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3,333,716

LIFTING BOOM CONTROL DEVICE

Filed Dec. 28, 1965

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Fig. 1.

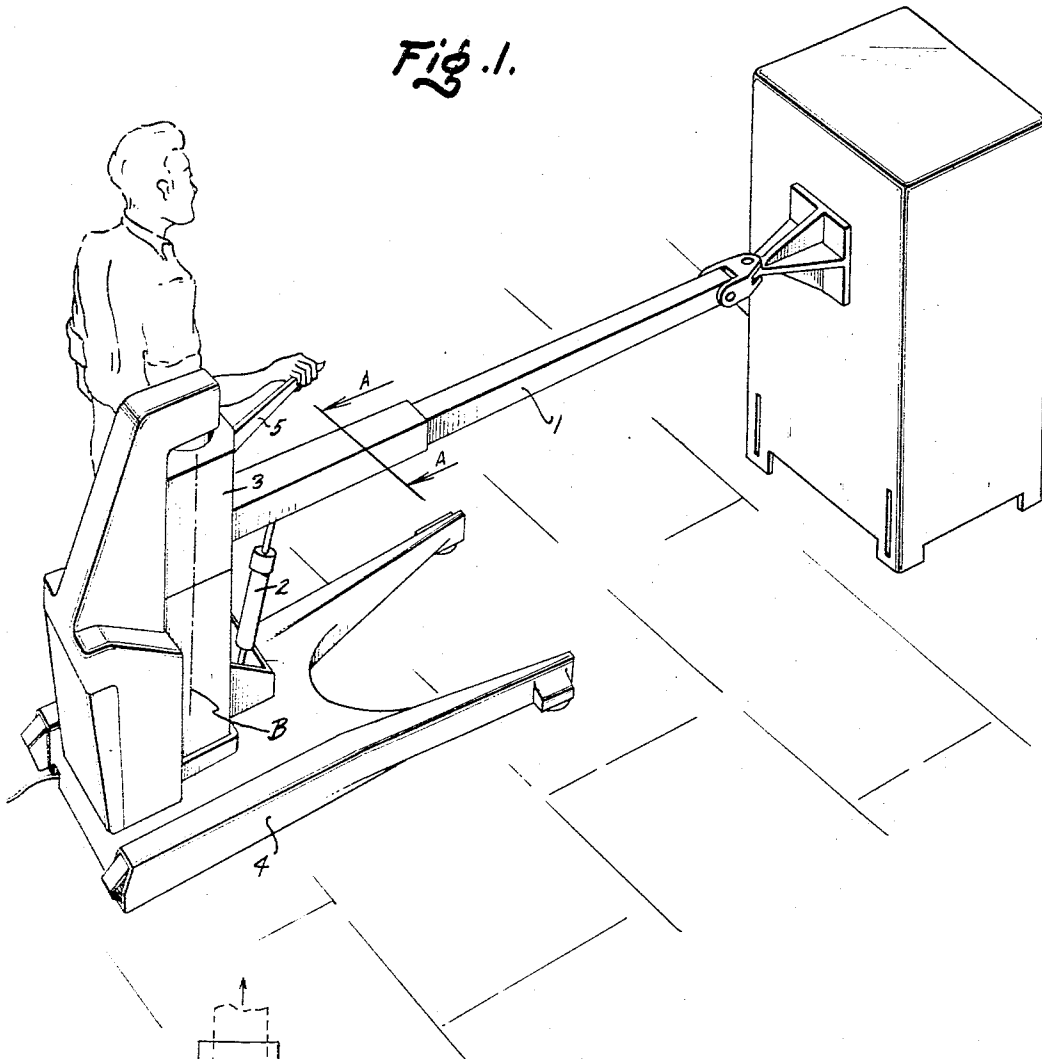
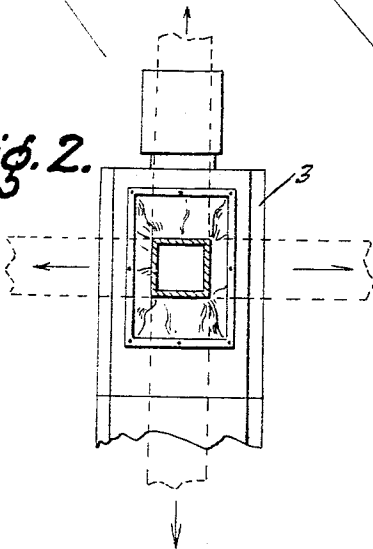


Fig. 2.



