July 7, 1970 EISHIRO KUSHIRO 3,519,248

CONSTANT VELOCITY LOWERING DEVICE

Filed Nov. 18, 1968 2 Sheets-Sheet 1

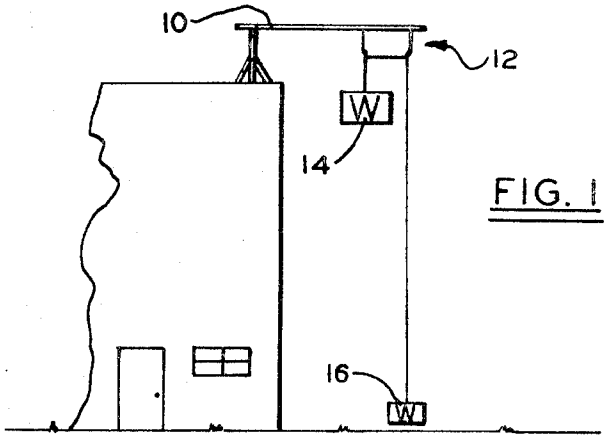
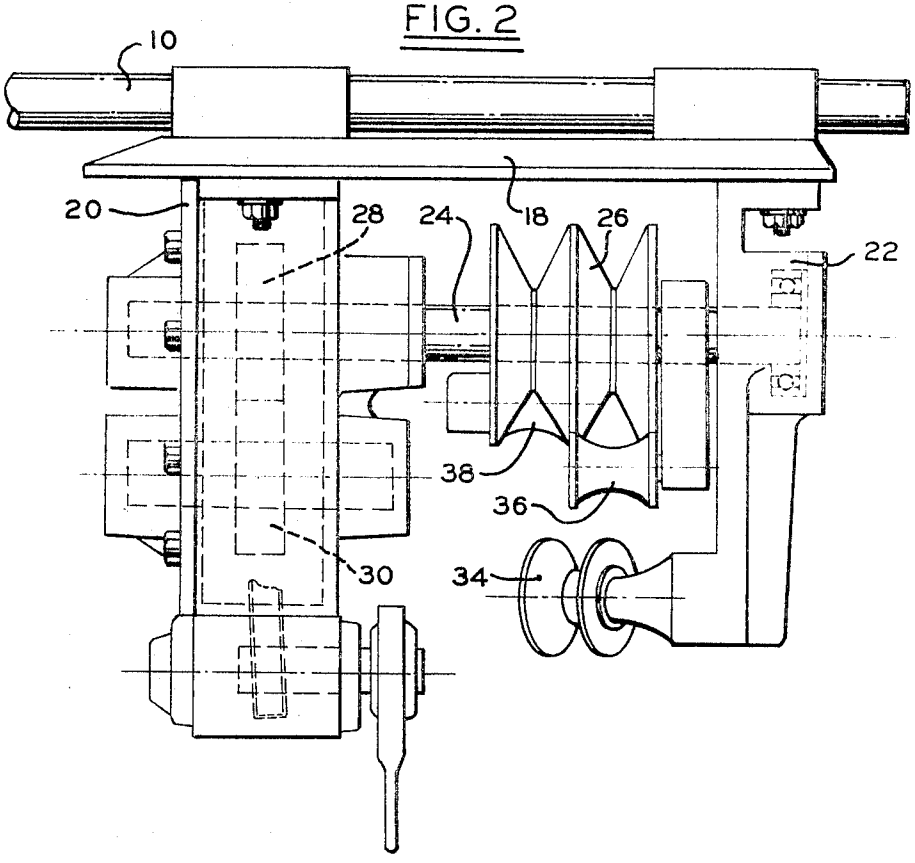


