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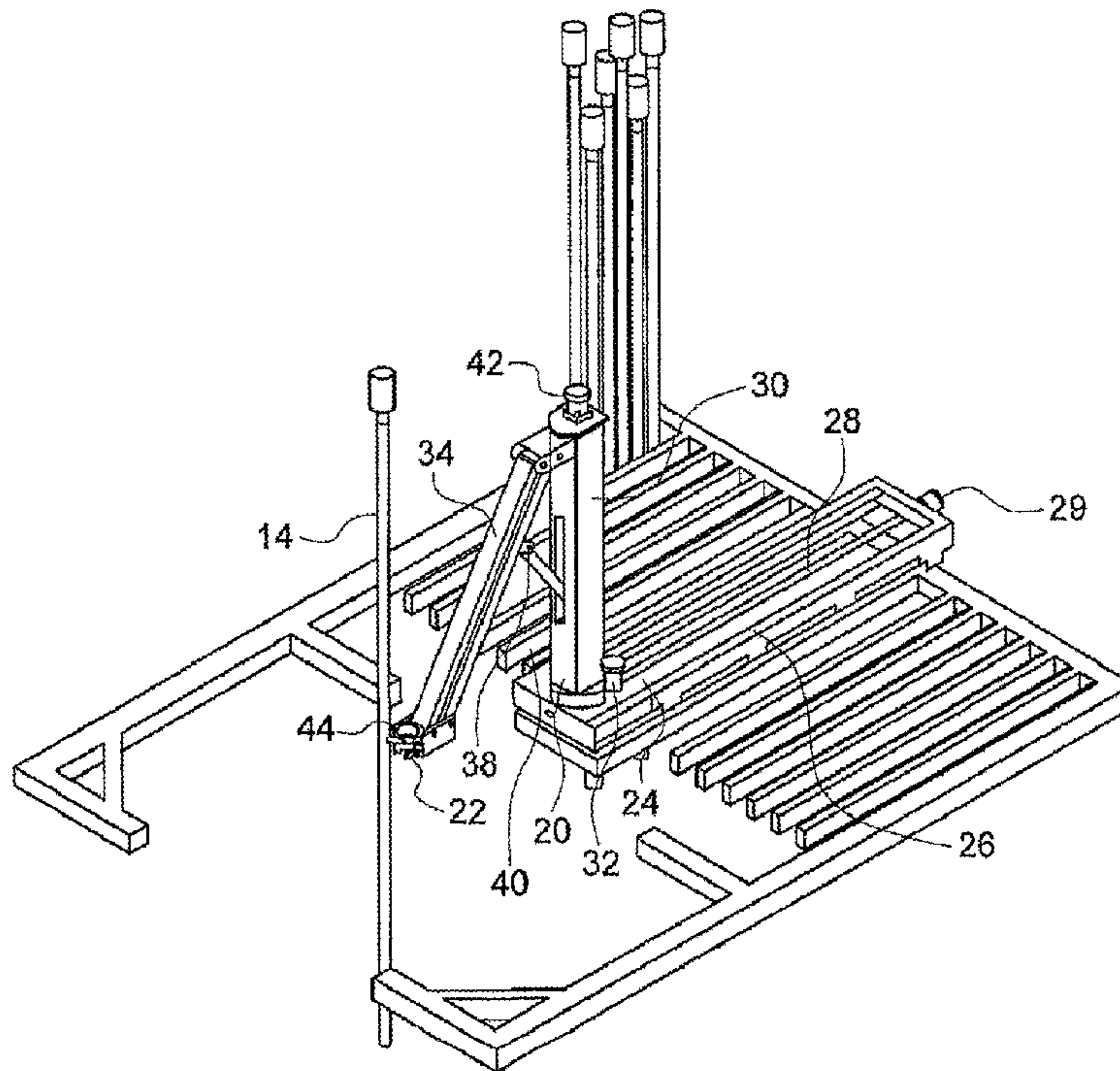
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(54) **Titre : BRAS DE GERBAGE AUTOMATIQUE DE TIGES DE FORAGE**

(54) **Title: AUTOMATED PIPE RACKING ARM ASSEMBLY**



(57) **Abrégé/Abstract:**

An automated pipe racking apparatus for use with an oil drilling or service rig having a mast, includes a pipe rack formed from a plurality of pipe rack fingers; a horizontal channel disposed within the pipe rack; an aim assembly having a base which slidingly



(57) Abrégé(suite)/Abstract(continued):

engages the horizontal channel and a motor for actuating the base within the channel, a post pivotally mounted to the base and a motor for actuating movement of the post about its longitudinal axis, a grasping arm pivotally attached to an upper end of the post, an extension arm for extending the grasping arm away the post and a motor for actuating the extension arm, a gripper head attached to an end of the grasping arm and comprising gripping jaws and a motor for actuating opening and closing movement of the gripping jaws, and a controller for controlling the movement of the components of the arm assembly. The base actuating motor, post actuating motor, extension arm motor, and the gripper jaw motor may be electric or hydraulic motors.

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ABSTRACT

An automated pipe racking apparatus for use with an oil drilling or service rig having a mast, includes a pipe rack formed from a plurality of pipe rack fingers; a horizontal channel disposed within the pipe rack; an arm assembly having a base which slidingly engages the horizontal channel and a motor for actuating the base within the channel, a post pivotally mounted to the base and a motor for actuating movement of the post about its longitudinal axis, a grasping arm pivotally attached to an upper end of the post, an extension arm for extending the grasping arm away the post and a motor for actuating the extension arm, a gripper head attached to an end of the grasping arm, and comprising gripping jaws and a motor for actuating opening and closing movement of the gripping jaws, and a controller for controlling the movement of the components of the arm assembly. The base actuating motor, post actuating motor, extension arm motor, and the gripper jaw motor may be electric or hydraulic motors.

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AUTOMATED PIPE RACKING ARM ASSEMBLY

Field of the Invention

[0001] The present invention is directed to an automatic pipe racking apparatus and process to
10 store and retrieve lengths of pipe, tubing, drill collars or drill string.

Background of the Invention

[0002] Drilling and service rigs utilize a mast with a string of drill pipe and/or tubing
suspended therefrom and having a bottom hole assembly (BHA) mounted on the lower end
thereof. A drill collar or collars having a larger diameter than said drill pipes are also utilized
15 to interconnect between the drill pipes and add weight to the drill string.

[0003] It is periodically necessary to pull the drill string or tubing from the well bore in order
to maintain the BHA, replace various components of the BHA, to perform various testing, or
to run other equipment into the well bore at the end of the drill string. In the standard process
to pull drill pipe from the bore, an elevator is connected to the drill pipe and a traveling block
20 is raised on the mast until a stand of pipe extends above the drilling rig floor. The stand may
include one to three sections of pipe totaling up to 90 feet in length. The pipe stand is
unthreaded from the remainder of the drill string and the lower end of the stand is moved onto
a support pad or set back by personnel. In the normal procedure, a man positioned in the upper
portion of the rig disconnects the upper end of the stand from the elevator and places the
25 upper end of the stand between a set of racking fingers. The traveling block may then be
lowered to pick up the drill string and the process is repeated.

