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Terpstra

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(54) **PICK AND PLACE DEVICE HAVING TWO PARALLEL AXES**

(75) Inventor: **Paul D. Terpstra**, Janesville, WI (US)

(73) Assignee: **Gilman Engineering & Manufacturing Co., LLC**, Janesville, WI (US)

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(52) **U.S. Cl.** **414/749.6**; 212/319; 414/626; 414/917

(58) **Field of Search** 212/316, 319; 414/749.1, 749.6, 751.1, 626, 917

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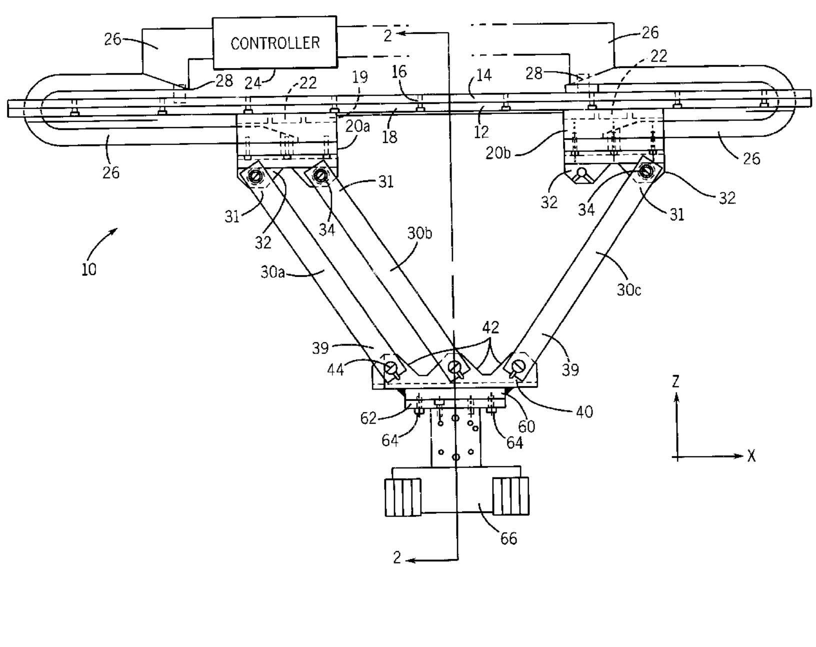
Primary Examiner—Janice L. Krizek
(74) *Attorney, Agent, or Firm*—Foley & Lardner

(57) **ABSTRACT**

An apparatus and method for picking and placing an object is disclosed. The apparatus includes an elongated frame, first and second carriages slidingly engaged with the frame, first and second connecting rods pivotally engaged with the first carriage at one end and at least a third connecting rod pivotally engaged with the second carriage at one end, and a gripper pivotally and operatively attached to the connecting rods at their other ends. The method of operation includes moving the gripper in a first direction (upwardly) by sliding the first and second carriages away from each other along the frame, moving the gripper in a second direction (laterally), perpendicular to the first direction, by sliding the first and second carriages together along the frame in the same direction, and moving, the gripper in a third direction (downwardly), opposite to the first direction, by sliding the first and second carriages toward each other along the frame.

