United States Patent

[11] 3,596,565

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[21] Appl. No. **844,839**
[22] Filed **July 25, 1969**
[45] Patented **Aug. 3, 1971**

[54] **REMOTELY CONTROLLED HYDRAULIC SYSTEM**
14 Claims, 7 Drawing Figs.

[52] **U.S. Cl.** ..... **91/411 R,** 105/240, 105/311 R, 298/35 M, 91/2
[51] **Int. Cl.** **F15b 11/16**
[50] **Field of Search** ..... 91/411, 361, 2; 105/240, 311, 311 C; 298/35 M

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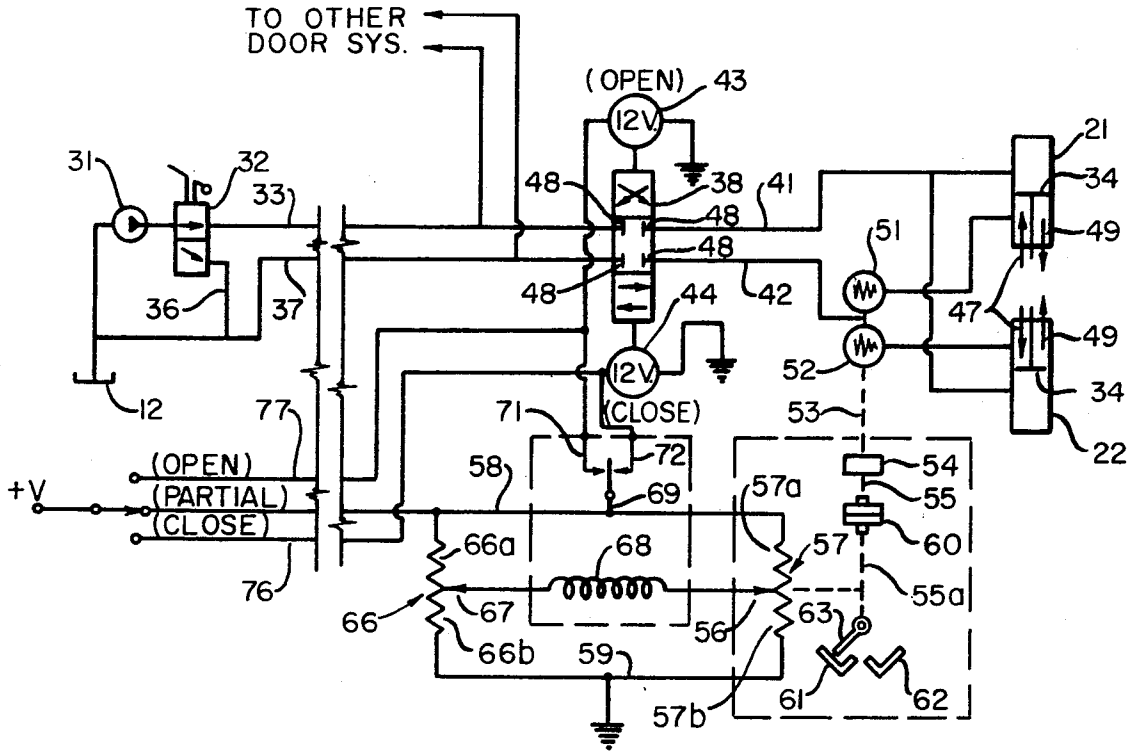
ABSTRACT: Heavy duty equipment such as construction equipment with adjustably positioned, remotely controlled, hydraulically actuated movable members.