5 [0004] The reverse process is performed when running the drill string back into the well bore. A man on a platform will remove a stand of pipe and connect it to the traveling block. When the traveling block is lifted, the lower end of the stand of pipe will swing into position above the well bore. The stand of pipe will then be connected to the remainder of the drill string.

[0005] There have been a number of attempts to automate the pipe racking procedure.

10 However, there remains a need in the art for an efficient and useful pipe racking apparatus.

Summary of the Invention

[0006] The present invention provides an automated pipe racking apparatus and process which will be utilized with a drilling or service rig having a mast with a traveling block suspended over a well bore. An elevator or set of elevators may be suspended from the
15 traveling block for grasping a drill pipe or drill stand. A racking assembly having a generally U-shaped frame is mounted on the mast. The racking assembly includes a first set of parallel racking fingers and a second set of parallel racking fingers with a space therebetween. The racking fingers are arranged to form a plurality of slots between adjacent fingers so that the pipe stands may be stored in the slots between the fingers.

20 [0007] In one aspect, the invention may comprise an automated pipe racking apparatus for use with an oil drilling or service rig having a mast, comprising:

- (a) a pipe rack formed from a plurality of pipe rack fingers;
- (b) a horizontal channel disposed within the pipe rack;
- 25 (c) an arm assembly comprising:

- 5 i) a base which slidingly engages the horizontal channel and a motor for actuating the base within the channel;
- ii) a post pivotally mounted to the base and a motor for actuating movement of the post about its longitudinal axis;
- iii) a grasping arm pivotally attached to an upper end of the post;
- 10 iv) an extension arm for extending the grasping arm away the post and a motor for actuating the extension arm;
- v) a gripper head attached to an end of the grasping arm, and comprising gripping jaws and a motor for actuating opening and closing movement of the gripping jaws; and
- 15 (d) a controller for controlling the movement of the components of the arm assembly.

[0008] In one embodiment, the base actuating motor, post actuating motor, extension arm motor, and the gripper jaw motor are each the same type of motor, and in one embodiment may be
 20 electric or hydraulic motors. In one embodiment, the controller comprises a joystick controller.

[0009] In one embodiment, the grasping arm may comprise two parallel elongate members, each of which is pivotally mounted to the post at one end, and to the gripper head at the other end. The gripper head may have an axis perpendicular to the post, which axis is substantially horizontal and remains substantially horizontal throughout the range of motion of the grasping
 25 arm. The gripper jaws may each comprise a pivoting attachment to the gripper head, such that the gripper jaws open and close by rotating about a substantially vertical axis, which is substantially parallel to the post.

5 [0010] In one embodiment, the extension arm may be pivotally attached to the grasping arm at a first end, and slidably disposed within the post at a second end, such that sliding movement of the second end causes the extension arm to extend or retract the grasping arm. The second end of the extension arm may be displaced by a linear actuator disposed within the post.

BRIEF DESCRIPTION OF THE DRAWINGS

10 [0011] In the drawings, like elements are assigned like reference numerals. The drawings are not necessarily to scale, with the emphasis instead placed upon the principles of the present invention. Additionally, each of the embodiments depicted are but one of a number of possible arrangements utilizing the fundamental concepts of the present invention. The drawings are briefly described as follows:

15 [0012] FIG. 1 is a perspective view of one embodiment of an automated pipe racking apparatus;

[0013] FIG. 2 shows a perspective view of the automated pipe racking apparatus shown in FIG. 1;

[0014] FIG. 3 shows a perspective view of the automated pipe racking apparatus shown in
20 FIG. 1;

[0015] FIG. 4 shows a perspective view of the automated pipe racking apparatus shown in FIG. 1;

5 [0016] FIG. 5 shows a perspective view of the automated pipe racking apparatus shown in FIG. 1;

[0017] FIG. 6 shows a perspective view of the automated pipe racking apparatus shown in FIG. 1;

[0018] FIG. 7 shows a perspective view of the automated pipe racking apparatus shown in
10 FIG. 1;

[0019] FIG. 8 shows a schematic of a joystick controller for controlling the automated pipe racking apparatus;

[0020] FIG. 9 shows detailed views of components of the automated pipe racking apparatus shown in FIG. 1; and

15 [0020a] FIG. 10 shows a perspective view of the automated pipe racking apparatus shown in FIG. 1.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0021] The invention relates to a pipe racking apparatus for a drilling or service rig. When describing the present invention, all terms not defined herein have their common art-
20 recognized meanings. To the extent that the following description is of a specific embodiment or a particular use of the invention, it is intended to be illustrative only, and not limiting of the claimed invention. The following description is intended to cover all alternatives, modifications and equivalents that are included in the spirit and scope of the invention, as defined in the appended claims.

5 [0022] The use of the terms "horizontal" and "vertical" herein are used primarily to denote relative orientation of some elements to the other. They are used in the expectation that the pipe racking apparatus is used to move substantially vertical pipe stands.

[0023] FIG. 1 illustrates a perspective view of an automated pipe racking apparatus (10) constructed in accordance with one embodiment of the present invention. A drilling or
10 service rig typically includes a mast (12) having a traveling block (not shown) suspended over the centerline of a well bore. An elevator or set of elevators (not shown) may also be suspended from the traveling block for grasping a drill pipe or drill stand. A drill pipe stand (14) consists of at least one pipe section and is often composed of three substantially identical pipes joined end to end and threaded together at joints. Each of the pipes on the lower end
15 includes a threaded coupling that may be threadably engaged with a complementary threaded coupling, such as at the top of another stand.

[0024] Accordingly, a continuous string of drill pipes can be made up and then lowered into the well bore. Two different operations are performed. As the pipe stands are successively lowered into the well, they are retrieved from a racking assembly (16), connected to the
20 existing drill string, and then inserted into the well bore. Conversely, when the drill pipe stands are removed from the well, they are lifted out of the well bore, disconnected from the drill string, and placed for storage in a racking assembly (16).

[0025] As seen in FIG. 1, a racking assembly (16) has a frame which is mounted on the mast (12). The racking assembly (16) includes a plurality of parallel racking fingers (18) which are
25 arranged to form a plurality of slots between adjacent fingers. The slots are slightly wider than

5 the diameter of the drill stand. The pipe stands (14) are stored in the slots between the racking fingers (18).

[0026] An arm assembly (20) forms part of the racking assembly. The arm assembly (20) is used to grasp pipe stands and to move them into and out of the racking assembly slots. The arm assembly comprises grasping jaws (22) which may be opened and closed to grasp a pipe stand
10 (14). The arm assembly (20) is configured to translate the grasping jaws primarily in two dimensions in the horizontal plane. Any vertical movement is incidental to horizontal movement of the arm, and is not intended to lift or lower the pipe stand (14).

