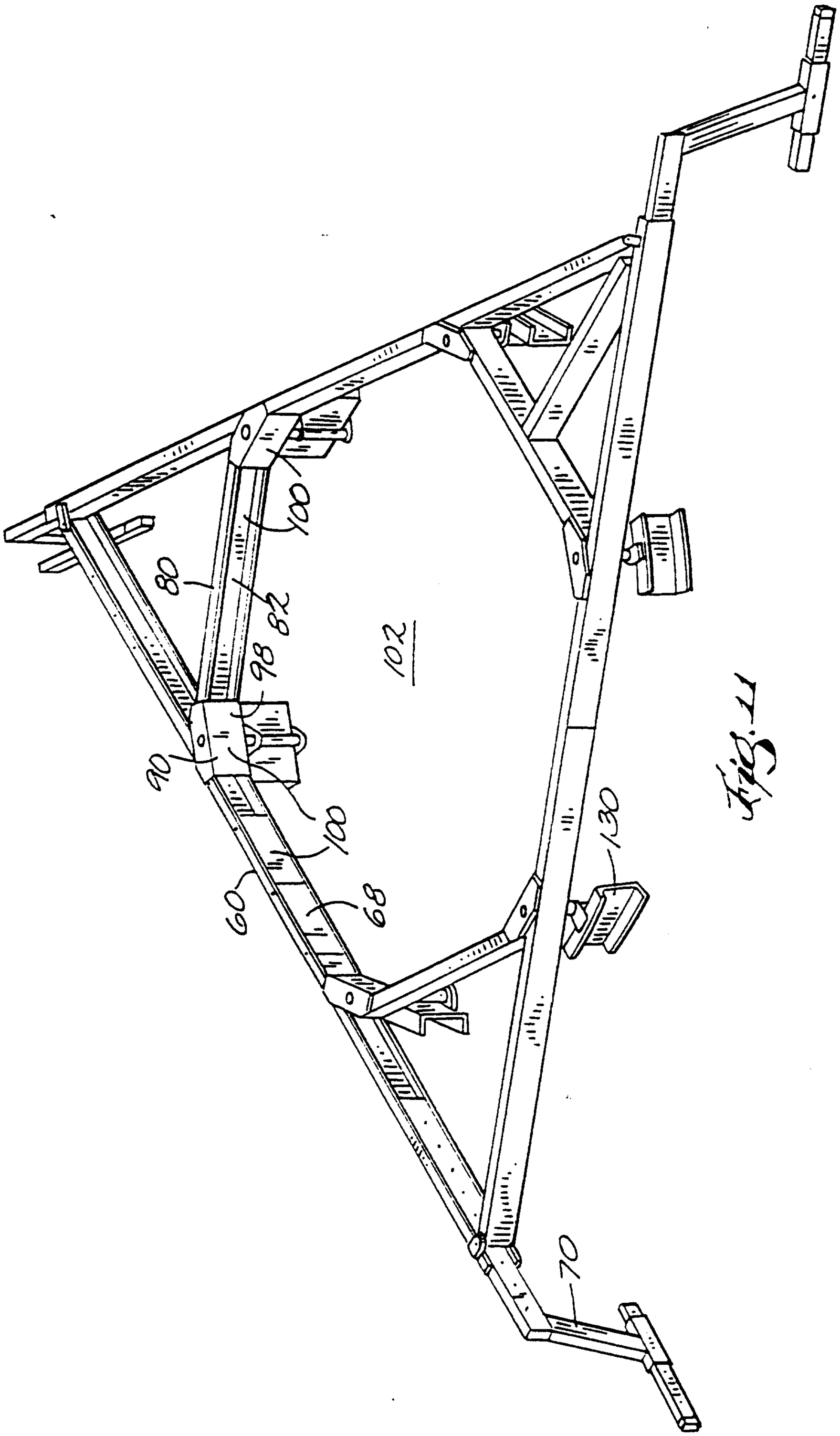
Fig. 10

Fig. 9



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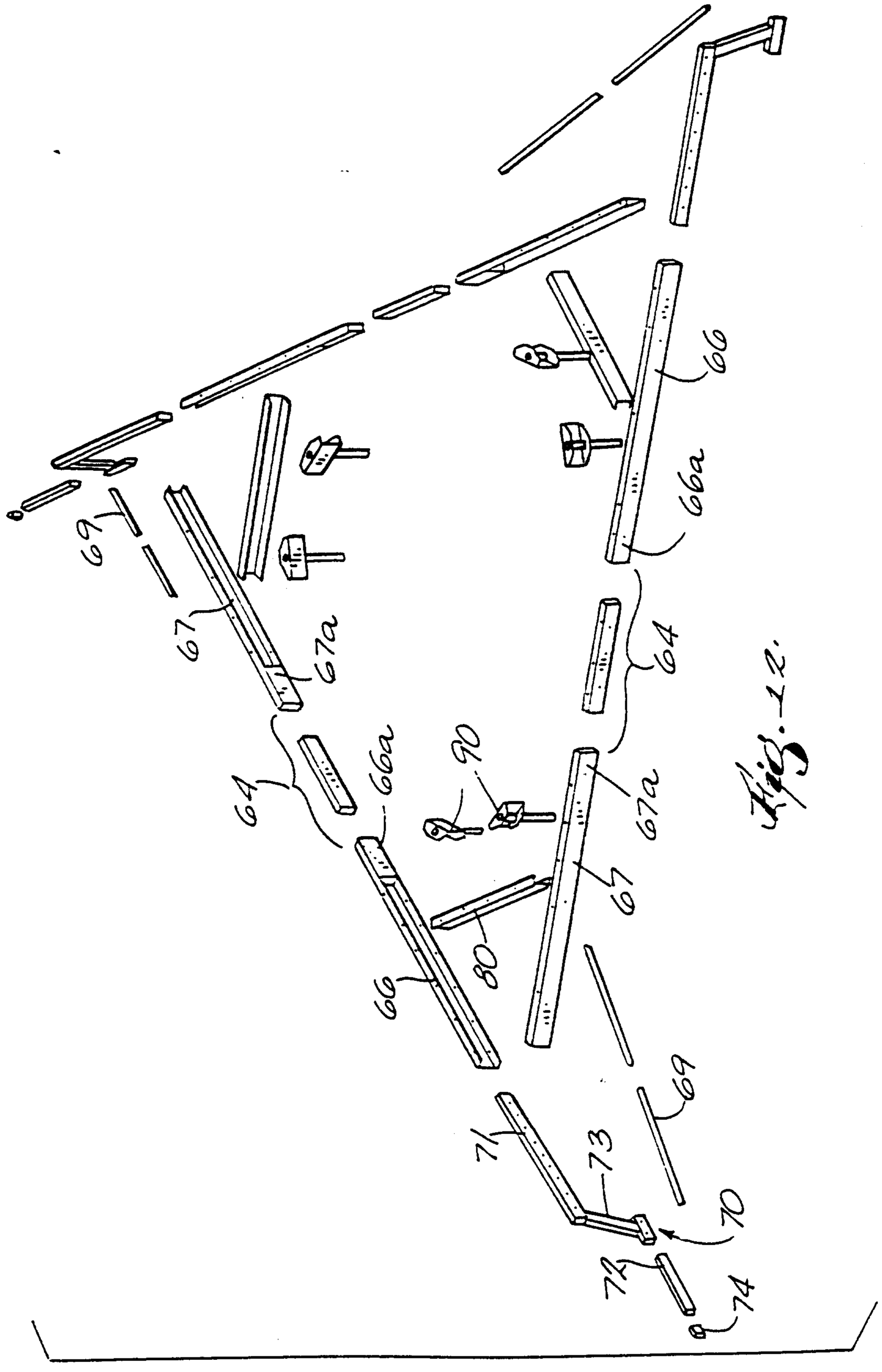

Fig. 12.

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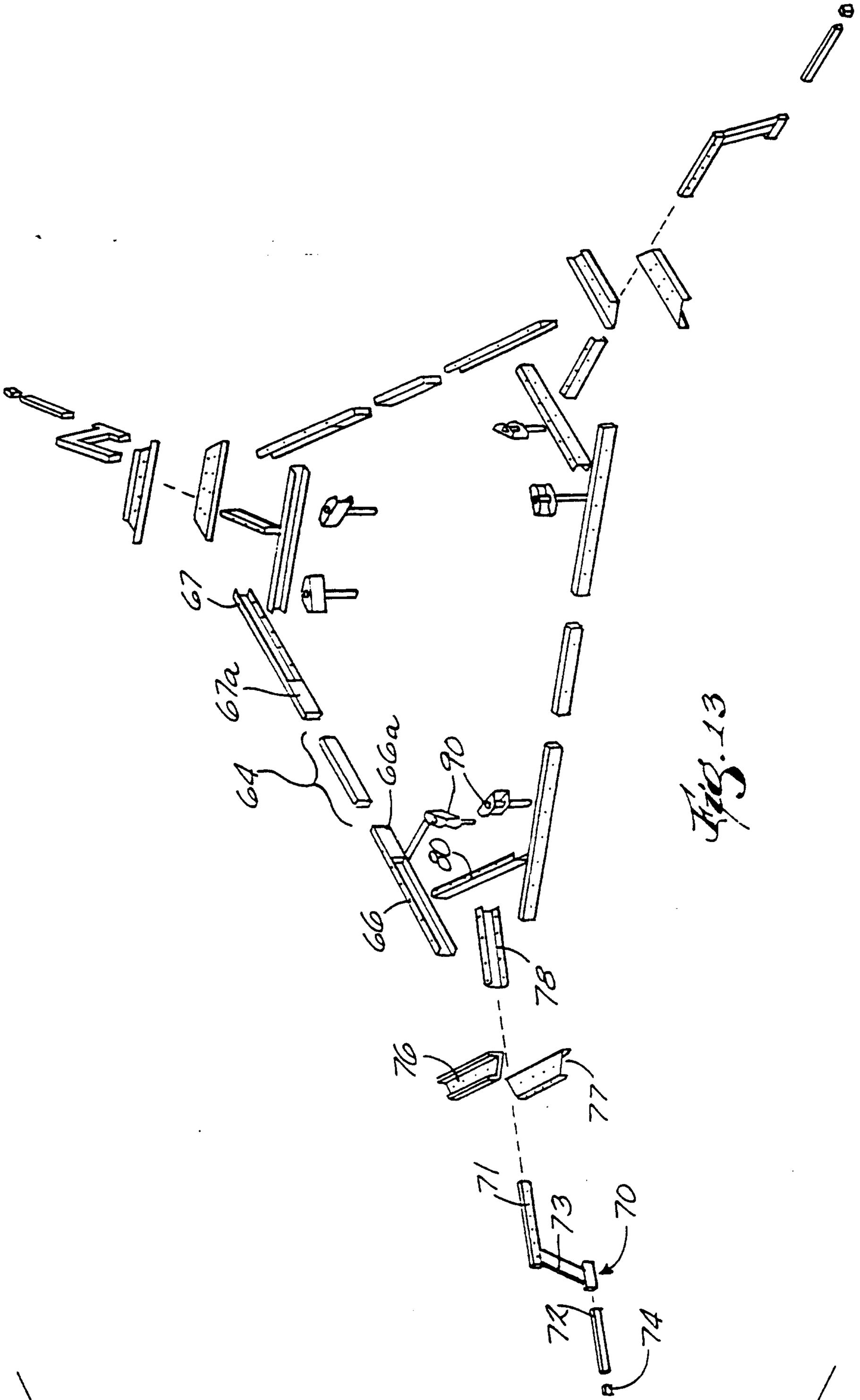

