United States Patent

Brazell

[15] **3,645,406**

[45] **Feb. 29, 1972**

[54] GANTRY CRANES

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[73] Assignee: **Southern Iron and Equipment Company,** Chamblee, Ga.

[22] Filed: **Oct. 24, 1968**

[21] Appl. No.: **770,170**

[52] **U.S. Cl.**.....**212/14,** 180/66 F, 180/79.2, 212/2

[51] **Int. Cl.**.....**B66c 5/02**

[58] **Field of Search**.....212/14, 13, 15, 124, 125, 38; 180/66 F, 79.2, 179.2 C

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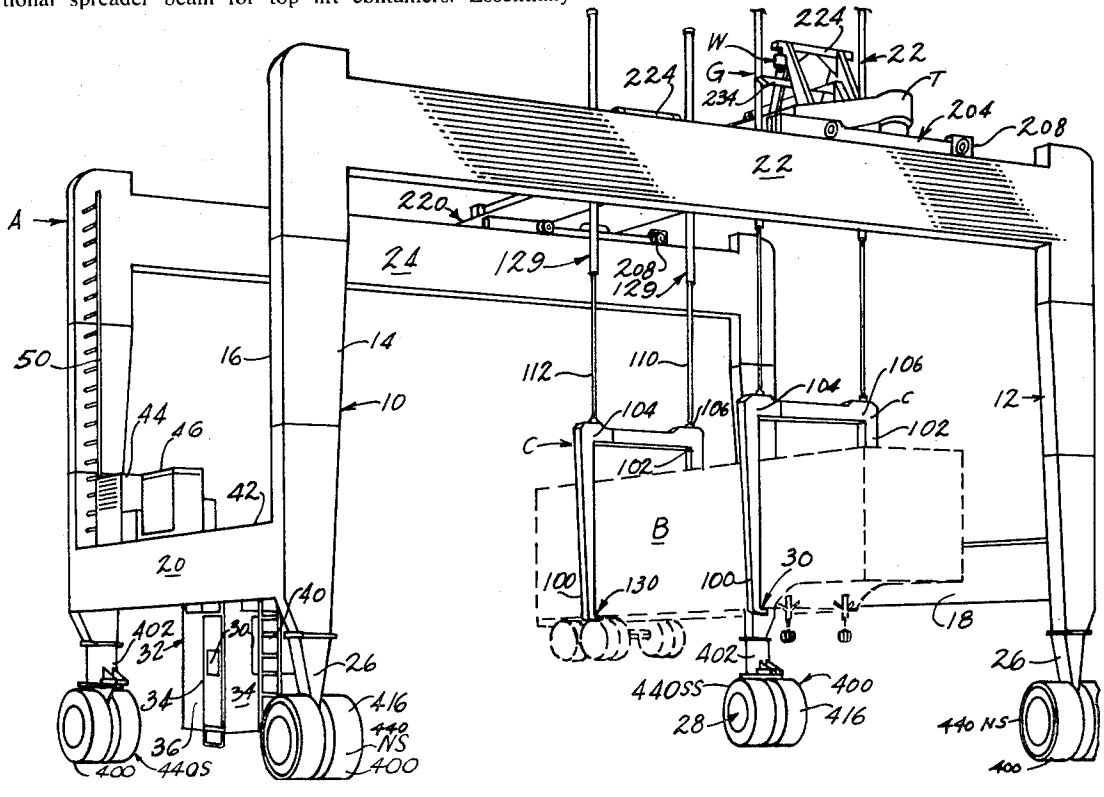
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[57] **ABSTRACT**

A gantry crane suitable for service in so-called piggyback operations where trailers or containers are handled to and from railroad cars. With a typical capacity of 50 tons the crane can move cargo with its bottom lift grappling arms or with optional spreader beam for top lift containers. Essentially hydraulic, the crane is self-propelled using a V-8 diesel engine to drive a plurality of hydraulic pumps. All power for load handling and crane movement is transmitted hydraulically. A stepless, reversible hydrostatic drive propels the crane in either direction at typical speeds up to 465 feet per minute. A hydraulic cylinder in each of the grappling arms provides the load-clamping force. Two cylinders are connected to each of the grappling arms for hoisting. A counterbalance valve at each of the hoisting cylinders provides fail-safe suspension of the load. Another hydraulic cylinder moves one grappling arm relative to the other so that loads of varying lengths can be handled properly. A stepless reversible hydrostatic drive is incorporated in each of two trolley trucks, which are controlled independently so the operator can rotate the load in a horizontal plane, plus or minus typically 35° from the track centerline and also the operator can move the trolley toward or away from his location. A servo-controlled power steering arrangement, incorporating a conventional Davis steering gear, allows steering about either pair of the nonsteered wheels. An automatic weighing system is incorporated to accurately determine and record the weight of the load simultaneously as the load is being handled. Load cells are used which are transducers that relate tensile force to an electrical signal which can be used to indicate the weight of the load and to print a ticket. The load cells are suspended from a frame. Drive wheels are driven directly from a hydraulic motor without the use of any gearing. Two steered struts include two hydraulic motors each, one for each wheel. The hydraulic motor may be of the fixed displacement type powered by a variable displacement pump which is reversible and driven by the engine at constant speed whereby the operator may vary the direction of travel and travel speed with a single control. Since the motors are connected in parallel, differential motion for steering and or maneuvering is available. The crane has a very short turning radius and under ideal conditions could approach pivoting about each of the fixed (nonsteered) struts. The trolley which supports the grappling arms is positioned by two independently driven trolley trucks that operate along rails mounted on girders. A trolley beam includes inverted rails which ride on double-flanged wheels of a spider assembly. This arrangement allows a variation in truck pivot centers as the trolley displaces the angular relationship and a dashpot at the end limits the travel of the spider and thus a displacement angle.

12 Claims, 30 Drawing Figures



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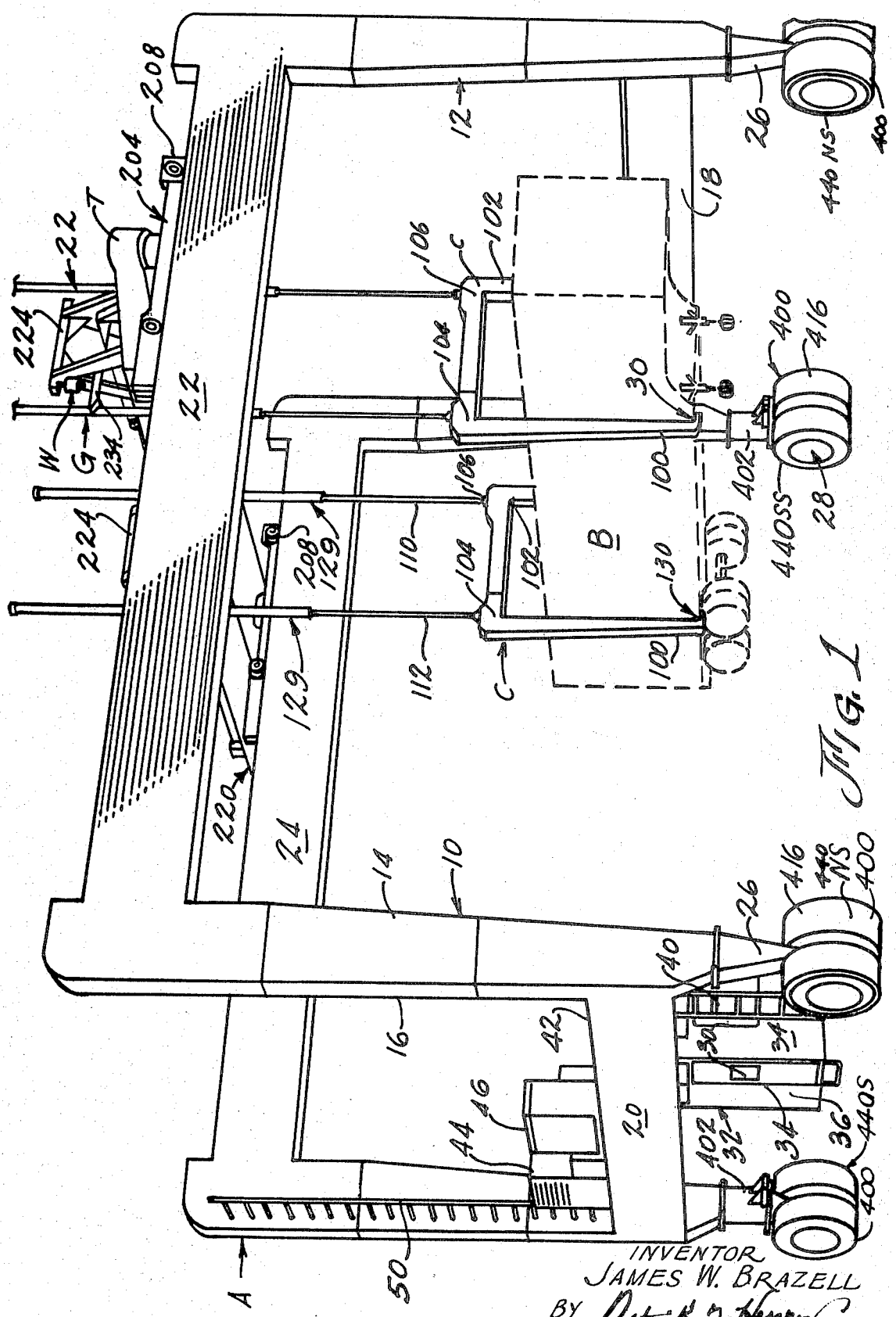