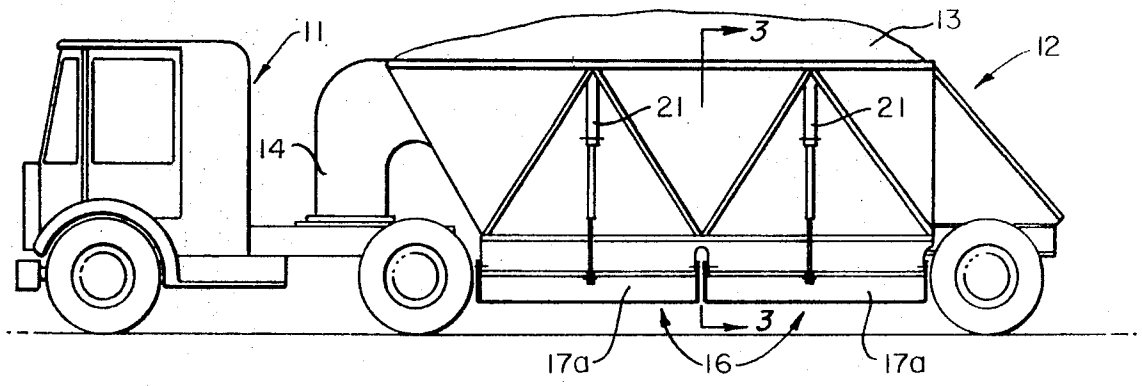


FIG. 1

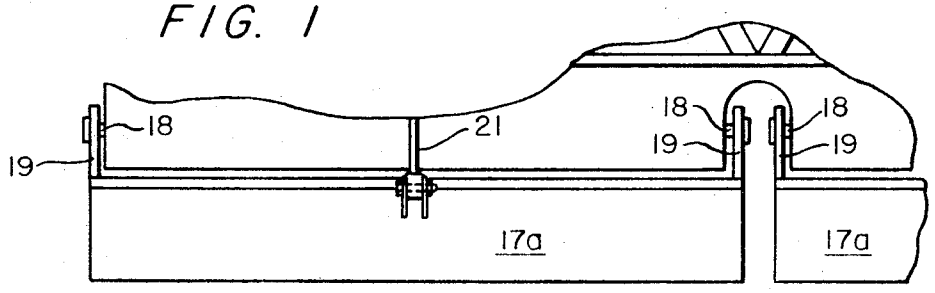


FIG. 2

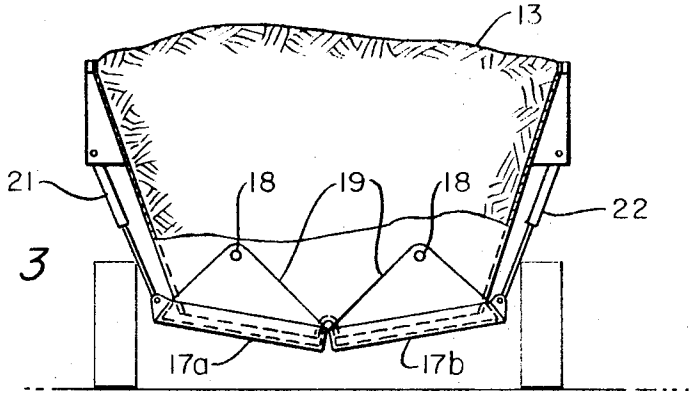


FIG. 3

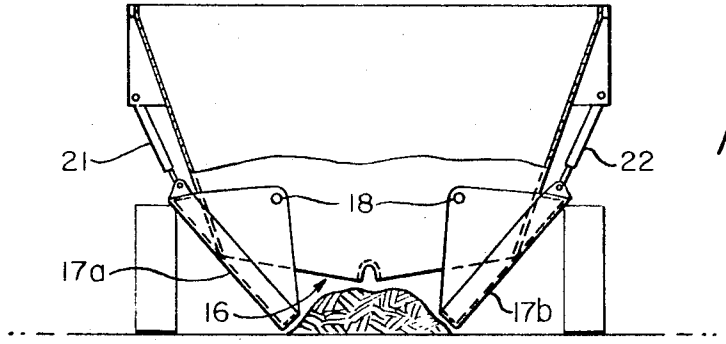


FIG. 4

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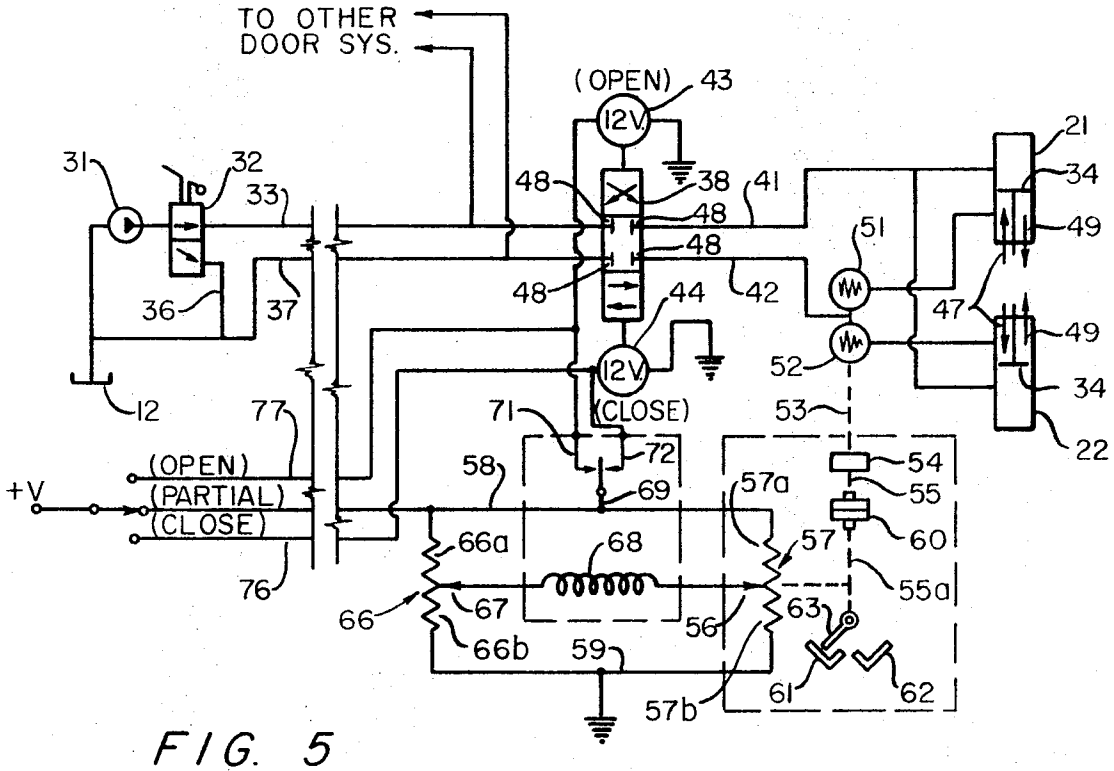