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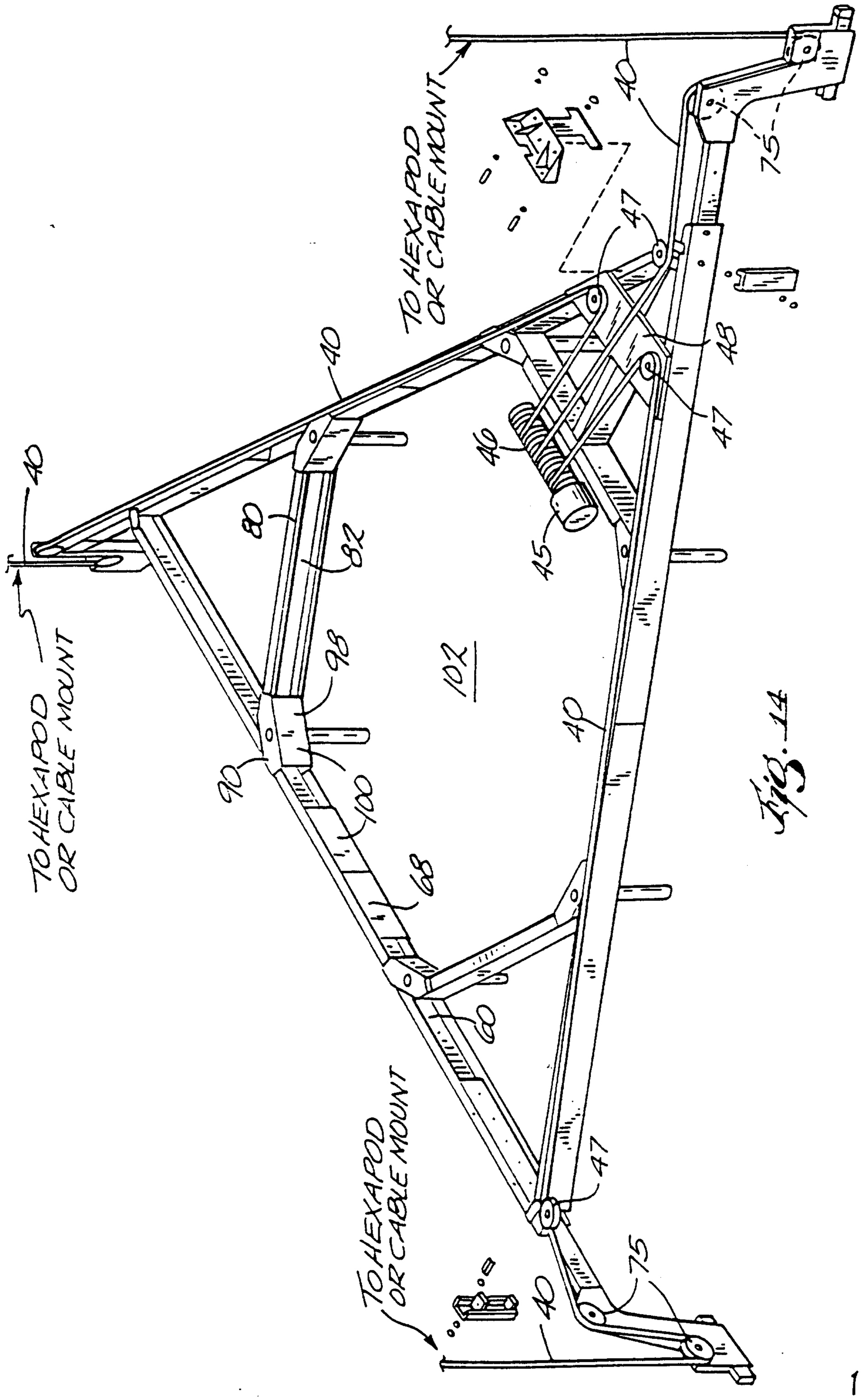
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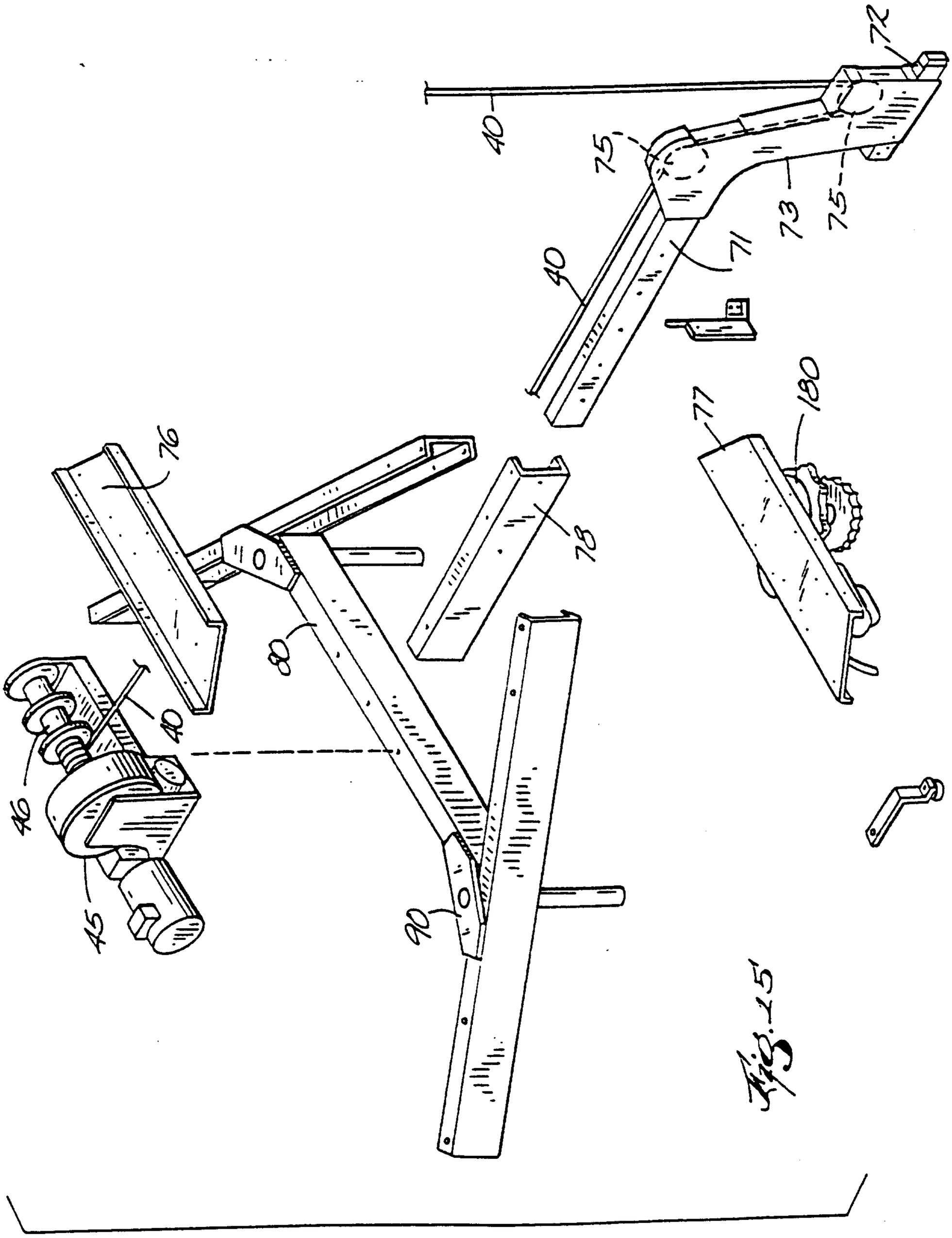
Fig. 14



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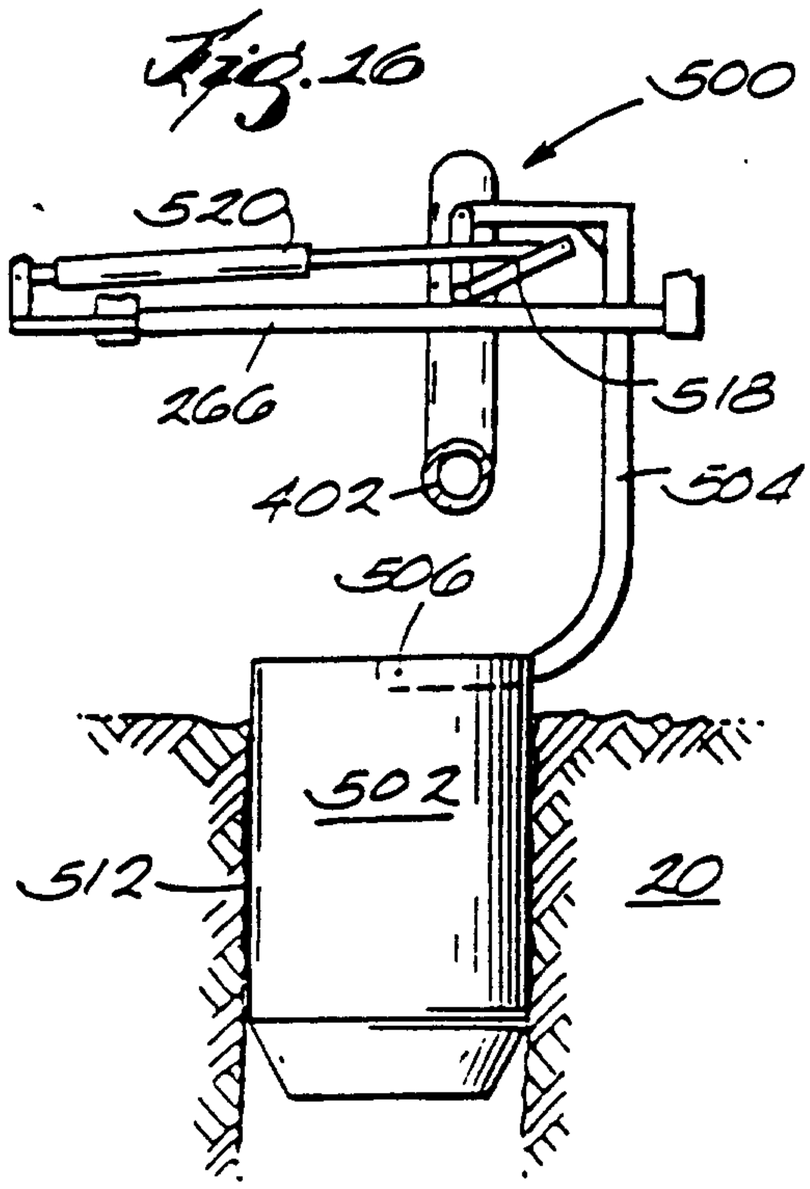

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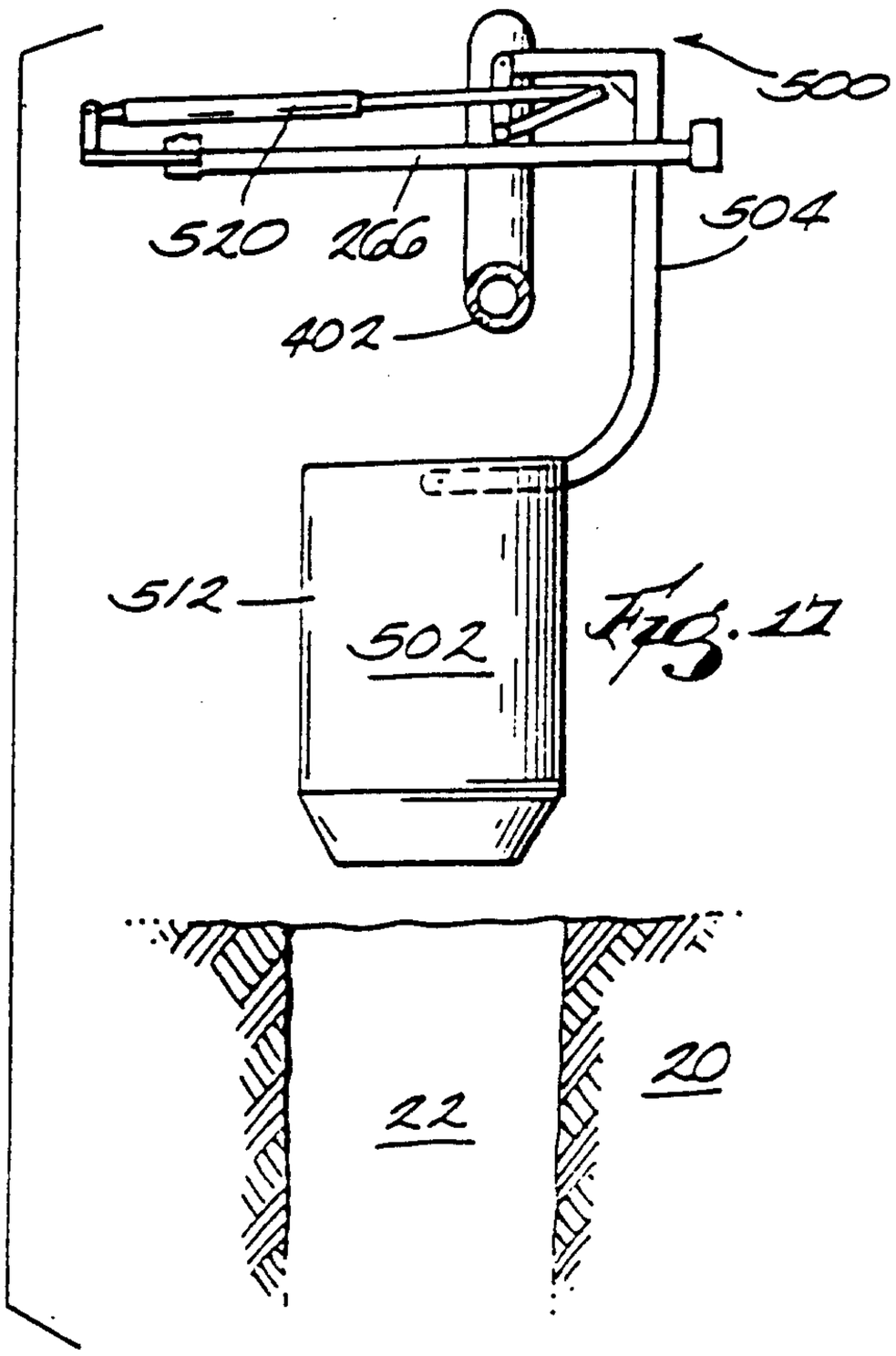