FIG. 1

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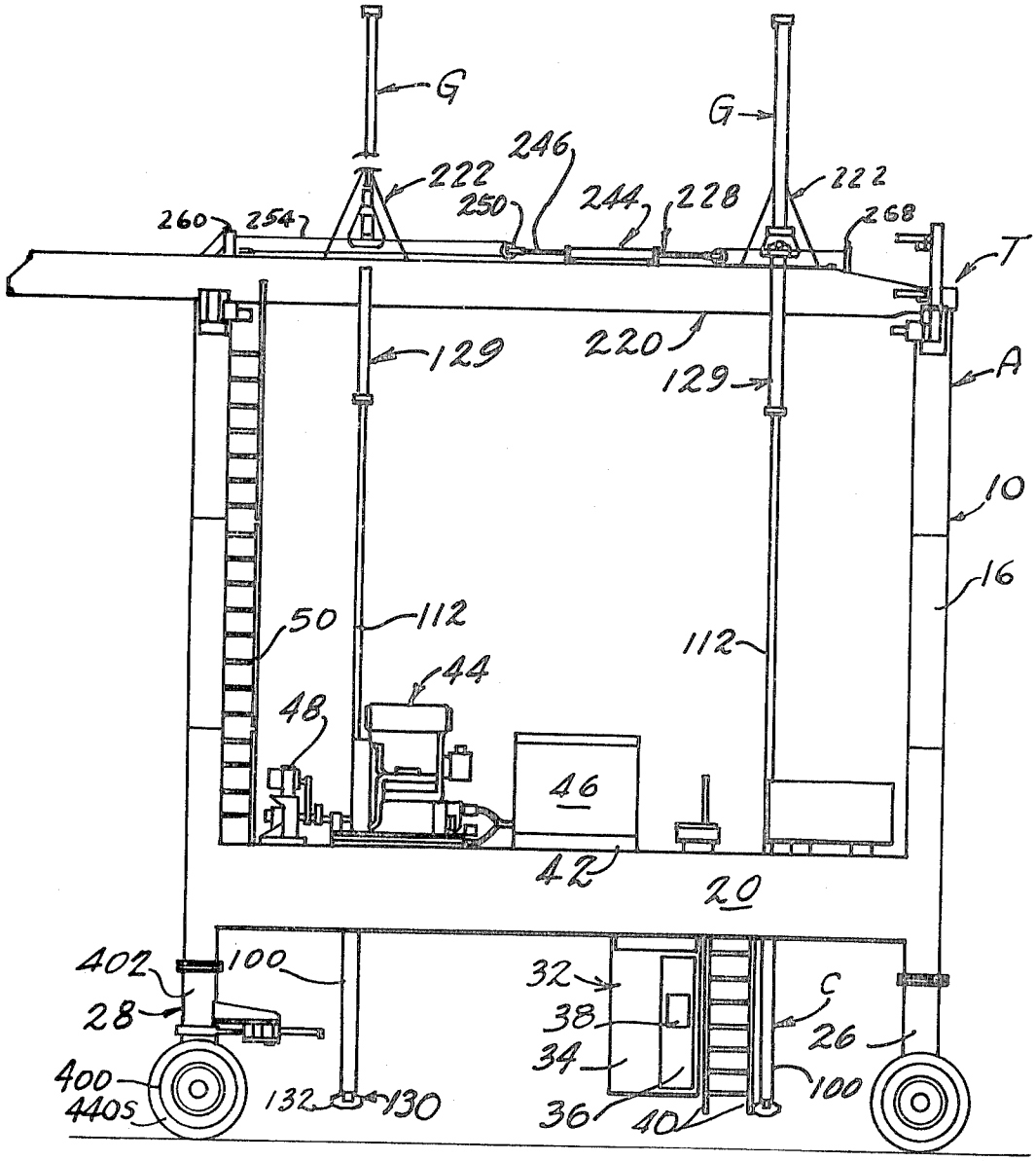


FIG. 2

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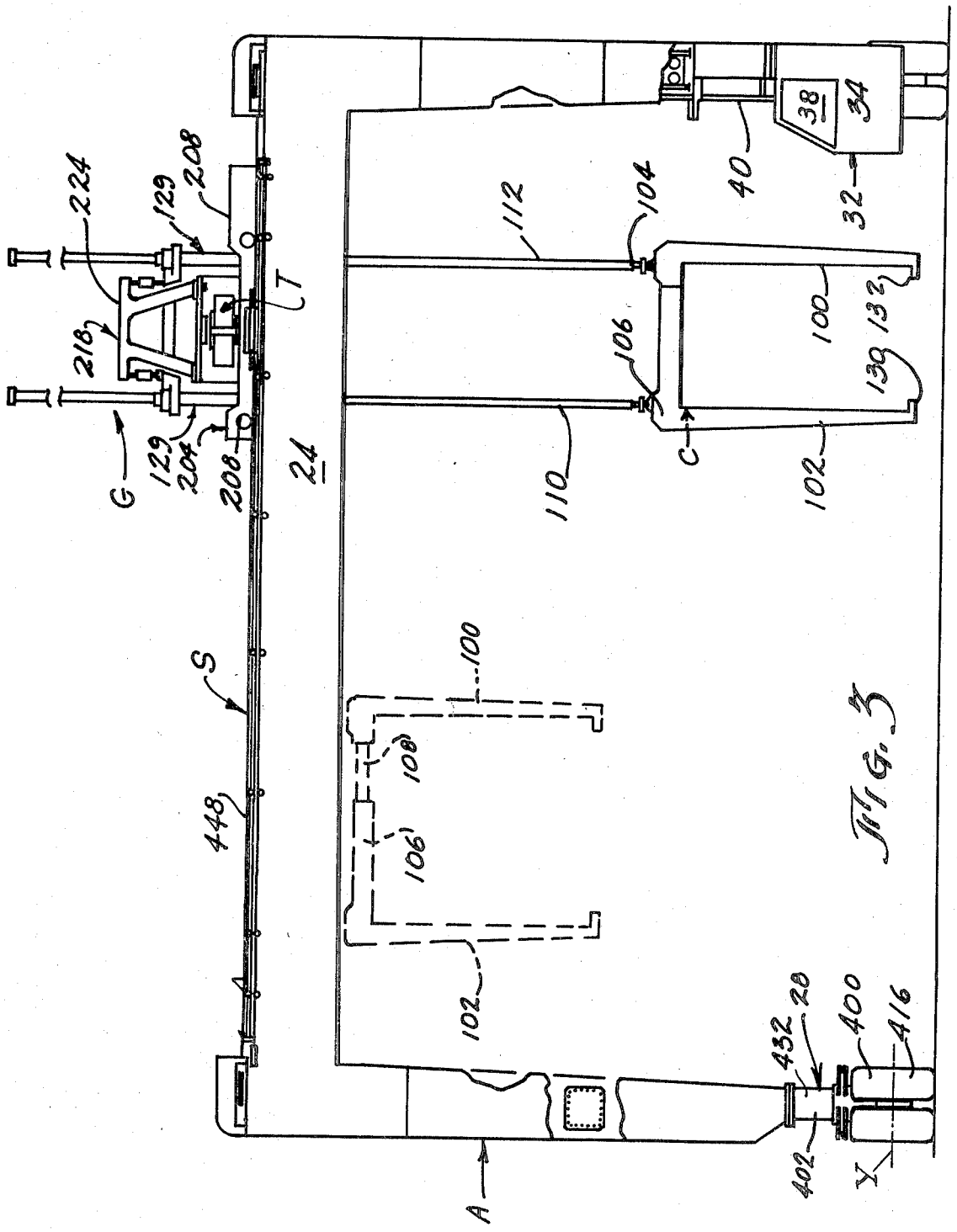


FIG. 3

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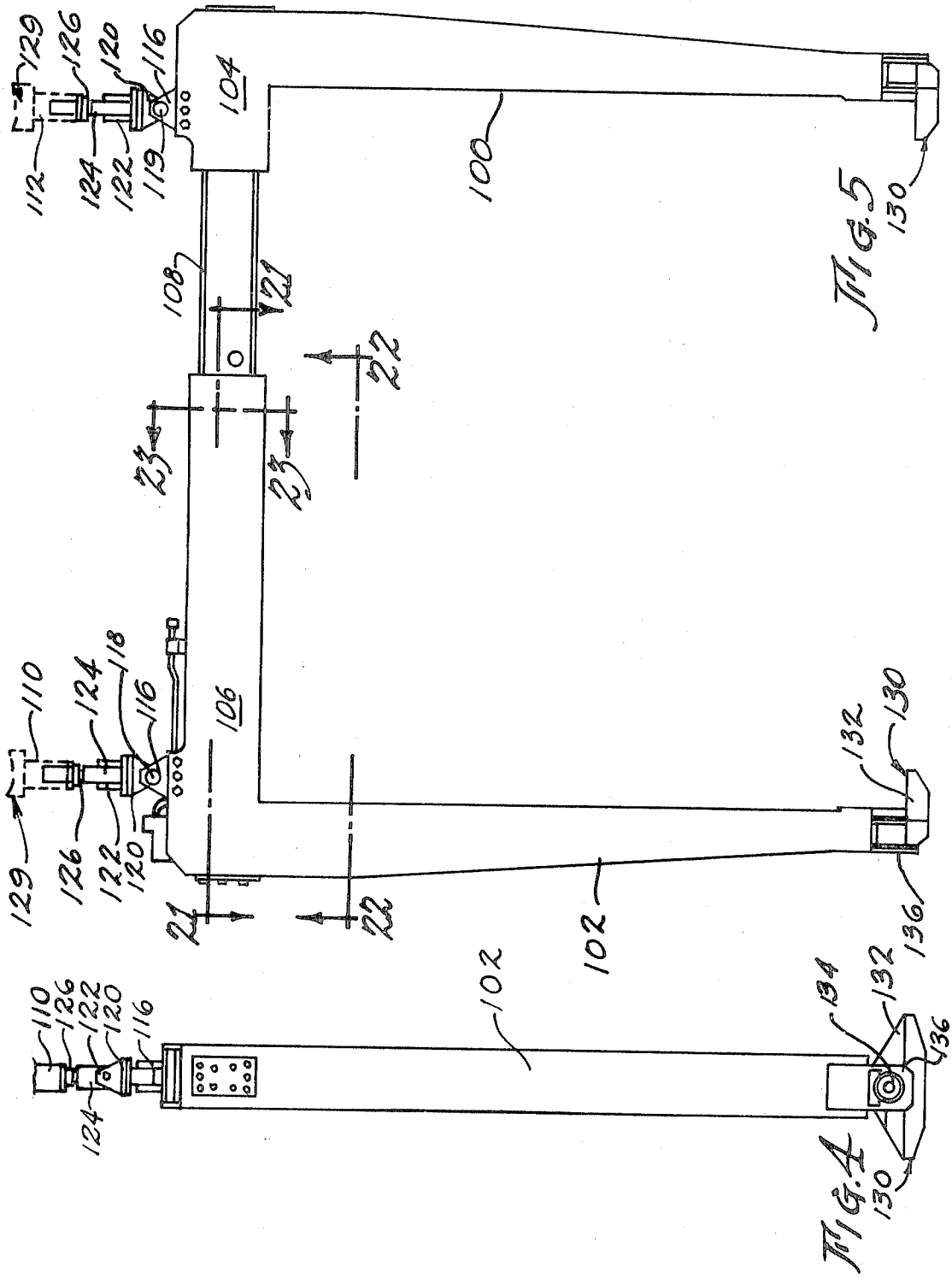
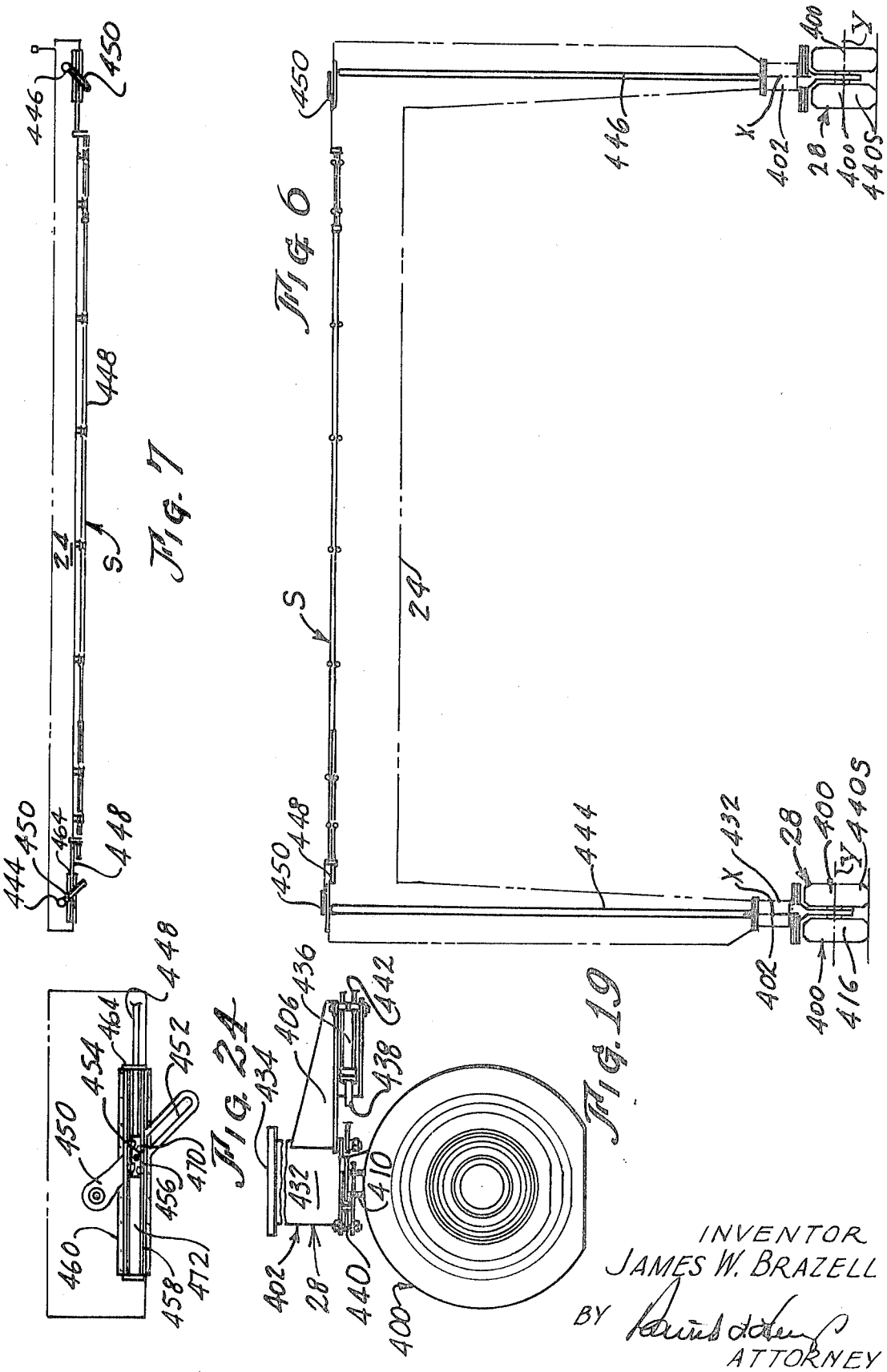