[0027] The arm assembly is moved towards and away from the mast with rollers (24) on a track (26). A worm gear assembly (28), a linear actuator or a similar mechanism powered by an
15 electric or hydraulic motor (29), for example, may be used to move the arm assembly along the track.

[0028] The arm assembly includes a vertical post (30) which is rotatable around its longitudinal vertical axis. A slew gear (not shown) is provided inside the base of the post, and is actuated by a slew gear drive motor (32).

20 [0029] A grasping arm (34) is attached to the top of the post (30) and is extendable away from the post by an extension arm (36). In one embodiment, one end (38) of the extension arm is pivotally affixed to the grasping arm, and the other end (40) is vertically moveable with the post (30). When the moveable end (40) is displaced downwards, it has the effect of drawing the grasping arm inwards, towards the post. When the moveable end (40) is displaced upwards, it
25 has the effect of extending the grasping arm outwards, away from the post. In one

5 embodiment, the moveable end (40) may be displaced by a linear actuator assembly (not shown or a worm gear assembly. As shown in the cutaway view of Figure 10, the moveable end (40) is pivotally attached to a collar (101) having an internal thread. The collar (101) is threaded onto a worm gear (102) having a complementary outer thread. As one skilled in the art will appreciate, rotation of the worm gear (102) by an electric or hydraulic motor (42) causes the collar to move
10 upwards or downwards within the post (30). Precise manipulation of the grasping arm is possible with this configuration.

[0030] In one embodiment, the grasping arm (34) comprises two parallel members which maintain their parallel relationship while having separate pivoting attachments at each end, forming a parallelogram. At the grasping end, a gripper head (44) maintains a horizontal position
15 regardless of the extension of the grasping arm. The gripper head (44) includes gripping jaws (46) which open and close to grasp and release a pipe stand. In one embodiment, the gripper jaws open and close by rotation about a substantially vertical axis and may be actuated with any suitable motor, such as an electric or hydraulic motor. In another embodiment, the gripper jaws open and close manually by pushing against the pipe stand once a lock is released electrically or
20 hydraulically. In yet another embodiment, the gripper comprises a magnetic head which can be activated or deactivated electrically, hydraulically or mechanically.

[0031] In one embodiment, each of the motors involved in actuating elements of the arm assembly may be of the same type, which simplifies assembly and maintenance. Each of the motors may be actuated by a control. In one embodiment, the arm assembly may be controlled by a joystick
25 mechanism or a programmable logic controller (PLC). An exemplary implementation is shown in Figure 8. Movement of the joystick in a forwards or backwards

5 direction actuates the extension motor on top of the post, causing the grasping arm to extend or retract. Movement of the joystick in a side-to-side manner may actuate the slew gear drive motor, rotating the post in either direction. The joystick may include a gripping jaws control, such as a button mounted on top of the joystick.

[0032] The connection between the controller and the arm assembly may be wired or wireless,
10 using connection technology well known to those skilled in the art. The remote control may comprise RF transmitters and receivers.

[0033] The Figures show a sequence where the arm assembly is moved to grasp a pipe stand in position within the mast, and move it to the pipe rack. In Figure 1, the arm assembly is moved along channel (26) by motor (29), and the slew gear motor is controlled to rotate the
15 post such that the gripper head and jaws are facing the pipe stand. In Figure 2, the grasping arm is extended towards the pipe stand by control of the extension motor (42). In Figure 3, the grasping jaws are used to clamp onto the pipe stand. In Figure 4, the grasping arm is retracted to pull the pipe stand out of the mast and into the racking assembly. In Figure 5, the post is rotated to turn the gripper head towards the pipe rack where the pipe stand is to be
20 stored. In Figure 6, the grasping arm is then extended until the pipe stand reaches the entrance of the pipe rack row. The assembly is then moved laterally within channel (26) until the pipe stand has reached its storage location. The grasping jaws are then opened to release the pipe stand, and the arm assembly then may be used to retrieve the next pipe stand disconnected from the drill string.

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5 WHAT IS CLAIMED IS:

1. An automated pipe racking apparatus for use with an oil drilling or service rig having a mast, comprising:

- 10 (a) a pipe rack formed from a plurality of pipe rack fingers;
 (b) a horizontal channel disposed within the pipe rack;
 (c) an arm assembly comprising:
 i) a base which slidingly engages the horizontal channel and a motor for actuating the base within the channel;
 15 ii) a post pivotally mounted to the base and a motor for actuating movement of the post about its longitudinal axis;
 iii) a grasping arm pivotally attached to an upper end of the post;
 iv) an extension arm for extending the grasping arm away the post and a motor for actuating the extension arm;
 20 v) a gripper head attached to an end of the grasping arm, and comprising gripping jaws or a magnet and a motor for actuating opening and closing movement of the gripping jaws or to activate/deactivate the magnetic head; and
 (d) a controller for controlling the movement of the components of the arm
 25 assembly.

2. The apparatus of claim 1 wherein the base actuating motor, post actuating motor, extension arm motor, and the gripper jaw motor are each the same type of motor.

30 3. The apparatus of claim 2 wherein the motors are electric motors.

4. The apparatus of claim 2 wherein the motors are hydraulic motors.

5 5. The apparatus of claim 1 wherein the controller comprises a joystick controller or a programmable logic controller (PLC).

6. The apparatus of claim 1 wherein the grasping arm comprises two parallel elongate members, each of which is pivotally mounted to the post at one end, and to the gripper head at
10 the other end.

7. The apparatus of claim 6 wherein the gripper head has an axis perpendicular to the post, which axis is substantially horizontal and remains substantially horizontal throughout the range of motion of the grasping arm.

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8. The apparatus of claim 1 wherein the gripper jaws each comprise a pivoting attachment to the gripper head, such that the gripper jaws open and close by rotating about an axis substantially parallel to the post.

20 9. The apparatus of claim 1 wherein the extension arm is pivotally attached to the grasping arm at a first end, and slidingly disposed within the post at a second end, such that sliding movement of the second end causes the extension arm to extend or retract the grasping arm.

25 10. The apparatus of claim 9 wherein the second end of the extension arm is displaced by a linear actuator disposed within the post.