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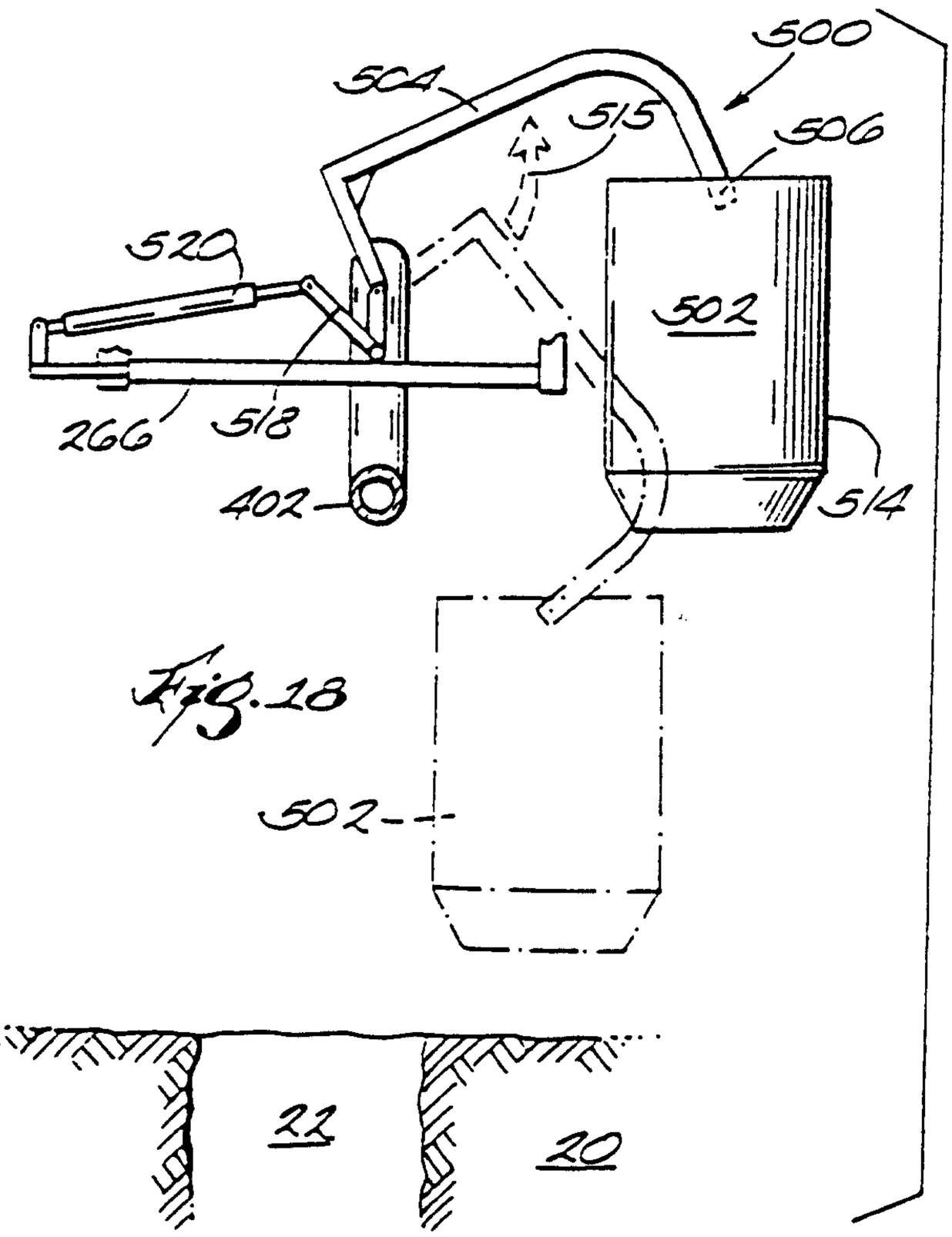

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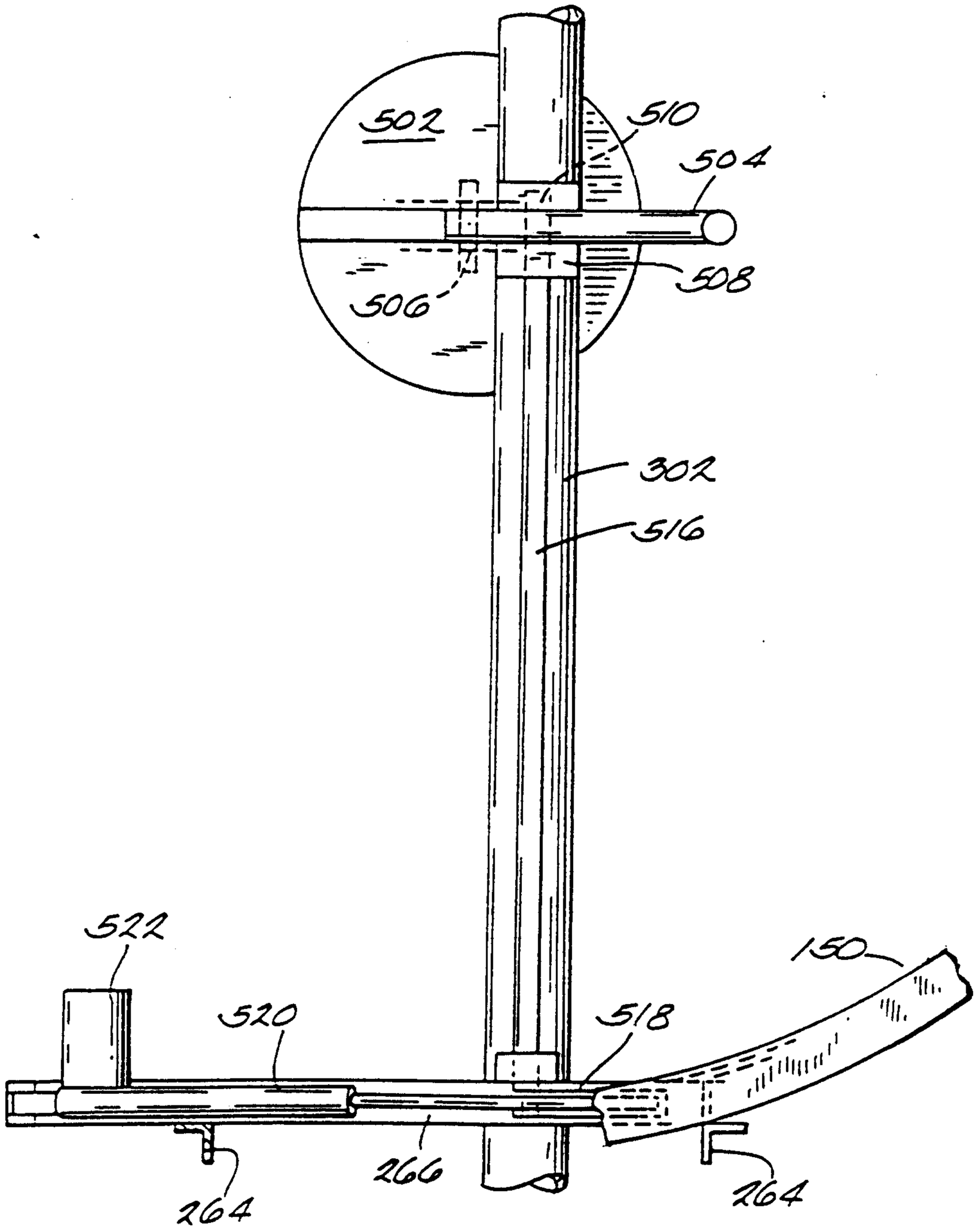

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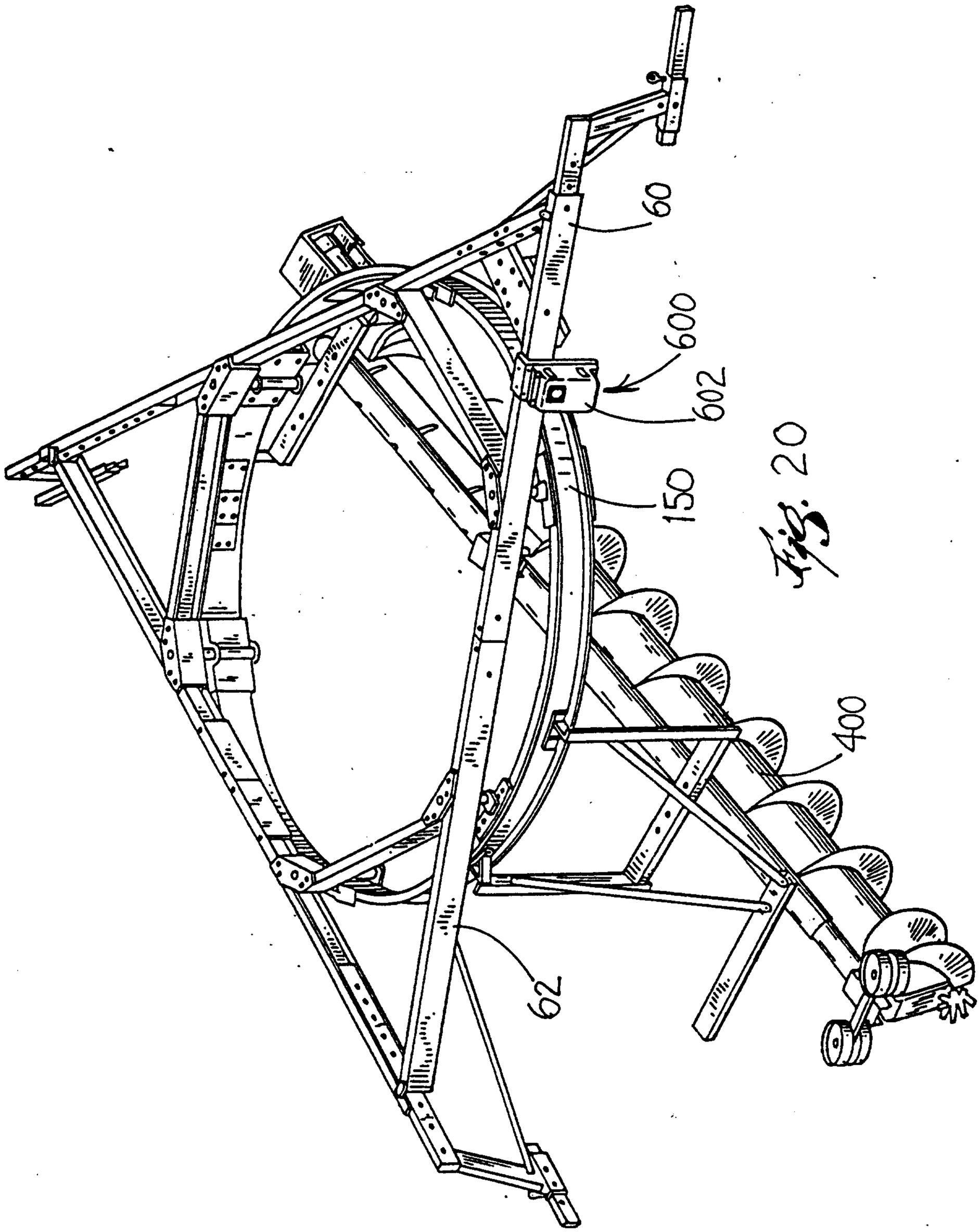