FIG. 5

FIG. 4

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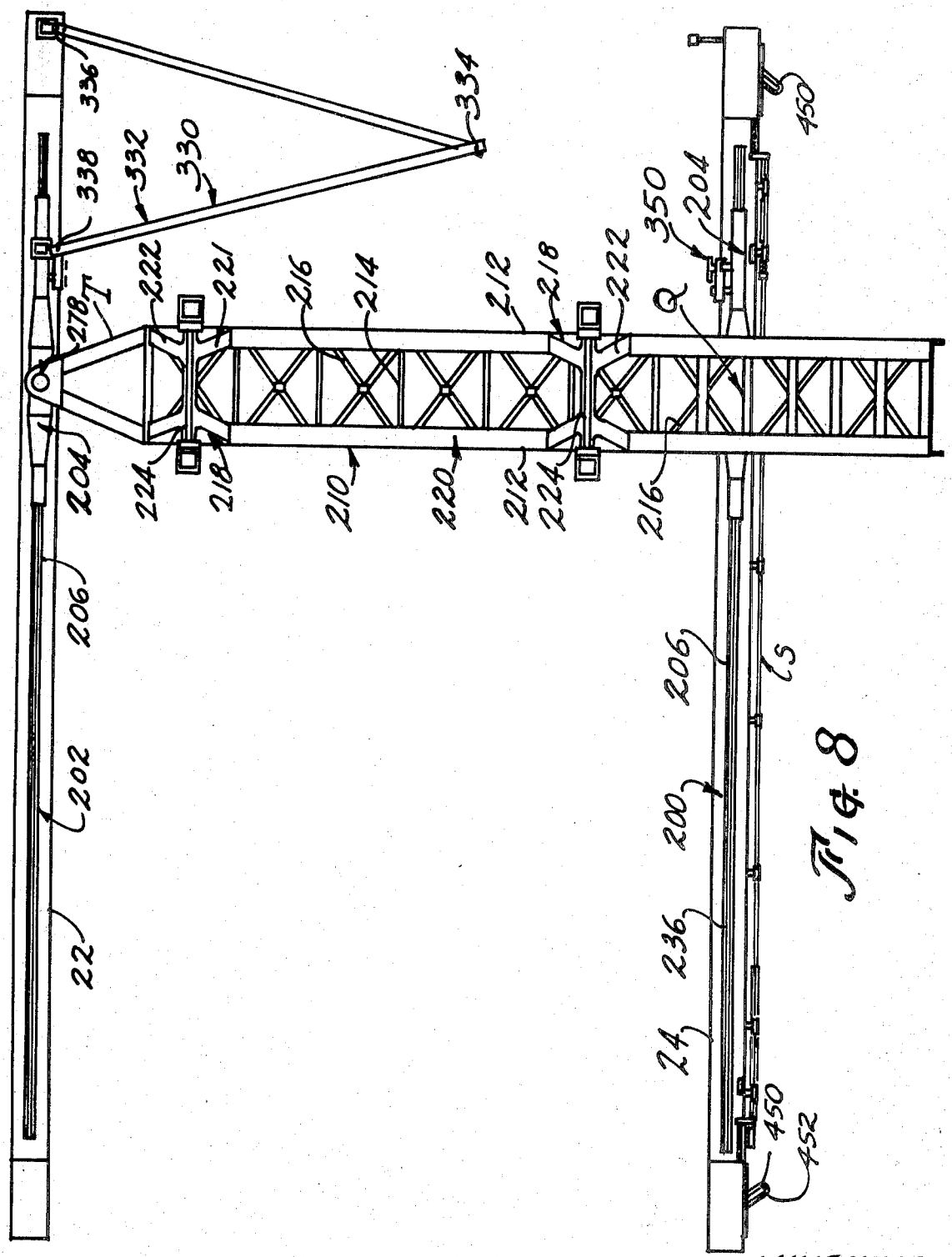


Fig. 8

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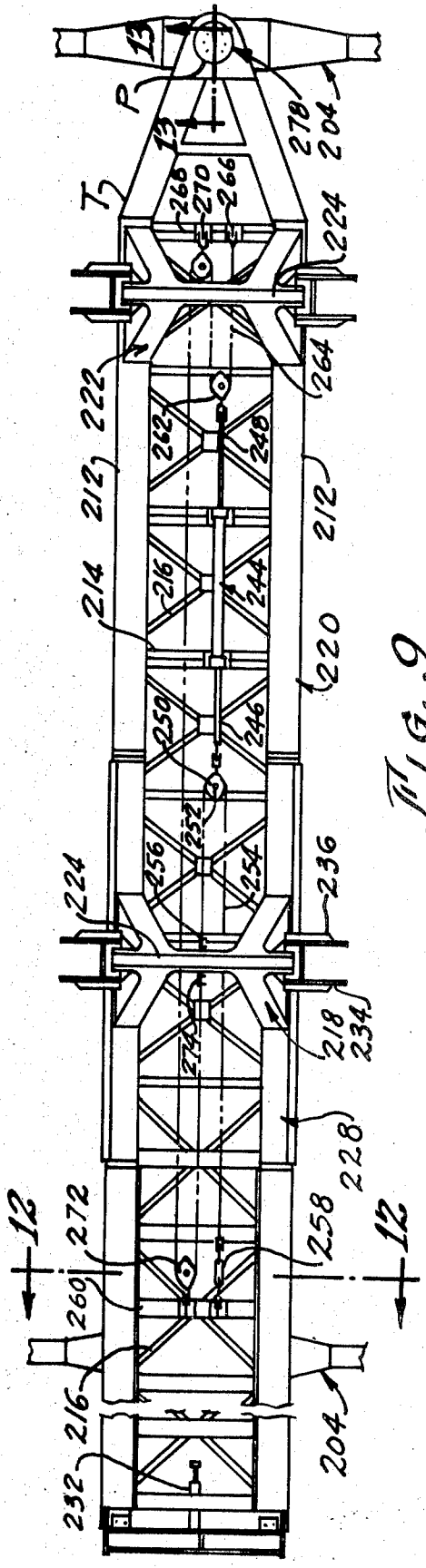