Replacement Sheet
1/10

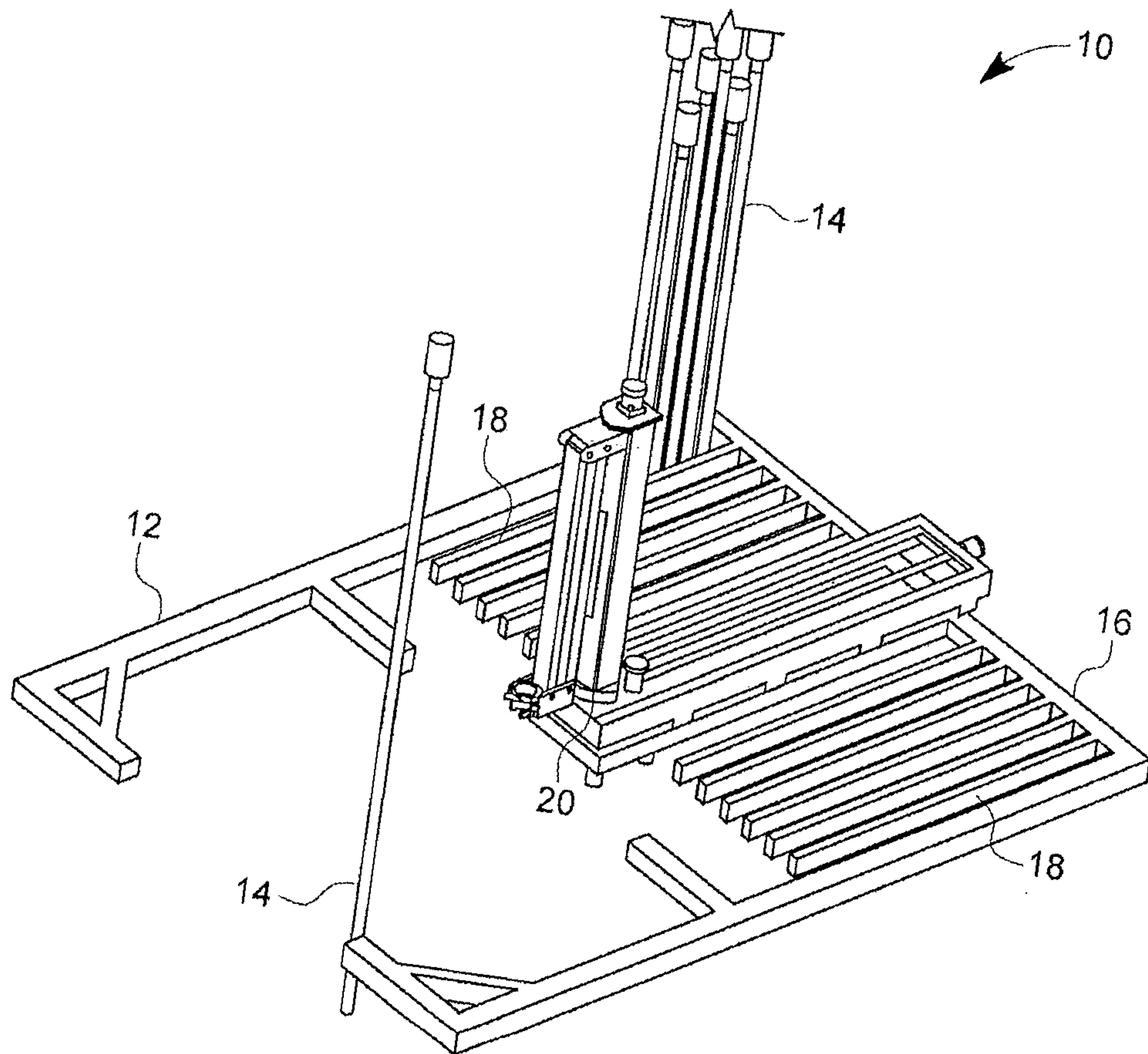


FIG. 1

Replacement Sheet

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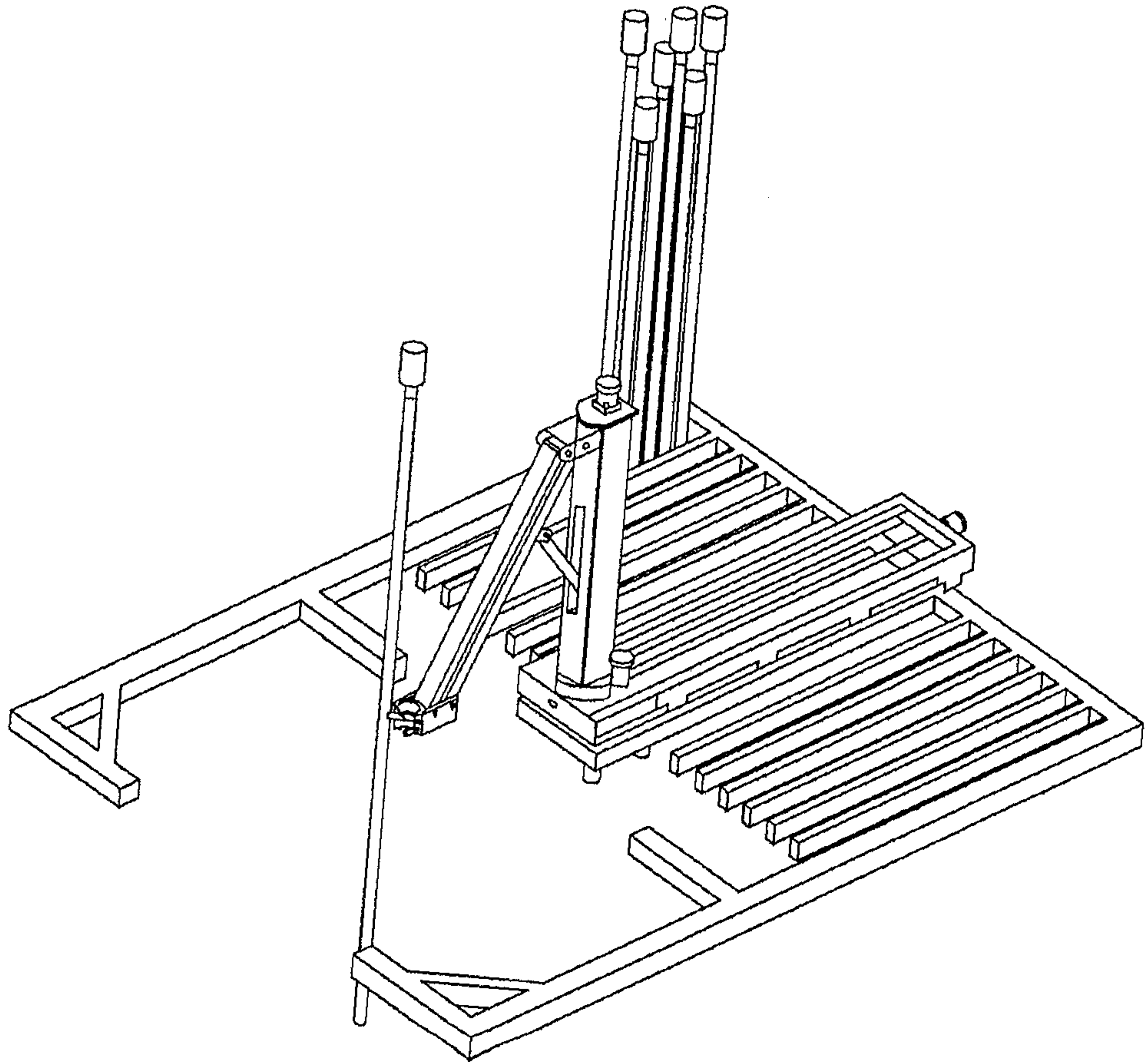