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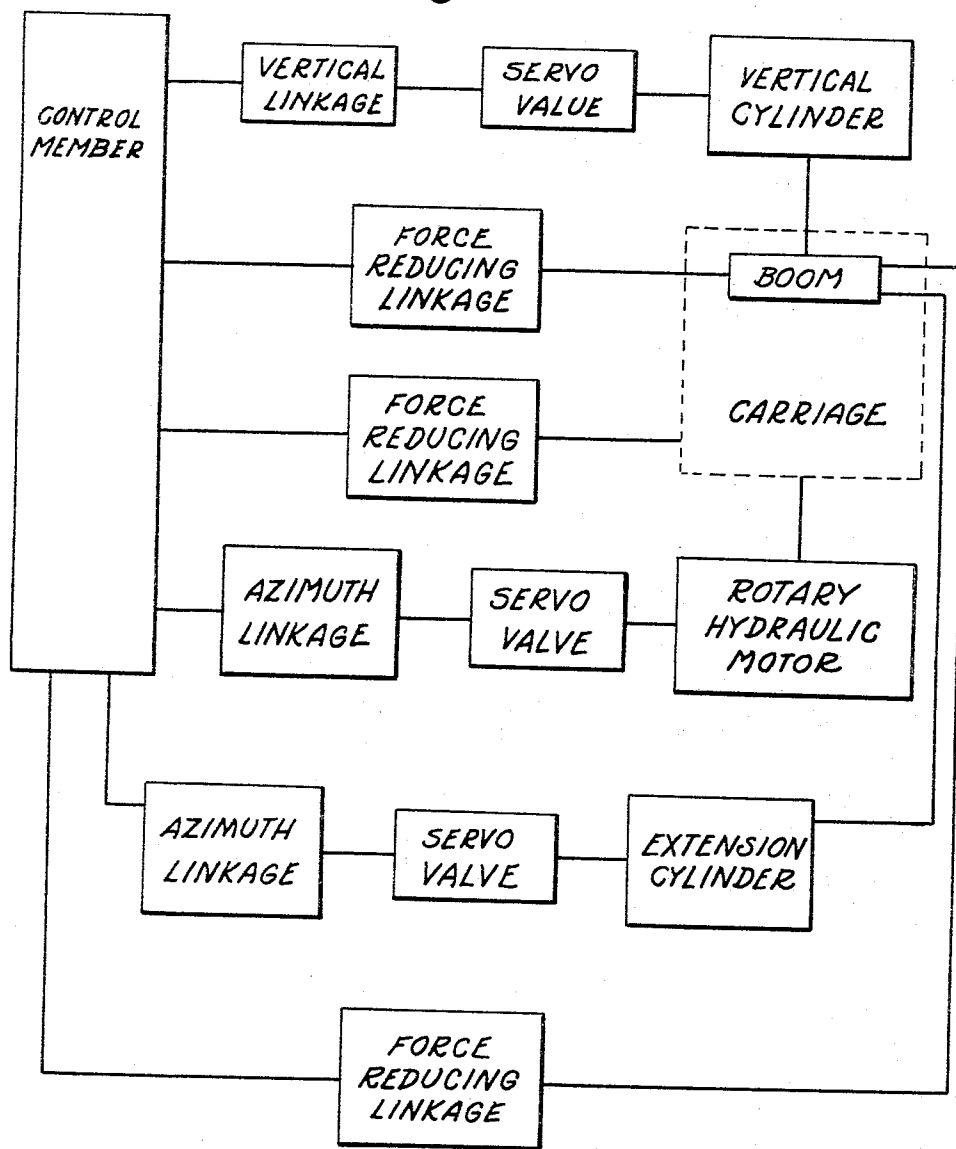
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Fig. 3.