FIG. 9

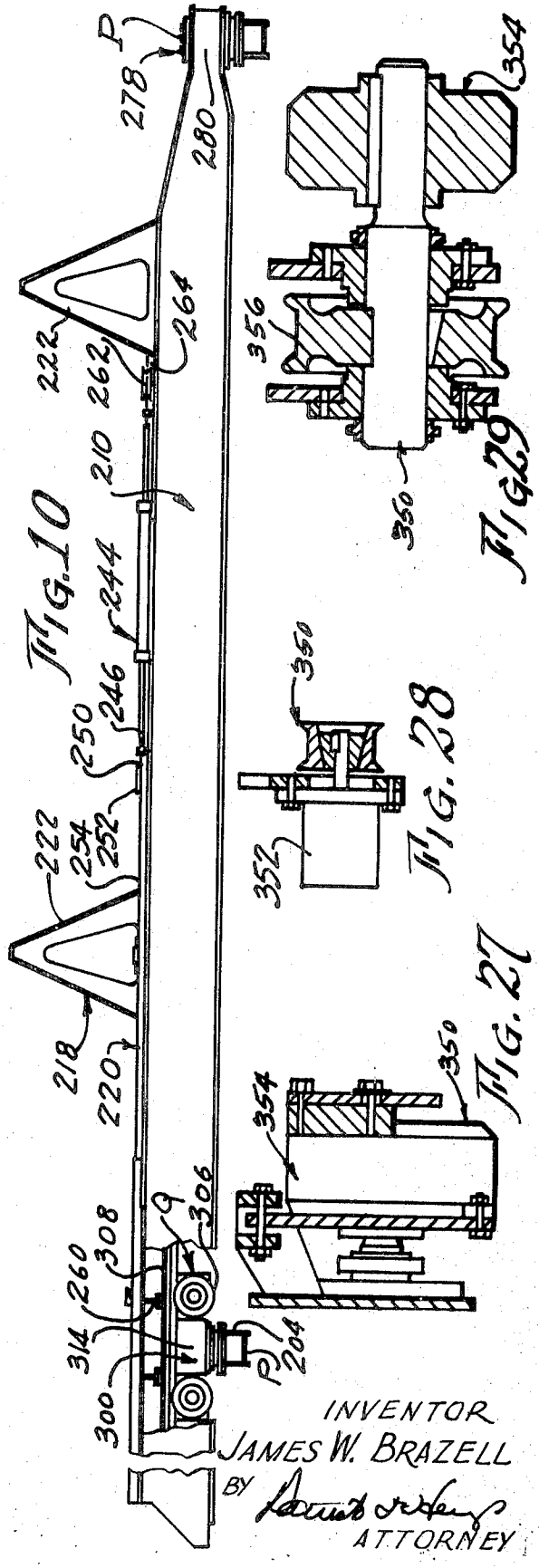


FIG. 10

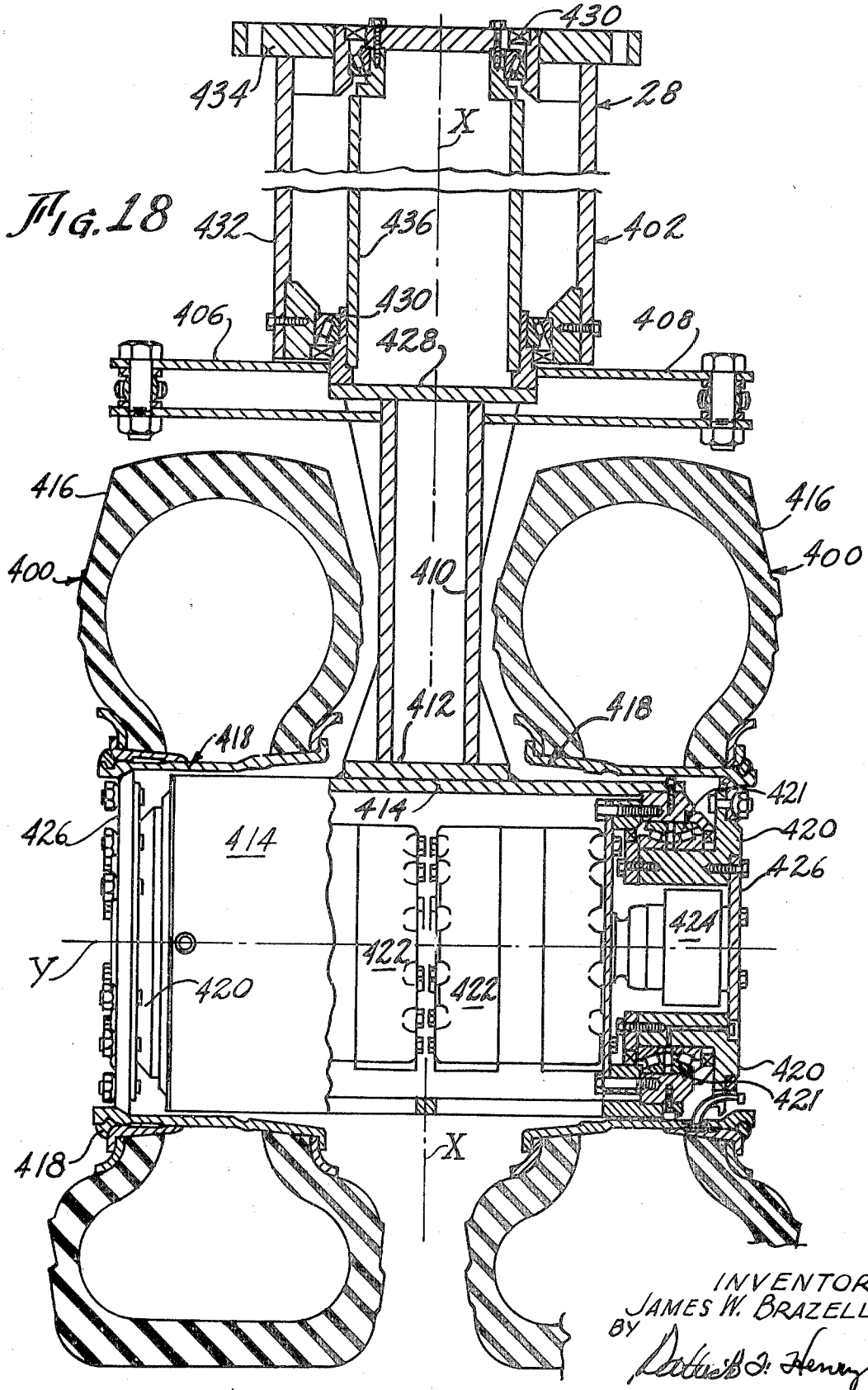
FIG. 29

FIG. 28

FIG. 27

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FIG. 18



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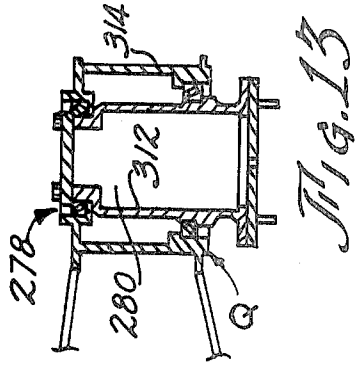


FIG. 13

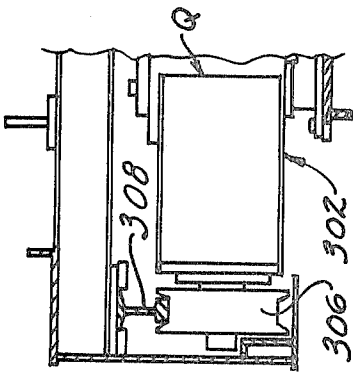


FIG. 12

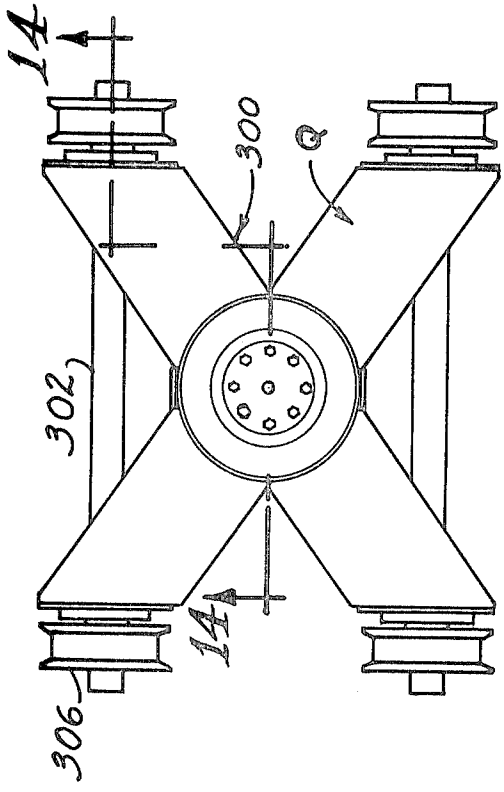


FIG. 11

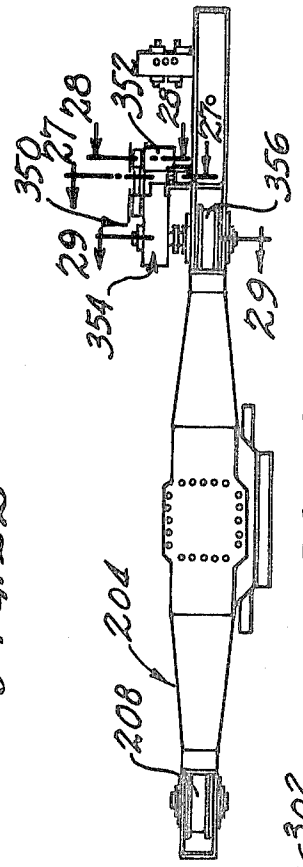


FIG. 25

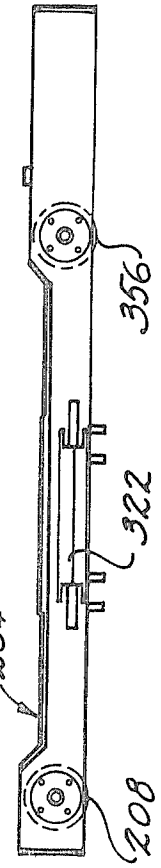


FIG. 26

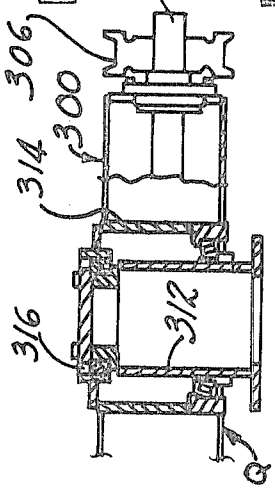


FIG. 14

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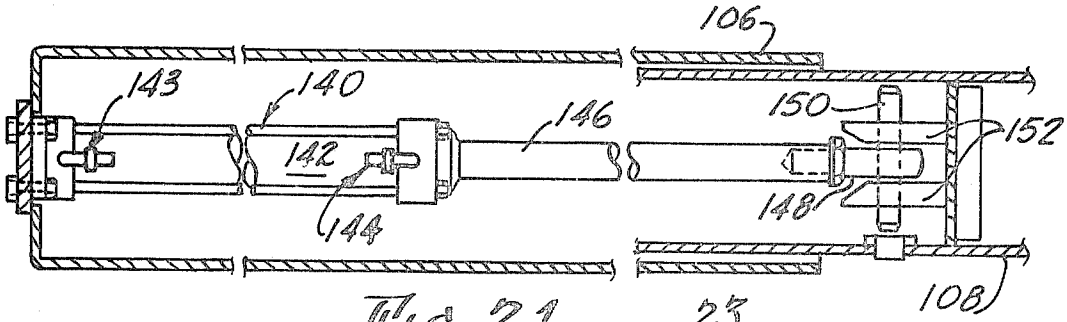