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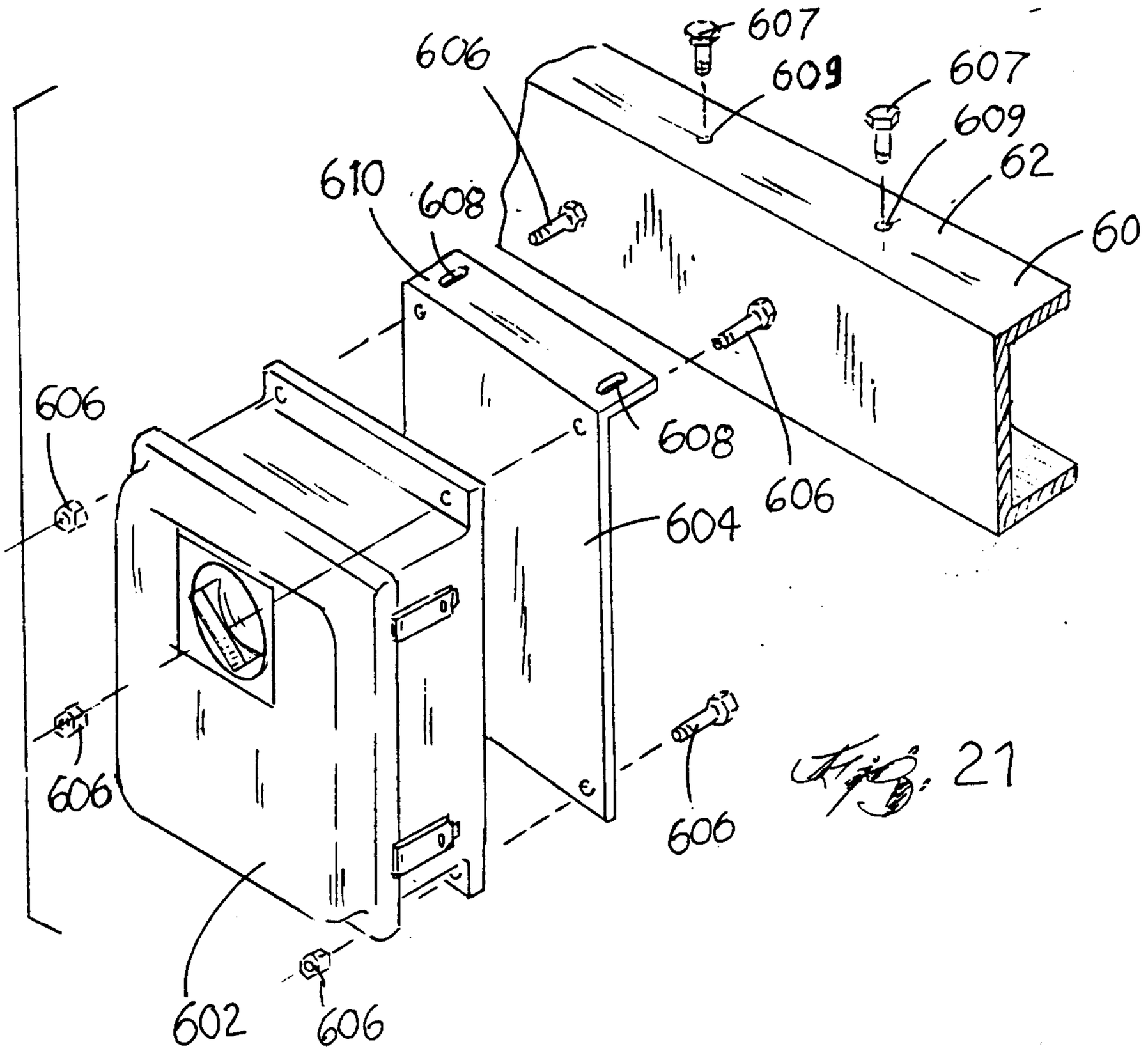
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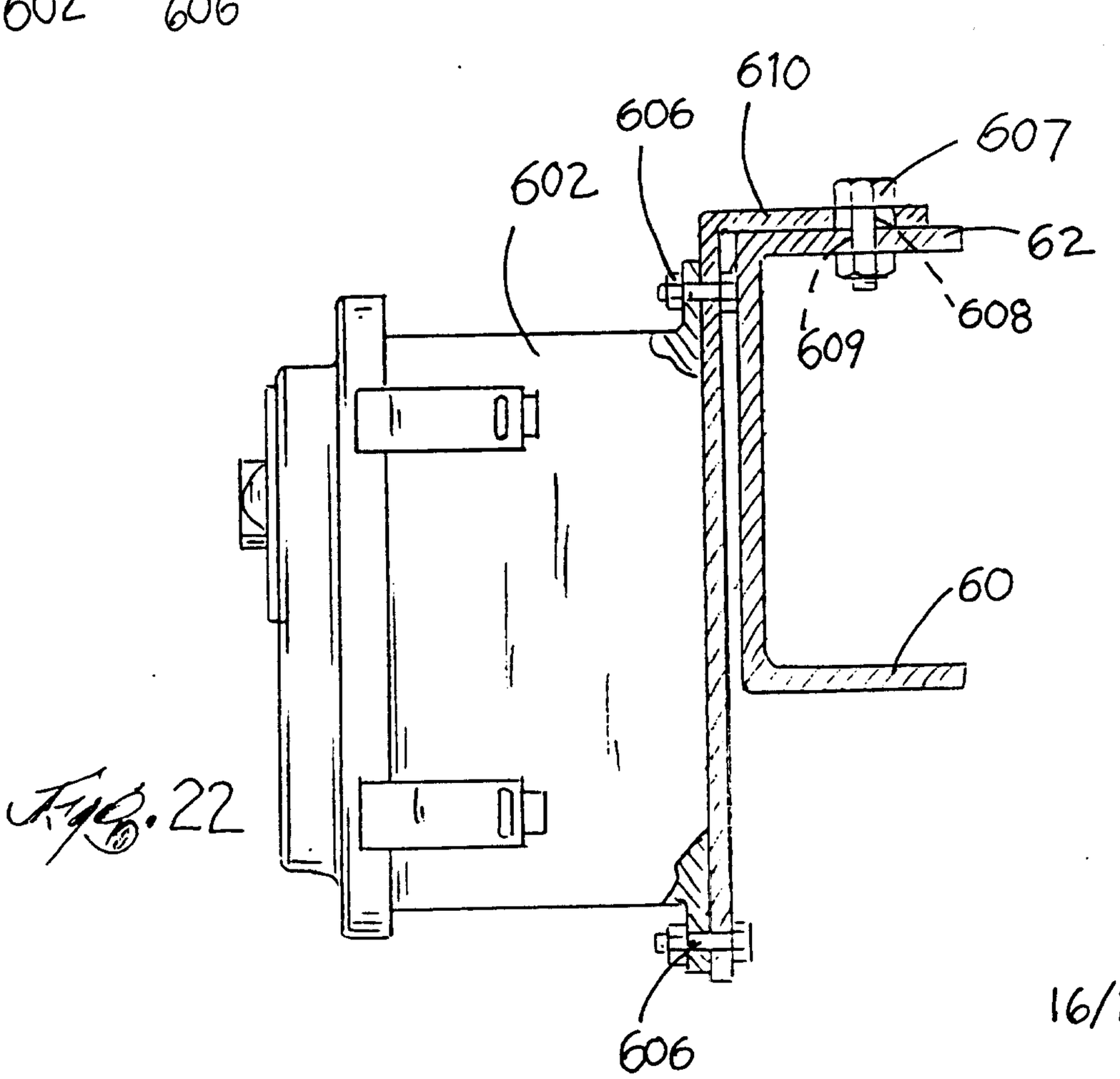
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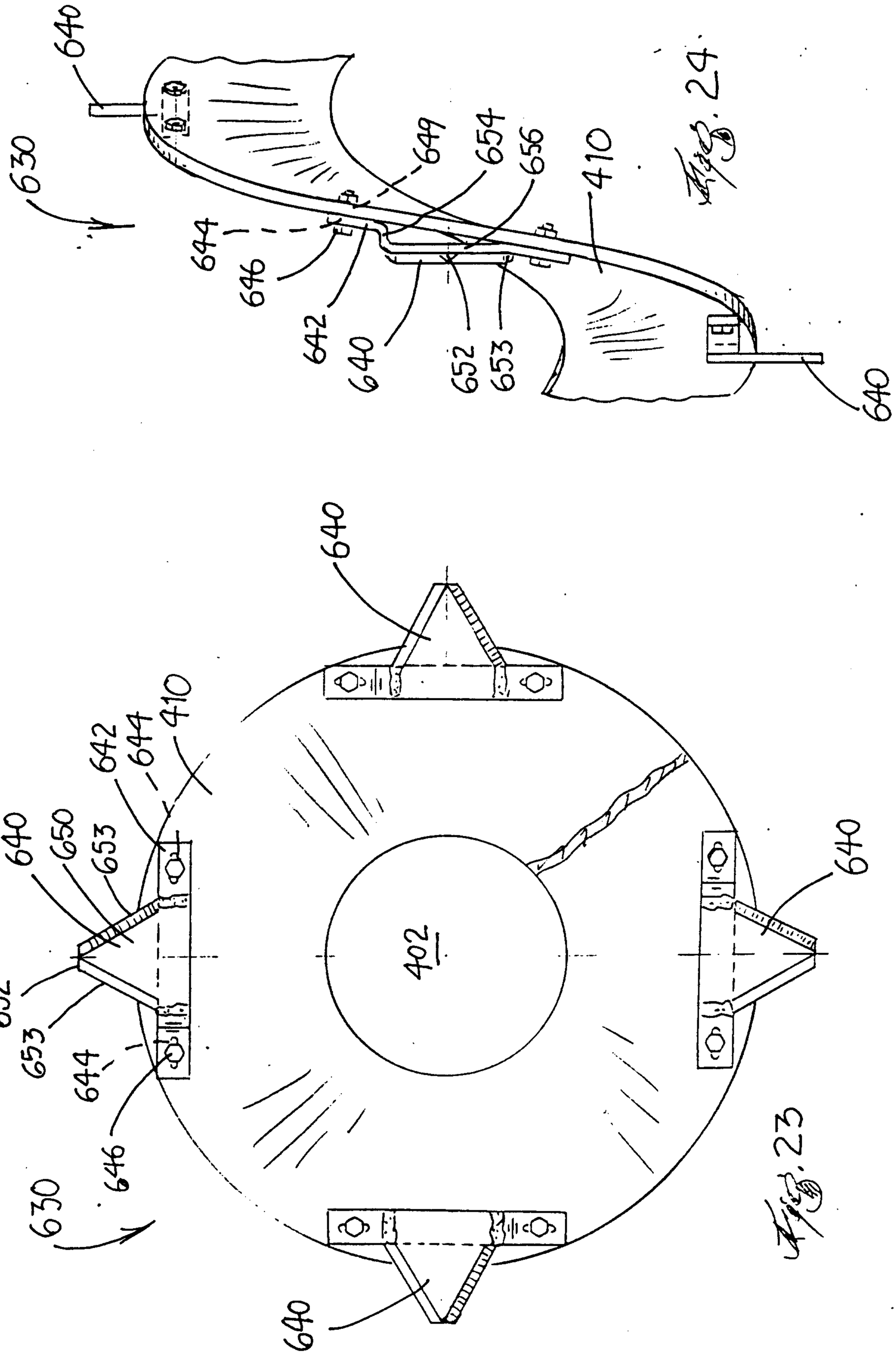
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Fig. 24

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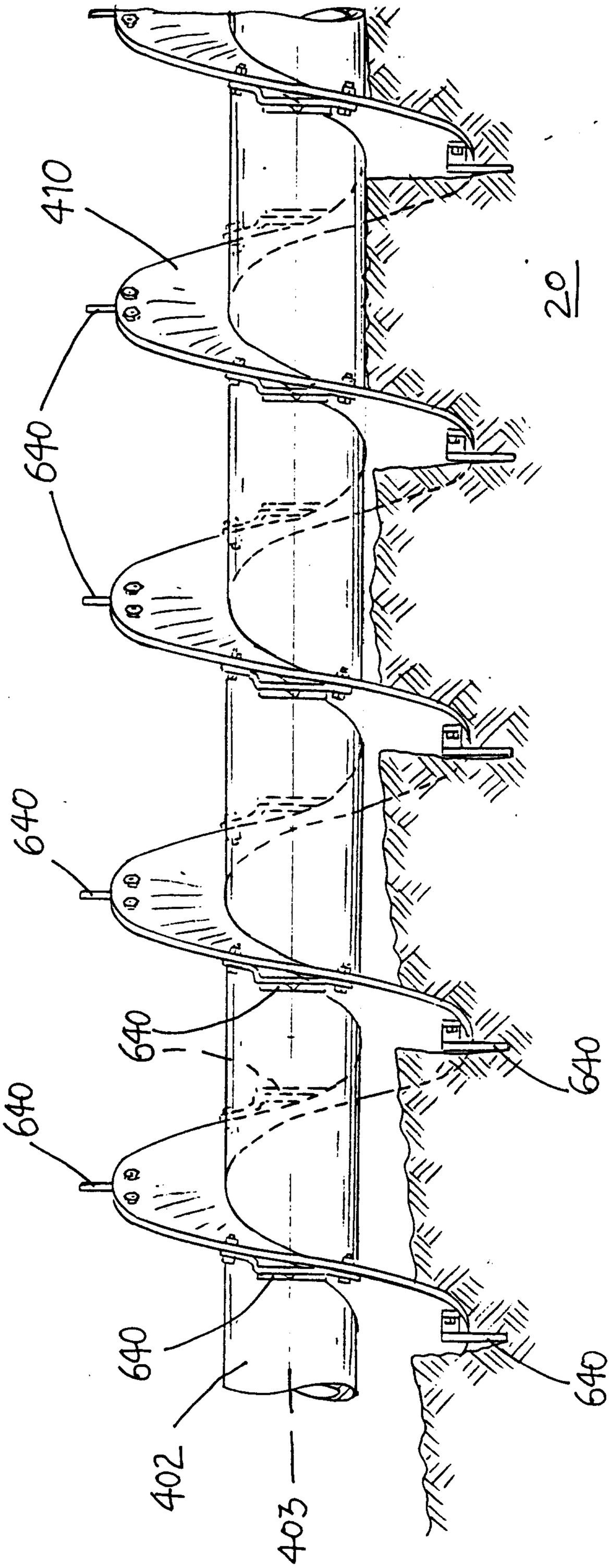
Fig. 23