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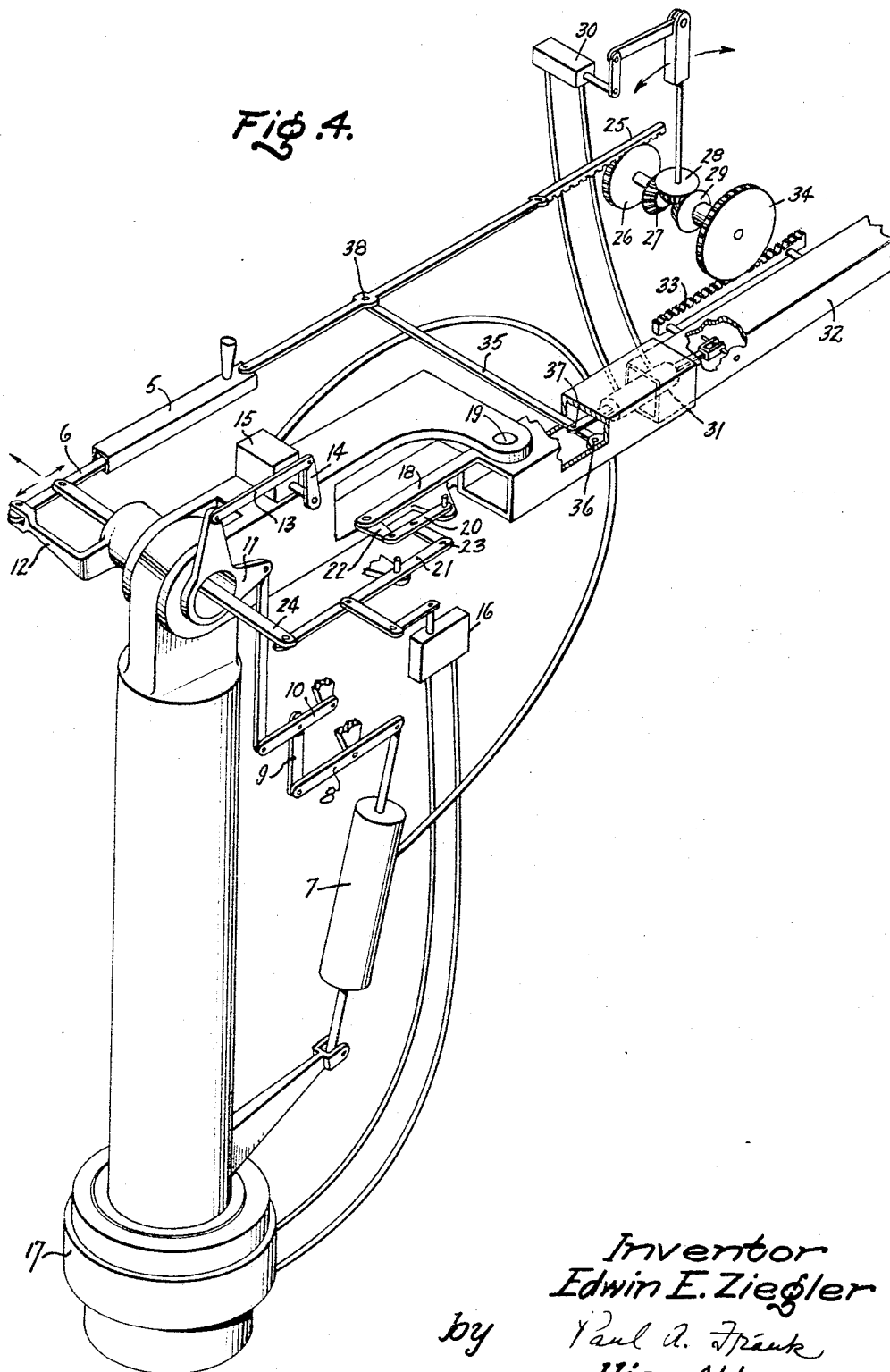
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3 Sheets-Sheet 3



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LIFTING BOOM CONTROL DEVICE

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9 Claims. (Cl. 214—130)

ABSTRACT OF THE DISCLOSURE

A material handling device having an extensible lifting boom carried by a hoist and carriage and controlled by a handle. The carriage is mounted for rotation about vertical pivots to accomplish azimuth rotation of the boom. The azimuth motor is located in the base of the hoist and the boom is pivoted in the carriage for vertical movement. A hydraulic cylinder mounted between the boom and carriage imparts vertical movement to the boom and an extensible cylinder causes the extensible boom to extend or retract. In each motion there is spatial correspondence between the control element and boom tip and also a diminished force is fed back by lever systems from the boom to the control handle to give "feel."