FIG. 21

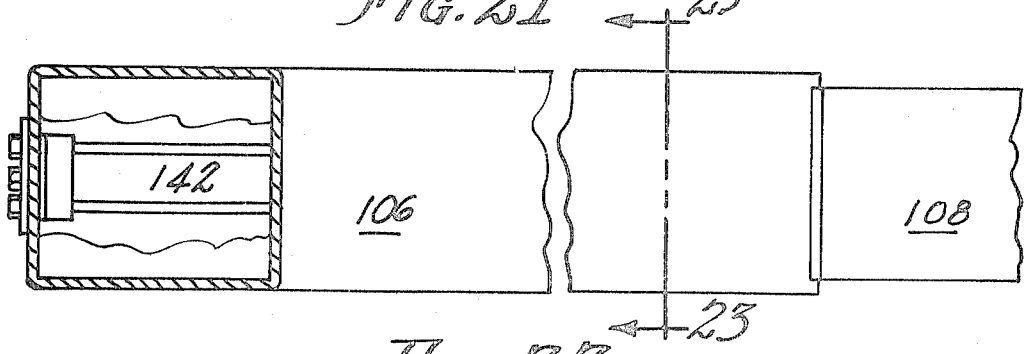


FIG. 22

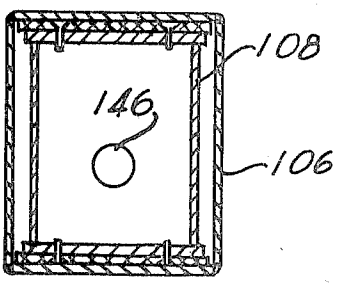


FIG. 23

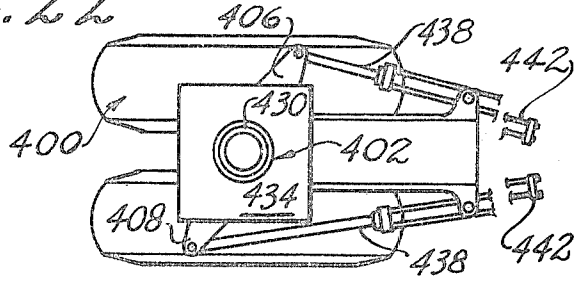


FIG. 20

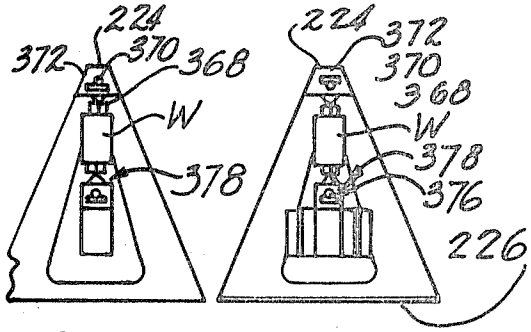


FIG. 16 FIG. 17

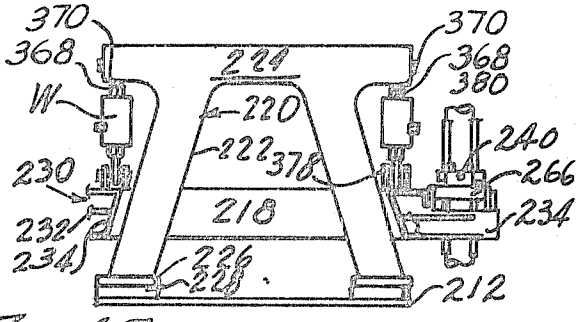
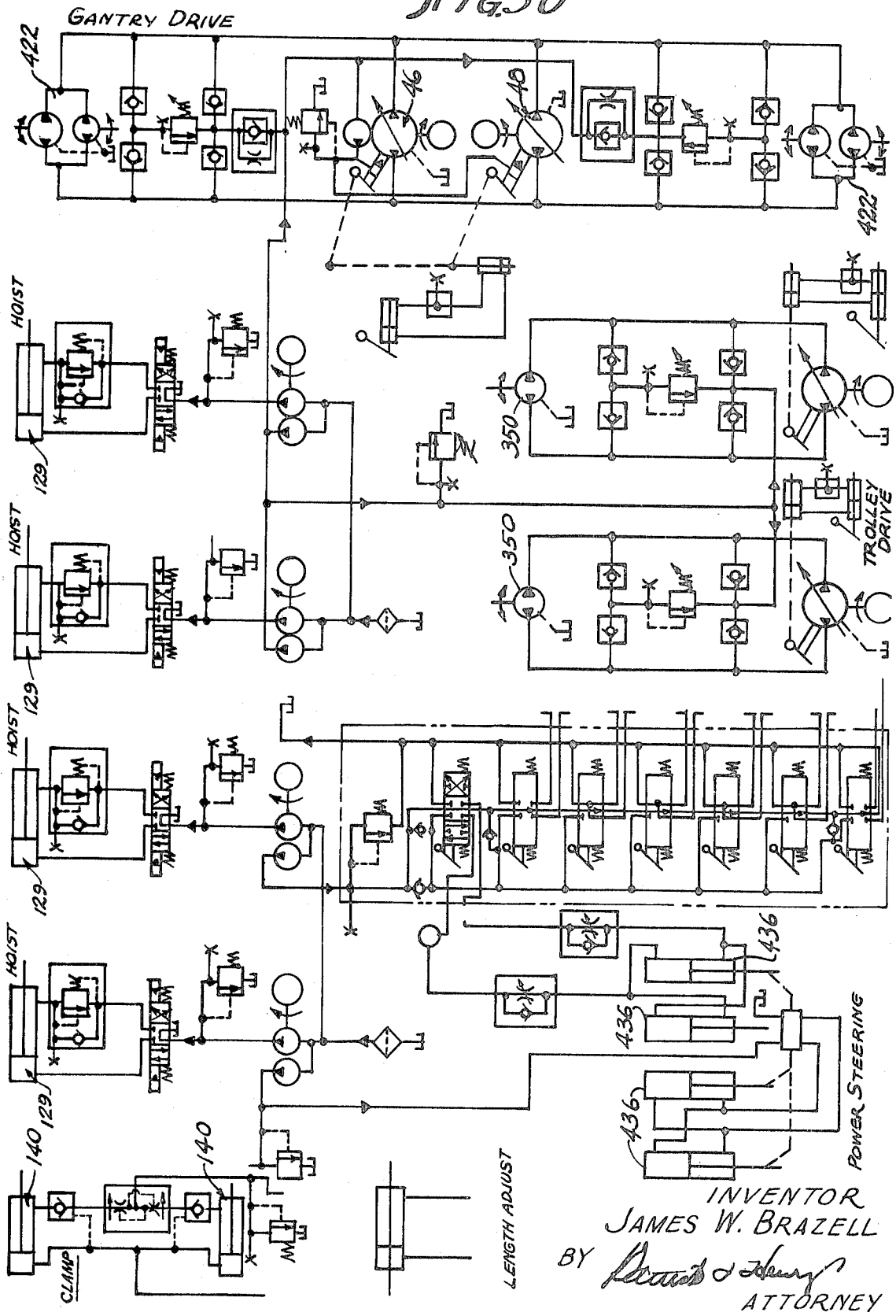


FIG. 15

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FIG. 30



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GANTRY CRANES

CROSS-REFERENCE TO RELATED APPLICATION

Ser. No. 500,615 filed by James W. Brazell et al. on Oct. 22, 1965, for "GANTRY CRANES," now U.S. Pat. No. 3,433,366.

BACKGROUND OF THE INVENTION

1. Field of the Invention

Cranes and similar lifting devices having arms or similar members which are movable and locatable to engage, move and position a load comparable to containerized freight. Other considerations would include the means in a gantry crane for steering and driving the entire crane as well as the means for grasping the load and turning the load as well as moving the load linearly.

2. Description of the Prior Art

The prior art includes the following U.S. Pat. Nos. cited in the above noted application: 2,936,907; 2,974,757; 3,051,321; 3,176,853; 3,190,237; 3,247,974; 3,051,321; 3,081,884; 3,061,106; 3,110,404; 1,486,235; 1,466,296; 2,063,909; 2,063,913; 1,419,129; 1,597,779; 1,671,252; 1,674,967; 1,748,708; 1,437,966; 1,509,400; 2,644,593; 2,701,065; 2,772,794; 3,081,883; 3,086,661.

The field of search according to classification which existed in June of 1964, could include Class 212, Subclasses 6, 13, 14, 15, 29 and 41; Class 14, Subclasses 38.20, 38.40 and 38.42; Classes 254, Subclasses 47; Class 294, Subclasses 81 and 86 LF.

SUMMARY

A gantry crane comprising a three-dimensional structure including a vertical frame and four corners each of which is supported by ground-engaging wheel assemblies, two of which wheel assemblies on opposite corners of the same sides are steerable and are power driven by means of individual hydraulic motors, steering means for each of said steerable wheel assemblies whereby said gantry crane may be steered about one of the four corners, transverse support means extending across said structure and having a space therebelow to accommodate a large load such as a trailer or containerized freight, movable, power-driven trolley assemblies mounted on said transverse frame on opposite sides thereof and supporting a trolley beam support from which is suspended a pair of spaced grappling arm assemblies each comprising a pair of grappling arm members carried together for movement towards or away from each other, said trolley beam being pivotally mounted on one end for angular displacement with respect to the transverse frame, support means for each of said grappling arm assemblies, said support means being respectively movable to bring said grappling arm assemblies closer together or further apart, and weighing means actuatable by said grappling arm support. The drive arrangement for two wheels and the steering arrangement therefor provides a facility of movement and transfer of power which is not obtainable in the prior art gantry cranes particularly from the standpoint of using a hydraulic motor to drive the steerable wheels on two corners of the structure which together with a modification of a well-known Davis steering mechanism provides a turning radius quite important in crowded railroad yards. Along with this, the facility of movement of the traversing trolley both as to linear movement across the gantry structure to carry the large container from one point to another combined with the versatility in controlling the two sets of grappling arms gives a significant ease of movement in the limited space available in railroad yards as compared with prior art devices. Perhaps just as important, is the particular way the trolley beam traverses and the particular way the grappling arms are supported for movement both with respect to each other and of their own independent grappling arms as well as the angular movement of both sets of grappling arms. Any prior art devices which closely approach the present structure in turning radius and operation employ combinations of mechanical devices which are much more complex and involved and difficult to maintain in handling such heavy loads. The present dual wheel arrangement on each of the steerable corners uses a hydraulic motor back-to-back for each wheel and hydraulic cylinder assemblies for turning the two wheels together as a unit about the centerline. Weighing has been a real problem in prior art devices and to incorporate a weighing feature in certain cranes required an interference with the type of load support and shifting arrangement which could have been used and would have been preferred had the weighing feature not been incorporated. The present crane incorporates the weighing feature in the trolley bean and grappling arm support assembly in general and is so arranged by using weight cells that may be activated to take a reading anytime the load is suspended and inactivated when desired without interferring with the traversing or turning of the load. It is not necessary for the operator, or for other employees, to undergo a separate step in order to weigh the load because according to the present arrangement the load weight may be ascertained without moving the load into a special position.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a perspective view of the present gantry crane with a typical load shown in broken lines.

