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(71) Applicant: WIND SHIP DEVELOPMENT CORPORATION
690 Main Street
Norwell, MA 02061(US)

(72) Inventor: Bates, Alexander P., Jr.
166 Otis Street
Hingham, MA(US)

(72) Inventor: Glucksman, Maurice A.
Commercial Street
Wellfleet, MA(US)

(74) Representative: Bardehle, Heinz, Dipl.-Ing. et al,
Patent- und Rechtsanwälte
Bardehle-Pagenberg-Dost-Altenburg & Partner Postfach 86 06 20
D-8000 München 86(DE)

(54) Sail support and control system.

(57) This invention provides an improved system for causing swinging of a boom of a sail support system as described in the above identified application, in which the boom support, which is rotatable about the mast or mast support is driven in rotation by hydraulic or pneumatic cylinders suitably arranged to rotate the boom about 90° to either side of the fore and aft position. In one embodiment of the invention two cylinders are symmetrically positioned in relation to the boom support so as to enable rotation of the boom 90° to port or starboard without interference of the cylinder rods with the boom support, and so that the rotating force can be applied to the boom support is never less than the force that is available from one cylinder acting at the maximum radius. Means is also provided to prevent the boom from swinging at an excessive rate, such as when it is being swung out to catch the wind, by controlling the flow of fluid out of the cylinders. Means is also provided for holding the boom in a desired position.

In a preferred embodiment of the invention, the boom support and the cylinders are mounted on a support frame on an upper deck of the ship, with means being provided for measuring the force applied by the frame to the ship. Since the cylinders act between the support frame and the boom support, the forces applied by the cylinders are isolated from the propulsion force measuring device.

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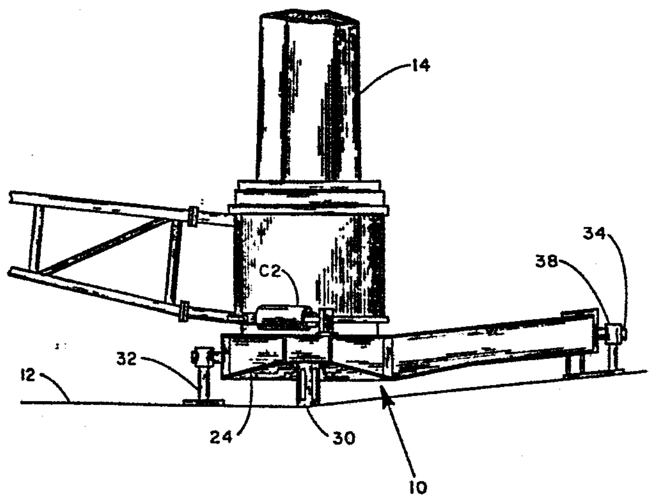
Fig. 1



RECHTSANWÄLTE
JOCHEN PAGENBERG DR. JUR., LL. M. HARVARD**
BERNHARD FROHWITTER DIPL.-ING.*
GÜNTER FRHR. v. GRAVENREUTH DIPL.-ING. (FH)*

PATENTANWÄLTE – EUROPEAN PATENT ATTORNEYS
HEINZ BARDEHLE DIPL.-ING.
WOLFGANG A. DOST DR., DIPL.-CHEM.
UDO W. ALTENBURG DIPL.-PHYS.

Applicant:
Wind Ship Development Corporation
690 Main Street
Norwell, MA 02061/USA

POSTFACH 860620, 8000 MÜNCHEN 86
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BACKGROUND OF THE INVENTION

In a co-pending application Serial 290,234 filed August 5, 1981, there is disclosed and claimed a sail support and control system designed for use as sail assist propulsion for a cargo vessel. In said system an unstayed mast carries a cantilever mounted boom which is horizontally rotatable on the mast. Rotation is effected by providing a winch on the boom which takes in and pays out sheets which extend from the end of the boom around suitably positioned fairleads to dead ends on the deck, to enable the boom to be swung to a desired orientation in relation to the ship, and to provide sheet tension to hold the boom in said desired orientation.

Although a sail support and control system as described in said application has been found satisfactory in commercial operation, it has been found that in some installations, the boom swinging system can cause difficulty, in that the sheet, which extends from the end of the boom to dead ends on the deck, may interfere with cargo handling, and is subject to wear, corrosion, and possible failure during use.

BRIEF DESCRIPTION OF THE FIGURES OF THE DRAWING

Figure 1 is a view in side elevation of a boom, boom support, and boom swinging mechanism embodying the features of the invention.

Figure 2 is a top plan view, partly in section, of the assembly of Figure 1.

Figure 3 is a rear view of the assembly of Figure 2, illustrating the support frame mounting.

Figure 4 is an enlarged top plan view, partly broken away, of the front portion of the support frame, illustrating the load measuring cell.

Figure 5 is a side elevation of Figure 4, partly broken away.

Figure 6 is an enlarged view of a portion of the assembly of Figure 5, illustrating the load cell mounting.

Figure 7 is a view of the assembly of Figure 2, in which the boom has been swung to starboard.

Figure 8 is a schematic diagram of the hydraulic system used to control the motion of the boom.

Figure 9 is a graph of the forces available from the cylinders at various boom angles.

DESCRIPTION OF THE ILLUSTRATED EMBODIMENT

Referring to the drawing, there is illustrated a sail support assembly comprising a support frame 10 mounted on the deck 12 of a vessel, a boom support 14 rotatably mounted on the frame 10, and a mast 16 rotatably mounted within the boom support 14.

The sail support assembly is similar in some respects to that shown in co-pending application serial 290, 234 filed August 5, 1981, in that the boom is mounted in cantilever fashion onto support 14 so that the boom can resist the downward force of its own weight and the upward force of the sail without supporting lines.

The support frame 10 comprises laterally extending portions 22 and 24 and a forwardly extending portion 26. The frame 10 is secured to the main deck 12 by pylons 28 and 30 disposed at the outer ends of the laterally extending portions, a trunnion 32 at the rear of the frame, and a pin 34 extending forwardly from the portion 26 into an aperture 36 in an upwardly projecting retaining member 38 fastened to the deck 12.

The frame mounting allows a slight amount of fore and aft movement to allow the measurement of the forward propulsion force applied to the ship by the sail. For this purpose a load cell L is mounted between a plate 40 fastened to the deck and a plate 42 fastened to the support frame, so that any forward movement of the frame resulting from forces applied thereto by the mast results in deformation of the load cell. Load cells for this purpose are well known in the art, and provide a changing electrical parameter with changing load, which information can be transmitted to a remote location such as the ships bridge.