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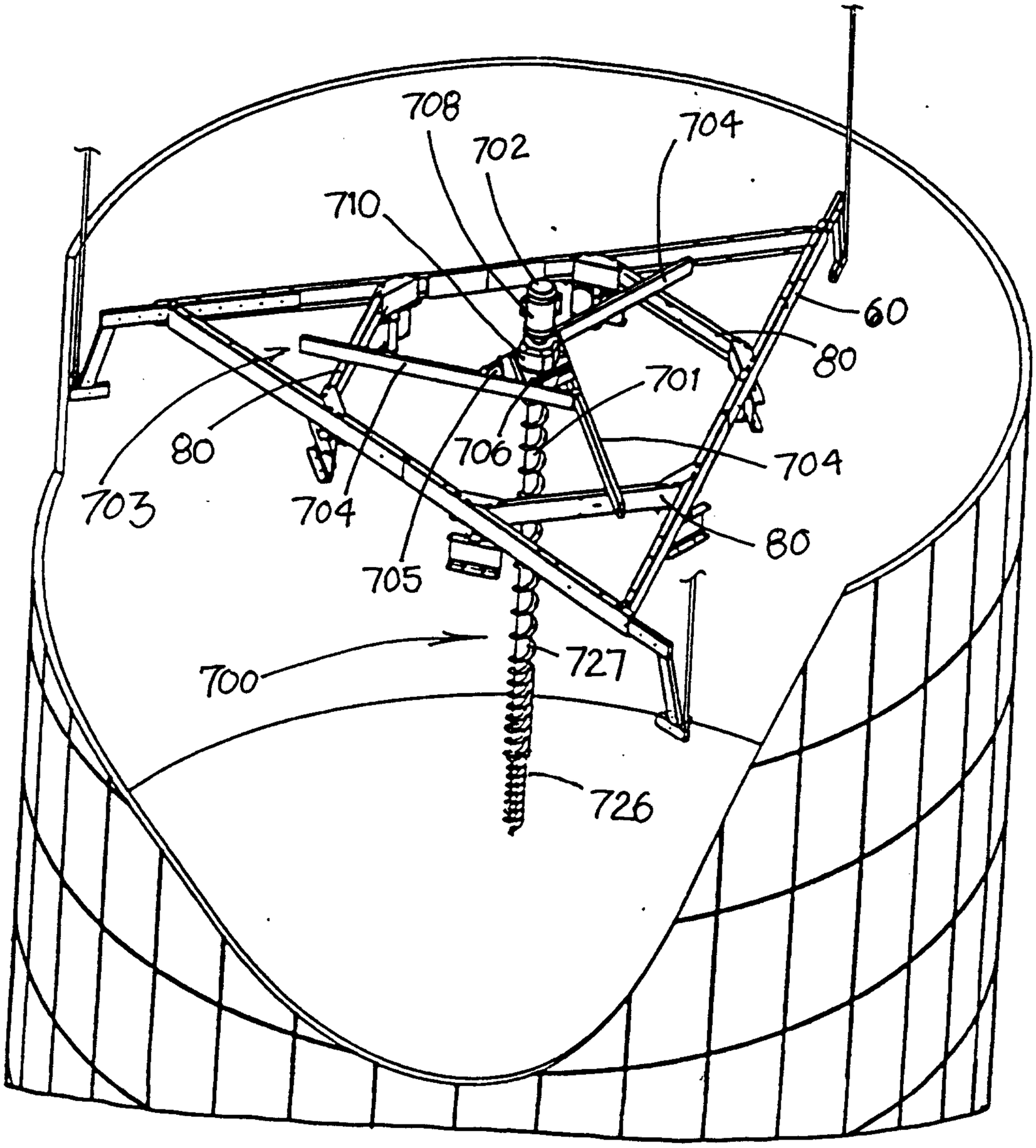
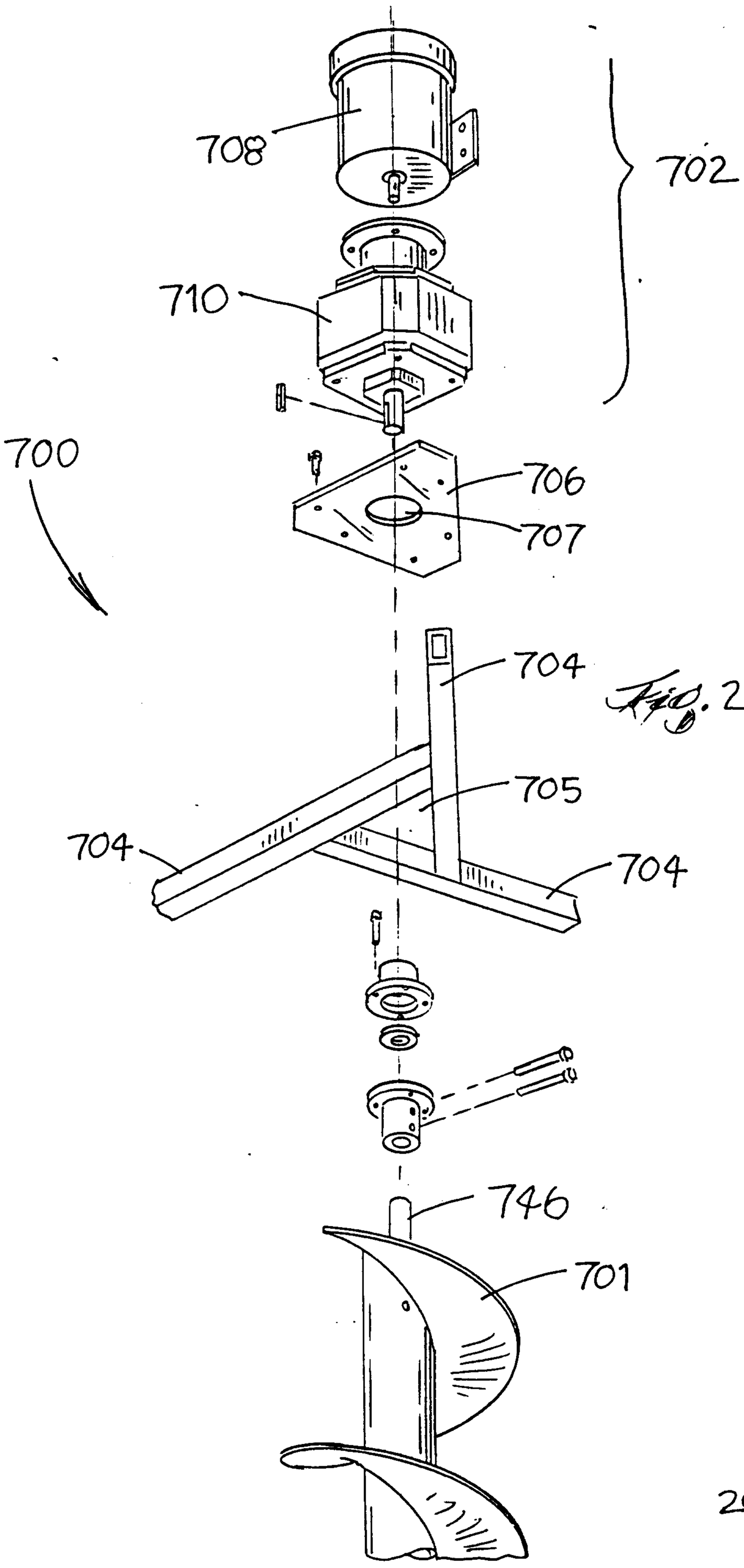


Fig. 26



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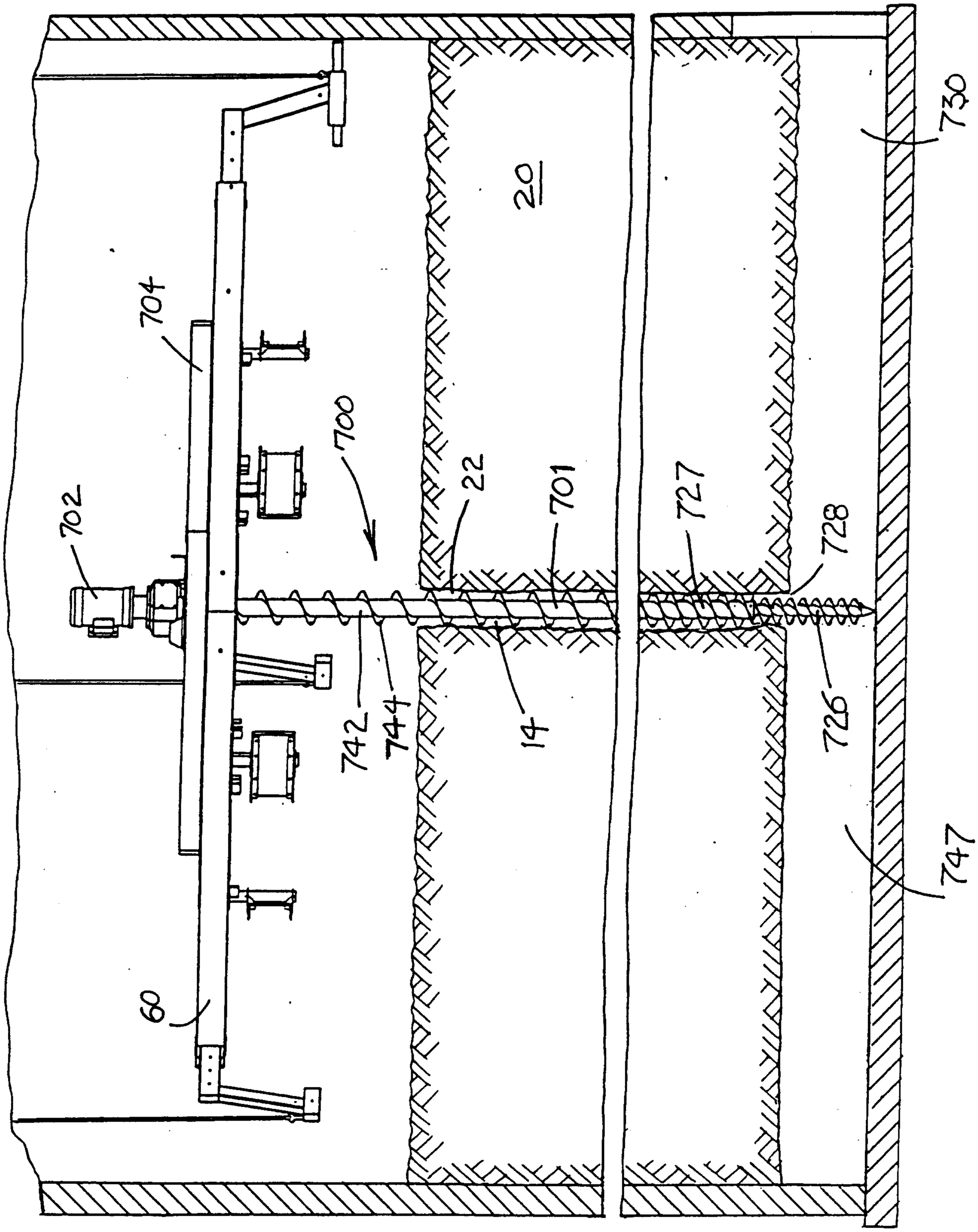