FIG. 1

FIG. 2



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FIG. 3

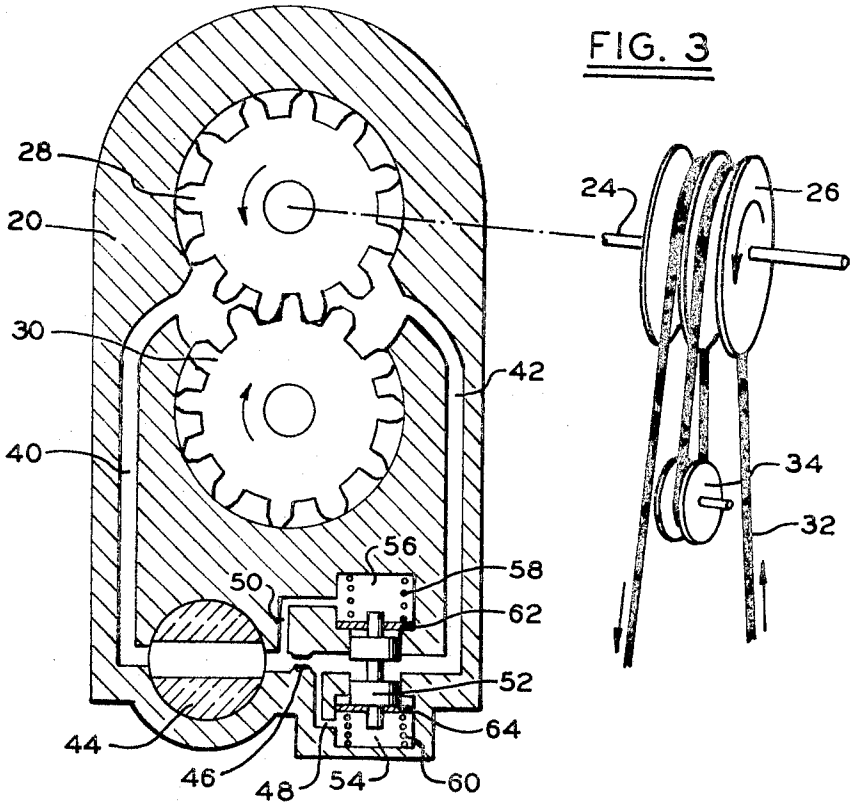


FIG. 5

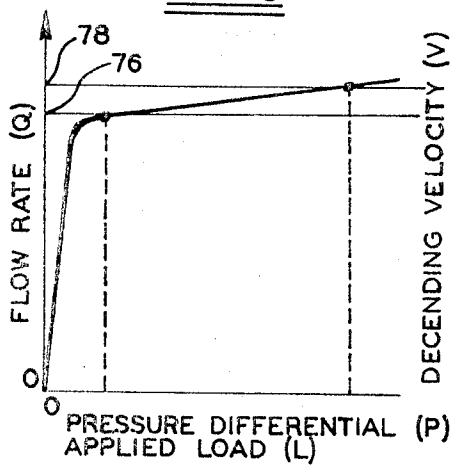
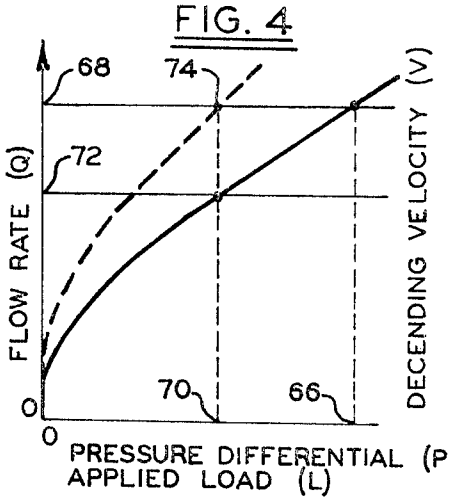


FIG. 4



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CONSTANT VELOCITY LOWERING DEVICE

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U.S. Cl. 254—150 8 Claims

ABSTRACT OF THE DISCLOSURE

A system for alternately raising and lowering opposite ends of a rope or cable arranged on a fixed pulley system so that the speed of descent remains essentially constant irrespective of the load on either end of the cable or of the height from which a load is lowered. The pulley shaft is attached to a gear pump through which a hydraulic fluid passes as the pulleys rotate. Fluid flow is automatically regulated in accordance with the torque applied to the pulleys, and hence to the gear pump, to cause the speed of rotation to remain essentially constant.

This invention relates to apparatus for use in lowering loads from an elevated position and, more specifically, to apparatus for maintaining an essentially constant speed of descent for a load attached to one end of a rope or cable which passes through a pulley system.

It is often more expedient and economical to lower loads from elevated positions by means of a simple rope and pulley arrangement rather than more complicated elevator systems, in spite of the other disadvantages of the former. One of these disadvantages is that some means, often with an external power source, are required in order to provide any degree of control over the speed of descent of varying loads. The present invention incorporates a gear pump with a hydraulic bypass circuit to control the volume rate of flow, and therefore the speed of rotation of the pump. The latter is directly coupled to the pulley for rotation in response to torque applied thereto by a freely descending load. Thus, the speed of rotation of the pulley, and hence the velocity of descent of the load, are directly controlled by the speed of rotation of the gear pump. This cooperative arrangement of the pulley, gear pump and fluid bypass circuit eliminates the need for an external power supply since the load provides the torque for rotation of the pump while the fluid bypass circuit controls the speed of rotation thereof and therefore the speed of descent of the load.