FIG. 2 is a side elevation view of the gantry crane shown in FIG. 1.

FIG. 3 is a front elevation view of the crane shown in FIG. 1.

FIG. 4 is a side elevation view of one of the grappling arm assemblies.

FIG. 5 is a front elevation view of the grappling arm assembly shown in FIG. 4.

FIG. 6 is an elevation view of the steering control with portions of the crane shown in broken lines.

FIG. 7 is a plan view of the steering control shown in FIG. 6.

FIG. 8 is a top plan view of the trolley frame for the grappling arm assemblies and the trolleys and the top of the gantry frame.

FIG. 9 is a top plan view of the trolley frame shown in FIG. 8.

FIG. 10 is a side elevation view of the trolley frame shown in FIG. 9.

FIG. 11 is an enlarged plan view of the spider frame assembly for the grappling arms.

FIG. 12 is a cross-sectional view taken along lines 12—12 in FIG. 11.

FIG. 13 is a cross-sectional view taken along lines 13—13 in FIG. 12.

FIG. 14 is a cross-sectional view taken along lines 14—in FIG. 11.

FIG. 15 is an enlarged elevation view of the A-frame support for the weight cells for the grappling arm assemblies.

FIG. 16 is an end elevation view of the A-frame support shown in FIG. 15 from one direction.

FIG. 17 is an end view of the A-frame shown in FIG. 15 from a different direction.

FIG. 18 is a cross-sectional view taken substantially medially and vertically through a pair of the steerable wheels on one corner of the gantry frame.

FIG. 19 is an elevation view of the steerable wheels shown in FIG. 18.

FIG. 20 is a plan view of the steerable wheel assembly shown in FIGS. 18 and 19.

FIG. 21 is a horizontal cross-sectional view taken through a portion of the grappling arm assembly substantially along lines 21—21 in FIG. 5.

FIG. 22 is a cross-sectional view taken substantially along lines 22—22 in FIG. 5.

FIG. 23 is a cross-sectional view taken substantially along lines 23—23 in FIG. 22.

FIG. 24 is an enlarged, top plan view of a detail of the "-Davis"-modified steering apparatus.

FIG. 25 is a top plan view of a trolley truck for the trolley beam assembly.

FIG. 26 is a side elevation view of the trolley truck shown in FIG. 25.

FIG. 27 is a cross-sectional view taken along line 27—27 in FIG. 25.

FIG. 28 is a cross-sectional view taken along lines 28—28 in FIG. 25.

FIG. 29 is a cross-sectional view taken along lines 29—29 in FIG. 25.

FIG. 30 is a hydraulic schematic diagram using conventional hydraulic symbols and including hydraulic operating components shown in other Figs.

DESCRIPTION OF THE PREFERRED EMBODIMENT

With reference initially to FIG. 1, the entire gantry is designated generally by letter A and comprises a gantry frame assembly suitably constructed from steel beams, plates and the like, in the form of an open frame comprising a front girder assembly 10 and a rear girder assembly 12, column assemblies 14, 16, a side beam assembly 18 and an engine assembly 20, which parts are respectively connected by a front trolley beam assembly 22 and a rear trolley beam assembly 24. Each of the four corners of the frame A supports a wheel support assembly, there being fixed wheel support assemblies 26 on opposite corners of the same side and steerable or movable wheel assemblies 28 on opposite corners of the same side and the fixed wheel assemblies sometimes is referred to as a fixed strut assembly and the steered or movable wheel assembly is sometimes referred to as a steered strut assembly. Mounted for movement across the trolley beam assembly 22, 24 is a trolley assembly designated generally by the letter T, having mounted thereon a grappling arm and weight support arrangement designated generally by the letter G which includes opposed pairs of grappling arms designated generally by the letter C. The grappling arm assemblies C are arranged to lift a typical trailer load of freight B by driving the gantry crane into position over a railroad car on which the trailer B is located, maneuvering the gantry through the steerable wheel assemblies 28 to be described later, and then lifting, shifting and otherwise positioning and moving the container trailer B to place it in condition on the ground to be towed away by the tractor or vice versa, that is, lifting the trailer after it has been driven to the location near the railroad freight car by the tractor and lifting, shifting and positioning the trailer B to place it on the railroad car.

As readily seen in FIG. 6, the steerable wheel assemblies 28 on opposite corners are related by means of a steering mechanism designated generally by reference numeral S which includes a modified Davis steering mechanism to be described later.

The gantry frame structure A is a rigid steel frame welded and or bolted together to provide a structural frame and support capable of withstanding considerable forces such as that involved in moving 50 tons weight suspended from the trolley beam assemblies 22, 24. The selection of the type and size and shape of the steel plates, steel beams and other reinforcing members which make up the column assemblies and girder assemblies, respectively, are a matter of selection by one having ordinary skill in the art of structural engineering.

An operator's cab 32 is fabricated from steel structural members covered with metal plate forming sides 34 in one of which sides 34 is located a door 36. The cab 32 is provided with various windows 38 providing maximum visibility for the operator. A steel ladder 40 is welded to the beam assembly 20 and leads to the platform 42 on the beam assembly 20 on which is supported a diesel engine 44 which drives a pump 46 which pumps hydraulic fluid for the operation of the gantry crane. A steering pump 48 is also driven from engine 44. The engine 44, pumps 46 and 48 are of conventional construction of the sort which may be obtained from Vickers, Inc., a division of Sperry Rand Corporation, P. O. Box 302, Troy, Michigan 48084, or equivalent equipment which may be obtained from other sources. A ladder 50 made from steel frame and metal rungs leads from the platform 42 of the beam assembly 20 to the trolley beam assembly 24.

GRAPPLING ARM ASSEMBLY C

There are two grappling arm assemblies C as seen in FIG. 1 and each comprises a pair of movable grappling arms 100, 102 which are elongated structural members formed from steel plate suitably reinforced and the arms 100, 102 are located generally vertical with inwardly extending hollow boxlike tube portions 104, 106 and portion 104 has an inner sliding member 108 constructed as an elongated frame. Each arm 100, 102 is suspended and supported near the top thereof from respective rods 110, 112 each having the lower end by means of a female clevis 116 connected by a pin 118 to a male clevis 120 to which is bolted another female clevis 122 which is mounted a knuckle assembly 124 locked by a collar 126 to the shaft or rod 110. Each rod 110, 112 is operated by a hydraulic cylinder device 129.

The lower end of each arm 100, 102 supports a shoe assembly 130 which comprises an inwardly extending lifting shoe 132 fabricated from steel plate and attached by means of a pivot pin 134 to a split plate arrangement 136 bolted, welded or otherwise secured to the lower end of the respective arm 100, 102. Shoes 132 extend beneath portions of the load such as the trailer B and engate the underside for purposes of lifting same.

Arms 100, 102 are separated or brought together by means of a hydraulic cylinder arrangement 140 shown in more detail in FIG. 21 and comprising a cylinder 142 controlled by means of hydraulic tube assemblies 143, 144 to actuate the piston rod 146 the end of which has an adjustable eye bolt 148 fitted over a pin 150 mounted between projecting support members 152 inside the sliding tube 108. The cylinder 142 is operated by controlling the hydraulic fluid in line 143 or the line 144 to extend or retract the rod 146 thereby extending or retracting the tube 108 inside of the tube 106.

TROLLEY ASSEMBLY T

The pair of grappling arms C described previously are supported for movement across the gantry crane on trolley assemblies T which operate on a track arrangement comprising a front or forward girder assembly 200 and a rear girder assembly 202 each supporting a wheel trolley assembly designated by reference numeral 204 and each consisting of an elongated frame riding inside of opposed rails 206 and supported for movement on spaced wheels 208 there being a forward wheel 208 and a rearward wheel 208 on each of the trolleys 204.

The trolleys 204 are also known as trucks and each supports the trolley beam assembly T which extends across the beams 22, 24 and is movably supported at one end on a truck or trolley 204 and as seen in FIG. 10 is movably supported near the other end on a spider assembly Q which is supported on the trolley or truck 204 on beam assembly 24. Spider assembly Q is a means movably supporting one end of the trolley beam which is designated generally by reference numeral 220, allowing limited linear movement of the trolley beam 220 with respect to the spider assembly Q as well as limited rotational movement about the centerline of the spider assembly Q in both directions.

The trolley assembly T comprises a trolley beam assembly 210 comprising a pair of spaced, elongated steel beams 212 rigidly connected by steel crossmembers 214 welded or bolted thereto and additionally reinforced by X-frames 216 comprising diagonal members extending between and welded or otherwise attached to the beams 212 and fastened together in the intersecting centers. The grappling arms 100, 102 are suspended by the respective cylinders 129 from a lift beam frame 218 movable suspended from weight cell members W which are movably mounted on large A-frame assemblies 221

comprising opposed A-shaped frames 222 rigidly connected together by a top crossmember 224 and having metal pads 226 resting on phenolic pads 228 on the trolley beam assembly 210.

The lift beam frame 218 is an elongated steel beam having bifurcated portions at each end designated generally by reference numeral 230 and constructed by welding or otherwise attaching horizontal plates 232 to vertical plates 234, 236 spaced from each other and providing a space in which is mounted the top end 236 of the hydraulic cylinders 129 for the grappling arms 100, 102. The operation of the weight cells W as related to the lift beam frame 218 and the grappling arms 100, 102 will be mentioned again later on.

The respective hydraulic cylinders for hoisting grappling arms 100, 102, sometimes referred to as the hoisting cylinders 129, are mounted in a gimbal on the respective ends of the lift beam frame 218. Thus, the respective hoisting cylinder 129 swings about a pin 240 which is included as part of the gimbal mounting and also swings in the member 235. This provides a universal mounting to the lift beam by the gimbal which is part of the hoist cylinder orientation and has to do with the accuracy of the weighing operation which will be referred to later on.

One of the A-frames 222, the one closest to the spider assembly Q, and therefore the respective pair of grappling arms 100, 102 suspended therefrom, is movable in either direction longitudinally for a limited amount on the trolley beam assembly 210 resting on the phenolic pads 228, such being a length of wide bearing surface on which the bottom of the A-frame 222 can move. This movement is controlled by the operator of the gantry crane from his respective control levers (not shown) inside the cab assembly 32, to actuate a double hydraulic cylinder assembly 244 comprising oppositely movable piston rods 246, 248 and rod 246 is connected by a clevis 250 to a pulley 252 having a control cable 254 moving therearound and one end of said control cable 254 is secured at 256 to one side of the A-frame 222 and the other end of the control cable 254 is attached to a pulley 258 which is secured to a cross-frame member 260 on the trolley beam assembly 210. The other rod 248 is attached to a pulley 262 which has a cable 264 thereon one end of which is secured at 266 to a frame member 268 on the trolley assembly 210 and the cable extends around another pulley 270 and lengthwise of the lift beam frame 218, through the A-frame 222 and around another reversing pulley 272 which is attached to the crossmember 260 and then the cable 264 is secured at point 274 to the A-frame. The hydraulic cylinder 244 and the previously described cable and pulley system provides a means for causing the A-frame to move in either direction on the trolley beam assembly 210 which is also a means for moving selectively the respective grappling arms 100, 102 on that A-frame 222 in either direction which provides a means for adjusting those grappling arms with respect to the load to be lifted.