17 Claims, 9 Drawing Sheets



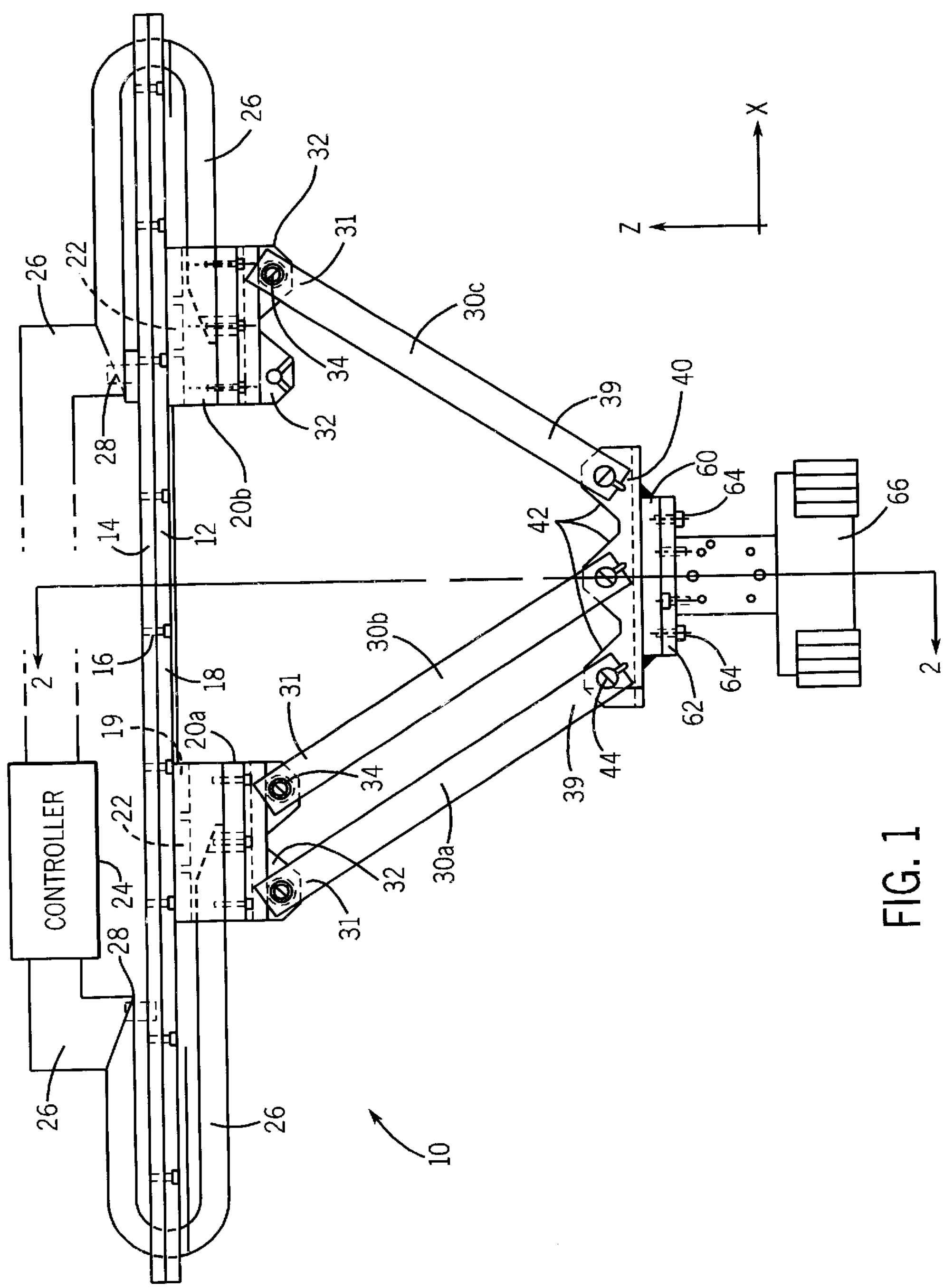

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FIG. 1

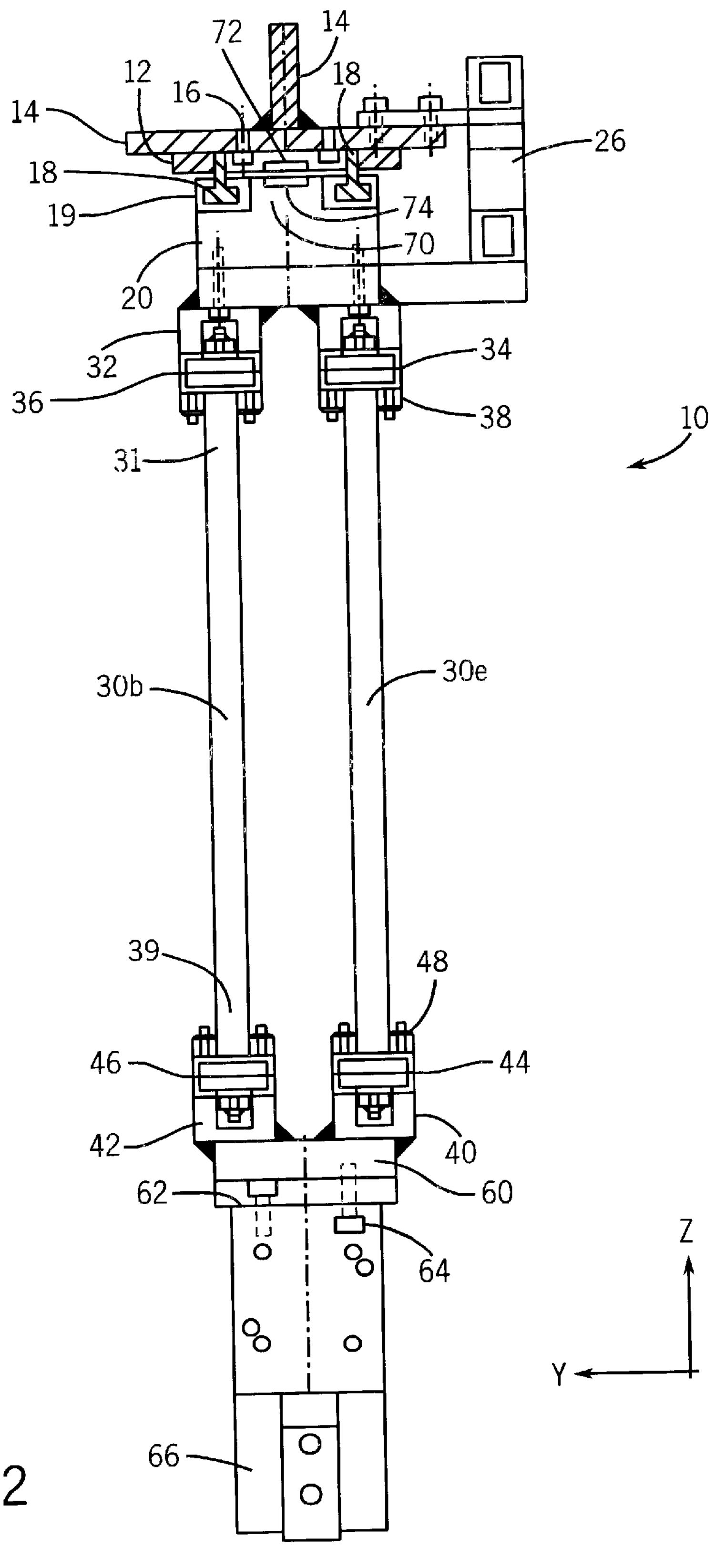
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FIG. 2

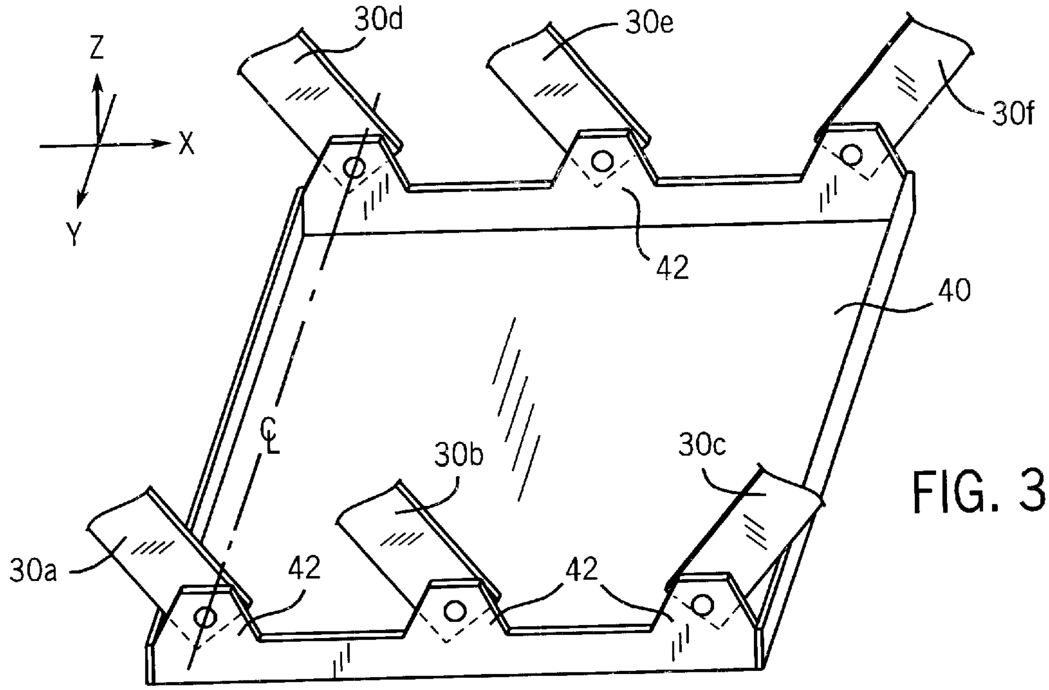
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FIG. 3A

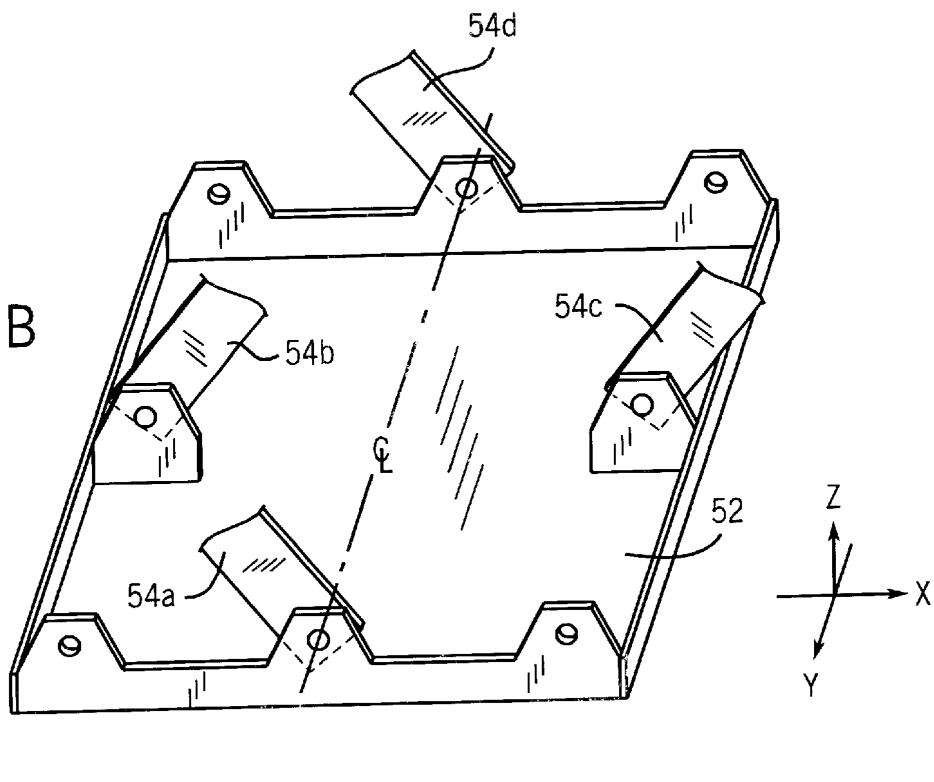
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FIG. 3B