To provide means for rotating the boom support to swing the boom to a desired angle in relation to the ship, and to hold the boom in the desired position without the rotating or maintaining force affecting the measurement of the propulsion force applied to the ship, a pair of hydraulic cylinders C1 and C2 are provided on the support frame, with the rod ends R1 and R2 thereof being connected to radially extending mounting ears 44 and 46 on the boom support, and the head ends of the cylinders being connected to the laterally extending portions 22 and 24 at the outer ends thereof.

The cylinders are so oriented in relation to the boom support that they are capable of rotating the boom support through approximately 90° in either direction from the centerline of the ship without interference between the rods R1 and R2 and the boom support.

The cylinders are also so oriented in relation to the boom support that when the boom is on the centerline of the ship, each cylinder is partially extended and the angle between the radius (the line between the rod connection to the boom support and the center of rotation of the boom support) and the axis of the rod is between the dead center position of 180° and the maximum torque position of 90°. The exact angle will depend on the length and stroke of the cylinders, and in a typical case will be between about 120° and 150°. The cylinders also must be so oriented that when one cylinder rod is in the dead center (180°) position the other cylinder rod is substantially at 90° to the radius to provide the maximum torque.

In the illustrated embodiment, the operation of the cylinders is controlled by the hydraulic system illustrated in Figure 8. The cylinders must not only be able to swing the boom to any position up to about 90° to port or starboard, they must also be able to hold the boom in a desired position, and must be able to limit the speed at which the boom swings, such as when the boom is swung out to catch a favorable wind.

For these purposes the hydraulic control circuit comprises a source of fluid pressure P, which is fed to a master control valve V1 which has left, center, and right positions. The valve V1 is normally in the center position and may be moved to the left or right position manually or by other means to cause the boom to swing to port or starboard respectively. Swinging of the boom occurs so long as the valve V1 is held in the left or right position (within the limits of travel of the boom), and stops when the valve V1 is released to return to the center position.

When valve V1 is shifted to the right, fluid flows through the valve V1 to valves V2 and V3 which are cam actuated in a manner to appear hereinafter. As illustrated in Figure 8, the valves V2 and V3 and the cylinders C1 and C2 are in a position which corresponds to the fore and aft position of the boom, and in such position when valve V1 is shifted to the right valve V2 admits pressure through supply line L1 and check valve K1 to the head end of cylinder C1, and valve V3 admits pressure through supply line L2 and check valve K2 to the rod end of cylinder C2.

Therefore shifting valve V1 to the right causes the boom to swing to starboard, and as can be seen from the diagram of Figure 8, shifting valve V1 to the left will cause the boom to swing to port.

On the initial counterclockwise rotation of the boom support, the extension of the piston rod of cylinder C1 forces fluid out of the rod end of the cylinder through a motion control valve V4 and check valve K4 valve V2 and valve V1 to the fluid supply tank T, and the corresponding retraction of the rod of cylinder C2 forces fluid out of the head end thereof through motion control valve V5, check valve K5 valve V3 and valve V1 to the fluid supply tank T..

The motion control valves limit the angular rate at which the boom can swing in the following manner. When the pistons C1 and C2 operate to swing the boom to allow the sail to catch a favorable wind, the wind pressure on the sail may be great enough that the resulting rotating force applied by the sail to the boom support tends to force the pistons of the cylinders to move faster than the boom support would be moved by the fluid supply from the pump P. The rotating force applied by the sail therefore tends to cause a reduction in pressure in the head end of cylinder C1 and at the rod end of cylinder C2.

The motion control valves are normally spring-biased to the closed position and are opened by pressure on a pilot line connected between the valve and a source of pressure, with the amount of opening being a function of the amount of pressure. The pilot line P4 of valve V4 is connected to the fluid supply line L1 feeding the head end of cylinder C1, and the pilot line P5 of valve V5 is connected to the fluid supply line L2 feeding the rod end of cylinder C2. The reduction of pressure on the supply lines L1 and L2 causes a corresponding reduction of pressure on the pilot lines P4 and P5 of valves V4 and V5 respectively, to allow said valves to move toward the closed position to thereby reduce the rate of flow of fluid cut of the cylinders and thereby limit the rate at which the boom can swing.

When the boom has rotated to starboard through an angle such that the rod of cylinder C2 has reached dead center, cam 48 on the boom support 14 operates a microswitch S1, which actuates a solenoid Q1 of valve V3 to shift it to the left so that the flow of fluid to cylinder C2 is reversed, and pressure is applied to the head end thereof. At this position of the boom support, the rotating force applied thereto comes only from cylinder C1, however the arrangement of the cylinders is such that in this position cylinder C1 is acting substantially perpendicular to the radius, so that it can apply maximum torque to the boom support. On further counter-clockwise rotation of the boom support, the force applied by cylinder C2 increases as the force applied by cylinder C1 decreases due to the decreasing radius.

To thereafter swing the boom inwardly (counter-clockwise) valve V1 is shifted to the left, so that fluid pressure is supplied to the rod end of cylinder C1 and to the rod end of cylinder C2 until the resulting clockwise rotation of the boom support causes cylinder C2 to again reach the dead center position, where the cam 48 actuates switch S1 to cause valve V3 to move back to its original position to thereby reverse the fluid flow to cylinder C2.

During such clockwise rotation, the fluid in the head end of cylinder C1 discharges through motion control valve V6 and check valve K6 with the rate of fluid discharge being controlled by the pressure on the rod end of cylinder C1 through the line P6. If the boom is being swung in from an angle such that the cylinder C2 has been taken past dead center, as illustrated in Figure 4, on the initial portion of subsequent counter-clockwise motion, fluid from the head end of cylinder C2 will be discharged through motion control valve V5, check valve K5, valve V3 and valve V1. After the dead center position of cylinder C2 has been passed, the shifting of valve V3 applies fluid pressure to the head end of cylinder C2, with the discharge from the rod end occuring through motion control valve V7, check valve K7, valve V3 and valve V1.

The above description relates to movement of the boom counter-clockwise to the starboard position. Movement of the boom clockwise to the port position is accomplished by moving the valve V1 to the left position, with the other valves operating in a manner analagous to that described above.

When valve V1 is in the center position, the head and rod ends of both cylinders are connected to the return line to the supply tank T, so that there is no pressure on pilot lines P4, P5, P6, P7 of the motion control valves. The motion control valves are therefore closed, and, in conjunction with the check valves in the supply lines, prevent fluid from discharging from either end of the cylinders.