FIG. 3

Replacement Sheet

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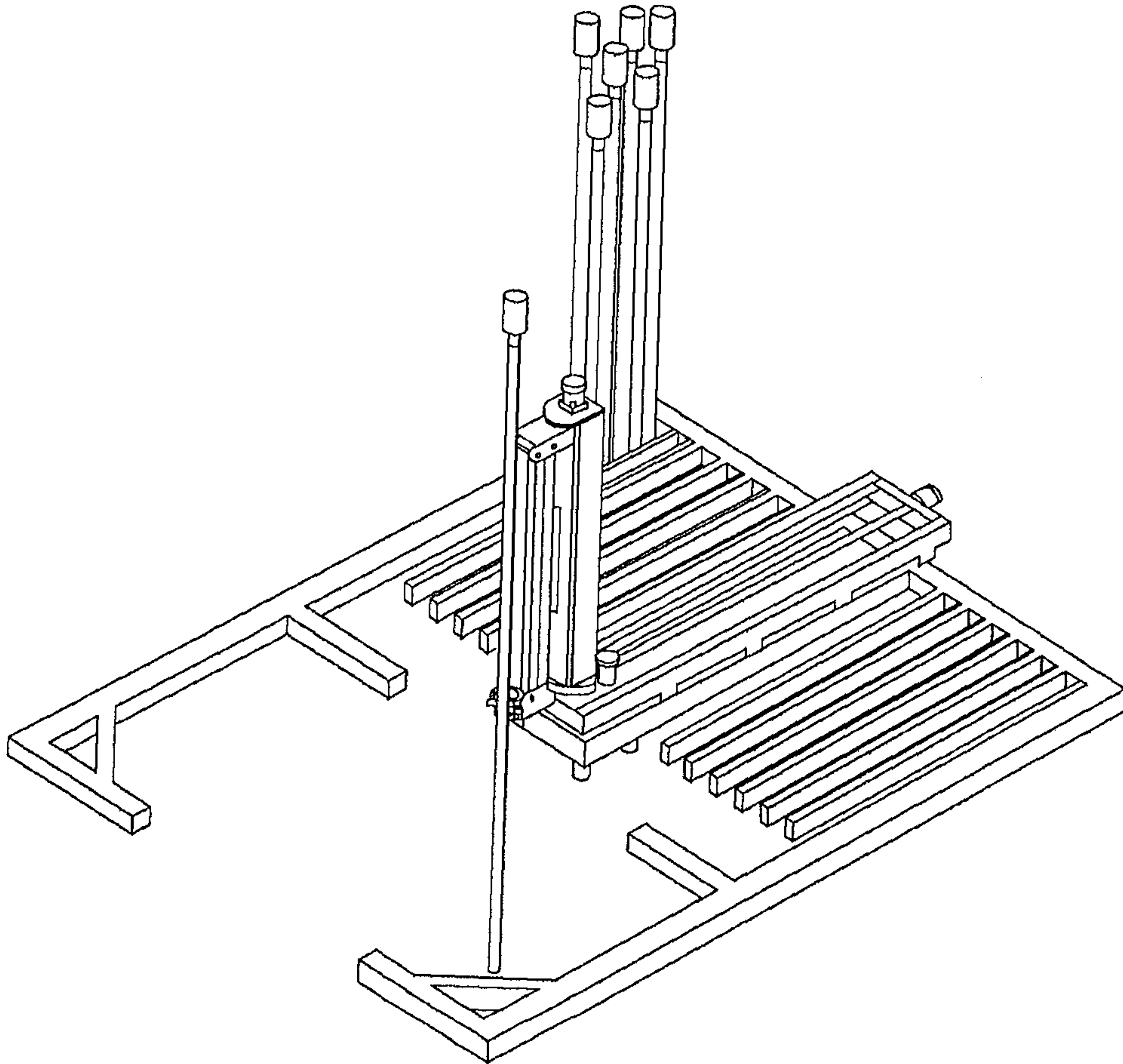


FIG. 4

Replacement Sheet
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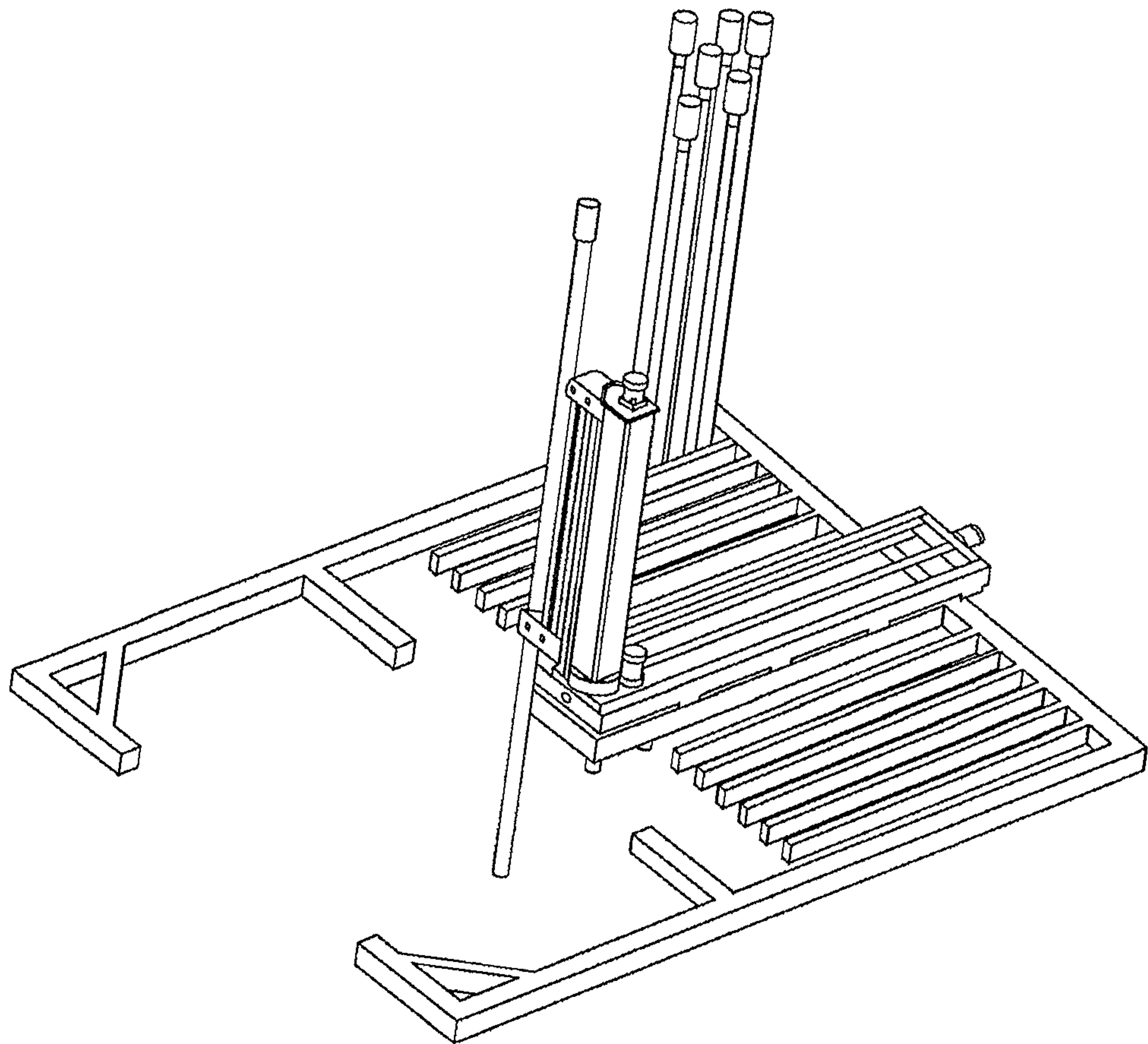