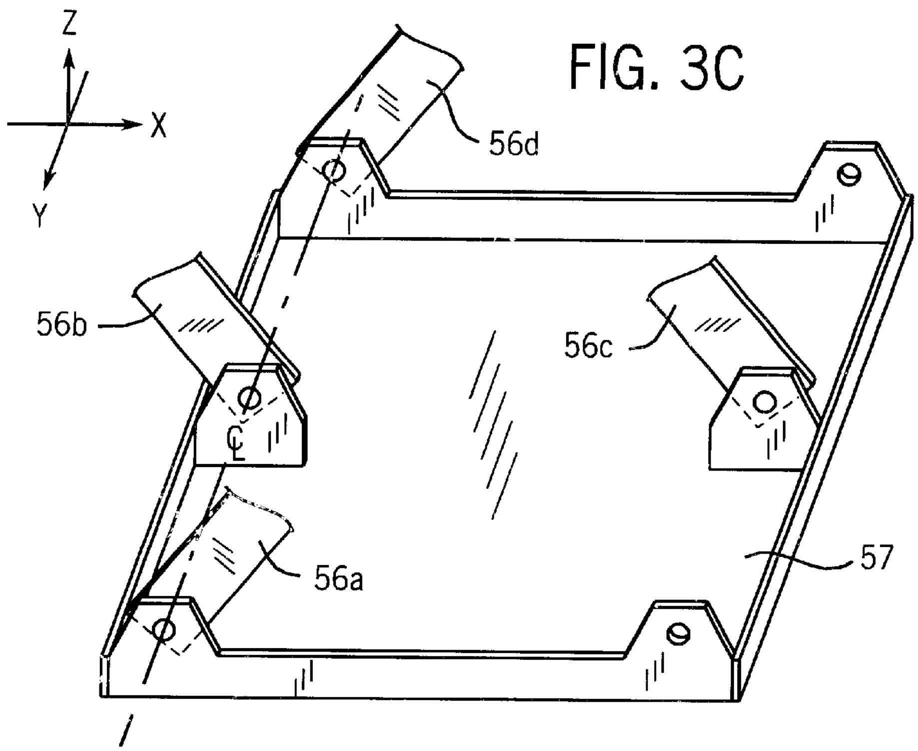


FIG. 3C

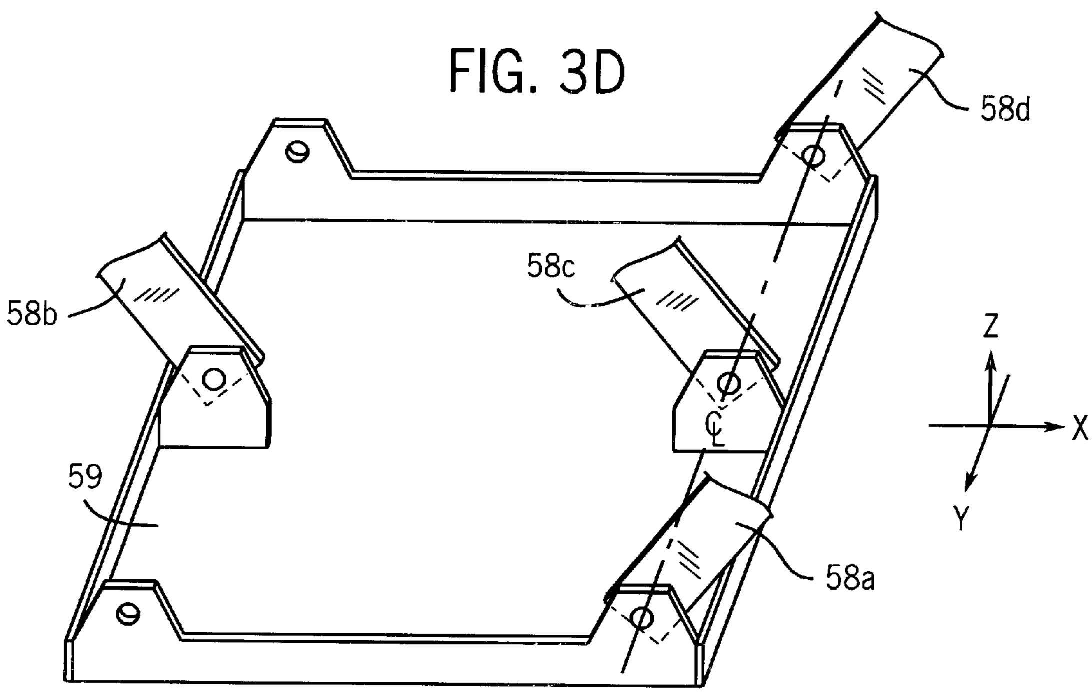


FIG. 3D

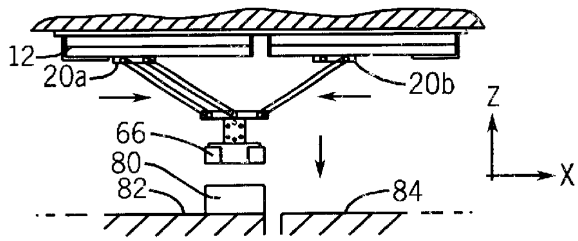


FIG. 4A

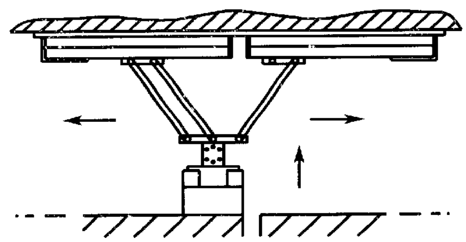
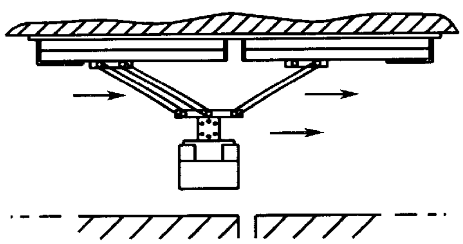


FIG. 4B



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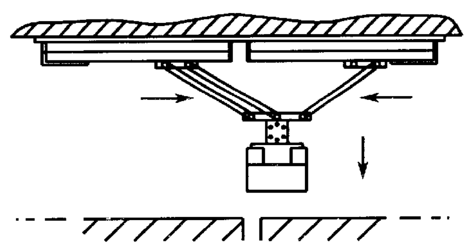


FIG. 4D

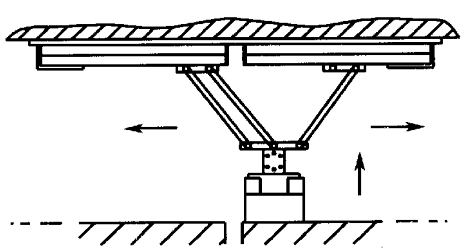
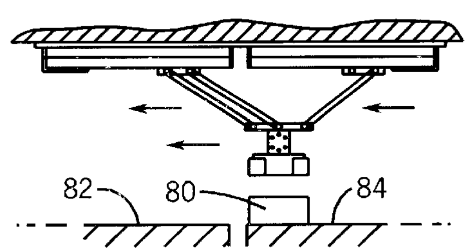