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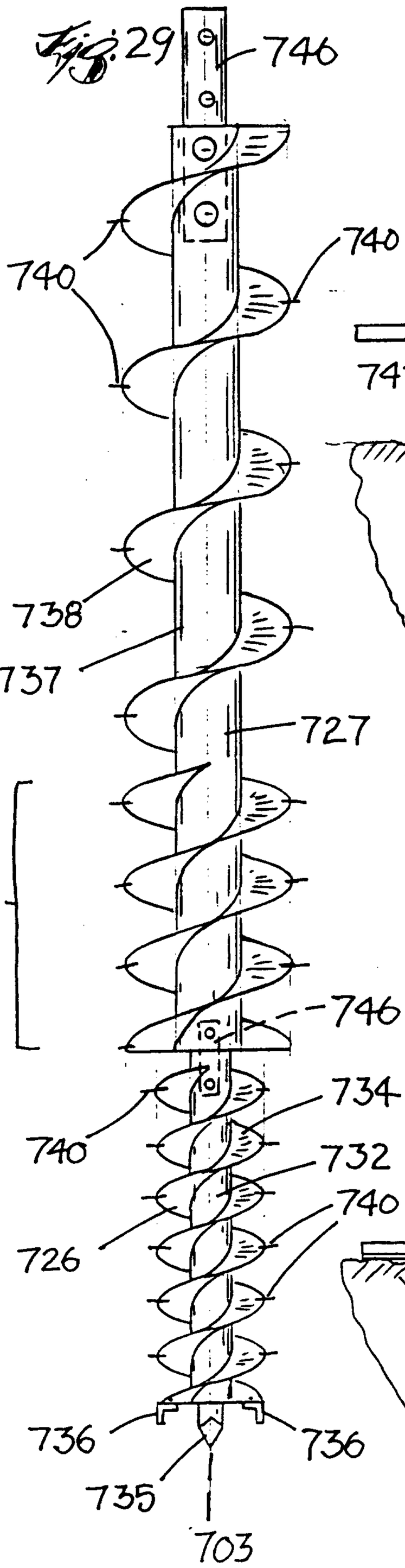

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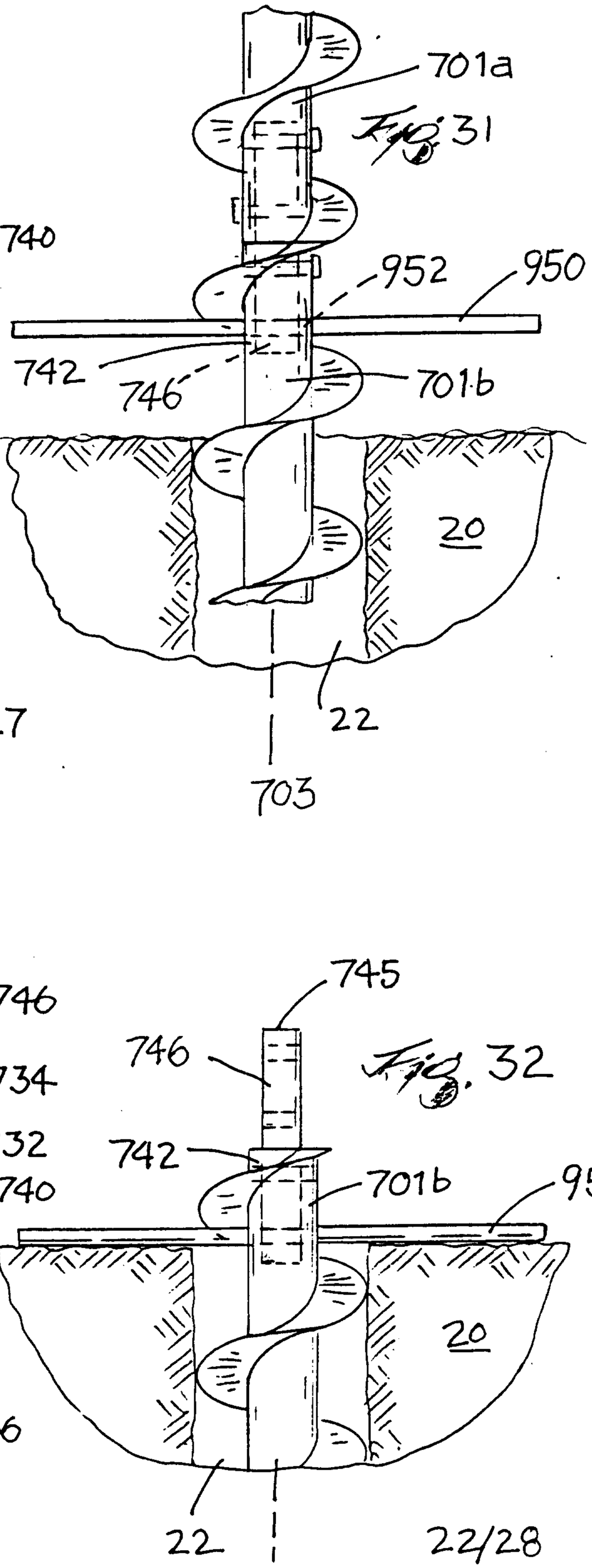

Fig. 31

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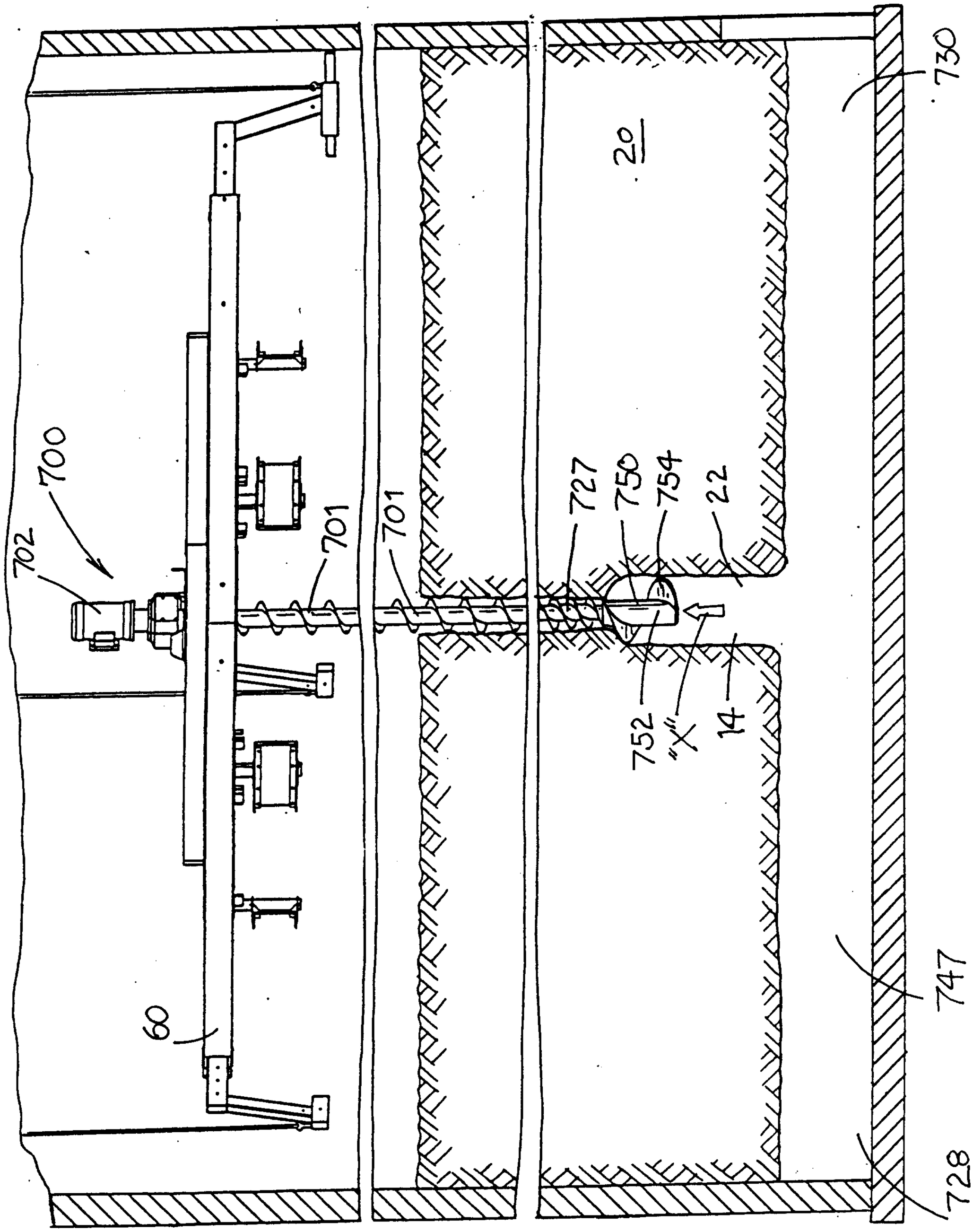