Therefore in any boom position, when the valve V1 is centered, the cylinders C1 and C2 lock the boom from swinging.

However, in case of an excessive rotating force applied to the boom support, such as by a high velocity wind gust, the hydraulic system allows the boom support to swing in a direction to reduce the force. This is accomplished by lines R4, R5, R6, and R7 which connect the cylinder ends to a relief inlet of the associated motion control valve. An excessive pressure at the relief inlet caused by an excessive pressure in one end of the associated cylinder causes the valve to open to reduce the pressure, and thereby allowing movement of the cylinder rod and the boom.

Referring to Figure 9, there is illustrated a graph showing the torque applied to the boom at various boom angles. As shown in the graph, the maximum torque of either cylinder occurs when the other cylinder is on dead center with no available torque. The graph also shows that the cylinder arrangement provides maximum total torque when the boom is on the centerline of the ship.

This arrangement is desirable for the following reason. Although a wind force may be applied to the sail in any boom position, including the fore and aft position, the maximum turning force applied to the boom from gravity and inertia forces resulting from the rolling motion of the ship occurs when the boom is on the centerline. Therefore the maximum combined turning force applied to the boom support from combined wind force and ship motion occurs when the boom is on the center line, and the cylinder arrangement illustrated in Figure 1 provides the maximum amount of torque at this boom position.

Although a greater torque could be applied to the boom support in the centerline position by having both cylinders perpendicular to the radius when the boom is on the centerline of the ship, such an arrangement would not allow the full 90° rotation in each direction due to interference between the cylinder rods and the boom support, and the maximum torque of a cylinder would not occur when the other cylinder is in the dead center position.

Although in the illustrated embodiment of the invention hydraulic cylinders are utilized to rotate the boom support, it will be understood that in some applications pneumatic cylinders or mechanical linear actuators may be used, provided that mechanical braking means is provided for retaining the boom in the desired orientation.

Since certain changes apparent to one skilled in the art may be made in the herein described embodiments of the invention without departing from the scope thereof, it is intended that all matter contained herein be interpreted in an illustrative and not a limiting sense.

CLAIMS

1. A sail support assembly, comprising a mast mounted onto a support, a boom support rotatably mounted on said mast, and at least two fluid actuated cylinders connected between the boom support and the mast support, said cylinders being so arranged that when the boom support is so oriented that the boom is on the centerline of the ship, the rods of the cylinders are partially extended, and when when the boom support has been rotated so that one cylinder is on dead center, the other cylinder is acting at its maximum radius from the center of rotation of the boom support.

2. A sail support assembly as set out in claim 1 in which the axis of each cylinder, when the boom is on the centerline of the ship, is disposed at an angle of between about 110° and 160° degrees to a line extending between the connection of the cylinder to the boom support and the center of rotation of the boom support.

3. In a sail support assembly, comprising a mast mounted onto a support and a boom support rotatably mounted about the mast, the improvement comprising fluid pressure actuated cylinders connected between the boom support and the mast support, said cylinders being so arranged that the total torque applied to the boom support by the cylinders is greatest when the boom is on the centerline of the ship.

4. In a sail support assembly, comprising a mast mounted onto a support and a boom support rotatably mounted in relation to the mast, the improvement comprising fluid pressure actuated cylinders connected between the boom support and the mast support, and control means for actuating said cylinders by fluid pressure, said control means having means for locking the fluid in said cylinders when they are not actuated to rotate the boom support in relation to the mast for thereby locking the boom into a stationary position.

5. A mounting structure for a ships mast, comprising a platform, a mast mounted on said platform, means mounting said platform on the ships structure in a manner such that the platform is capable of a limited amount of forward movement when a force having a forward component is applied to the mast, and means for measuring the amount of said forward movement.

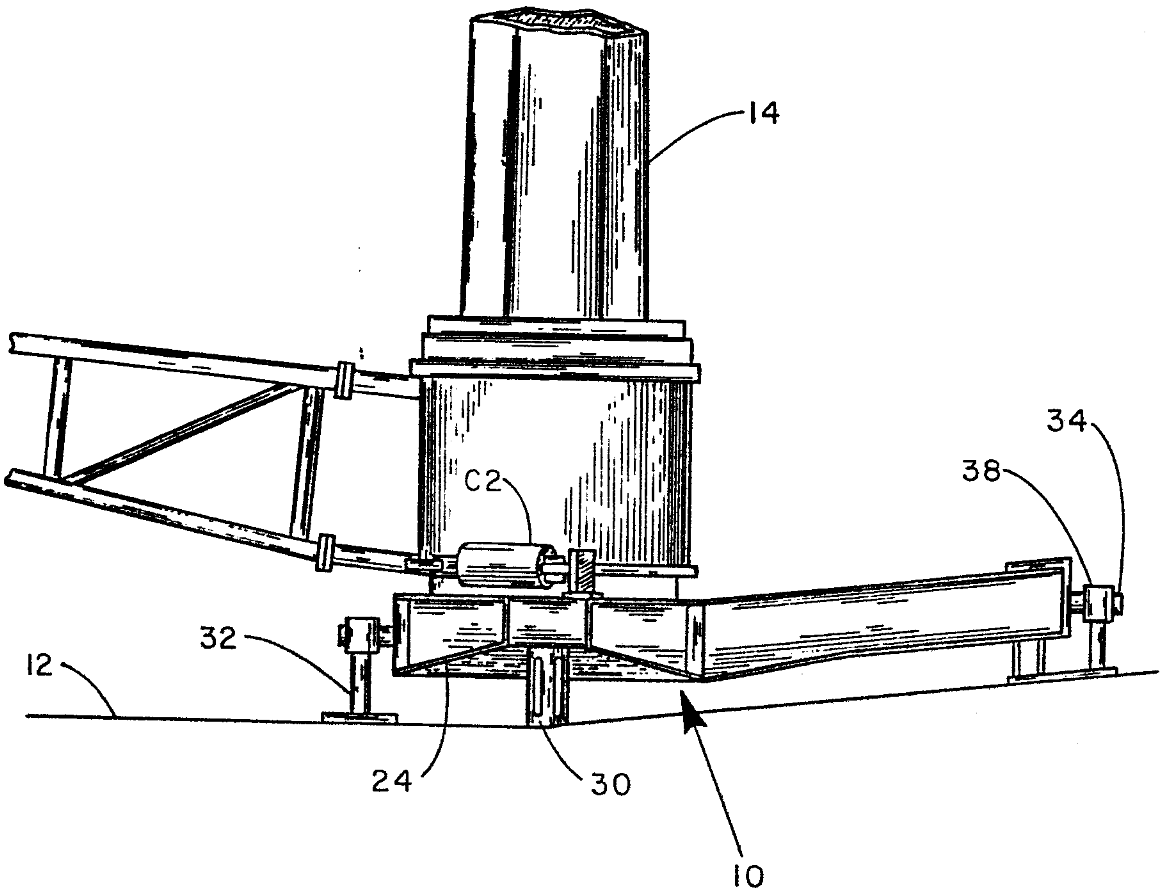
6. A structure as set out in claim 5 in which a rotatable boom support is mounted for rotation in relation to the mast, and means for rotating the boom support in relation to the mast, said means acting between the platform and the boom support whereby forces necessary to cause rotation of the boom or to maintain the boom in a desired position do not cause movement of the platform in relation to the ship.