FIG. 4E

FIG. 4F



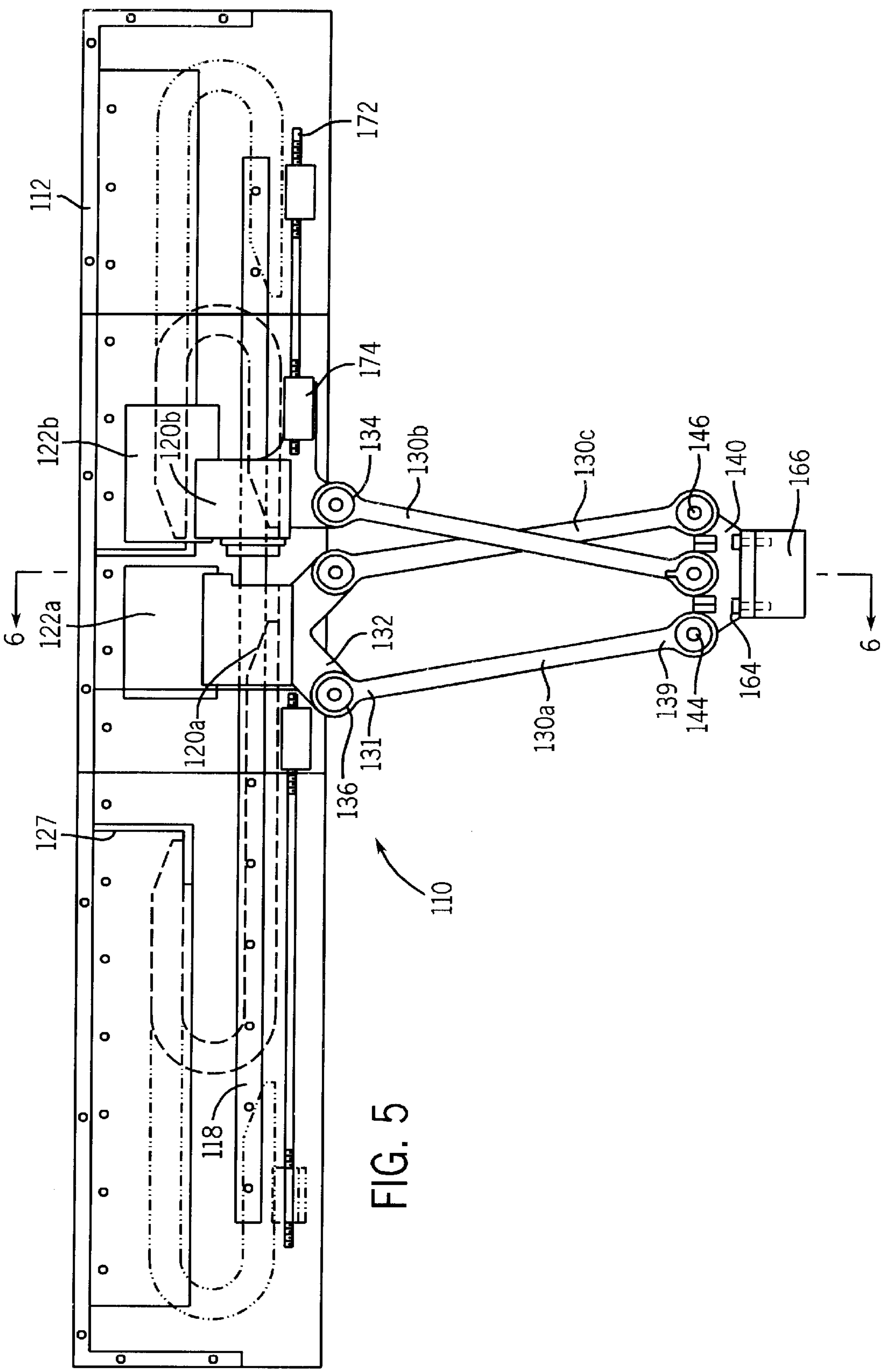

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FIG. 5

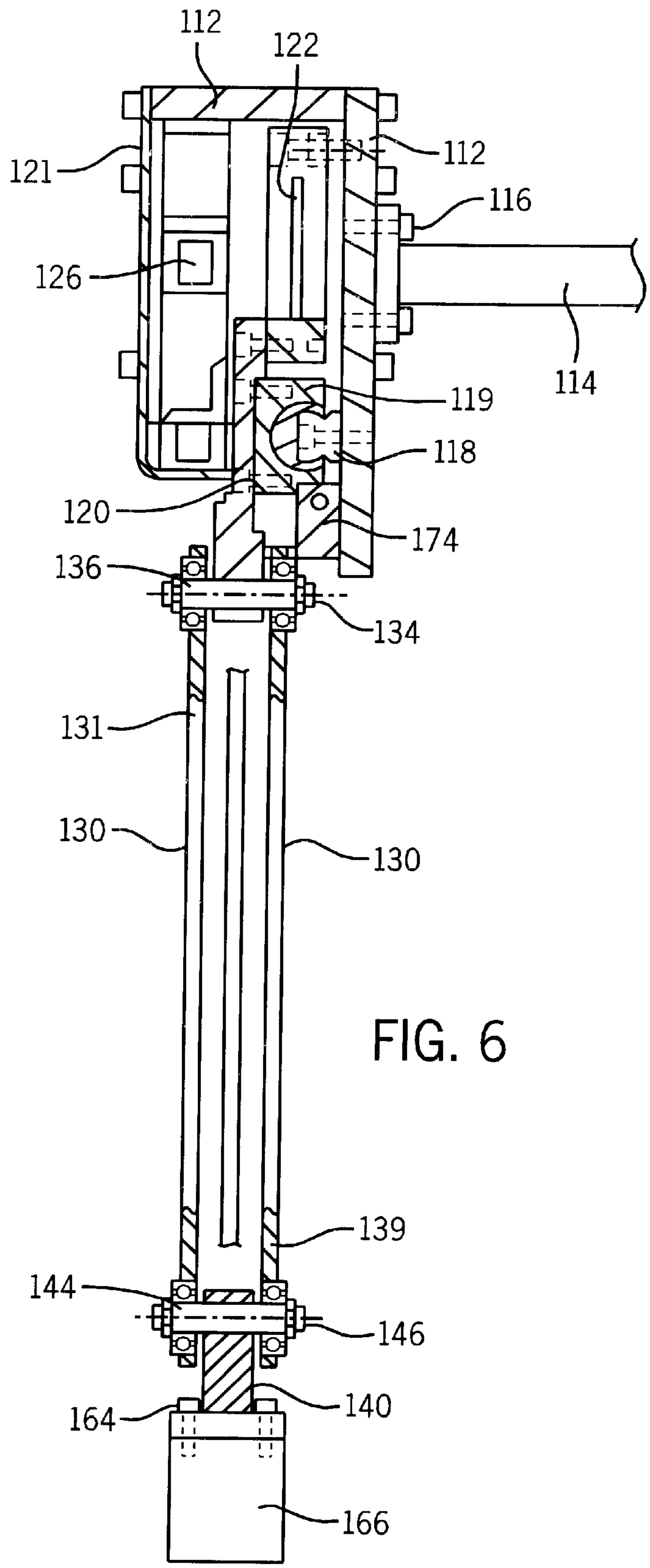
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FIG. 6

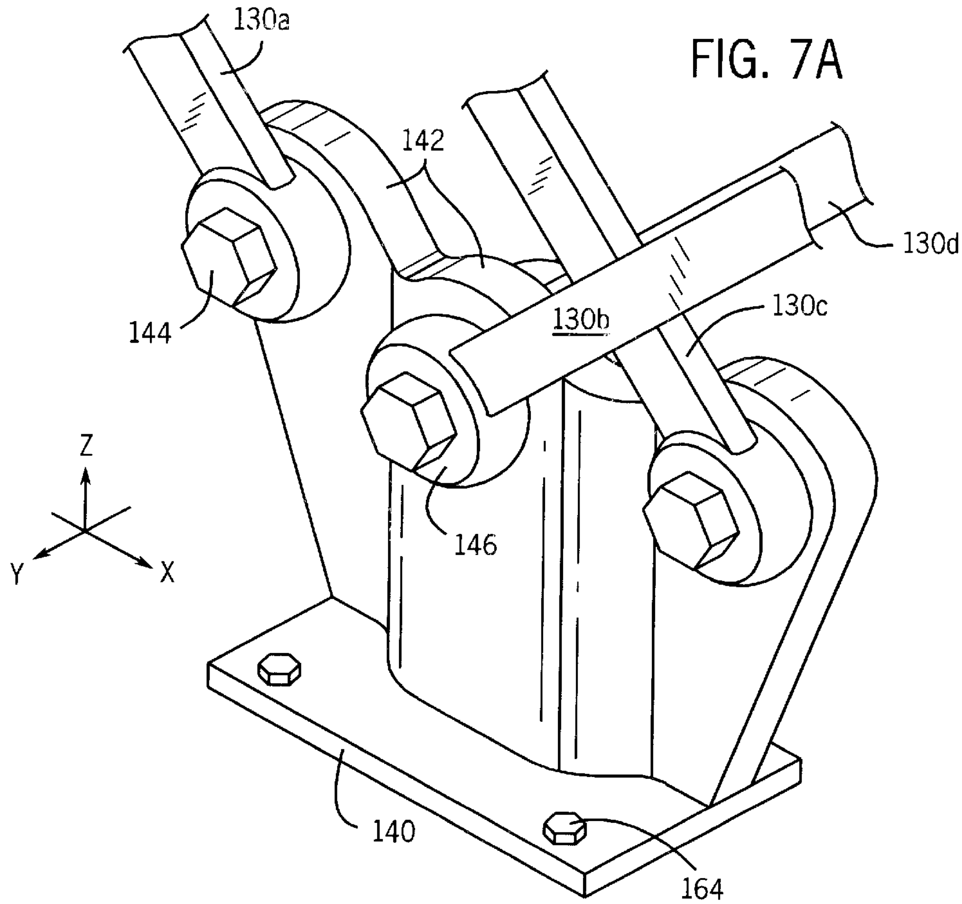
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FIG. 7A

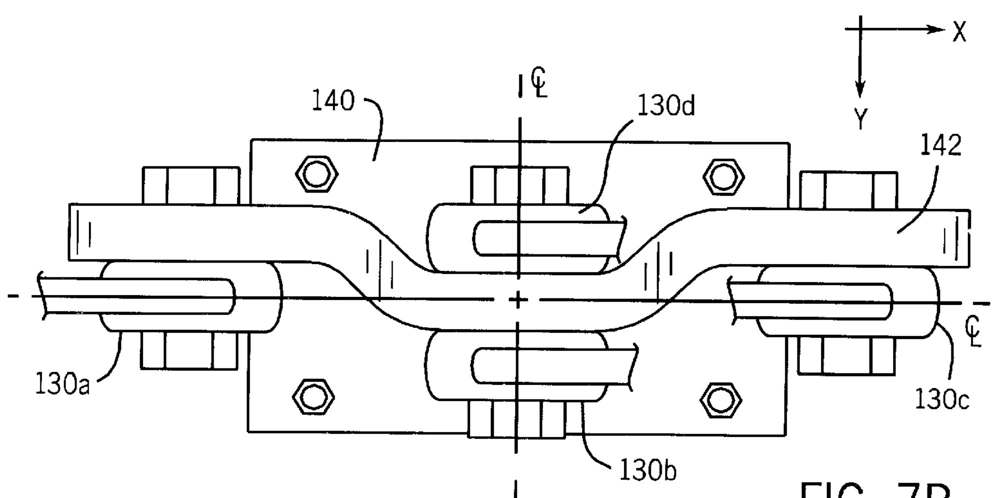
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FIG. 7B