Referring to FIG. 8 it will be seen that the trolley 204 on one side supports the trolley beam assembly 210 on a trunnion assembly designated generally by reference numeral 278 which comprises a sleeve, housing or collar 280 formed on the end of the trolley beam assembly 210.

The grappling arms 100 are movable towards or away from each other as well as being movable transversely of the gantry which is the direction of movement between members 10 and 12. In addition, each grappling arm 100 is movable with respect to grappling arm 102 so as to adjust for the width therebetween which also provides adjustment for the load to be lifted and for bringing the shoes 132 into firm engagement with the load. The angle of the load lifted may be changed during movement by the operator of the gantry by actuating the hydraulic controls in the cab 34 to move the trolley assembly T. The rods 110, 112 can be elongated in the manner shown in FIG. 3 and retracted to cause the shoes 130 to move from a low position to a high position shown by the dotted lines in FIG. 3 thereby providing vertical adjustment of the load and of the shoes 130 when there is no load for the purpose of engaging and disengaging the load regardless of the vertical height of the bottom of the load. As will appear hereinafter with respect to a discussion about the load cells W, it is unnecessary for the load to be deposited to be weighed since it is suspended from the weighing means.

Adjustment of one of the grappling arms 100 on A-frame assembly 222 with respect to the other grappling arm arrangement 102 is accomplished by operation of the hydraulic cylinder 244 and the cable is maintained in the taut condition by means of the adjustment of the rods 246, 248 from the cylinder 244. When the rod 246 is retracted and the rod 248 is extended the A-frame assembly 222 on the phenolic pads 228 is caused to move toward the hydraulic cylinder 244 but when the rod 248 is retracted and the rod 246 extended the A-frame assembly 222 is caused to move in the opposite direction. This provides a means for adjusting the distance between the two pairs of grappling arms 100, 102.

Angular adjustment of the grappling arms with respect to the shortest distance between the two respective rails 206, which is also the distance between the two trolley assemblies 204 when they are in the same relative position on the respective rails 206, is accomplished by means of the spider assembly Q which provides a means whereby the end of the trolley beam 212 may be moved inwardly or outwardly with respect to the respective trolley 204 and also a means for providing angular displacement with respect to the rails 206. The spider assembly Q is shown in more detail in FIGS. 11 through 14, inclusive, and comprises a large, rigid-X spider frame 300 constructed from heavy steel plate suitably reinforced and formed in rigid boxlike sections which may be seen in FIGS. 13 and 14. Shafts 302, 304 on opposite ends of the spider frame 300 have wheels 306 thereon which are double flanged to travel on rails 308 rigidly mounted beneath the trolley beam assembly 210, there being two rails 308 one on each side. The entire spider frame 300 is rotatably carried on the top of the respective trolley 204 by means of a cylindrical sleeve 312 mounted on the trolley 204 and having a larger cylindrical sleeve or collar 314 which is rigidly formed with and affixed as a part of the spider frame 300 in the center thereof, rotatably mounted thereon and supported on a bearing assembly 316 whereby the entire spider frame may rotate on the trolley 204. The spider frame 300 is freely rotatable about the cylindrical member 312 and is also longitudinally movable along the respective rails 308 which allows an angular displacement of, for example, 35° either way from center at which point in a typical installation the pivot points P of the respective trolleys 204 will be a little over 42 feet apart. The normal rail, center-to-center distance perpendicularly between the respective rails 206 would be something like 35 feet. A dashpot assembly 322 at the end of the trolley 204 limits the travel B of the spider Q and thus the displacement angle.

The phenolic pads 228 are graphitized for better movement of the A-frame assembly 222 in a longitudinal direction on the trolley beam assembly 210 and the trolleys 204 are freely movable along the rail independently of one another plus the angular displacement by means of the rotation of the spider assembly Q. This provides a means for adjusting the grappling arms 100, 102 angularly with respect to the load being lifted, linearly with respect to each other as well as adjusting the respective pairs of arms with respect to each other transversely of the load to be lifted. Control of the angular relationship of the trolley beam assembly is accomplished by the operator controlling independently the two wheel trolley assemblies 204, one of which can be held stationary while the other is moved in either direction along its respective rail 206 or one may be moved in one direction while the other is moved in the opposite direction and movement takes place around the trunnion 278 on one side and around the spider assembly Q on the sleeve 312 on the other side.

The hydraulic cylinder 244, the trolleys 204 and other hydraulic apparatus are supplied by means of hoses carried by a folding support means 330 comprising rigid frames 332 consisting of longitudinal frame members 333 and transverse frame members 335, there being two such frames 332 con-

nected by means of a pivot arrangement 334 and one of the frames 332 is connected by a pivot arrangement 336 to the front trolley beam assembly 22 and the other frame 332 is connected by a pivot arrangement 338 to the trolley 204 on that side. As the trolley 204 moves on its respective rail 206, the support means 330 extends and collapses depending upon the direction of movement carrying the supply hoses therewith.

The individual wheel trolley assemblies 204 are driven by means of respective, individual drive means 350 each comprising a hydraulic motor 352 which through a transmission means 354 drives a drive wheel 356 in contact with the upper part of the gantry crane on the respective front, top beam assembly or rear top beam assembly 22, 24 respectively. The respective hydraulic motor 352 for each respective trolley truck 204 is controlled selectively and individually by the operator and the direction of the motor is reversible so that the trolley 204 may be run in any direction on the respective top beam assembly 22, 24 to cause the trolley to operate in either direction on the respective rail 206.

The weight cells W, sometimes referred to as load cells, are electrical transducers which relate tensile force to an electrical signal. The signal from each cell W is added to the others and communicated as an electric signal connected to a printing apparatus which prints the weight of the total load. The load cells W are suspended by ball joints 368 each of which includes a pin 370 mounted on a web plate 372 on the upper intersecting portion of the A-frame 220. The lift beam 218 is suspended from the load cells W by means of a ball joint 374 which includes a pin 376 mounted through a pair of spaced support members 378 on the beam 218 and through a ball joint element 380. As seen in FIG. 15, there is a load cell W on each side of the A-frame and the suspension of the lift beam 218 on the respective load cell W parallel and in pure tension during the weighing operation regardless of the hoist cylinder orientation. As mentioned previously, the hoisting cylinders are universally mounted to the lift beam 218 by means of a gimbal 240. The ball joints, also referred to as spherical rod ends, are disclosed in U.S. Pat. No. 2,781,238. The load cells W are not per se claimed as the present invention and may be obtained on the open market from BALDWIN-LIMA-HAMILTON, a subsidiary of Armour & Company, Waltham, Massachusetts, 02154, and are disclosed in Bulletin 401—1, Revised August of 1966. The electronic portion of the system, that is, the transmittal of the signal from the load cells W electrically to a printer to make a ticket is a standard commodity and per se is not a part of or disclosed in the present application since it is found commonly in a number of platform scale applications and other known weighing systems and methods. This is not to say, however, that the present arrangement of the weighing system in a gantry crane arrangement through the use of the suspension of the grappling arms 100, 102, the hoist cylinders 129, the lift beam arrangement with lift beam 218, the load cells W and the general arrangement is not original or commonly known.

GANTRY DRIVE AND STEERING

It is important to note that the drive arrangement is a direct drive from a hydraulic motor to the wheels without the use of any gearing so that power transmission efficiency is practically a hundred percent. Simplicity of the drive is extremely important and makes it economical both to produce and maintain. The gantry crane is designed to have a very short turning radius. Each of the wheels 400 is individually driven and rotatable about a horizontal axis Y and the drive arrangement will be described later on. The pair of wheels 400 are mounted for common rotation about the axis X and the set of wheels 400 on the cab side is steered directly by means of a spring-centered valve (not shown) in the cab 32 which operates selectively a right strut 406 and a left strut 408 both of which are connected to a vertical control sleeve 410 which is attached by means of attachment plate 412 to a housing 414 on which is mounted the wheels 400 each of which has a tire 416 thereon mounted on a rim 418 which is attached to a spindle 420 in a bearing assembly 421. A hydraulic motor such as a Vickers MHT—250—R1—11, sold by Vickers, Inc., a division of Sperry-Rand Corporation, P. O. Box 302, Troy, Michigan, 48084, as described in the Vickers, Inc. drawing No. 520250 and the Catalog Service Parts Information on MHT—250 Vane Motors, 422 is connected by means of an all steel flexible gear coupling 424 of the sort sold by Sier-Bath Gear Company, Inc., 9252 Kennedy Boulevard, North Bergen, New Jersey, and described in their Catalog C5 (revised) which is attached by means of a plate 426 to the wheel spindle 420. Sleeve 410 is attached at the top to a bearing plate housing 428 having a sleeve bearing assembly 430 thereon in which rotatably rests the bottom part of the gantry frame structure A column assembly 26, 28 which comprises a large outer cylindrical sleeve or housing 432 attached by means of an attachment plate 434 to the respective column assembly 26, 28 and supporting inside another housing or sleeve 436 having the bottom resting in the bearing assembly 430 for rotation therein and the top mounted in a bearing assembly 430 for rotation therein with respect to the fixed outer sleeve 432. According to this arrangement, the sleeve 410 and the entire assembly of the pair of wheels 400 is rotatable with the inner sleeve 436 inside of the outer sleeve 432 with respect to the respective column 26, 28 of the gantry frame, for purposes of steering about the vertical centerline X. The gantry turns quickly and if ideal conditions are met it will pivot about either of the fixed (nonsteered) struts typically in one form with a turning radius of 68 feet through the use of fairly precise nonlinear coordination of the steered struts. A Davis steering gear principle which dates back perhaps to 1904 is a mechanical arrangement disclosed in a book entitled "-MECHANISM" by S. Dunkerley, Third Edition, published by Longmans, Green, and Co. 39, Paternoster Row, London, in which it is stated "§98. Davis' Steering Gear for Motor-cars.- In parallel motions, some point in one of the links either approximately or exactly describes a straight line. In the mechanism about to be described a straight line is likewise traced out, but the straight line is not the locus of some particular point, but of the point of intersection of two links of the mechanism.