FIG. 5

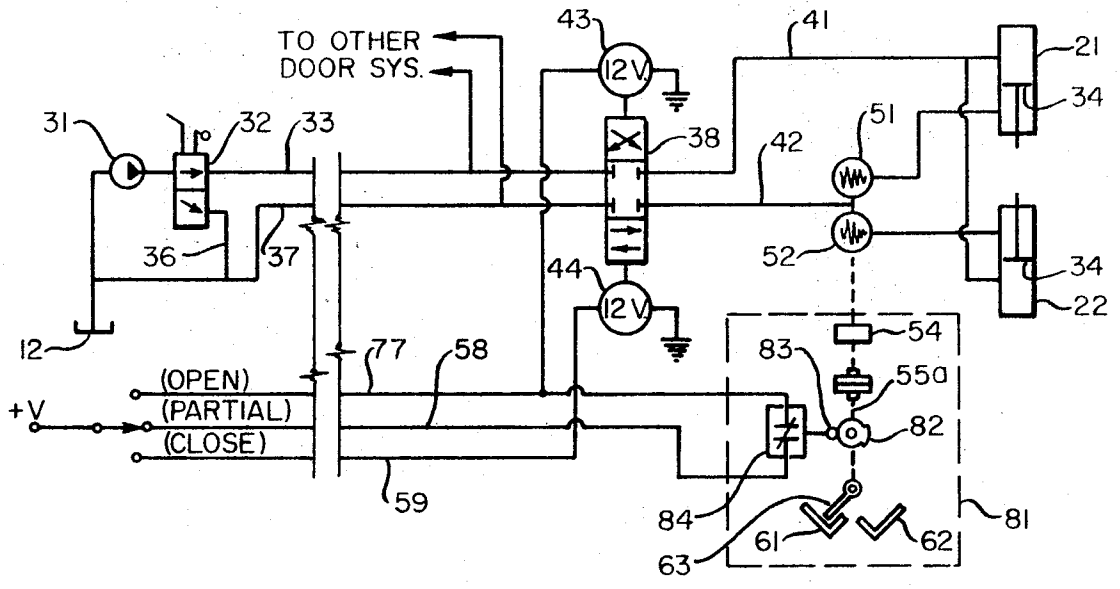

FIG. 6

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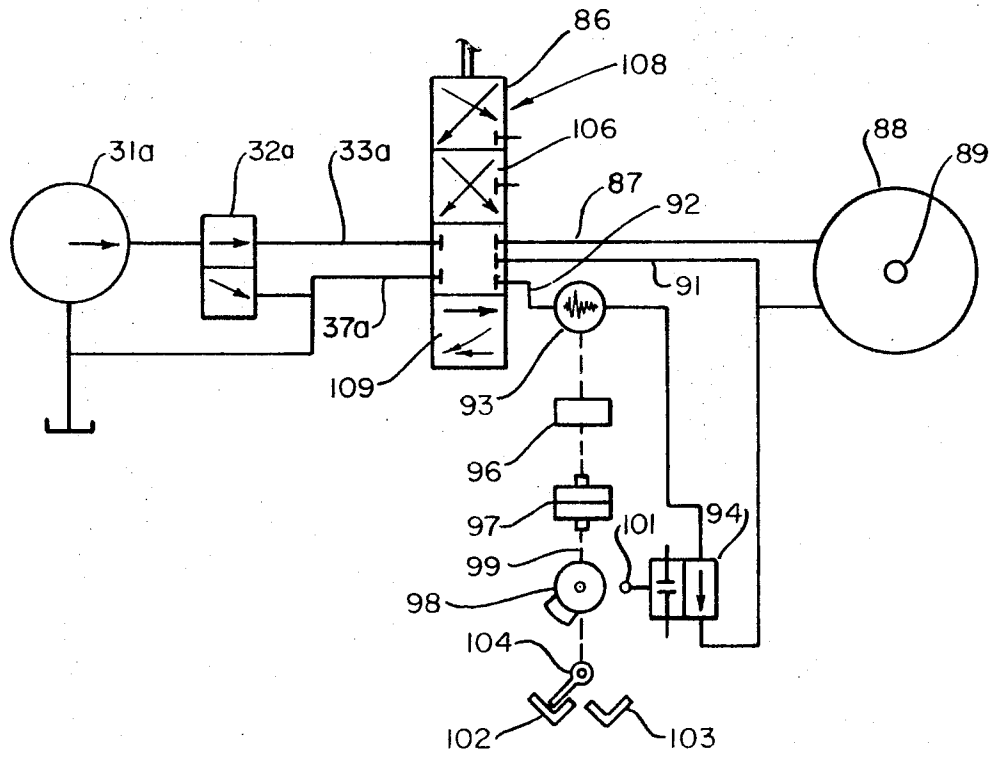

FIG. 7

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REMOTELY CONTROLLED HYDRAULIC SYSTEM

BACKGROUND OF THE INVENTION

This invention relates generally to heavy duty, remotely controlled, hydraulically operated equipment, and more particularly to equipment for the heavy construction industry.

In the construction industry, materials such as sand, dirt, rock, gravel and the like are often transported by earth moving equipment to be used as fill. One type of such equipment includes a tractor-trailer combination. The trailer comprises a large top-loading bin having sloping sides and ends which converge at discharge openings at the bottom. One or more pairs of doors or closures are adapted to selectively open and close the discharge opening.

Successful use of large size trailers in heavy construction service requires features in the door operating system that may or may not be required in other services. Unlike mining or other fixed haul operations, embankment dam construction involves hauling different kinds of materials from different locations on a balanced basis to allow the various zones of the dam to be raised in an integrated fashion. Furthermore, the hauling unit or trailer must provide the preliminary distribution of the material on the dam rather than simply dumping a full load at a fixed terminal point.

The optimum size of the dumped windrow is dependent upon the type and condition of the material being dumped, the width of the zone being raised, the lift height allowable at that point, and proper integration with the final spreading and compacting equipment in use. If the windrow is large, then it becomes difficult to handle with equipment of normal size. For these reasons, it is important that trailers have an adjustable door opening for dumping that is intermediate between full-closed and full-open, thus allowing control of the size of the dumped windrow. After the dumping is completed, the doors are preferably opened fully to completely clear the trailer, particularly when hauling wet or sticky materials.

Absent any drift, the intermediate door opening position can be left unchanged for the duration of a given haul operation. At other times, however, changing dumping zones, changing pits, changes in material, moisture content, etc., may require frequent adjustment of the intermediate door opening setting or position.

One type of trailer includes two completely independent door systems which first allow dumping the rear half of the trailer, thereby maintaining weight on the tractor driving wheels, and then dumping the front half of the trailer to complete the operation. Each pair of doors operates independently of the other and has three control positions; full-closed, an adjustable intermediate position, and full-open. The three opening settings for each of the two door systems are controlled by the operator as he drives across the fill and the dumping zone.

One type of system for setting the intermediate opening includes a cam which moves with the door to operate a cam valve when the door reaches a predetermined intermediate opening position. The actuation of the cam valves causes interruption of the hydraulic flow to the associated door operating ram thereby holding the door at this position. This type of direct control subjects the sensing elements to the rugged environment prevailing at the doors. Changes in the door opening setting require access to the door region and sensing element which may not be easily accessible.

The setting or adjustment of the adjustable position of the controlled member should not require special tools and should be simple and convenient whereby adjustment can be expeditiously accomplished in the field. The control system components should preferably be rugged for use in the construction environment or located in a position in which they are protected from the environment.