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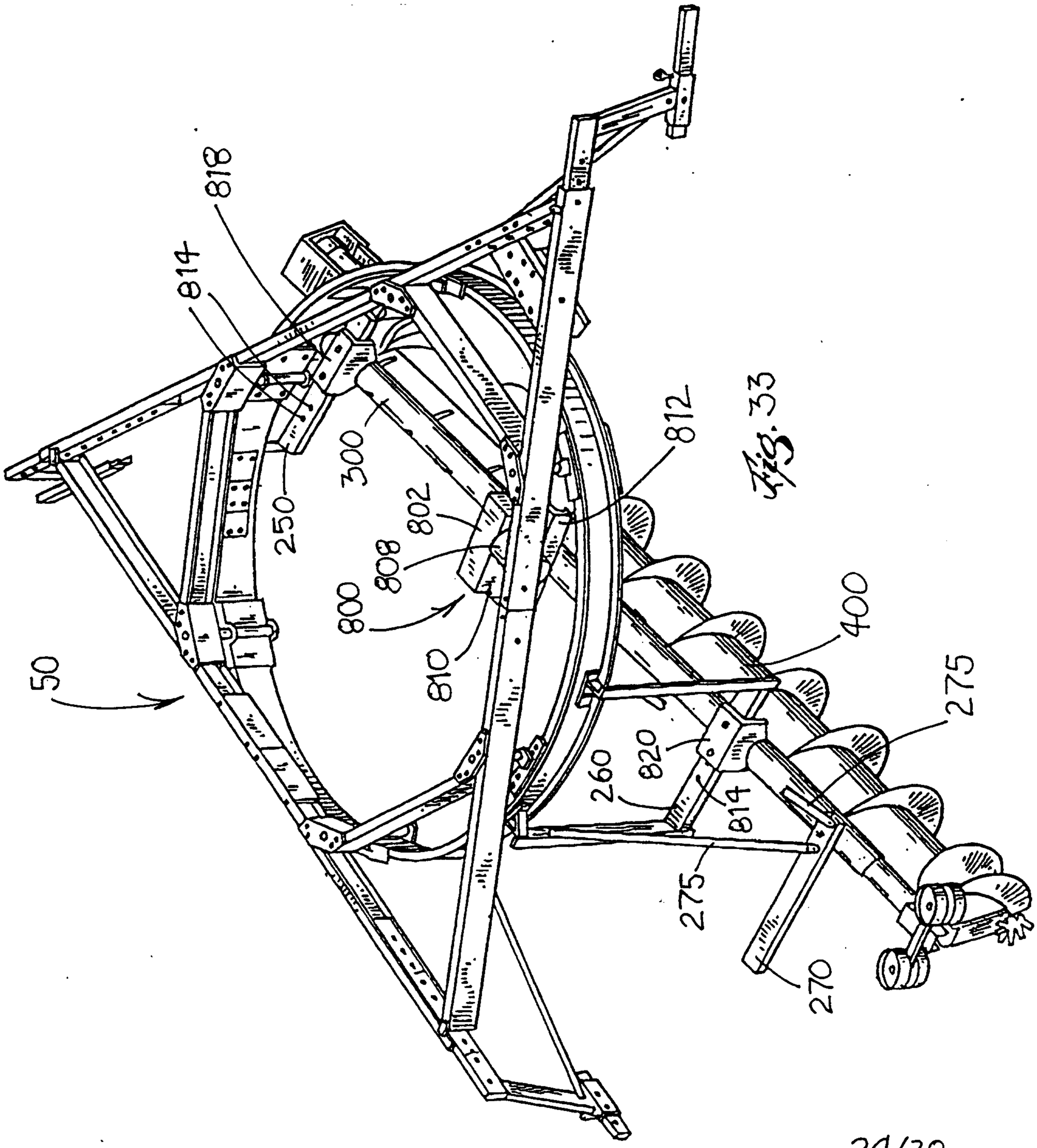
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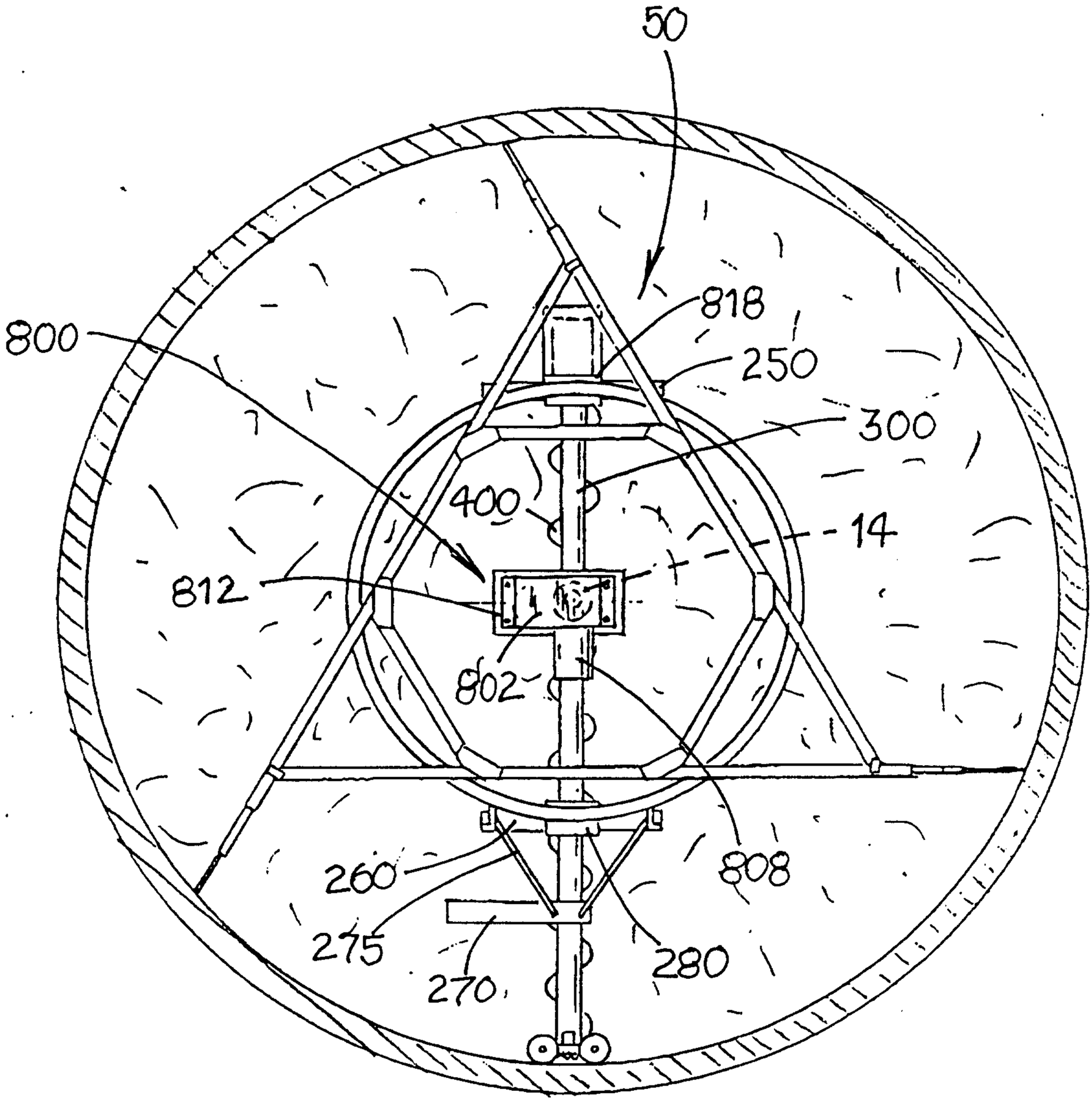
Fig. 33



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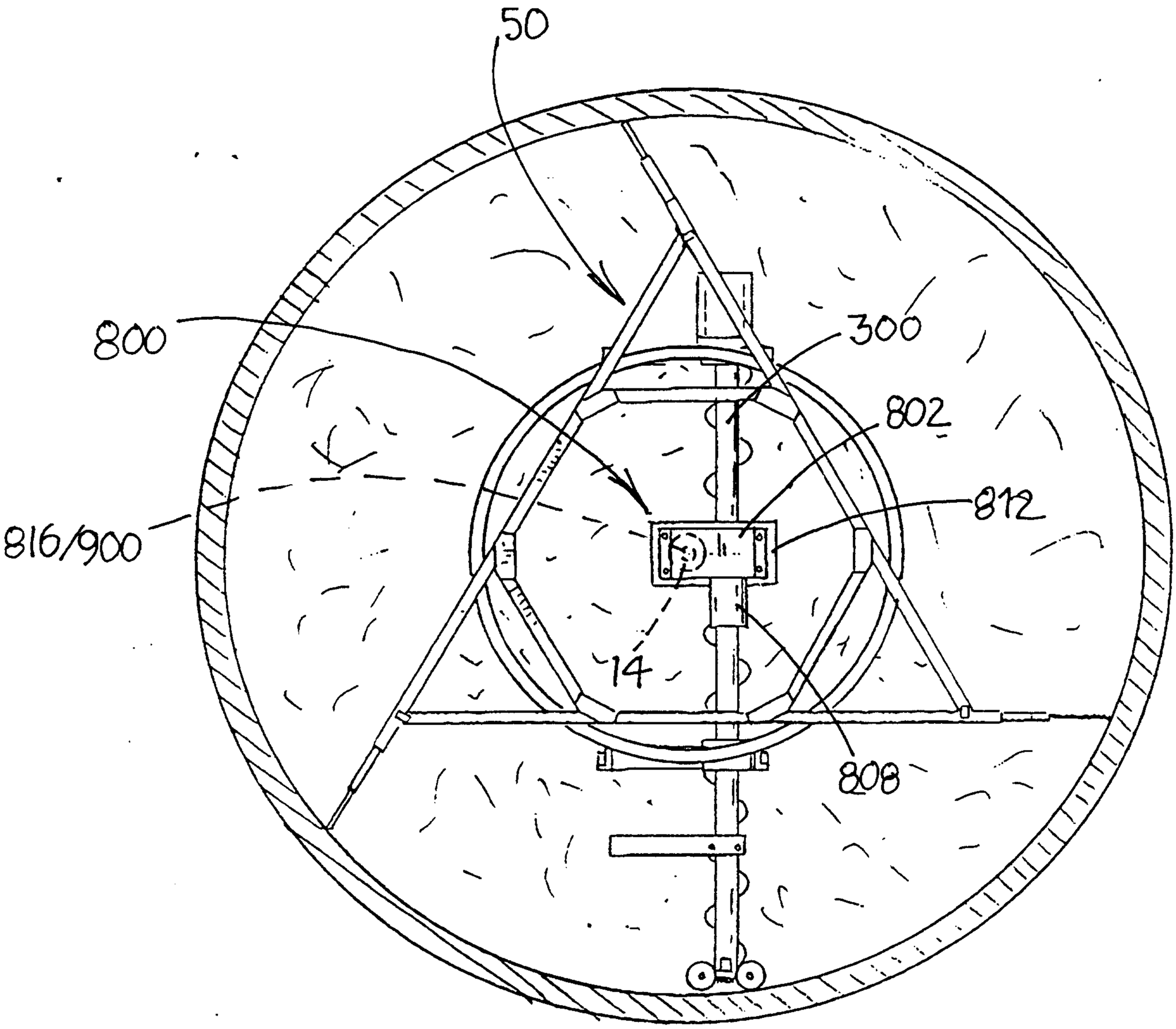

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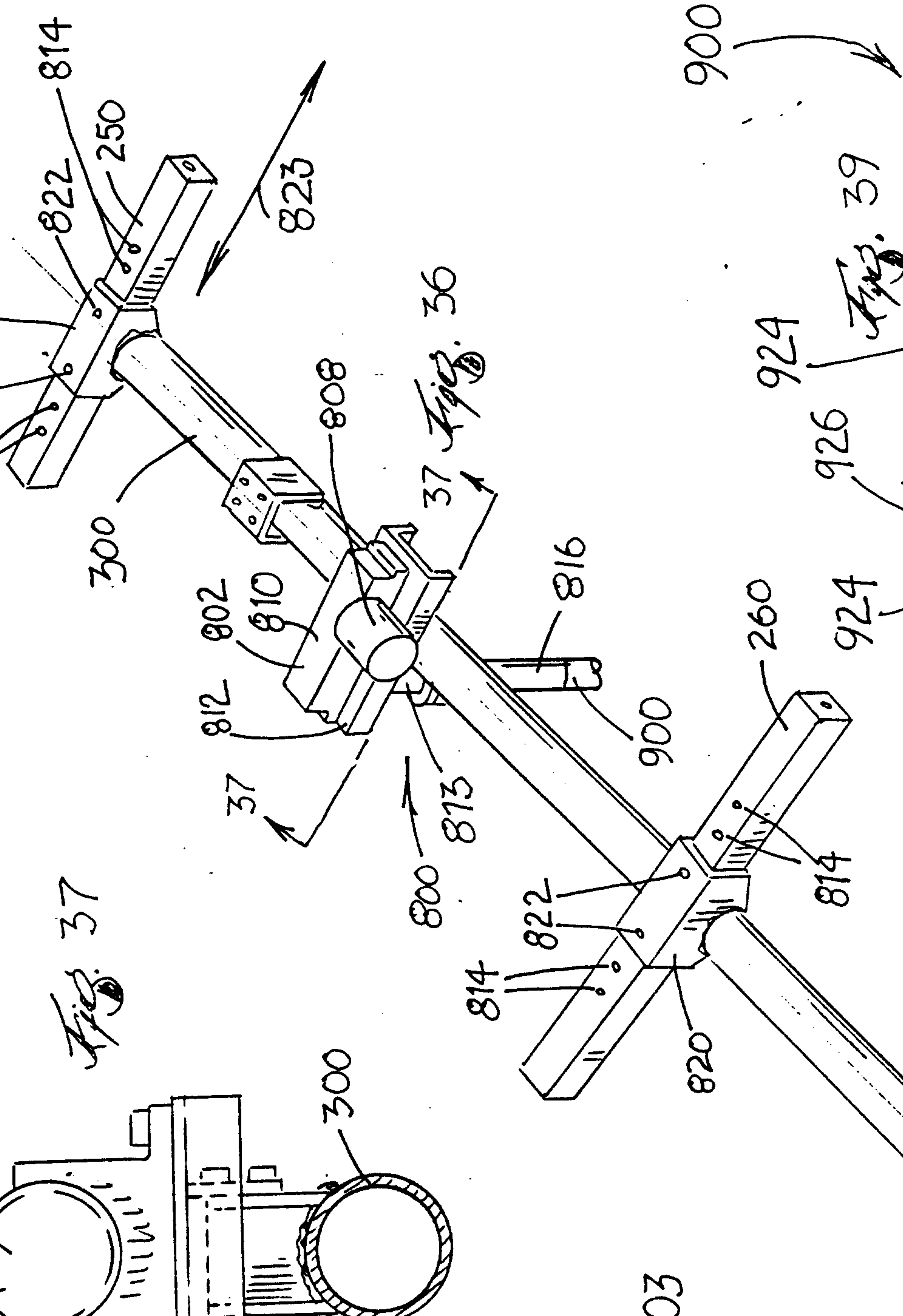