My invention relates to a hydraulically operated boom. This invention relates particularly to a hydraulic boom having return "feel" and has correspondence of movement between a control handle and the boom in azimuth and elevation. The apparatus will be described particularly in relation to a boom but is understood to be equally adapted to remote control of devices such as guns, power shovels or any other extended member wherein the characteristics of this invention are important.

In the movements of objects, it is a common occurrence that one wishes to move an object under load. When one wishes to move some object against a force of some sort, it is advantageous to have a "feel" in the control handle or shaft which corresponds to the amount of force put forth in overcoming the resistance to such movement. It is further advantageous if there is a spatial correspondence between the control handle and the object being moved. If both "feel" and spatial correspondence are present in the apparatus, the operator's situation is most analogous to his physically moving the load. In prior art machines where these characteristics are absent, the operator must spend time to learn a new set of relationships between movement and "feel" of the control handle and the movement of the load.

A chief object of the present invention is to provide a lifting boom having a return "feel" which is a small portion of the force being exerted and having a spatial correspondence between the boom and the control handle. With my invention, the operator can position the load with deftness and accuracy.

Another object of this invention is to provide a system adaptable to control any device pivoted for universal movement.

Another object is to provide a compact easily controllable system for hoisting loads wherein the operator's control movements are the same as he would use in physically moving the load. Thus in an emergency the operator's spontaneous reactions are most likely to be correct.

Another object of my invention is to provide a device capable of doing the work of one or more men with corresponding less work and fatigue to the operator.

Another object of this invention is to provide a single control element or actuator for operating a plurality of operating motors in conjunction to accomplish the single purpose of moving an object about a pivot.

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These and other objects will be more readily perceived from my description which follows.

Briefly stated, my invention is a control device which operates to move any extended member about a pivot in azimuth or vertically and to change the length of the extended member. The movements of the extended member correspond in direction to the movements of the single control member. In addition, some of the force applied to the extended member is fed to the control member to give it "feel." Thus the extended member moves in the direction of motion of the control member and some of the force applied to the extended member is fed to the control member. In this way the operator will know the direction of motion of the extended member and will have an idea of the amount of force being applied to the extended member.

The attached drawings illustrate a preferred embodiment of my invention in which:

FIGURE 1 is a perspective view of an embodiment of my invention and shows a perspective view of a preferred embodiment of my invention wherein the system is used as a refrigerator handling apparatus.

FIGURE 2 is a view taken along line A—A of FIGURE 1.

FIGURE 3 is a block diagram showing the organization of the system.

FIGURE 4 is a perspective view of the mechanism of my invention in skeleton schematic diagram.

In FIGURE 1 is shown an automatic hoist with an operator. This hoist is used for moving refrigerators or similar objects about, perhaps in a factory.

The boom 1 of this hoist is moved in its vertical direction about a pivot point on the carriage element by the cylinder 2. Azimuth orientation of the boom is accomplished by rotation of the boom about the vertical axis B as carriage 3 rotates about a vertical axis on pivot points located in the body of the hoist. In this way the carriage 3 is free to be rotated about these pivot points clockwise and counterclockwise. The hydraulic motor to rotate the carriage will normally be located in the base 4 of the hoist so that torque can be imparted to the carriage element. As shown, the vertical lifting cylinder 2 is fastened between the carriage and boom. Thus extension moves the boom in a vertical direction about a pivot in the carriage. The hydraulic pump (not shown) and servo units for vertical, extension and rotary movements can be located in the base 4 of this lift.

The block diagram of FIGURE 3 shows the elements of the operating system and their relationships in a general way. The system is divided into essentially three different control systems.

First, the vertical control system starts from the control member 5 and controls the boom in vertical movement. The control handle or member 5 operates a linkage between the shaft and valve. This linkage causes the valve element of a servo valve to operate a power element of the servo valve. The valve power element allows hydraulic pressure to be applied on a selective basis to the vertical cylinder and moves the piston in the cylinder. Attached to the vertical cylinder, as shown in FIGURE 1, is the boom. Attached to the boom near its pivot point is a force reducing linkage which in turn applies a much reduced force back into the control lever so that the operator may have a "feel" in the control lever in a vertical direction.