Remote control of other hydraulically actuated heavy-duty equipment is also important for example, the positioning of

cutting blades in scrapers and levelers; positioning of concrete mixing and handling equipment, loaders and the like used in the construction industry.

SUMMARY OF THE INVENTION AND OBJECTS

There is provided hydraulically controlled equipment of the type which includes a hydraulically actuated movable means such as doors or blades. Control means are located at the operator location for permitting the operator to control the position of the movable member, for example, doors between two extreme positions and an adjustable intermediate position. Said hydraulic system includes a fluid metering device connected in the fluid line between the hydraulic supply means and the hydraulic motive means, such as motor or rams, which activiate the members to meter the fluid supplied to the motive means, and means responsive to said metering device for interrupting the flow of hydraulic fluid to said motive means to stop the member or doors at an adjustable intermediate position when a predetermined amount of hydraulic fluid has been supplied. The system also includes means for automatically compensating for drift.

It is a general object of the present invention to provide an improved hydraulic system for controlling a hydraulically operated member.

It is another object of the present invention to provide a door opening system for earth moving equipment in which the intermediate door opening position may be simply, quickly and readily adjustable by unskilled field personnel or by the operator without special tools and without taking the truck out of a haul system longer than is absolutely necessary.

It is a further object of the present invention to provide a hydraulic system for operating movable members which is extremely reliable and trouble free.

It is still a further object of the present invention to provide a hydraulic system in which the control sensing means are remotely located in a protected portion of the material carrier.

It is another object of the present invention to provide a system in which the controls for the operators are simple to operate.

The foregoing and other objects of the invention will become more clearly apparent when taken in conjunction with the following description and drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a side elevational view of a tractor trailer incorporating the present invention.

FIG. 2 is an enlarged view of the doors associated with the trailer of FIG. 1.

FIG. 3 is a sectional view taken along the line 3–3 of FIG. 1 and showing the doors in the closed position.

FIG. 4 shows the doors in FIG. 3 in their fully open position.

FIG. 5 is a schematic diagram of an electrical control system for controlling the hydraulic door rams for operating the doors.

FIG. 6 is a schematic diagram of another electrical control system incorporating the present invention.

FIG. 7 is a schematic diagram of a hydraulic control system for controlling operation of hydraulically operated members.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The invention is described with reference to typical earth moving equipment. It will, however, be apparent that the invention is equally as useful in connection with the control of other hydraulically driven members. Referring to Figure 1, the equipment comprises a tractor **11** adapted to tow a trailer **12** which is filled with construction material **13**. The trailer is suitably attached to the tractor by means of a gooseneck attachment **14**. The trailer illustrated includes discharge openings **16** each having a pair of discharge doors **17***a*, **17***b*. The discharge doors are mounted on spaced pins **18** disposed on opposite ends of the opening **16**. The pins are engaged by door brackets **19**. Hydraulic rams **21**, **22** located on opposite

sides of the trailer engage the corresponding door. The rams are adapted to pivot the doors around the pivot point pins **18** and open the doors upwardly as shown in Figure **4**. It will be apparent that hydraulic motors or operators may be substituted for the rams.

In accordance with the preferred embodiment of the present invention, the hydraulic fluid supplied to the hydraulic rams is controlled by an electrical control system of the type shown in Figure **5**. Referring to Figure **5**, the hydraulic system includes a hydraulic pump **31** which, in the present example, is located on the tractor and provides hydraulic fluid under pressure from the reservoir **12** to the hydraulic rams **21**, **22** disposed on opposite sides of the trailer. The hydraulic fluid from the pump passes through a pressure relief valve **32** which is adapted to continuously supply hydraulic fluid to the hydraulic line **33** at predetermined pressure. However, when the piston **34** associated with each ram reaches its limiting position and no further fluid can flow, the bypass valve **32** bypasses the fluid to the line **36** back to the reservoir **32**. The pressure relief valve thereby controls and maintains constant pressure on the line **33**. A return line **37** serves to return fluid from the hydraulic pistons to the reservoir **12**.