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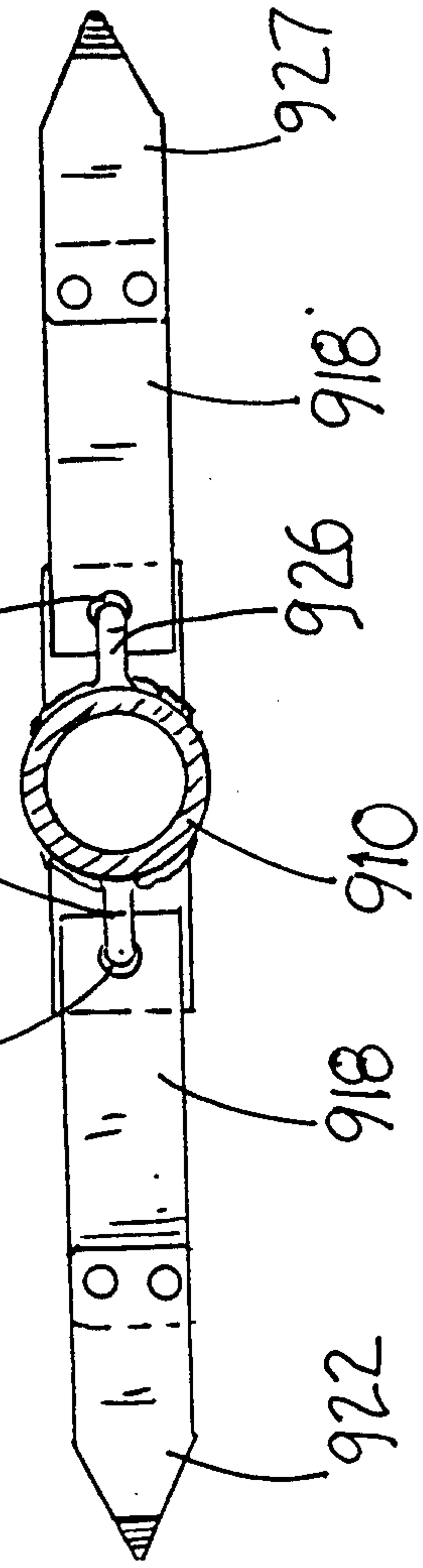

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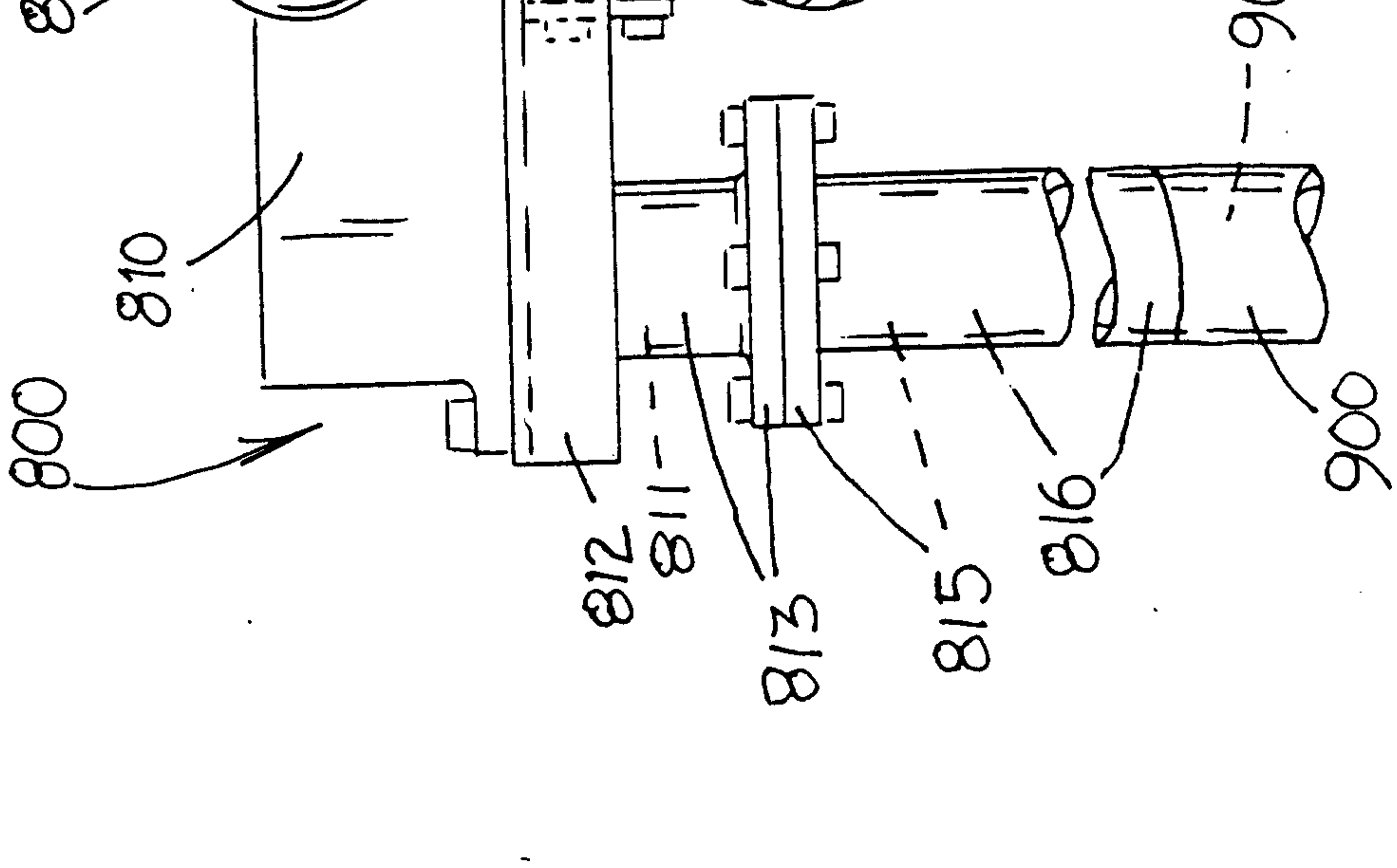
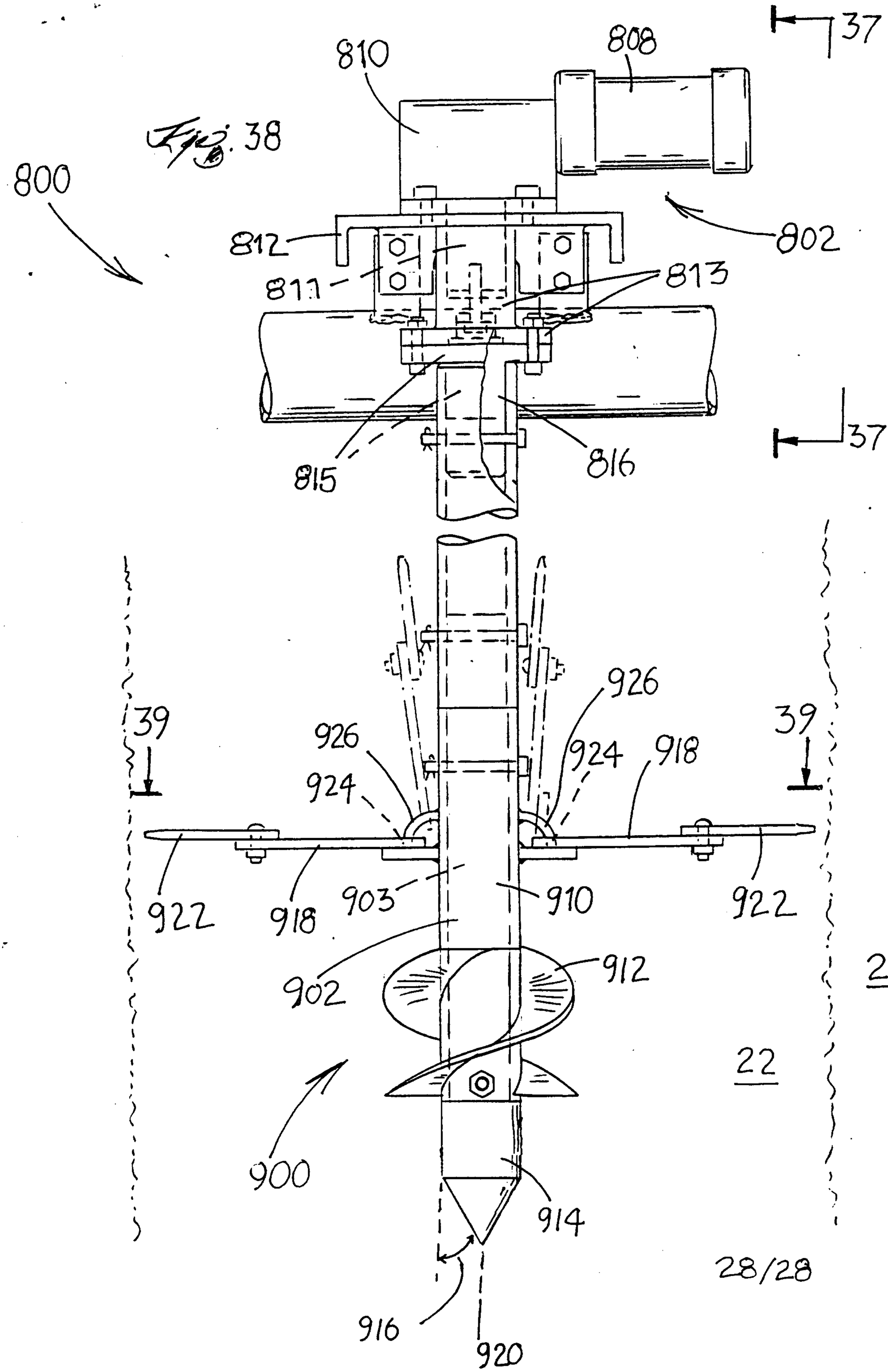


Fig. 37

Fig. 38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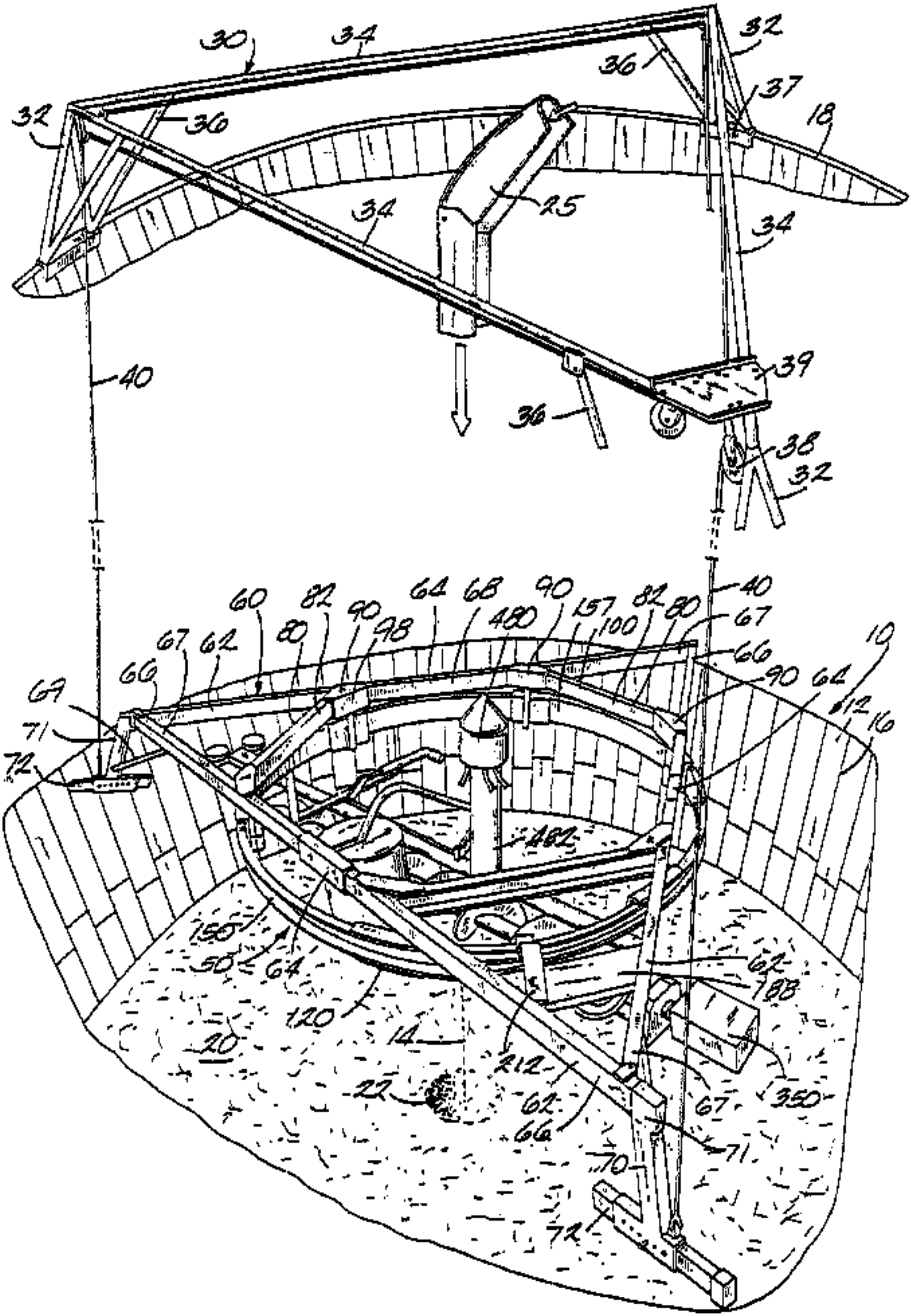
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