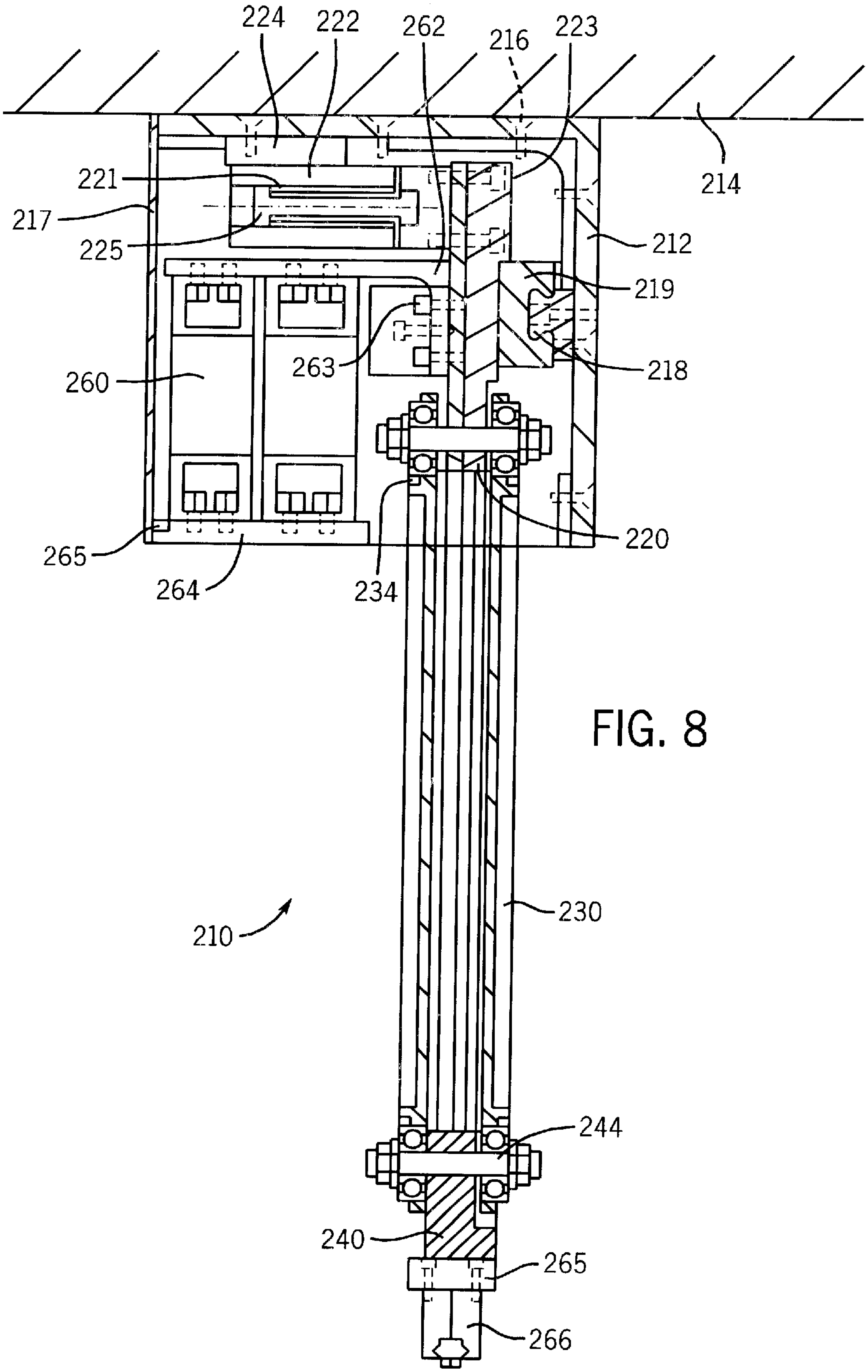
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FIG. 8

PICK AND PLACE DEVICE HAVING TWO PARALLEL AXES

FIELD OF THE INVENTION

This invention relates to a device for picking-up a part from a first manufacturing station and thereafter placing and releasing the part in a second station. Such devices are typically used in robotics and automatic manufacturing applications and are commonly referred to as "pick and place" devices or "transfer mechanisms".

BACKGROUND OF THE INVENTION

Pick and place devices known in the art typically incorporate two axes of motion configured perpendicular to each other. For example, two independently operated pneumatic slide carriages can be mounted on axes perpendicular to each other, wherein the first carriage supports the second carriage. The two carriages can be driven either by linear servo motors or by ball screws and rotary servo motors. An example of such a two-axes, two-carriage device is illustrated in U.S. Pat. No. 5,086,559 to Akatsuchi.

The disadvantage of such prior art devices is that the first carriage axis carries the second carriage axis. Therefore, the first axis must robust enough to carry the weight of the part being moved in addition to the weight of the second axis, and the driving force propelling the first axis must be large enough to accelerate and decelerate the part in addition to the second axis. Another disadvantage is that the accuracy of the motion of the second axis depends on the accuracy of the mounting that attaches the second axis to the first axis. If the two axes are not mounted exactly perpendicular to each other, the motion will not have the desired accuracy. Moreover, the mounting is often fixed during manufacturing and cannot be adjusted in the field.

Instead of using two independently powered carriages on two perpendicular axes, some pick and place devices utilize a barrel cam driven by an electric motor, or a pneumatic cylinder moving the carriages in a cam slot. Pick and place devices utilizing U-shaped cam slots are illustrated in U.S. Pat. No. 5,564,888 to Doan, and U.S. Pat. No. 4,740,134 to Dixon. A pick and place machine utilizing a generally Y-shaped cam slot is illustrated in U.S. Pat. No. 4,451,196 to Harada et al.

A primary disadvantage of these cam-type prior art devices is that they provide little, if any, provision for adjustment of the device motion ranges. Typically, the motion of the device is fixed, thereby requiring that the parts handling system be built around the dimensions of the pick and place device. If the pick and place device does not have the exact range of motion specified by the manufacturer, the parts handling system must subsequently be redesigned.

Using another type of transfer apparatus, U.S. Pat. No. 3,065,861 to Cruciani discloses a rope crane having substantially parallel carrying ropes with a pair of blocks connected to one another. By winding the rope of one capstan and paying out the rope of another capstan, the pair of blocks can be carried to any desired point located between two predetermined locations. The main disadvantage of this rope crane is that, since it relies on gravity, it can only exert a positive force in the upward direction (i.e., a "pull force"), and cannot exert a positive force in the downward direction (i.e., a "push force"). The inability to provide a positive pushing force prohibits the device from operating effectively as a pick and place device, particularly if the device is inverted (e.g., located under the automation system).

U.S. Pat. No. 4,687,400 to Lichti discloses another type of device for moving objects in a closed container. This complex device has four degrees of freedom (i.e., up-and-down, back-and-forth, opening and closing the fingers, and rotation around a horizontal axis) but requires manipulation of four arms to obtain the desired motion. Linear horizontal motion is complicated as it requires a combination of vertical and rotational motion. Therefore, it is too complex and expensive for cost-effective use in an application requiring only two degrees of freedom (i.e., up and down, side-to-side).

U.S. Pat. No. 4,190,912 to Nilsson discloses a device for lifting and transferring a hospital patient. Rotation of a lever, pivotally attached to a connecting rod at a predetermined angle, raises, translates, and then lowers a patient in and out of bed. However, due to its design, the range of vertical movement is fixed through the entire lift and transfer cycle (i.e., the mechanism must place at the same level it picks). Thus, this mechanism can-only move from a first predetermined location to another predetermined spot at approximately the same height as the first location, and has limited flexibility.

A need, therefore, exists for a two-axis pick and place device that is simple in construction, highly accurate, programmably adjustable, robust in operation, and yet cost effective.