A solenoid valve **38** is connected in the fluid supply and return lines **33** and **37** and serves to selectively connect these lines to the hydraulic lines **41**, **42** which supply fluid to opposite sides of the pistons **34**. The four-way valve includes actuating solenoids **43** and **44**. When the solenoid **43** is actuated, it serves to connect the supply and return lines **33**, **37** to the lines **42**, **41**, respectively, as shown by arrows, to move the pistons in the direction indicated by the arrows **47** which is the direction for opening the doors connected to the pistons. When the valve is not energized, lines **33**, **37** and **41**, **42** are blocked as indicated at **48** whereby no fluid flows to or from the hydraulic pistons. The pistons are thereby maintained in a fixed position. When the solenoid **44** is energized, the lines **33**, **37** are connected to lines **41**, **42**, respectively, and the pistons are moved in the direction shown by the arrows **49** which is the closing direction for the doors connected to pistons **34**. As previously described, when the pistons achieve either of the two extreme positions, the pistons are maintained under the predetermined pressure supplied to line **33** thereby keeping the doors in the fully open or fully closed position with predetermined force.

Hydraulic motors **51** and **52** are connected in parallel in the line **42**. The output shaft of each hydraulic motor will rotate in proportion to the amount of fluid being supplied to the respective piston and will, therefore, inferentially indicate the position of the piston. If the output shafts of the two motors are mechanically coupled, the motors form a flow divider that synchronizes the operation of the two rams. The two metering motors **51**, **52** can be replaced by a single duplex pump motor that combines both these units in a single casing. Units of this type are readily available and widely used as flow dividers.

If the door or member associated with one ram tends to bind or otherwise operate slowly, the fluid divider will automatically increase the pressure on that ram and reduce the pressure on the other. In the extreme case, the slow ram will see twice the system pressure while the fast ram will see zero pressure. This provides a very effective synchronizing means between the two rams and allows use of a single feedback mechanism for the entire door system thereby reducing the control system complexity and cost.

The coupled shafts **53** of the metering motors **51** and **52** are connected to a gear reducer **54**. A gear reducer is preferably used since a practical and economical size of motor **51**, **52** will make a number of revolutions in delivering enough fluid to the ram to fully open and close the doors. The small gear box is inserted to thereby give an appropriate ratio whereby the output shaft **55** will undergo approximately one revolution between fully open and fully closed positions of the doors. As the metering motor turns, it will drive the movable electrical tap **56** along the resistor **57** to vary the electrical resistance **57***a*, **57***b* between the tap and the lines **58**, **59**, respectively. A slip clutch **60** is inserted in the output shaft **55** and stops **61**, **62** limit rotation of the shaft by abutting the member **63** mounted for rotation with the shaft. Preferably, the gear reducer is chosen to give slightly more than one full revolution of the output shaft as the door goes from fully closed to fully open.

The fixed stops **61**, **62** are positioned so as to allow the shaft **55***a* to make slightly less than one full revolution. In this way, any tendency for the system to drift because of fluid leakage is automatically corrected. For example, if the metering motor has lagged in rotation in the "opening" direction, the output shaft will lag in its position correspondingly. However, when the door closes, the output shaft will attempt to turn back beyond its fixed stop, i.e., past zero, because of the lag. When the output shaft **55***a* reaches its fixed stop, the slip clutch will operate allowing the metering motor to continue to turn until the door finally reaches its fully closed position. The output shaft and door are thereby resynchronized and the drift error cancelled. Drift errors in the opposite direction are cancelled by the equivalent action when the door reaches its fully open position.

Correcting system drift errors by use of a slip clutch has the effect of reducing the range of possible intermediate door opening settings from 0—100 percent to about 5—95 percent. However, this is no practical disadvantage in the heavy equipment industry. Actually, system drift will be quite small in the usual case since the metering motors ordinarily will have essentially zero pressure drop across them with a corresponding reduction in slippage. Furthermore, since the system corrects itself in each full cycle of operation, very serious ram blowby, system leakage, etc., would have to occur before serious positioning errors would occur. Normal system repair and maintenance would preclude this degree of hydraulic system degradation.

Another advantage of employing a slip clutch is to provide a predetermined torque limit between the metering motor shaft and the sensing means employed, thus allowing use of relatively small and simple control devices such as the potentiometer described.

Referring again to the drawing, the resistor **57** forms two legs **57***a*, **57***b* of a bridge circuit. A potentiometer **66** including tap **67** defining resistor portions **66***a* and **66***b* between the tap **67** and lines **58** and **59** respectively forms another two legs of a bridge. A coil **68** is connected between the bridge terminals defined by taps **56** and **67**. One bridge terminal **59** is grounded and voltage +V is applied to the other bridge terminal. The coil **68** operates contactor **69** of a polarized relay. The contactor connects the voltage +V to one or the other of the contacts **71**, **72**, when the bridge is unbalanced. When the bridge is balanced, contactor **69** remains in a center or neutral position and neither contact **71** or **72** is energized.