In a somewhat similar manner, the control handle operating in azimuth, from right to left as shown in FIGURE 1, operates a servo valve or valves to cause a reversible hydraulic motor to turn the boom and carriage in a clockwise or counter clockwise direction. The force applied to the carriage affects a force reducing linkage connected to

the control handle. The force reducing linkage gives the control handle a "feel" in azimuth.

By the means described above, the operator is able to control the boom in three dimensions.

The boom and carriage provide a connection between the two systems. This connection is shown schematically by the boom being shown within the carriage. Also, a connection is provided by the control handle to which both systems are mechanically coupled.

Finally, the extension system is operated by the handle 5 moving forward or back and causing servo valves to allow hydraulic pressure to be applied to a cylinder and causes extension or contraction of the cylinder. The boom is extended or shortened as the piston moves in the cylinder. "Feel" is imparted through a force reduction linkage which applies a part of the extension force to the control handle.

FIGURE 4 illustrates details of the three actuators. It is realized that a variety of possible arrangements are possible utilizing the same principle. The elevator actuator or hydraulic cylinder 7 is shown (FIG. 4) pushing against or pressing against the short arm of a lever 8. In practice, this short arm of a lever can be a cam arrangement and the cam is fastened through a shaft to the long arm of the lever. Thus, in practice, the elevator actuator presses directly against a cam on the boom rather than at the end of a lever. The lever action however, is preserved by means of the cam.

The first lever 8 operates through a link 9 against second lever 10 and this in turn operates through levers 11 and 12, against the control handle 5. The linkages shown in FIGURE 4 thus operate to apply about $\frac{1}{12}$ of the force from the elevator actuator to the control handle. As the boom is moved vertically from place to place, the force required to move it is reflected back into the control handle thus giving "feel." The first, second and third lever arms may have a series of holes in each arm. By connecting the links between different holes, ratios can be varied to give a greater or lesser "feel."

Attached to the control handle are also link 13 and lever 14 which operate the control valve 15. This valve operates to feed control pressure to the elevation actuator when it is desired to raise the boom. Similarly, if it is desired to lower the boom, the valve allows the release of fluid from the elevation actuator.

An electric motor and fuel pump (not shown) are located in the base of the hoist and contribute pressure selectively through the valves.

The position of the control handle 5 is related to the position of the boom; however, there is not a one-to-one correspondence of position. Rather, the control handle may move through about 10 or 15 degrees while the boom is moving through 50 or more degrees.

Movement of the control handle 5 from right to left causes the rotatable carriage to pivot about its vertical axis. The boom is carried along with the carriage and the end of the boom will swing in a wide circle. The rotatable element is designed to swing 90° clockwise and 90° counter clockwise from a central position making a total swing of 180°.

The lever and link system shown (FIGURE 4) operates in a similar manner to that shown in the elevation control schematic. Again, the valve 16 is mounted on the carriage and is actuated through a lever system having variable links. Movement of the control handle to right actuates this valve so as to feed fluid to the rotatable motor 17 and cause the carriage to move in a clockwise or counter clockwise direction. A rotary hydraulic actuator of the type called Flo-Tork and sold by Flo-Tork Inc., of Orrville, Ohio, can be used, if desired.

As in the elevation control system, a force reducing means is found here. The force reducing lever system shown reduces the force on the handle to about $\frac{1}{10}$ of the force applied to the boom. This is enough to supply a "feel" to the operator. As shown, the level arm 18 extends

from the boom which is pivoted at 19. Force is transmitted through force reducing levers 20, 21 and connecting links 22, 23, and 24 to the control handle.

The extension control system operates in a manner similar to the elevation and azimuth systems. In this system, movement of the handle 5 moves rack 25. Gear 26 moves gears 27 and 28. Since gear 29 does not move the spider and planetary gear 28 rotates and opens servo 30. Servo 30 allows hydraulic pressure to feed to cylinder 31 and boom element 32 slides in or out as moved by the cylinder. Rack 33 will move pinion 34 and gear 29 to restore the spider and planetary gear 28 to neutral.

The extension force reducing system, shown here, lever 35 and pivots 36, 37 and 38 reduce the extension force on the handle to about $\frac{1}{11}$ of the force applied to the slidable boom. The extension system is connected to the azimuth and vertical system by the control handle 5 which slides forward and back over the control shaft 6.