7. A structure as set out in claim 6 in which said means for rotating the boom comprises hydraulic cylinders connected between the boom support and the platform.

8. A structure as set out in claim 7 in which said cylinders are so oriented that the total torque applied by the cylinders to the boom support is greatest when the boom is in the fore and aft position.

9. A mounting structure for a ships mast, comprising a platform carrying a mast, said platform having support portions extending laterally on each side of the mast and another support portion extending in a fore and aft direction in relation to the mast, said laterally extending portions being secured to the ship by pylons which are sufficiently flexible to allow a small amount of forward movement of said platform in relation to the ship when a force having a forward component is applied to the mast, said other support portion having a retaining pin disposed in an aperture in a retaining plate attached to the ship so as to permit only fore and aft movement of the support, and means measuring the amount of forward movement of said platform in relation to the ship.

Fig. 1



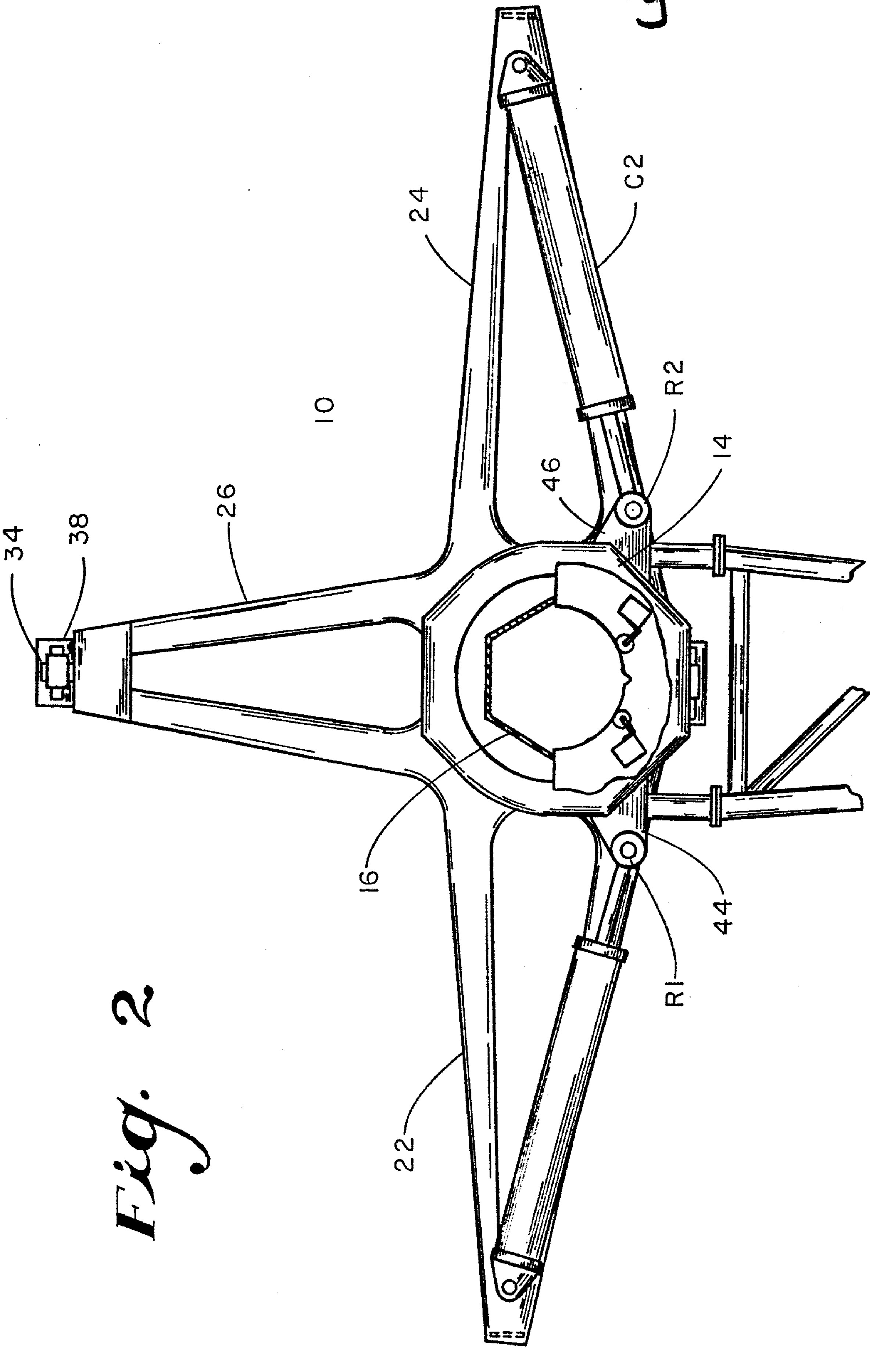


Fig. 2

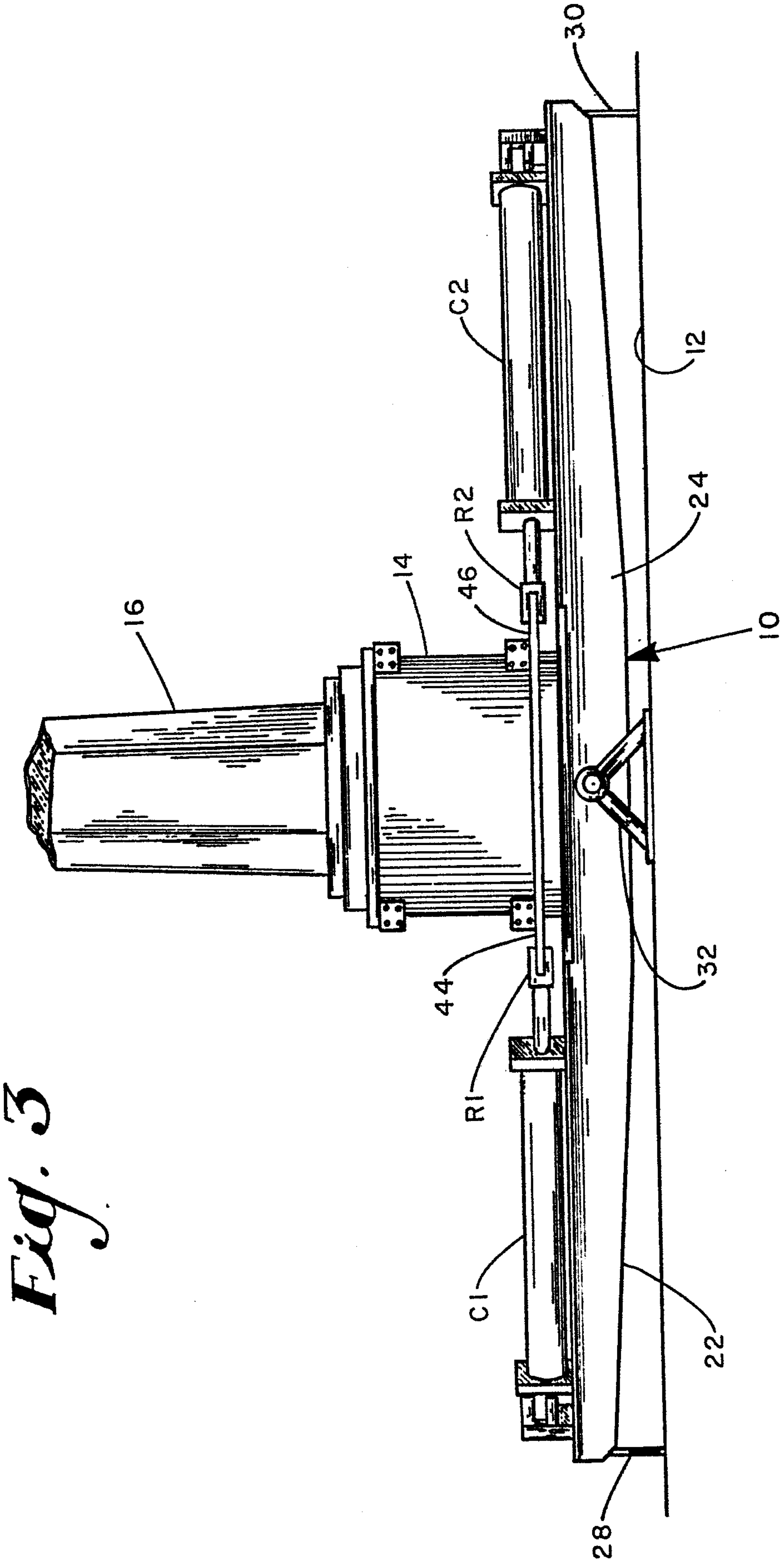
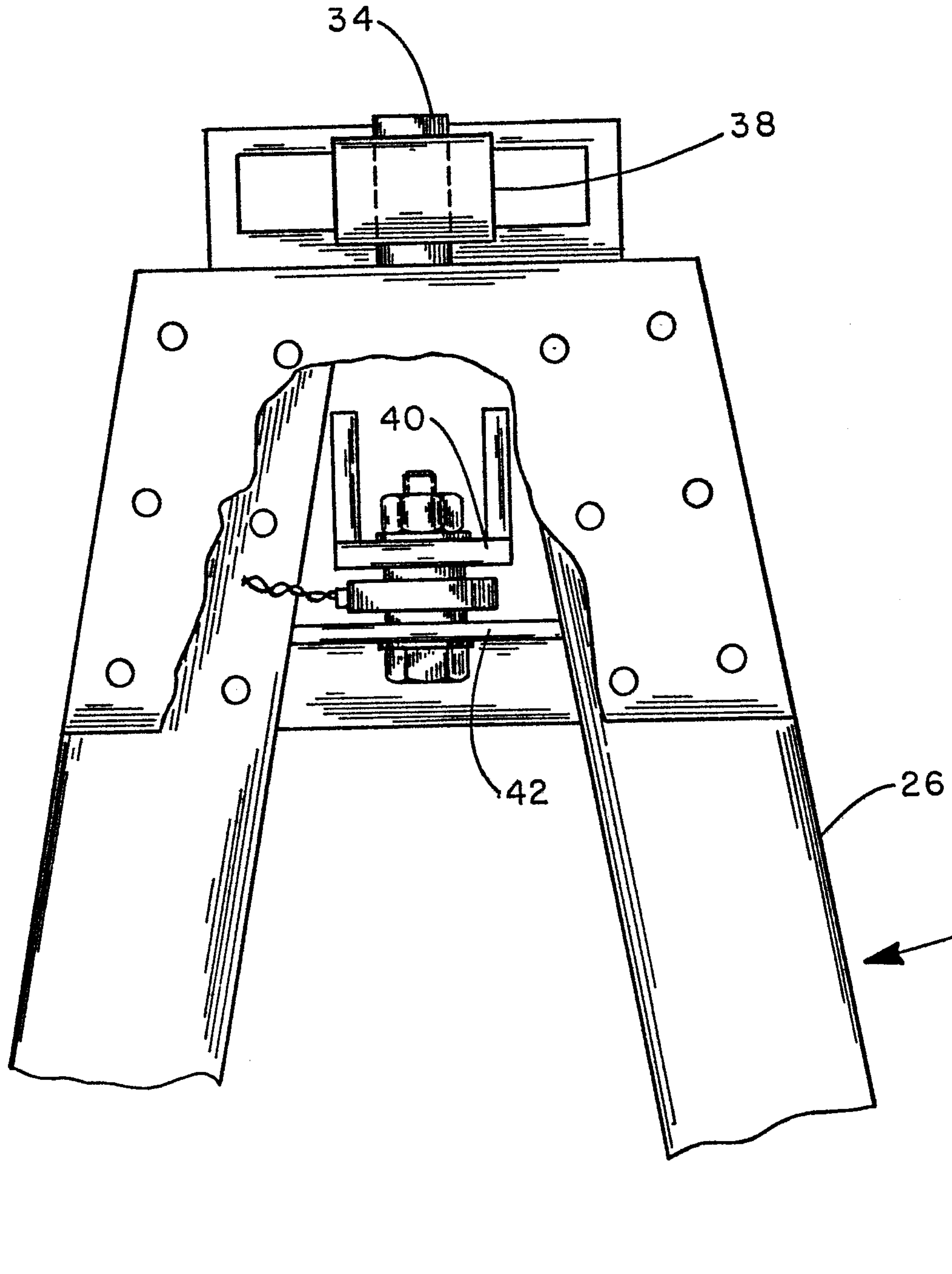