With the control switch in the operator's location set to connect the voltage +V to the line **58**, the contactor **69** will contact either contactor **71** or **72** to energize the corresponding solenoid **43** or **44** to operate the solenoid valve to supply fluid to the hydraulic pistons until tap **56** is moved to bring the bridge into balance. The position is controlled by moving tap **67**, and the door can be made to follow by moving the tap **67**. Thus, by providing a setting potentiometer in the operator's cab, he can continuously adjust the intermediate door opening.

In order to close the doors, the operator connects the voltage supply +V to line **76** energizing solenoid **74**, causing the pistons to move in the direction indicated by arrows **49**. The doors are maintained closed by the hydraulic pressure supplied to the pistons via line **33**. When the dumping area is reached, the operator connects the voltage supply to line **58** and the doors open to the position determined by setting of the tap **67**. It is noted that the operator can at this time control or move the doors by moving the tap **67**. When the load is discharged, the operator may switch back to the closed position connecting the voltage supply to line **76** or to the open position connecting the voltage to line **77** and energizing solenoid **43** and causing the pistons to move in the direction in-

dicated by the arrows 47. This assures complete discharge of the material. Thereafter, the operator switches to the close position. The above sequence of operation from fully closed, to intermediate, to fully open and back to fully closed is the preferred operation since it will correct for drift errors in either direction.

It is to be observed that the electrical control system and metering motors can be located remote from the doors where they will not be subjected to the rugged environment. The controls may be as simple as a three-position switch and a potentiometer. Lamps may be incorporated in the lines to give the operator a visual indication of the cycle and the potentiometer can be calibrated to indicate the intermediate door opening.

A full servosystem has been described; that is, a system in which the operator can move the door in either direction when the switch is in the intermediate position. By eliminating the contact 72, the operator can only control the position to which the door opens.

Referring to Figure 6, there is shown a control system which employs a switch 84 for controlling the valve 38 to stop the doors at the intermediate point. In Figure 6, the same reference numerals are applied to parts which correspond to those in Figure 5. The sensor assembly shown in the dotted block 81 differs from the sensor assembly previously described in that it includes a cam 82 mounted on the shaft 55*a*. The cam 82 is adapted to move the button or plunger 83 which opens the normally closed switch 84. When the operator's switch is set to apply voltage to the line 58, fluid will be applied to the door rams 21, 22 to open the doors. When the cam 82 strikes the button 84, the switch is opened to thereby deenergize the valve solenoid. The valve returns to its neutral position wherein the rams are held in the intermediate position.

As before, operation of the switch by the operator to connect the voltage +V to line 59 will actuate the rams to close the doors. Adjustment of the intermediate position is affected by properly setting the cam 82 relative to the position at the stop 63 on the shaft 55*a*, or by moving the position of the stops 61, 62. The control system in Figure 6 requires a mechanical adjustment. However, the assembly is removed from the door position and can be located in an easily accessible portion of the equipment. Thus, adjustment can be easily accomplished. The system again includes means with stops 61, 62 for compensating for leakage or drift.

A control system which is entirely hydraulic is shown in Figure 7. A hydraulic motor is shown in place of a ram. A hydraulic pump 31*a* supplies hydraulic fluid under pressure to the bypass valve 32*a* and thence to the lines 33*a* and 37*a*. A valve 86 is connected in the lines 33*a* and 37*a*. The valve is under the control of the operator to be positioned in one of three positions. Three output lines are associated with the valves. The line 87 provides fluid under pressure to the motor 88 to cause rotation of shaft 89 to fully close the associated door and maintain the same under pressure. The line 91 is adapted to provide hydraulic fluid under pressure to the motor to rotate the shaft 89 to fully open the associated door. The fluid line 92 is connected to a metering motor 93 and thence through a two-way valve 94 to join with line 91 and apply fluid under pressure to drive the motor and rotate the shaft in an opening direction to an intermediate position. A gear reduction box 96 is connected to the motor shaft and thence to a slip clutch 97. A cam 98 is mounted on the output shaft 99 of the slip clutch and is adapted to activate the two-way valve 94 by depressing the plunger 101. A stop assembly including stops 102, 103 and member 104 affixed to the shaft serves to stop the rotation of the shaft 99.

In operation, to open the door from the closed position to the intermediate position, the valve 86 is adjusted whereby the connections between the lines 33*a*, 37*a* and 87, 91 and 92 are as indicated at 106 wherein the pressure line 33*a* is connected to the metering motor line 92 through the valve 94 to the motor 88. When the cam 98 has rotated to depress the plunger 101, the valve 94 closes and motor rotation is stopped at the intermediate position which is preset by adjustment of the cam 98.