In an ordinary vehicle the fore carriage is usually pivoted to the rest of the frame, and the two front wheels rotate loosely on one axle attached to the fore carriage. When running on a curved path, the common axis of the two front wheels will always intersect the back axle, and sharp corners can consequently be turned with ease and safety. In motor vehicles, the driving axle is almost invariably the rear axle, and there is no pivoted fore carriage. The two front wheels rotate freely on different axles, and these axles can be turned, in a horizontal plane, through certain angles by some kind of mechanism. In order to take sharp corners at high speeds with ease and safety, the condition that has to be satisfied is that the axles of the two front wheels should intersect the rear axle in the same point; but the axes may be at different heights. In the majority of cases this condition is only approximately satisfied, but in Davis' steering gear it is exactly fulfilled."

The steerable wheel assemblies 28 on opposite sides of the gantry crane, unlike the Davis mechanical arrangement are controlled hydraulically as will be described later on. For the purpose of the present discussion as to the turning radius and the like, it will suffice to say that each of the steerable wheel assemblies 28 comprises a pair of wheels 400 which rotate about a vertical axis X which is the vertical centerline of a rotatable bearing assembly 402 to be described hereinafter.

There is a separate motor 422 for each of the wheels 400 as shown in FIG. 18 and the motors are mounted back to back each having a respective coupling 424 connected by the respective plate 426 to the drum of the respective wheel 400 and each of the preferred hydraulic motors is of the fixed displacement type and is powered by a variable displacement pump, which is a common item of commerce, and which is

reversible and is driven by the engine at a constant speed. The operator may vary the direction of travel and travel speed with a single control and the motors 422 are connected in parallel to allow differential motion for steering and or maneuvering. That is, one of the motors 422 for one of the wheels 400 may turn with the wheel in one direction while the other motor is turning with its wheel in the opposite direction and different rates of speed may be used to accomplish maneuvering.

As mentioned previously in connection with the steering apparatus, the rotation of the wheel assembly nearest the cab 32 is accomplished by means of the respective right and left struts 406, 408 which are operated by respective hydraulic cylinders 436 each having a piston rod 438 therein pivotally connected by a pivot assembly 440 to the respective right or left strut 406, 408. Hydraulic lines 442 lead to the pump and are controlled by the operator in the cab 32 to move the steered pair of wheels 400 to rotate same in one direction or the other. The steering wheel is designated as 440 S in FIG. 1 and the slave-steered but movable wheel arrangement on the opposite side on the same side is designated by reference numeral 440 SS for slave-steered and the slave-steered set 440 SS is controlled by the steering apparatus utilizing in part the Davis mechanism mentioned previously which is shown diagrammatically in FIGS. 6 and 7. Vertical struts 444, 446 inside of respective column assemblies 28, 28 are connected to the respective inner sleeves 436 for the purpose of controlling the wheel assemblies 400 SS and 440 S respectively. A horizontal, floating push rod 448 extending across the rear top beam assembly 24 the top of each of the respective struts 444, 446 is connected to a radial arm member 450 which has an elongated slot 452 therein in which is mounted a sliding member 454 carried by a sliding element 456 mounted in a track 458 on a bracket 460 mounted on the top of the column 24 and the respective ends of each end of the floating push rod 448 is connected to the sliding member 456. The far-sided strut 444 is coordinated as a slave from the near-sided strut 446 by means of the push rod 448 and the radial arms 450 connected to the respective struts 444, 446. In a head position of the struts 444, 446, the centerlines of the radial arms 450 will intersect at a point one wheel base ahead and on tread centerline. The far-side strut 444 is assisted in movement by means of a servovalve of the sort sold by Vickers, Inc., division of Sperry-Rand Corporation, Detroit, Michigan, as shown in their drawing M—229856, Series SV20, Catalog page M—5150 and entitled "Hydraulic Linkage power Steering Valve." More details on the Vickers valve is shown in the Service Parts Information M—1721—S. Without this valve 464 and related cylinders, the forces in the Davis mechanism would be excessive. In reality, the Davis mechanism only signals the servo valve 464 which in turn rotates the far side strut 444. Three balls 470 mounted in the push rod groove 448 between the track 458 of the bracket 460 act as a fail-safe device which prevents damage to the mechanism in case of hydraulic malfunction and the three balls will break away from the push rod groove 472 if there is any excessive tendency for the push rod to elongate or compress.

Servo valve 448 energizes hydraulic cylinders 436 on the slave wheel 440 SS and the mechanical elements 444, 450 are position feedback devices which cancel the servo valve 448 signal in the desired position.

The respective two pair of wheels 400 rotate about their respective horizontal Y and pivot about the axis X in response to the bellcrank arrangement of the struts 444, 446 and the lever radial arm member 450. The rod 448 is constrained to slide in the direction parallel to the member 24 so that by pushing the rod 448, the wheels 400 can be turned through any required angles. The servo valve 464 is actuated by the rod 448 to move the strut 444 in response to the movement of strut 446 operating the slave wheels 440 SS to accomplish the result in steering to cause the front wheel axles to intersect in the back axle which in this case is the axis of the nonsteered wheels 400 NS and the gantry can run in a curved path with perfect ease and safety. The front wheels 440 S and 440 SS can run at different speeds to suit the curvature of the path, because they rotate individually and independently of each other as well as each pair; and the back wheels can rotate at different speeds because the back axles are separate. The advantages of the Davis mechanism are preserved but at the same time power has been added by way of hydraulic means to assist otherwise forces would be excessive. It should be understood that the struts 444, 446, unlike the Davis mechanical device, do not actually turn the wheels 440 S and SS since the turning is by power steering and the strut 444 and arm 450 are part of the control system which is a compensating means to get a Davis result but with a power, hydraulic steering and safety control.

While I have shown and described a particular embodiment of my gantry this is by way of illustration for one skilled in the art and does not constitute any sort of limitation on my invention since various changes, alterations, forms, omissions, departures, variations, eliminations, substitutions, additions, combinings and characterizations may be made in the particular embodiment shown without departing from the scope of my invention as defined by interpretation of the appended claims.

What is claimed:

1. In a gantry crane for lifting a large, heavy load such as a trailer loaded with cargo wherein there is a three-dimensional gantry structure including members providing four corners each of which is supported by at least one ground-engaging wheel and there being a space within said structure and above the ground in which the load to be moved may be transported and manipulated by driving said gantry over said object or said object into said gantry, means for driving said gantry crane to move said wheels and means for steering said gantry crane by turning at least the wheel on one corner thereof, load-moving means mounted on said gantry crane for engaging, lifting and moving the load on the gantry structure, including means on said crane supporting said load for movement thereon, and means on said gantry crane for moving said load-moving means angularly as well as linearly with respect to said frame, whereby said load-moving means may be moved linearly across said frame in one direction or the other and also may be positioned angularly with respect to the load the combination therewith of:

a. one corner of said frame having a power-driven, steerable wheel mounted thereon and the other corner of said frame on the same side having a movable controlled wheel thereon and there being means for steering said controlled wheel in response to the movement of said power-driven wheel,

b. said power-driven, steerable wheel having a hydraulic motor thereon and there being other hydraulic means for moving said wheel rotatably on said corner of said gantry crane in one direction or the other, and

c. control means operable by the movement of said steerable wheel and connected to said other controlled wheel on the same side of the other corner to signal the movement of said other controlled wheel, and hydraulic power steering means connected with said other controlled wheel and responsive to said control means for moving said controlled wheel in response to the movement of said steered wheel,

d. said control means including a modified Davis steering arrangement with a control member, and a servo valve connected to said hydraulic power steering, said servo valve being operated by said control member which controls said hydraulic power steering means of said other controlled wheel.

2. The gantry crane in claim 1:

there being power-driven wheels on each corner of one side, each of said power-driven wheels comprising two wheels mounted together for rotation about a common axis, individual hydraulic motors mounted on said wheels and each being connected to a respective wheel for independent operation, and each wheel being connected directly to a respective motor.

3. The gantry in claim 1:
said wheels being coaxial and said hydraulic motors being mounted coaxially, means supporting each of said wheels bearing means for said wheels, and a flexible coupling from each of said motors to each of said wheels.

4. The gantry in claim 3:
said motors being attached to a common support each with a shaft protruding therefrom and said means supporting each wheel being a spindle with said motor shaft inside thereof.

5. The device in claim 1 including a fail-safe means operated by said control means to disengage automatically when preset forces are exceeded.

6. The gantry in claim 1:
one corner of said gantry having a hydraulically steered wheel assembly thereon,
the other corner on the same side having a hydraulically steered wheel assembly thereon controlled by said wheel assembly on said corner first named,
hydraulic power means on each wheel comprising an individual hydraulic motor on each wheel,
and means between said wheel on one corner and the wheel on the other corner to cause the one to control the other, said means including a mechanical member and a hydraulic servo valve which balances the forces.

7. The gantry in claim 1:
one of said corners having a power-driven wheel assembly thereon and the other corner on the said side having a power-driven wheel assembly driven thereon, each of said wheel assemblies having individual hydraulic motors thereon flexibly coupled to a wheel.

8. The gantry in claim 7: there being two motors on each wheel assembly, each motor having a motor shaft protruding therefrom and said shafts of the same wheel protruding in opposite directions.

9. The gantry in claim 7: each wheel assembly being rotatable for steering and there being a hydraulic means operable to move said wheel selectively and means for controlling said hydraulic means so as to control the steering of each wheel.

10. The gantry in claim 9: said hydraulic means comprising a cylinder on each wheel, and the wheel on one side being the control wheel and the other being a slave wheel controlled thereby.

11. In a gantry crane for lifting a large, heavy load such as a trailer loaded with cargo wherein there is
a three-dimensional gantry structure including members providing four corners each of which is supported by at least one ground-engaging wheel and there being a space within said structure and above the ground in which the load to be moved may be transported and manipulated by driving said gantry over said object or said object into said gantry,
means for driving said gantry crane to move said wheels and means for steering said gantry crane by turning at least the wheel on one corner thereof,
load moving means mounted on said gantry crane for engaging, lifting and moving the load on the gantry structure, including
means on said crane supporting said load for movement thereon,
and means on said gantry crane for moving said load moving means in "c" angularly as well as linearly with respect to said frame, whereby said load moving means may be moved linearly across said frame in one direction or the other and also may be positioned angularly with respect to the load the combination therewith of:
a. said load moving means and said means supporting said load comprising a support member extending across spaced, opposed gantry structure members that extend parallel to each other,
b. said support member being supported for rotary movement on one end of a truck member that travels along one of said structure members and the other end being supported for both rotary and linear movement on a second truck member that travels on said other structure member,
c. said support member for said load moving means being supported on one end on a spider assembly comprising a frame having wheels thereon operating in tracks on said support member, said spider frame being movably and rotatably mounted on said truck member.

12. The gantry in claim 11:
said truck member each being mounted on a linear track on the top of said gantry, each truck member having a drive wheel thereon engaged with said track, and hydraulic means for operating said drive wheel.

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