Fig. 3

Fig. 4



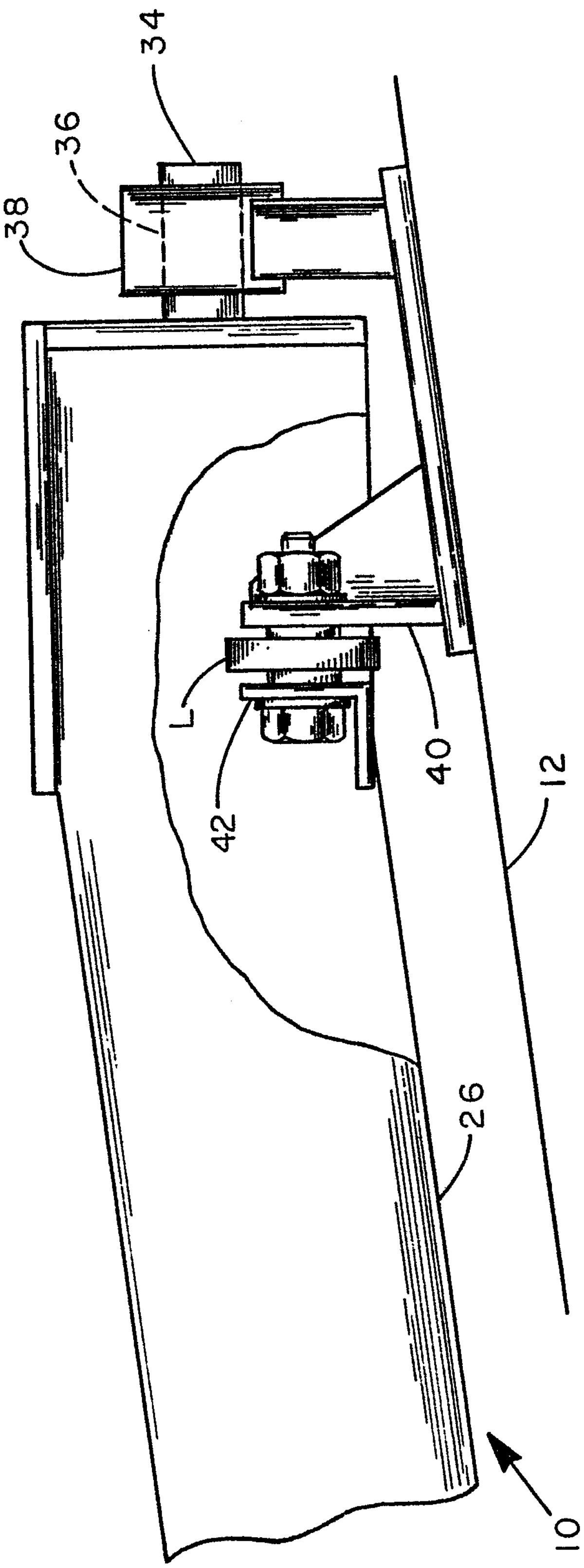


Fig. 5

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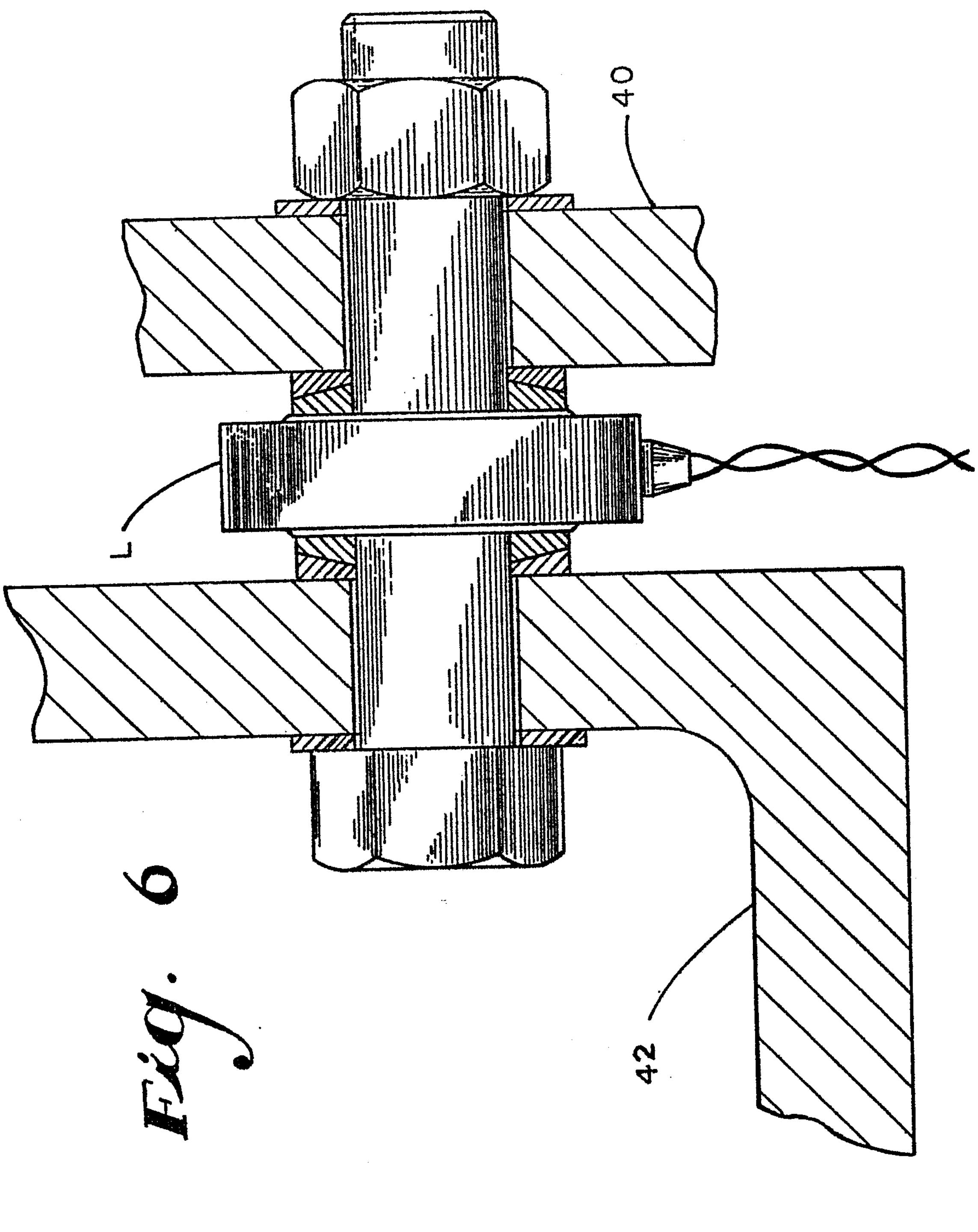