FIG. 5

Replacement Sheet

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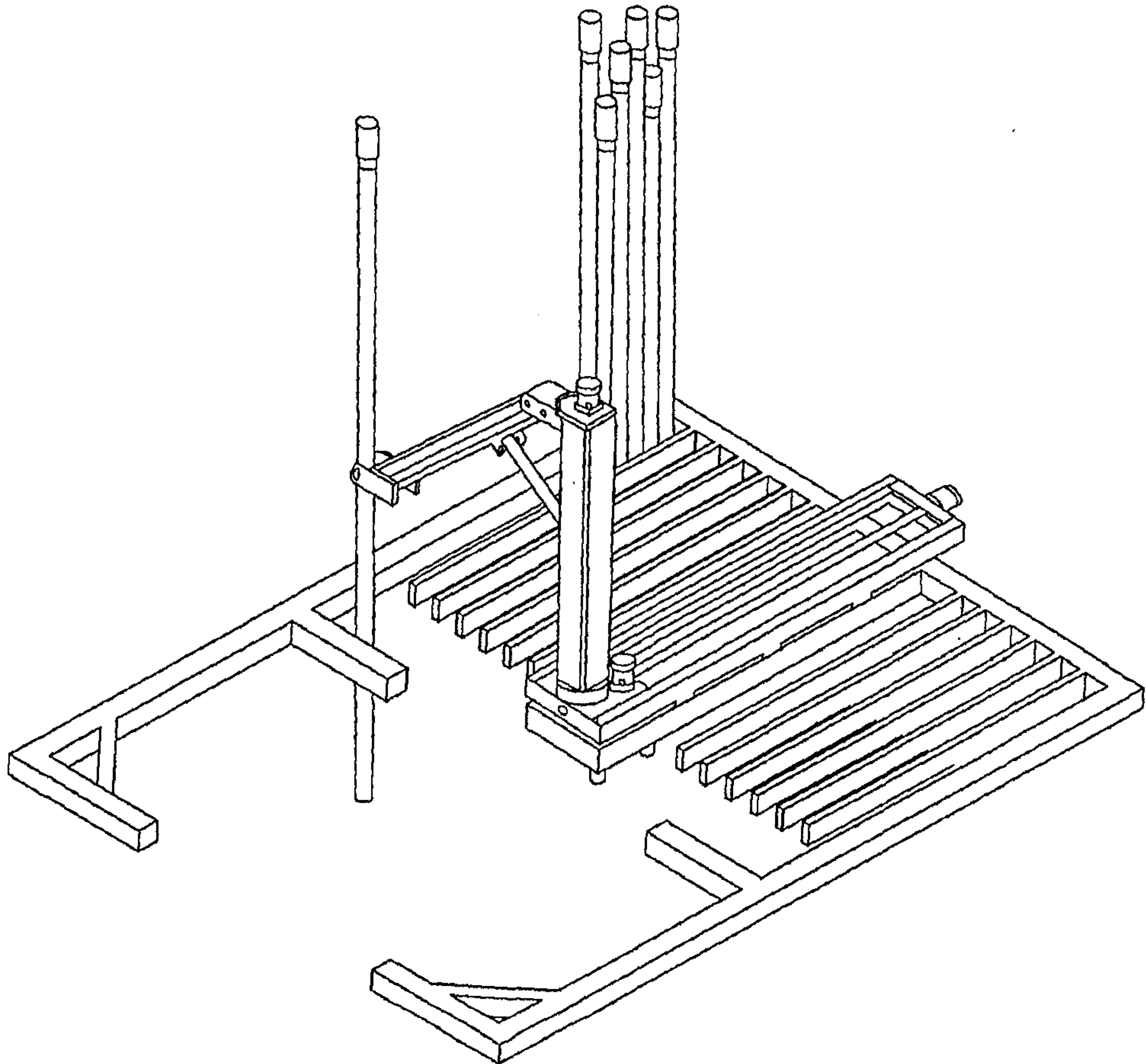