It is a principal object of the invention to provide a system for lowering varying loads from an elevated position utilizing a simple and expedient pulley arrangement and also having the advantage of providing an essentially constant speed of descent.

Another object is to provide means for lowering objects or loads of various weights from an elevated position wherein only the weight of the load is utilized to power the apparatus which provides an essentially constant velocity of descent for the load. A further object is to provide apparatus of the type mentioned above which automatically maintains an essentially constant descending speed irrespective of both the weight of the load and the height from which it is lowered.

Still another object is to provide a simple and economical cable and pulley arrangement suitable for use in the vertical transportation of personnel with speed and safety, including means for stopping the movement at any intermediate point.

Other objects of the invention will in part be obvious and will in part appear hereinafter.

The invention accordingly comprises the features of

construction, combination of elements, and arrangement of parts, which will be exemplified in the construction hereinafter set forth, and the scope of the invention will be indicated in the claims.

For a fuller understanding of the nature and objects of the invention reference should be had to the following detailed description taken in connection with the accompanying drawings, in which:

FIG. 1 is a basic diagram showing merely the fundamental manner of employment of the invention;

FIG. 2 is an elevational view showing the structure of a portion of the invention;

FIG. 3 is a partly diagrammatic view showing internal portions of the apparatus of FIG. 2 and illustrating the manner of operation thereof;

FIG. 4 is a graphical representation of certain quantities associated with operation of similar apparatus not employing the present invention; and

FIG. 5 is a graphical representation of the same quantities in apparatus which incorporates the present invention.

The diagram of FIG. 1 is intended merely to show the basic manner in which the invention may be employed. A right horizontal support **10** is suitably mounted at the elevated position from which loads are to be vertically transported. Suspended from support **10** is apparatus **12**, shown in later figures in more detail, and including a pulley system through which passes a flexible rope or cable having end portions **14** and **16** to which are attached loads indicated by the letters W and *w*, respectively. The load W attached to end **14** is of greater weight than the load *w* attached to end **16**, the latter of which may comprise essentially no load or, for example, an open receptacle or the like for receiving a load placed therein when end **16** is in the upper position. The greater weight of load W will cause end **14** to descend, and consequently end **16** to ascend, in accordance with operation of apparatus **12** as explained in the following paragraphs.

Referring now to FIG. 2, the structure of apparatus **12** is shown in greater detail. Suitable means are provided for suspending support structure **18** from rigid support **10**. Spaced sections **20** and **22** are attached to support **18** and include suitable bearing means for rotational support of the opposite ends of shaft **24**. Pulley wheel **26** is mounted upon shaft **24** for rotation therewith. Section **20** forms an enclosure for a gear pump and a closed loop fluid circuit for the hydraulic fluid passing through the pump. The pump includes the usual pair of toothed wheels **28** and **30**, with wheel **28** mounted upon the end of shaft **24** which is journaled in section **20** for rotation therewith. Thus, shaft **24**, pulley wheel **26** and pump wheel **28** are mutually connected for cooperative rotation.

Details of the gear pump and fluid circuit associated therewith are shown in FIG. 3, with a somewhat diagrammatic cooperative showing of the shaft and pulley arrangement. The pulley system supports line **32**, comprising any suitable rope, cable, or the like, which extends from end **16** (FIG. 1) around pulley wheel **26**, around smaller wheel **34**, again around wheel **26** and down to end **14**. Wheel **34** is rotatably supported on a shaft fixedly extending from section **22**. The axis of rotation of wheel **34** is preferably offset, for example, at an angle of about 22 degrees, with respect to the axis of shaft **24**. Also, line **32** passes between rollers **36** and **38** (FIG. 2), rotatably mounted on suitable fixed arms to maintain tight frictional engagement between line **32** and pulley wheel **26**, whereby any slippage of line **32** through the pulley system is effectively prevented. Thus, line **32** may move only as the pulley wheels rotate.