Fig. 6

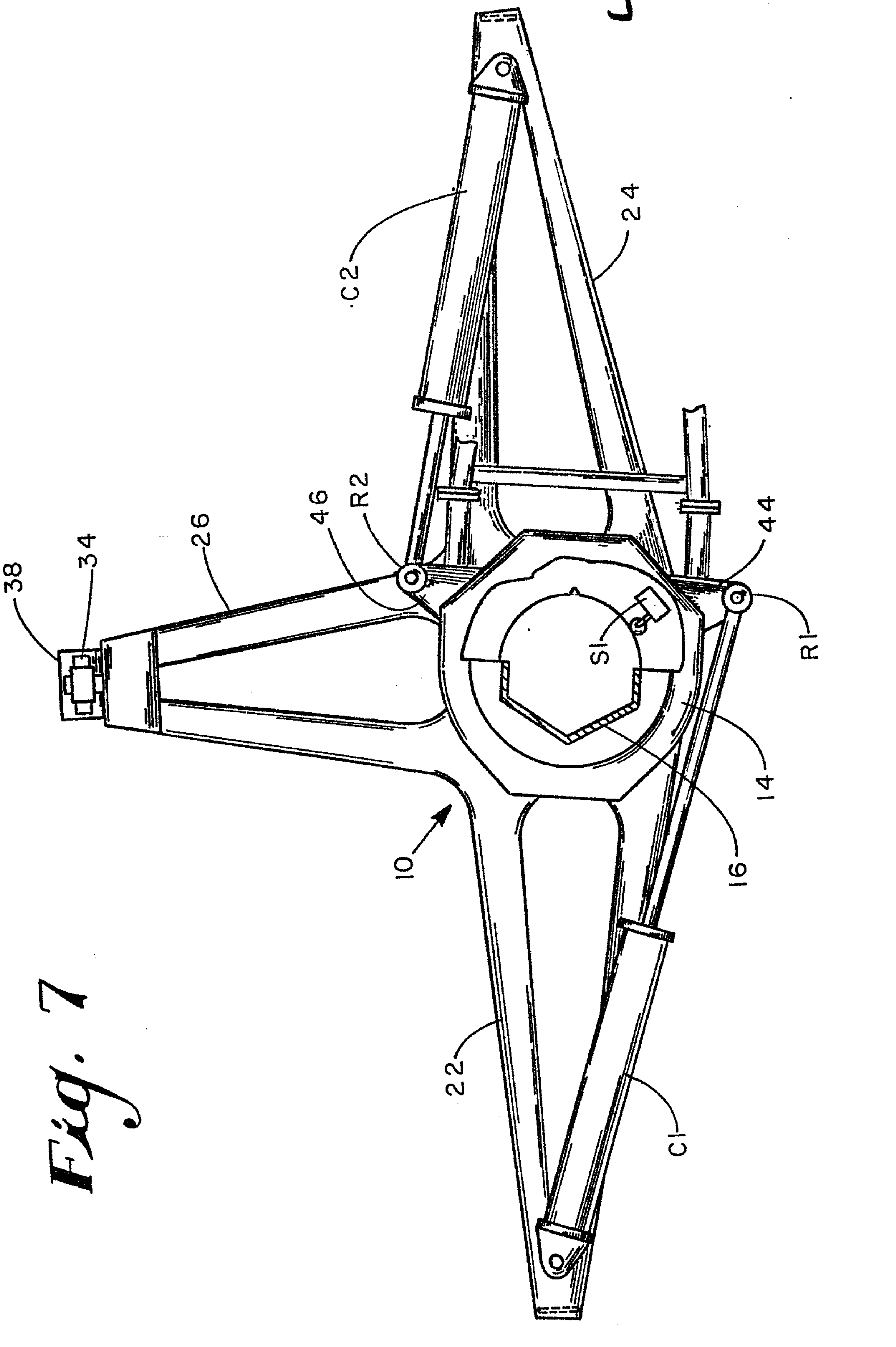
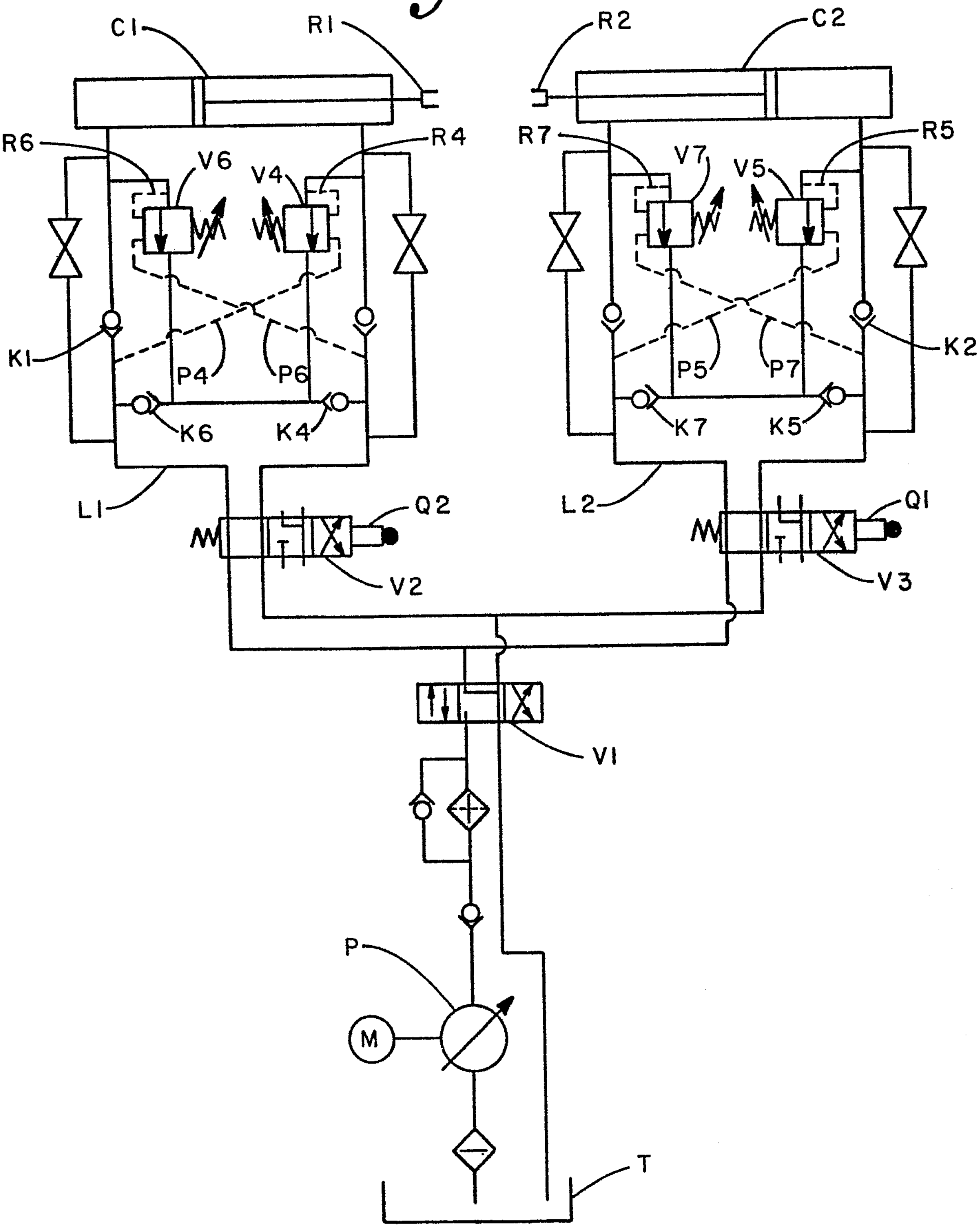