FIG. 6

Replacement Sheet

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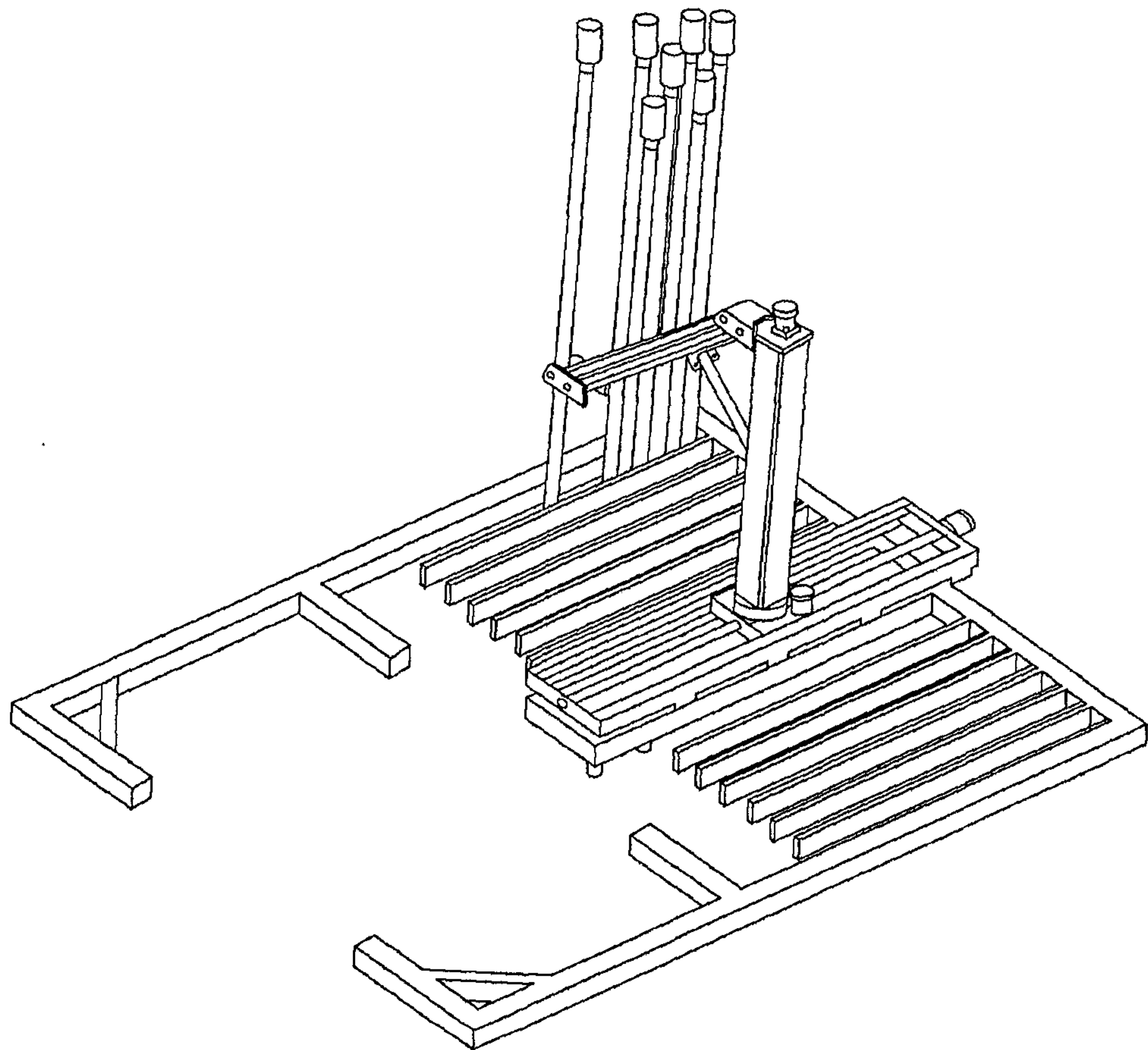
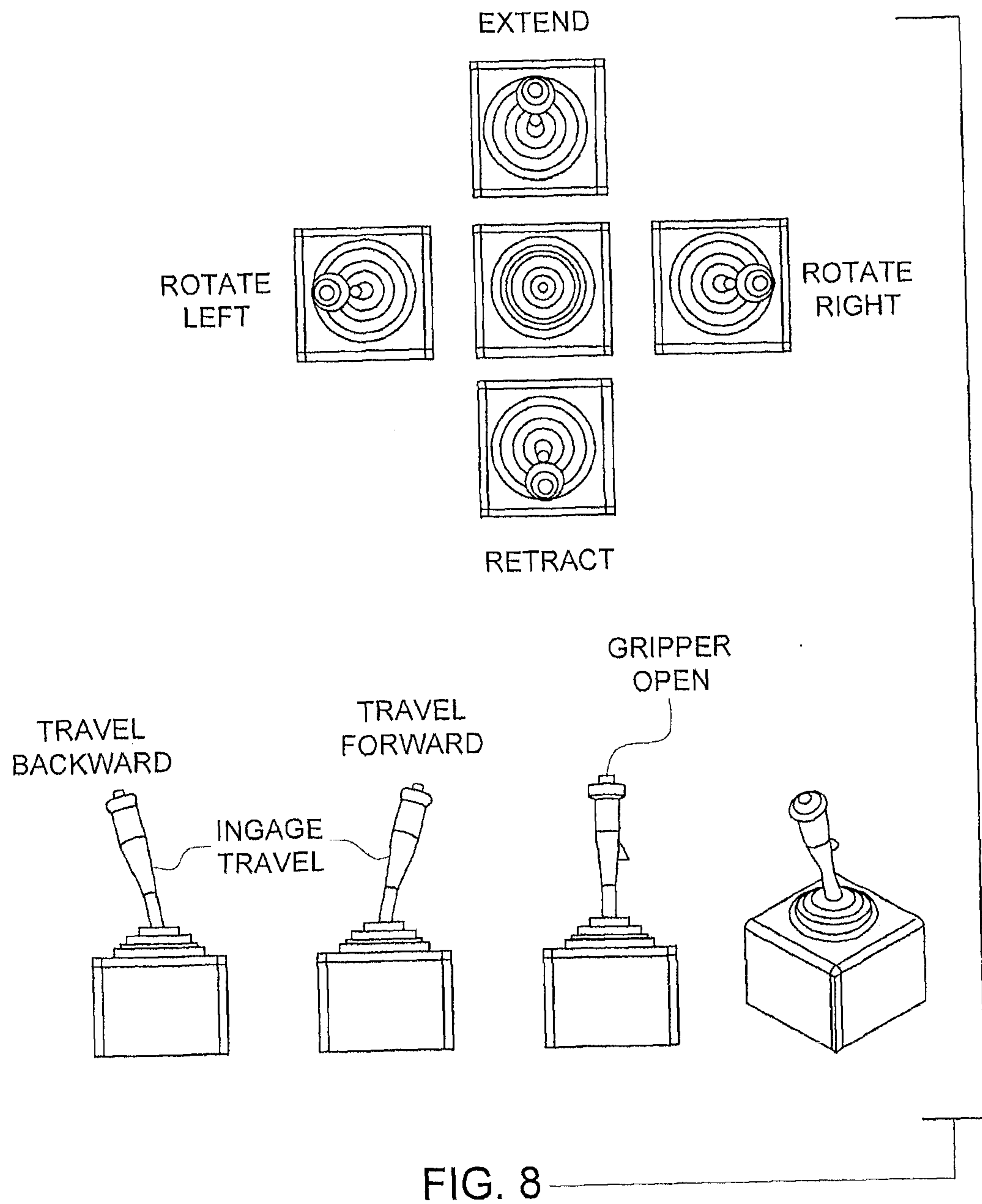