The gear pump communicates on opposite sides with inlet and outlet conduits **40** and **42**. Rotatable shutoff valve

44 is provided in conventional fashion and is shown in FIG. 3 in the open position. In series with shutoff valve 44 is measuring orifice 46 having bypass conduits 48 and 50 adjacent opposite sides thereof. Flow control valve 52 is arranged for lateral movement to vary the rate of flow through the closed fluid circuit around the gear pump. In the illustrated embodiment valve 52 comprises a reciprocally movable spool type valve having opposite end portions exposed to hydraulic pressure in chambers 54 and 56. The latter communicate, through bypass conduits 48 and 50, respectively, with opposite sides of measuring orifice 46. Thus, the opposite ends of spool valve 52 are, in effect subject to the pressure differential across orifice 46 and the valve will be moved thereby. Compression springs 58 and 60 provide equal set pressures on the opposite ends of valve 52 tending to maintain the latter in the neutral or mid-point position by bearing upon washers 62 and 64, respectively, which loosely contact the ends of the valve. Washers 62 and 64 are of larger diameter than the openings through which the spool portions of valve 52 move so that, upon movement of the valve in either direction, only that spring in the direction in which the valve is moved continues to exert a biasing force. As shown in FIG. 3, for example, washer 62 is retained by the shoulder defining the smaller diameter opening, whereby spring 58 no longer exerts a biasing force.

Referring now to the graph of FIG. 4 the relationship of certain quantities associated with operation of a pulley and gear pump arrangement utilizing a fluid circuit having only a fixed restriction (i.e., with no variable flow control means) is illustrated. In such a system, the flow rate of hydraulic fluid through the gear pump will bear a proportional relationship to the square root of the differential pressure across the restriction. The relationship would be the same, in a system of this type, between the load applied in terms of torque on the gear pump, and the speed of rotation of the pump. As applied to the present system, this could likewise be expressed as the relationship between the resultant load on the descending end of the cable and the speed of descent of that end of the cable. That is, the differential pressure between the pump discharge and suction pressures is nearly proportional to the pump driving torque irrespective of the pump rotational velocity. Thus, the differential pressure is in direct proportion to the weight of the load on the rope, whereby both values may be expressed on the horizontal coordinate. The descending velocity of the load, on the other hand, is a direct function of the rotational speed of the gear pump which, in turn, is dependent on the rate of flow of hydraulic fluid therethrough. Thus, both descending velocity V and flow rate Q may be expressed on the vertical coordinate of the graph.

An assumed load corresponding to the value on the horizontal scale denoted by the reference numeral 66 will exert a given torque on the gear pump and produce a proportional pressure differential between the suction and discharge sides of the pump, also represented by the point 66. The relationship of flow rate to pressure differential in a system having a restricting orifice of a fixed size, being a square root function as previously mentioned, may be graphically represented by the solid line in FIG. 4. Thus, the pressure differential value indicated by the numeral 66 would result in a flow rate having a value corresponding to the point on the graph denoted by the numeral 68. This flow rate would produce a particular speed of pump and pulley rotations and hence descending velocity of the load. If the load, and consequently the pressure differential, were changed to a value corresponding to the point denoted by the reference numeral 70 the flow rate would correspond to the value denoted by numeral 72 in the same system. Thus, the descending velocity would be drastically changed by the indicated change in applied load. In order to maintain the flow rate, and consequently the descending velocity, essentially constant when changing the load from the value at point 66 to the value at point 70 the characteristic curve would have to be changed to follow that indicated by the dotted line in FIG. 4. This is accomplished, according to the present invention, by changing the size of the restriction in accordance with the applied load.

FIG. 5 represents the relationship of the same variables used in FIG. 4 when the flow restriction in the fluid bypass line is adjusted in accordane with the present invention. As the load is varied between minimum and maximum values, denoted on the graph by the points $L_{min.}$ and $L_{max.}$, the pressure differential between the suction and discharge sides of the pump varies in the same proportion as formerly since the operation of valve 52 is related only to the differential pressure across measuring orifice 46. For example, assuming a load to be applied to line 32 to cause movement thereof in the direction indicated by the arrows in FIG. 3, pulley wheel 26 and the gear pump would be rotated in the direction shown. Thus, hydraulic fluid will flow in a counterclockwise direction through the pump and bypass circuit, as seen in FIG. 3. Fluid pressure will be higher, of course, on the upstream side of orifice 46 which in this example is the side connected by conduit 50 to chamber 56, whereby the upper end of valve 52 is subject to higher pressure than the lower side, as shown in FIG. 3, and the valve is moved to the illustrated position. The valve operates as a variable restriction to control the rate of fluid flow therethrough while likewise serving to change the pressure differential across orifice 46 until such differential is essentially zero. It will be noted that when a load is applied to the opposite end of the line, all of the movable elements operate in the opposite direction from that shown in FIG. 3, but with the same result.