Fig. 7

Fig. 8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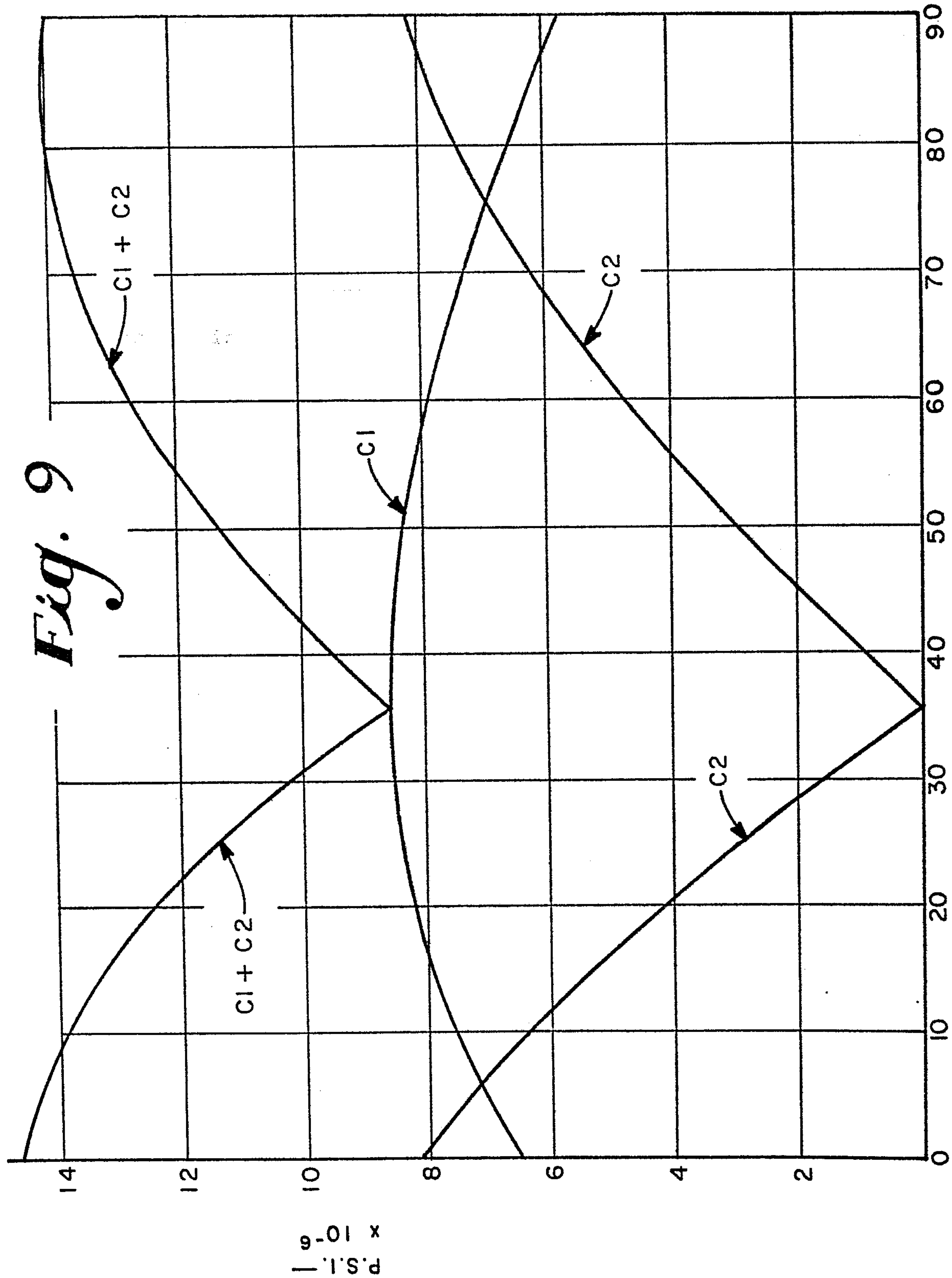
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Fig. 9