OBJECTS AND SUMMARY OF THE INVENTION

Accordingly, it is a primary object of the present invention to provide a pick and place device which overcomes the disadvantages previously described.

It is another object of the present invention to provide a pick and place device that can be programmed to move in accordance with the computer instructions of many different manufacturing operations.

It is still another object of the present invention to provide a pick and place device that has carriages which move along two parallel axes instead of two perpendicular axes, to increase the accuracy of movement.

In accordance with one aspect of the present invention, there is provided a pick and place device comprising a single elongate frame extending in a longitudinal direction, first and second carriages slidingly engaged on the frame, first and second motors which drive each of the first and second carriages to slide along the frame, a gripper for gripping an object to be relocated, a first linking arrangement including at least two connecting rods pivotally attached to the first carriage at one end and pivotally attached to the gripper at the other end, and a second linking arrangement including at least one connecting rod pivotally attached to the second carriage at one end and pivotally attached to the gripper at the other end.

In accordance with the present invention, the method of picking and placing an object includes the steps of sliding the first and second carriages away from each other along the frame substantially simultaneously in opposite directions which moves the gripper in an upward direction, sliding the first and second carriages along the frame substantially simultaneously in the same direction which moves the gripper in a lateral direction, and sliding the first and second carriages toward each other along the frame substantially simultaneously in opposite directions which moves the gripper in a downward direction.

In accordance with another aspect of the present invention, there is provided a pick and place device including carriages slidingly engaged with a frame, a platform with an attached gripper, and at least four connecting rods extending between the platform and the carriages, the platform having a first range of motion in a first direction and a second range of motion in a second direction that is substantially perpendicular to the first direction. The first range of motion depends on the length of the frame and the length of the connecting rods. The second range of motion depends on the length of the frame only.

In accordance with still another aspect of the present invention, there is provided a pick and place device comprising an elongate frame extending in a longitudinal direction, a first carriage assembly slidingly engaged with the frame and including at least two pivotally mounted connecting rods, a second carriage assembly, operatively independent from the first carriage assembly, slidingly engaged with the frame and including at least two pivotally mounted connecting rods, a platform pivotally connected to the connecting rods of the first and second carriage assemblies, and a motor which drives each of the first and second carriage assemblies to slide along the frame. Sliding the carriage assemblies along the frame away from each other exerts a force to move the platform in a first direction. Sliding the carriage assemblies along the frame in the same direction exerts a force to move the platform in a second direction which is substantially perpendicular to the first direction. Sliding the first and second carriage assemblies along the frame toward each other exerts a force to move the platform in a third direction, substantially opposite to the first direction.

BRIEF DESCRIPTION OF THE DRAWINGS

The features of the present invention which are believed to be novel are set forth with particularity in the appended claims. The invention itself, however, together with further objects and advantages thereof, may best be understood by reference to the following description when taken in conjunction with the accompanying drawings in which:

FIG. **1** is a side view of a first embodiment of a pick and place device according to the present invention;

FIG. **2** is a cross-sectional view of the first embodiment of the pick and place device, taken along line II—II of FIG. **1**;

FIGS. **3**A–**3**D are perspective views that schematically illustrate different embodiments of the mounting configuration for the platform of FIG. **1**;

FIGS. **4**A–**4**F are side views illustrating various positions during the operation of the pick and place device in accordance with the present invention;

FIG. **5** is a side view of a second embodiment of a pick and place device of the present invention;

FIG. **6** is a cross-sectional view of the second embodiment of the pick and place device, taken along line VI—VI of FIG. **5**;

FIGS. **7**A and **7**B are perspective and top views, respectively, that schematically illustrate the mounting configuration for the platform of FIG. **5**; and

FIG. **8** is a cross-sectional view of another embodiment of the pick and place device of the present invention, illustrating an angle frame configuration for mounting to an adjacent structure.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. **1** shows a side view of a first embodiment of a pick and place device **10** according to the present invention, while FIG. **2** shows a cross-sectional view taken across lines II—II of FIG. **1**. In this embodiment, support frame **12** is mounted to an overhead structure **14** using fasteners **16**, illustrated here as mounting bolts. The fasteners may alternatively include screws, rivets, or welding.

In FIG. **1**, the support frame **12**, extends overhead in a longitudinal direction and provides at least one single axis bearing rail **18** on which two independent carriages **20*a*** and **20*b*** slide. Bearing rail **18** extends outwardly from support frame **12**, and each carriage **20** includes at least one bearing **19** which engages the bearing rail **18** for smooth sliding of carriages **20** along the rail.

A motor **22** is contained within and drives each of the carriages **20**. In a preferred embodiment, the motor is a linear servo motor, but may include other suitable drive means such as a ball screw and rotary servo motor, or timing belt drive and rotary servo motor. The motors **22** driving the two independent carriages **20** may be controlled using a computer numerical control (CNC) controller **24** or any other two-axis controller. CNC controller Model No. 8000 available from Giddings & Lewis, Inc. of Fond du Lac, Wis., may be used to control motors **22**. The power connection to the motors **22** are made to carriages **20** by cable carriers **26** which allow carriages **20** to slide along bearing rail **18** without tangling or breaking of the wires. Cables are connected at one end to the controller **24** and at the other end to the motor **22** of each carriage **20**. The cable carriers **26** are attached to support frame **12** by cable carrier fasteners **28**, illustrated here as mounting bolts. The fasteners may alternatively include screws, rivets, or other suitable attachments. Carriages **20** are driven by the motors **22** back and forth along a single axis in the longitudinal direction of support frame **12**. Therefore, carriages **20** each have one degree of freedom, i.e., side-to-side in FIG. **1**.

The pick and place device **10** of the present invention also includes a plurality of connecting rods **30**. One end **31** of each of the connecting rods **30** is pivotally connected to one of the carriages **20** by mounting to a flange **32** of the carriage **20**, using a pivot joint **34**. Each pivot joint **34** preferably includes a bearing **36**, e.g., a ball bearing or a block bearing, for smooth pivoting, and may also include bearing fasteners **38**, e.g., set screws, hex nuts, or bolts. In the embodiment of FIG. **1**, each carriage **20** has four flanges **32**, arranged in two rows each having two adjacent aligned flanges as shown. Flanges **32** of each carriage **20** are preferably formed integrally with the carriage, either as a monoblock structure or by welding a flange member to the carriage.

The other end **39** of each of the connecting rods **30** is pivotally mounted to a platform **40**. In the embodiment shown in FIG. **1**, platform **40** has six flanges **42**, arranged in two rows each having three adjacent aligned flanges as shown. Connecting rods **30** are mounted to flanges **42** using a pivot joint **44**, preferably including a bearing **46**, e.g., a ball bearing or a block bearing, and may also include bearing fasteners **48**, e.g., set screws, hex nuts, or bolts. Flanges **42** of platform **40** are also formed integrally with the platform, either as a monoblock structure or by welding.

At least three connecting rods **30** are required to control the parallelism of the platform to the support frame. More connecting rods **30** may be used to increase stability of the platform **40** and/or allow transfer of heavier loads. It is important to note that all of the connecting rods should not be in a single line (i.e., linear alignment), but instead should be mounted to platform **40** such that they provide a stable transfer force that does not allow undesirable twisting forces across the plane of platform **40**.

In the embodiment shown in FIGS. **1** and **2**, four connecting rods **30*a*, 30*b*, 30*d*** (located directly behind **30*a*** in FIG. **1**), and **30*e*** (located directly behind **30*b***), are pivotally mounted to the first carriage **20***a* and to platform **40**. Two additional connecting rods **30***c*, **30***f* (located directly behind **30***c*), are pivotally mounted to the second carriage **20***b* and to the platform **40**.

FIGS. **3**A–**3**F show perspective views of the platform **40**, indicating schematically how the connecting rods **30** are configured on the flanges of platform **40**. In FIG. **3**A, the six connecting rods **30***a–f* are configured as shown in FIGS. **1** and **2**, i.e., arranged along the perimeter of the platform **40** in two rows each having three connecting rods. Four connecting rods **30***a*, **30***b*, **30***d*, **30***e* are connected to the first carriage **20***a* in order to keep platform **40** level with respect to the support frame **12**, while only two connecting rods **30***c*, **30***f* are required to be connected to the second carriage **20***b*. Note that less than six connecting rods can be used. Since three points define a plane, using only connecting rods **30***a*, **30***c*, and **30***e* would represent one example of the minimum number of rods needed to keep the platform **40** level. Note that using connecting rods **30***a*, **30***c*, and **30***d* would not keep the platform level, since rods **30***a* and **30***d* are connected along a centerline that is perpendicular to the axis of motion (+/−X direction). With only three connecting rods, the two rods from the same carriage cannot be mounted along such a perpendicular centerline.