The action of the valve to produce an essentially constant flow rate produces a curve substantially as shown in FIG. 5, where the value of flow rate, and consequently of descending velocity, varies only between the values represented by the points 76 and 78 from the minimum to the maximum loads applied. The slight downward slope to the right of the lines emanating from points 76 and 78 denotes the variation from the ideal system due to internal leakage of the pump. The slight upward slope of the curve representing operation of the present system would be that caused by the setting spring constant of springs 58 and 60. Thus, the descending velocity varies somewhat with the weight of the load but such variation is negligible for all practical purposes and is intended, for purposes of the present application, to be included within the scope of the term "constant velocity."

When the shutoff valve 44 is in the closed position there is no flow, and consequently no rotation of the gear pump or pulley. Since rollers 36 and 38 hold the rope or cable tightly against the stationary pulley wheel, as previously explained, the load is stationary, and the flow regulating valve 52 is in the mid-point or fully open position. When shutoff valve 44 is moved to the fully open position to allow descent of the load, the pressure differential across orifice 46 which is immediately created when flow begins, moves valve 52 to a position which results in substantially constant pressure across the measuring orifice, and a constant descending velocity results. The transition time from the beginning of operation to the set constant descending velocity is very short and, for all practical purposes, negligible. A suitable external handle, such as that denoted by reference numeral 80 in FIG. 2, are provided on shutoff valve 44 to permit easy movement thereof between the open and closed positions. If desired, a rope slightly shorter than the distance of travel of the load may be attached between handle 80 and the load so that valve 44 is moved to the closed position by the tightening of the rope just before the load reaches the lowermost position or, for that matter, any intermediate position. Other means of operation of the shutoff valve may be easily devised in accordance with the needs of a particular application.

It will thus be seen that the objects set forth above, among those made apparent from the preceding descrip-

tion, are efficiently attained, and since certain changes may be made in the above construction without departing from the scope of the invention, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

What is claimed is:

1. In a rope and pulley system for free descent of a load from an elevated position, means for automatically maintaining a substantially constant speed of said descent, said means comprising, in combination:

(a) first means for maintaining said rope in frictional engagement with said pulley, whereby the latter is rotated without slippage of said rope by the weight of said load;

(b) a gear pump arranged for movement by rotation of said pulley to displace a hydraulic fluid from suction to discharge sides of said pump; and

(c) second means for maintaining the flow rate of said fluid through said gear pump substantially constant irrespective of the rotational torque applied thereto said pulley and gear pump are connected for mutual rotation so that the velocity of rotation of each is interdependent, said second means includes a fluid bypass circuit connecting said discharge and suction sides and an adjustable flow regulating valve in said circuit.

2. The invention according to claim 1 wherein said bypass circuit includes a fixed measuring orifice and said flow regulating valve is adjusted to maintain substantially constant pressure on each side of said orifice.

3. The invention according to claim 2 wherein said flow regulating valve is moved laterally across a portion of said bypass circuit to variably restrict flow therethrough by means of differential fluid pressure exerted on opposite ends of said valve through conduits communicating with said circuit adjacent each side of said measuring orifice.

4. The invention according to claim 3 wherein said flow regulating valve is biased in a neutral position, wherein it presents minimum restriction to flow of fluid through said circuit, by setting springs.

5. The invention according to claim 4 wherein said system is reversible to allow rotation of said pulley, and thereby said gear pump, in opposite directions with the same characteristics of operation, whereby fluid may flow through said circuit and said flow regulating valve may be moved laterally across said circuit in either direction.

6. The invention according to claim 5 wherein a pair of said setting springs are arranged to bear on opposite ends of said flow regulating valve and provide a predetermined biasing force opposing movement of said valve away from said neutral position while only one of said springs continues to exert a biasing force after movement of said valve in either direction.

7. The invention according to claim 6 wherein a shut-off valve, selectively operable externally of said fluid bypass circuit, is provided in said circuit in series with said flow regulating valve.

8. The invention according to claim 7 wherein said pulley system includes a second pulley wheel having an axis of rotation disposed at an angle with respect to the axis of the pulley wheel connected to said gear pump.

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HARVEY C. HORNSBY, Primary Examiner

U.S. Cl. X.R.

188—92; 254—158, 160, 178, 186