One of the important features of my invention is that the azimuth force reducing means and the vertical force reducing means are connected to one end of the control member while the extension force reducing means is connected to the other end of the control member.

The showing of FIGURE 4 is expanded and schematic so that the components of the apparatus can be exposed in a form easily understood. Electrical, hydraulic or mechanical systems can be used interchangeably without departing from the scope of the invention.

Although it is readily apparent that several embodiments of the invention may exist, this invention is not limited thereto since many modifications may be made by one skilled in the art, and it is intended by the appended claims to cover all such modifications as fall within the true spirit and scope of the invention.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. A material handling device comprising in combination
 - a control member having a control shaft and a control handle slidable on said control shaft,
 - an extensible boom having an extensible section slidable in a non-extensible section,
 - means actuated by said control member for applying force to said boom in azimuth,
 - force reducing means for applying a force equal to a predetermined portion of the azimuth force to the control member,
 - means actuated by said control member for applying force to said boom in a vertical direction,
 - force reducing means for applying a force equal to a predetermined portion of the vertical force to the control member,
 - means actuated by said control member for applying moving force to a part of said boom to change the length of said boom,
 - force reducing means for applying a force equal to a predetermined portion of the change of length moving force to the control member comprising a lever with one end pivoted to said non-extensible section, the other end pivoted to said control handle and an intermediate point serving as the anchor point for said length changing means for applying force to said movable section.
2. A control device as recited in claim 1 in which said extensible boom is pivoted about a horizontal axis in a carriage which swings in azimuth about a vertical axis in response to said azimuth force applying means, and said azimuth feedback means comprises a series of levers fulcrumed for force reduction and operatively connected between said boom and said control handle.
3. A control device as recited in claim 1 in which one end of a hydraulic piston is attached to said movable section and the other end is attached to said anchor point of said lever so that movement of said

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hydraulic piston moves said movable section, a first rack attached to said movable section, a second rack attached to said control handle and a differential gear means movable in accordance with difference of motion between said first and second rack for controlling the movement of said hydraulic piston.

4. A control device for moving an extended member comprising

a control member having a control shaft and a control handle slidable on said shaft,

an extensible boom,

means actuated by said control member for applying force to said boom in a vertical direction,

force reducing means for applying a force equal to a predetermined portion of the vertical force to the control member,

means actuated by said control member for applying moving force to part of said boom to change the length of said boom,

force reducing means for applying a force equal to a predetermined portion of the change of length moving force to the control member,

means actuated by said control member for applying force to said boom in azimuth,

force reducing means for applying a force equal to a predetermined portion of the azimuth force to the control member comprising a series of levers connected to each other and fulcrumed for force reduction between said boom and said control handle.

5. A control device as recited in claim 4 in which said vertical force reducing means comprises

a series of levers connected to each other and at one end of said series to the control shaft and at the other end to the vertical force means and fulcrumed to reduce the force feedback from the vertical force means to the handle.

6. A control device as recited in claim 5 in which said extensible boom has an extensible section slidable in a non-extensible section, and

said azimuth force reducing series of levers is attached at one end to said non-extensible section and at the other end to said control shaft so that motion in azimuth is transmitted therebetween.

7. A device for moving an extended member comprising

a control member,
an extensible boom,

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means actuated by said control member for applying force to said boom in azimuth,

force reducing means for applying a force equal to a predetermined portion of the azimuth force to the control member,

means actuated by said control member for applying moving force to a part of said boom to change the length of said boom,

force reducing means for applying a force equal to a predetermined portion of the change of length moving force to the control member,

means actuated by said control member for applying force to said boom in a vertical direction,

force reducing means for applying a force equal to a predetermined portion of the vertical force to the control member, comprising a series of levers connected to each other and at one end of said series to the control handle while the other end is connected to the vertical force means and fulcrumed to reduce the force feedback from the vertical force means to the control member.

8. A control device as recited in claim 7 in which said change of length force reducing means comprises

a lever connected at one end of said extensible boom, at the other end to said handle and fulcrumed to reduce the change of length force as applied to the handle.

9. A control device as recited in claim 8 in which said control member comprises

a control handle slidably mounted on a control shaft and said azimuth and vertical force reducing means are attached to said control shaft and said length changing force reducing means is attached to said control handle.

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