FIG. 7

Replacement Sheet

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Replacement Sheet

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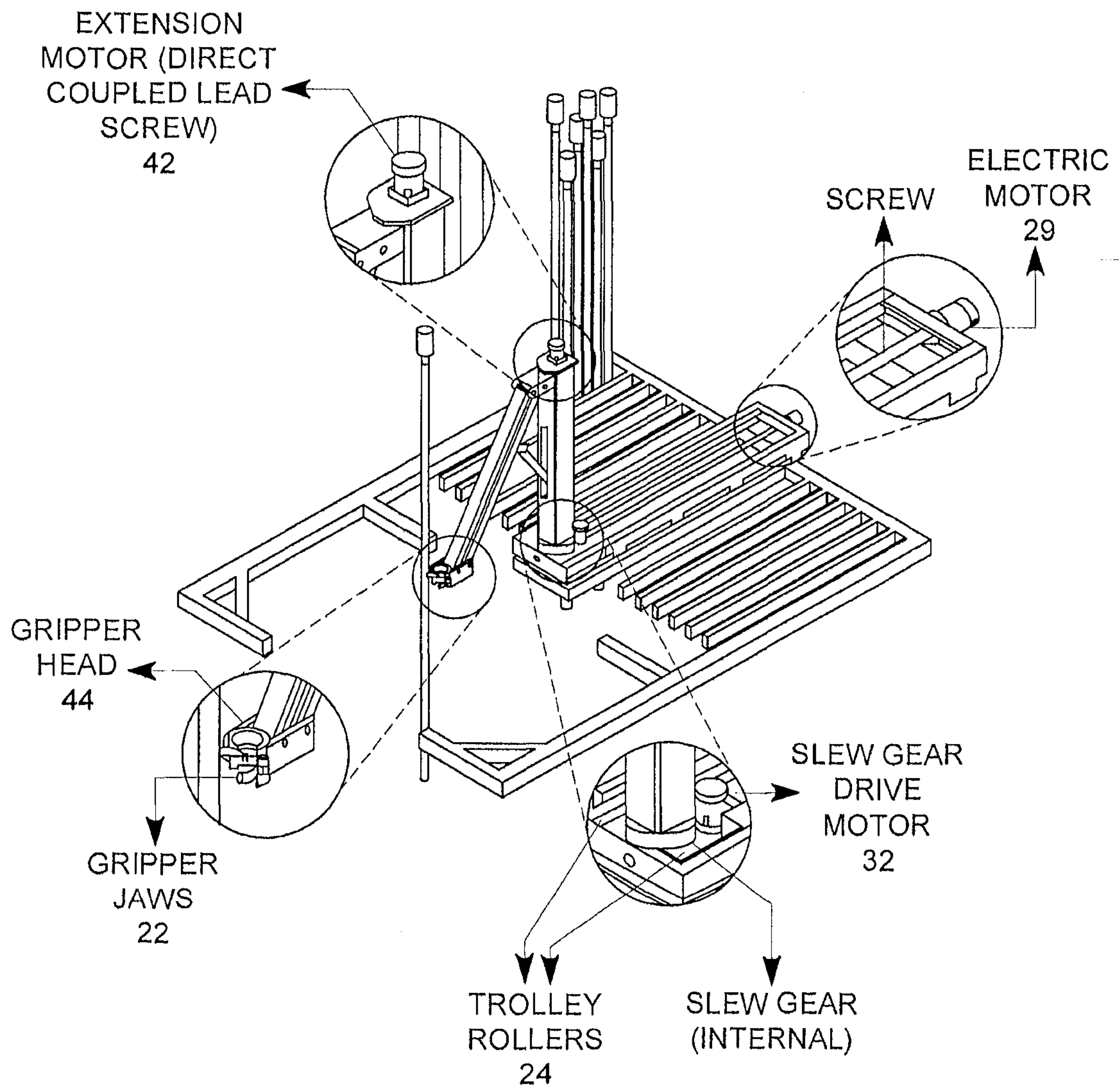


FIG. 9

Replacement Sheet

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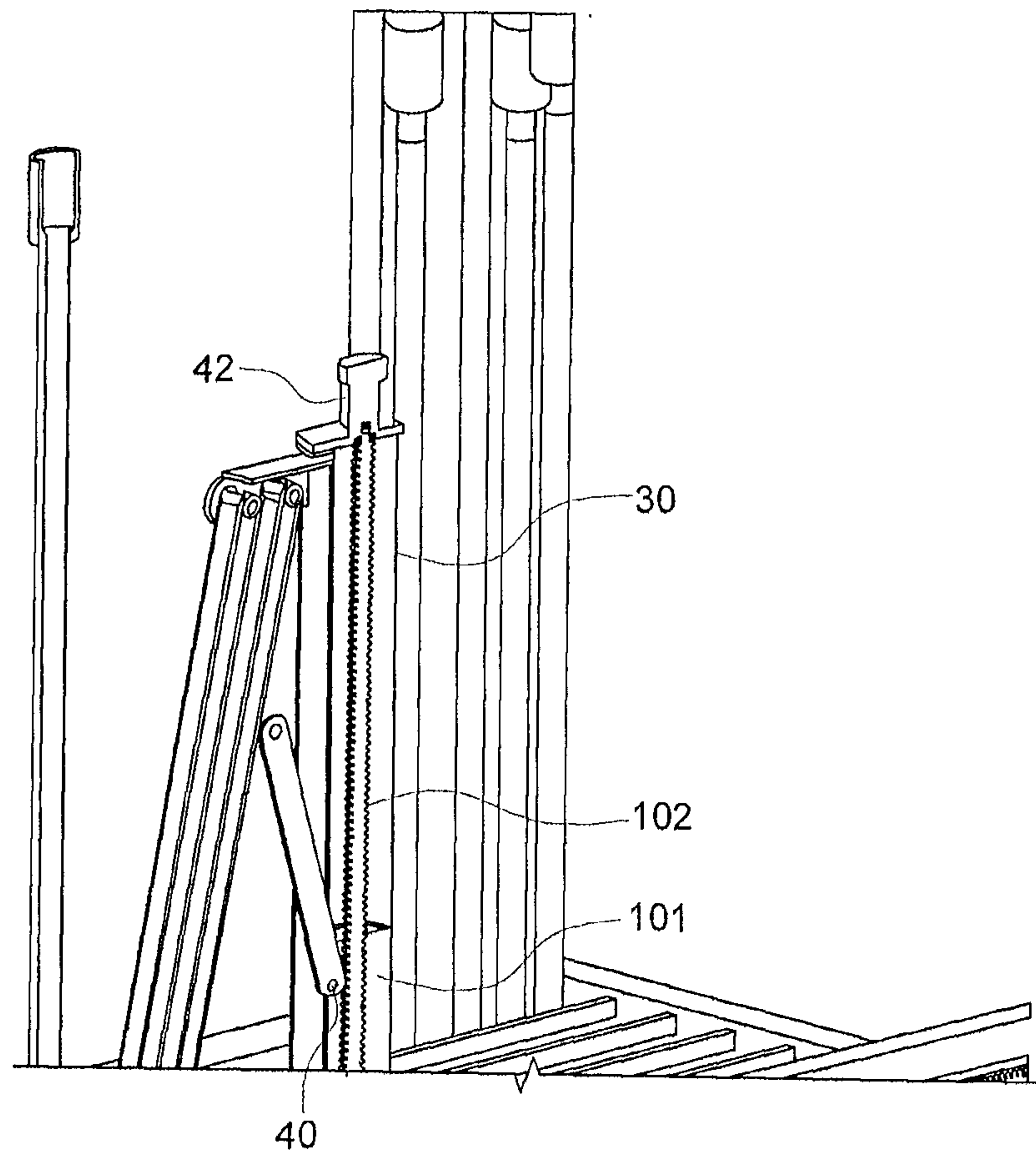


FIG. 10