FIG. **3**B illustrates a second embodiment for the mounting configuration of the connecting rods **30** to a different platform **52**. In this embodiment, only four connecting rods **54***a*, **54***b*, **54***c*, and **54***d* are used to support platform **52** as shown. Note that this four-point support, arranged in three rows of one-two-one rods each, still serves to keep the platform **52** level because the two connecting rods **54***a*, **54***d* are mounted at opposite edges of the platform and configured to straddle the perpendicular centerline of the other two connecting rods **54***b*, **54***c* as shown. If either connecting rod **54***b* or **54***c* from carriage **20***b* were removed, the platform **52** could tilt around the centerline. If, however, either one of connecting rods **54***a* or **54***d* from carriage **20***a* were removed, the platform would not tilt because the connecting rods **54***b* and **54***c* from the same carriage **20***b* would prevent it. For heavier loads, a three-point mounting configuration using connecting rods **54***a*, **54***b*, and **54***c* would tend to twist the platform, since rod **54***a* is moving along a different parallel axis than rods **54***b* and **54***c*. Hence, a four-point mounting configuration is used to minimize twisting forces.

FIG. **3**C illustrates a third embodiment of the connecting rod mounting configuration. In this embodiment, four connecting rods **56***a*, **56***b*, **56***c*, and **56***d* are used to support platform **57** and arranged as three rows of one-two-one connecting rods each as shown. Note that at least one of two connecting rods from the same carriage are not mounted on the centerline between the other two connecting rods, i.e., rod **56***c* is not mounted in line with rods **56***a*, **56***b*, and **56***d*. This configuration keeps the platform **57** from tilting around the centerline. If either connecting rod **56***b* or **56***c* were removed, the platform would tilt.

FIG. **3**D illustrates a fourth embodiment for the platform mounting configuration. In this embodiment, the four connecting rods **58***a*, **58***b*, **58***c*, and **58***d* are used to support platform **59**. Again note that at least one of the two connecting rods from the same carriage are mounted off of the perpendicular centerline in order to counteract the tilting forces applied to the platform by the other connecting rods.

Again referring to FIGS. **1** and **2**, a mounting plate **60** is fastened to the bottom surface of the platform **40**, preferably by welding. An adapter plate **62** is fastened to the mounting plate **60** by fasteners **64**, illustrated as mounting bolts. In the embodiment shown here, a pneumatic gripper **66** is mounted to adapter plate **62**. The use of adapter plate **62** increases the versatility of the pick and place device **10** of the present invention by allowing a number of different grippers **66**, including mechanical, pneumatic, and magnetic grippers, to be used with the pick and place device as desired. One example of a mechanical gripper which could be used with the pick and place device **10** is Model No. RPL-3 available from Robohand, Inc. of Monroe, Conn.

In the embodiment of FIG. **1**, a linear servo motor **70** is used on each carriage **20**. As can best be seen in FIG. **2**, the magnets of a motor stator **72** extend along the longitudinal axis between support frame **12** and a motor coil or windings **74** attached to each carriage. The motor stator **72** is fastened to the support frame **12** by adhesive. Hence, using a linear servo motor, the stator **72** is fixed to the support frame and the motor coil **74** propels the carriage along the frame. One example of a linear servo motor which could be used with the present invention is The MegaThrust Series "Y" linear motor available from NSK Corporation of Ann Arbor, Mich.

FIGS. **4**A through **4**F illustrate the movement of the pick and place device **10** of the present invention during its operation. In FIG. **4**A, the pick and place device is shown in an initial position wherein the platform **40** is raised above an object **80** to be moved. In the example shown in FIGS. **4**A–**4**F, the object **80** is being moved from one station, such as a first conveyor belt **82**, to another station, such as a work fixture **84**.

In a first step, the two independent carriages **20** are moved along the longitudinal axis of the support frame **12** (X axis) toward each other such that the platform **40** is lowered, along the axis perpendicular (Z axis) to the axis of the support frame, to the position shown in FIG. **4**B.

The gripper **66** is then activated to "pick" the desired object **80**.

In a second step the two independent carriages **20** are moved along the longitudinal axis of the support frame **12** away from each other such that the platform **40** is raised to the position shown in FIG. **4**C to raise the object. The gripper **66** remains activated. The range of motion of the platform **40** as it is raised and lowered is limited by the length of the support frame **12** and the length of the connecting rods **30**.

Preferably, in the first and second steps, the two independent carriages **20** move along the longitudinal axis of the support frame **12** at substantially the same speed. However, if the two independent carriages do not move at the same speed, the platform will be displaced along the longitudinal axis of the support frame (i.e., horizontally) instead of only being displaced perpendicular to the longitudinal axis of the support frame (i.e., vertically). Although it is generally desirable that the platform be displaced solely along the vertical axis during the raising and lowering of the platform to "pick" the load (since it is easier to program and control), it may be determined that some horizontal motion may be advantageous in some applications.

In a third step, the two independent carriages **20** move along the support frame in the same direction at substantially the same speed such that the load is transferred along the longitudinal direction of the support frame **12** to a desired position as shown in FIG. **4**D. The range of motion of the platform along this longitudinal axis is limited only by the length of the support frame. As before, if the two independent carriages do not move along the longitudinal axis of the support frame (i.e., horizontally) at the same speed, the platform will be displaced in a direction perpendicular to the longitudinal axis of the support frame (i.e., vertically) as it is moved along the longitudinal axis. Again, although it is generally desirable that the platform be displaced solely along the longitudinal axis of the support frame during transfer of the load, some applications may require simultaneous movement along both the vertical axis and the horizontal axis. In such a case, the path of the platform (and object) would be diagonal or curved instead of coincident with the X and Z axes.

In a fourth step, the two independent carriages **20** are again moved toward each other along the longitudinal axis of the support frame **12** to again lower the platform to the position as shown in FIG. **4**E. The gripper is then deactivated to "place" the desired object in a particular location.

In a fifth step, after placing the load, the two independent carriages **20** are again moved away from each other along the longitudinal axis of the support frame to again raise the platform to the position as shown in FIG. **4**F. The gripper remains deactivated. Preferably, in the fourth and fifth steps, the two independent carriages move along the longitudinal axis of the support frame at the same speed, unless otherwise required for particular applications.

In a sixth step, the two independent carriages **20** are moved along the support frame in the same direction such that the platform is returned to its starting position as shown in FIG. **4**A. Following return of the pick and place device to its starting position, the operation illustrated in FIGS. **4**A–F is repeated for each object to be transferred.

FIG. **5** is a side view of a second embodiment of a pick and place device **110** of the present invention, and FIG. **6** is a cross-sectional view thereof taken across lines VI—VI of FIG. **5**. Support frame **112** is mounted to a mounting structure **114** using fasteners **116**, again illustrated here as mounting bolts. The fasteners may alternatively include screws, rivets, or welding. As shown above in FIGS. **1** and **2**, the support frame **112** extends overhead in a longitudinal direction and provides a bearing rail **118** on which two independent carriages **120** are mounted. In this embodiment, the bearing rail **1 18** extends laterally from the support frame **112**, and each carriage **120** includes at least one bearing **119** which engages the bearing rail **118** for smooth sliding of carriages **120** along the rail. A front cover **121** is fastened to the support frame **112**.

A motor **122** is again operatively connected to and drives each of the carriages **120**. The motors **122** are controlled through cable carriers **126** which allow carriages **120** to slide along the bearing rail **118**. In this embodiment, each cable carrier **126** is connected at one end to a controller (not shown) and at another end to the motor **122** of each carriage **120**. The carriers **126** are mounted to support frame **112** by a mounting bracket **127**.

The pick and place device **110** also includes at least three connecting rods **130**. One end **131** of each of the connecting rods **130** is pivotally connected to one of the carriages **120** by mounting to a flange **132**, using a pivot joint **134**, preferably including a bearing **136** (e.g., a ball bearing or a block bearing) for smooth pivoting. Each carriage **120** has two flanges **132**. Flanges **132** of each carriage **120** are formed integrally with the carriage, either as a monoblock structure or by welding. The other end **139** of each connecting rod **130** is pivotally mounted to a platform **140**.