To drive the motor to its extreme position, the valve 86 is adjusted to the position 108 wherein the line 33*a* is connected to the line 91 and the line 37*a* to the line 87.

Thereafter, to drive the motor to its other extreme position, the three-way valve 86 is moved to the position indicated at 109 whereby pressure is applied to the motor along line 87 to rotate it in the opposite direction. The lines 91, 92 are connected to the return line 37*a*.

The control valve in the embodiment shown can be located at the operator position. On the other hand, the complete hydraulic system may operate through pilot lines which control hydraulic actuators on the valve 86.

There has been provided a control system to remotely control hydraulically actuated movable members. The control can be located at a protected position. The system includes means whereby drift is automatically compensated by operation of the control member between two extreme positions. The control system is simple in design and relatively easy to adjust to provide selected intermediate positions for the movable, hydraulically operated controlled members. The connections between the operator location and the operating mechanism for the controlled member can be electrical or hydraulic.

It is apparent that the invention is not to be limited to a tractor-trailer combination but rather that it is applicable to equipment which is remotely controlled to control hydraulically actuated movable members to be selectively positioned.

I claim:

1. A control system for use in equipment of the type which includes hydraulic fluid supply means, a movable member, hydraulically driven motive means connected to drive said movable member and hydraulic lines connected between said supply means and said motive means comprising fluid metering means including a hydraulic motor having an output shaft which rotates responsive to the flow of fluid through said motor for metering the fluid supplied to said motive means, interrupting means including a control valve for controlling the flow of fluid to said motive means and means responsive to predetermined rotation of said shaft for controlling said valve means to interrupt the flow of fluid to said motive means to stop said movable member at a predetermined position.

2. A control system as in claim 1 in which said control valve comprises a solenoid valve and said means responsive to predetermined rotation of said shaft comprises electric circuit means.

3. A control system as in claim 2 in which said electrical means includes a switch, and said shaft carries a cam adapted to operate said switch.

4. A control system as in claim 3 wherein said electrical means comprises a potentiometer adapted to be driven from said shaft and a bridge circuit associated with said potentiometer.

5. A control system as in claim 1 wherein said means for interrupting the flow of fluid to said motive means comprises a hydraulically actuated valve means, and means are associated with said shaft for controlling the flow of hydraulic fluid to said valve means.

6. A control system for use in equipment of the type which includes hydraulic fluid supply means, a movable member adapted to be moved between first, second and adjustable and intermediate positions, a hydraulically driven motive means connected to drive said movable member between said first and second positions and hydraulic lines connected between said supply means and said motive means adapted to supply hydraulic fluid to said motive means to move the same from said first to said second position and back including a fluid metering means in the hydraulic lines for metering fluid supplied to said motive means and providing a measure thereof, a control valve disposed in said fluid hydraulic lines to control the flow of fluid to said motive means, means responsive to a predetermined measure of fluid for controlling said valve to

interrupt the flow of fluid to said motive means to stop said movable member at said intermediate position, and means for thereafter controlling said valve to selectively apply fluid to said motive means to selectively move the movable member to the first or second position.

7. A control system as in claim 6 wherein said fluid metering means includes a movable member and wherein said means responsive to a predetermined measure of fluid comprises means responsive to movement of said movable member.

8. A control system as in claim 7 wherein said fluid metering means comprises a hydraulic motor with a rotatable shaft and said means responsive to movement is responsive to rotation of said shaft.

9. A control system as in claim 8 in which said control valve comprises a solenoid valve and said means responsive to predetermined rotation of said shaft comprises electric circuit means.

10. A control system as in claim 9 in which said electrical means includes a switch, and said shaft carries a cam adapted to operate said switch.

11. A control system as in claim 10 wherein said electrical means comprises a potentiometer adapted to be driven from said shaft and a bridge circuit associated with said potentiometer.

12. A control system as in claim 8 wherein said means for interrupting the flow of fluid to said motive means comprises a hydraulically actuated valve means, and means are associated with said shaft for controlling the flow of hydraulic fluid to said valve means.

13. A control system as in claim 8 in which said shaft includes first and second portions with slip means disposed between said first and second portions whereby the second portion can stop while the first portion continues to rotate, and stop means for interrupting rotation of said second portion prior to said movable member reaching its first and second positions.

14. A control system as in claim 13 including a gear reduction means associated in said first shaft portion whereby said second portion rotates one revolution responsive to movement of said movable member between the first and second positions.