In the embodiment shown in FIGS. **7**A and **7**B, platform **140** has four flanges **142**. Connecting rods **130** are mounted to flanges **142** using a pivot joint **144**, preferably including a bearing **146** (e.g., a ball bearing or a block bearing) for smooth pivoting. Flanges **142** of platform **140** are formed integrally with the platform, either as a monoblock structure or by welding. An adapter plate (not shown) may also be used, if desired. A gripper **166** is mounted to a bottom surface of platform **140** by fasteners **164**, illustrated as mounting bolts. The fasteners may alternatively include screws, rivets, or welding.

As stated above, at least three connecting rods are required. More connecting rods may be used to increase stability of the device and/or allow transportation of heavier loads. It is important that all of the connecting rods are mounted to platform **140** such that they provide a stable lifting force which does not allow undesirable twisting forces across the plane of the platform. Hence, FIG. **7**B shows a top view of platform **140**, indicating how the four connecting rods **130***a–d* are mounted on flanges **142** of platform **140**. Accordingly, two X-axis aligned connecting rods **130***a,* **130***c,* are pivotally mounted to the first carriage **120***a* and to platform **140**. Two additional Y-axis aligned connecting rods **130***b,* **130***d,* are pivotally mounted to the second carriage **120***b* and to platform **140**. This symmetrical connecting rod arrangement provides the proper lifting forces without exerting undesired twisting forces on the platform.

In the embodiment of FIG. **5**, an encoder scale **172** extends along substantially the entire length of the support frame **112** and is used, with encoders **174** located on each of the carriages **120**, to track the position of each carriage along the support frame **112**. The motors **122** driving independent carriages **120** may be controlled using computer numerical control (CNC) or any other two-axis control devices. Therefore, the location of each carriage **120** along the support frame **112** is communicated to the control device by the respective encoder **174**. Encoder Model No. RGH 22, available from Renishaw, Ltd., U.K., may be used to provide this function.

FIG. **8** illustrates a cross-sectional side view of a third embodiment **210** of the pick and place device of the present invention, which uses an angle frame **212** mounted to an adjacent structure **214** using fasteners **216**, illustrated as mounting bolts. The fasteners may alternatively include screws or rivets. A front cover **217** is also mounted to the angle frame **212**. At least one bearing rail **218** is mounted to the angle frame **112** to provide sliding support for the carriage **220** as shown.

In this embodiment, a linear motor **222** is used to move each carriage **220**. A motor magnet **221** is mounted to angle frame **212** using fasteners **223**, illustrated as mounting bolts. A spacer **224** is provided between motor magnet **221** and angle frame **212**. A motor coil **225** extends from each carriage **220** into motor magnet **221**. Each carriage **220** includes a bearing **219**, illustrated as a block bearing, which engages a bearing guide for smooth sliding of carriages **220** along bearing rail **218**. Cable carriers **260** are mounted to an angle bracket **262** using fasteners **263**. A plate support **264** is mounted to front cover **217** by fasteners **265**. Cable carriers **260** are also mounted to support plate **264**.

As before, connecting rods **230** are pivotally mounted at one end **231** to the carriage **220** using pivot joints **234**, and at the other end **239** to platform **240** using pivot joints **244**. A gripper **266** is mounted either to an adapter plate (not shown) or to the bottom surface of platform **240** using fasteners **265**, illustrated as mounting bolts.

In review, it can now be seen that the present invention provides an improved two-axis pick and place device that is more efficient in construction and operation than previous designs. The present invention provides a highly accurate, programmably adjustable, robust machine that can easily be controlled using conventional two-axis controllers. It is the interconnecting linkage between the two independent carriages and the gripper that translates motion along a longitudinal axis, such as the horizontal axis, into motion perpendicular to that axis, such as the vertical axis.

While specific embodiments of the present invention have been shown and described herein, further modifications and improvements may be made by those skilled in the art. In particular, it should be noted that more than three connecting rods can be used to provide additional load-handling capabilities and machine stiffness. Also note that most any type of pick and place gripper and/or platform could be substituted for those shown in the figures. Furthermore, while the invention has been described using an individual motor to control each independent carriage, it should be recognized that a single motor in conjunction with various types of linkages and drives could control two carriages. Numerous other hardware and software modifications may also be made to customize the present invention for various other applications. All such modifications which retain the underlying principles disclosed and claimed herein are within the scope of the invention.

What is claimed is:

1. A pick and place device comprising:

an elongated frame having a major axis;

a first carriage and a second carriage slidingly engaged with the elongated frame and each having only one degree of freedom;

a pickup head;

at least three connecting rods extending between the pickup head and the first and second carriages;

the pickup head having a first degree of freedom along a first axis substantially parallel to the major axis of the frame, and a second degree of freedom along a second axis, substantially perpendicular to the first axis, wherein movement of the carriages only along the major axis is translated by the connecting rods into movement of the pickup head along both the first and second axes.

2. The pick and place device according to claim **1**, further comprising at least one motor for driving each of the first and second carriages independently of the other carriage, the at least one motor being under the control of a position controller.

3. The pick and place device according to claim **1**, wherein moving the first and second carriages apart brings the pickup head closer to the frame.

4. The pick and place device according to claim **3**, wherein shifting the first and second carriages in the same direction moves the pickup head parallel to the frame.

5. The pick and place device according to claim **1**, wherein at least two connecting rods extend between each of the first and second carriages and the pickup head.

6. An apparatus for moving an object, comprising:

an elongate frame extending in a longitudinal direction;

a first carriage assembly slidingly engaged to move along the frame and including a first pivotally mounted connecting rod;

a second carriage assembly slidingly engaged to move along the frame operatively independently from the first carriage assembly and including second and third pivotally mounted connecting rods;

a head assembly pivotally mounted to the first, second and third connecting rods of the first and second carriage assemblies; and

at least one motor configured to independently drive each of the first and second carriage assemblies to slide along the frame,

wherein moving the carriage assemblies along the frame away from each other exerts a force to move the head assembly in a first direction, moving the carriage assemblies along the frame in the same direction exerts a force to move the head assembly in a second direction which is substantially perpendicular to the first direction, and moving the carriage assemblies along the frame toward each other exerts a force to move the head assembly in a third direction which is opposite to the first direction.

7. The apparatus according to claim **6**, comprising at least four connecting rods, at least two being pivotally mounted to each of the first and second carriage assemblies.

8. The apparatus according to claim **6**, wherein the connecting rods are pivotally mounted to the head assembly in such a manner that the orientation of the head assembly with respect to the elongate frame remains constant throughout the operation of the apparatus.

9. The apparatus according to claim **8**, wherein the at least one motor drives the two carriage assemblies at substantially the same rate of speed such that the head assembly moves in paths that are orthogonal to the frame.

10. The apparatus according to claim **8**, wherein the at least one motor drives the two carriage assemblies at substantially different rates of speed such that the head assembly moves in paths that are not only orthogonal to the frame.

11. A transfer device comprising:

at least one rail member extending in a longitudinal direction;

first and second carriages slidingly engaged with the at least one rail member;

first and second motors adapted to independently drive each of the first and second carriages to slide along the at least one rail member;

a platform;

a first linking arrangement including a first connecting rod having first and second ends, the first connecting rod pivotally attached to the first carriage at the first end and pivotally attached to the platform at the second end; and

a second linking arrangement including second and third connecting rods having first and second ends, each of the second and third connecting rods pivotally attached to the second carriage at the first end and pivotally attached to the platform at the second end,

wherein the platform is transferred from one position to another position that can be a different distance from the at least one rail member when at least one of the carriages slides along the at least one rail member.

12. The transfer device as claimed in claim **11**, wherein the first and second linking arrangements, combined, include at least four connecting rods.

13. The transfer device as claimed in claim **11**, wherein the second connecting rod is attached to the second carriage at a different pivot location than the third connecting rod attached to the second carriage.

14. The transfer device as claimed in claim **11**, further comprising a gripping device mounted to the platform.

15. The transfer device as claimed in claim **11**, wherein the rail member comprises first and second rails in parallel alignment, and wherein the first and second carriages are slidingly engaged with the first and second rails, respectively.

16. The transfer device as claimed in claim **11**, wherein the first, second, and third connecting rods are attached to the platform in such a manner that the platform remains parallel to the rail member throughout the operation of the transfer device.

17. The transfer device as claimed in claim **11**, further comprising a programmable position controller for controlling the first and second motors.

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