

May 21, 1968

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3,384,350

PNEUMATICALLY-OPERATED DEVICE FOR MANIPULATING HEAVY LOADS

Filed Sept. 22, 1966

2 Sheets-Sheet 1

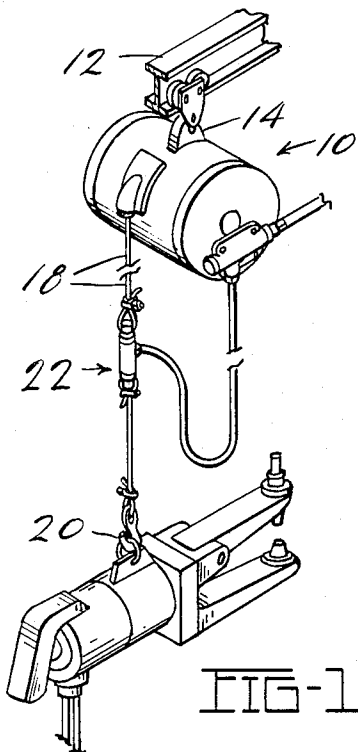


FIG-1-

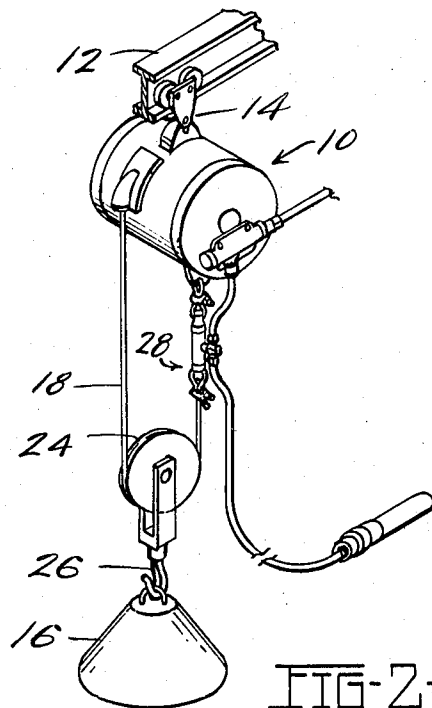


FIG-2-

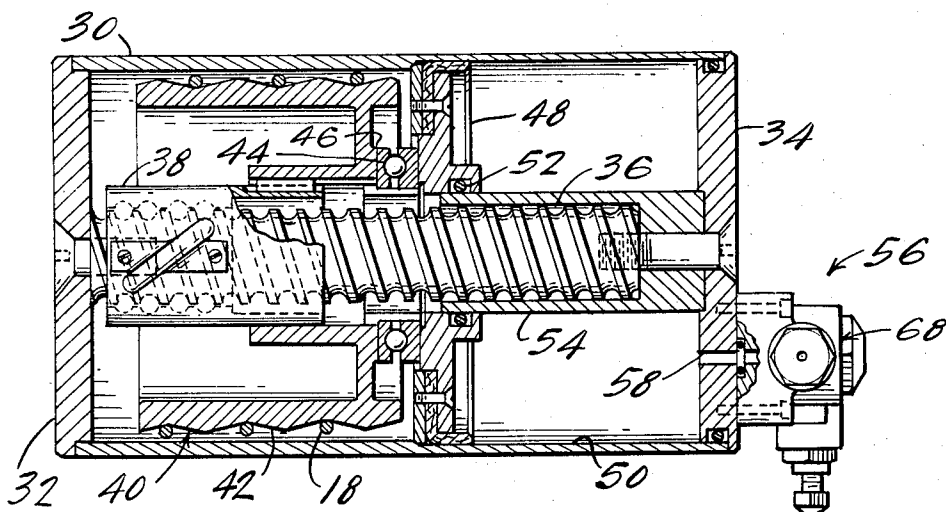


FIG-3 -

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2 Sheets-Sheet 2

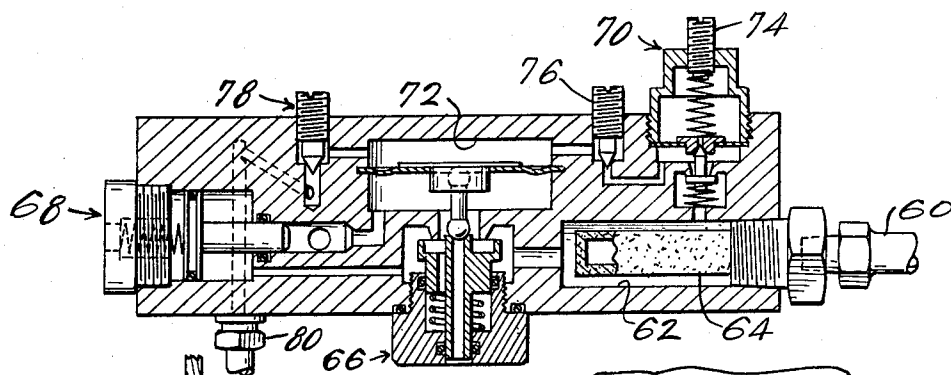


FIG-4-

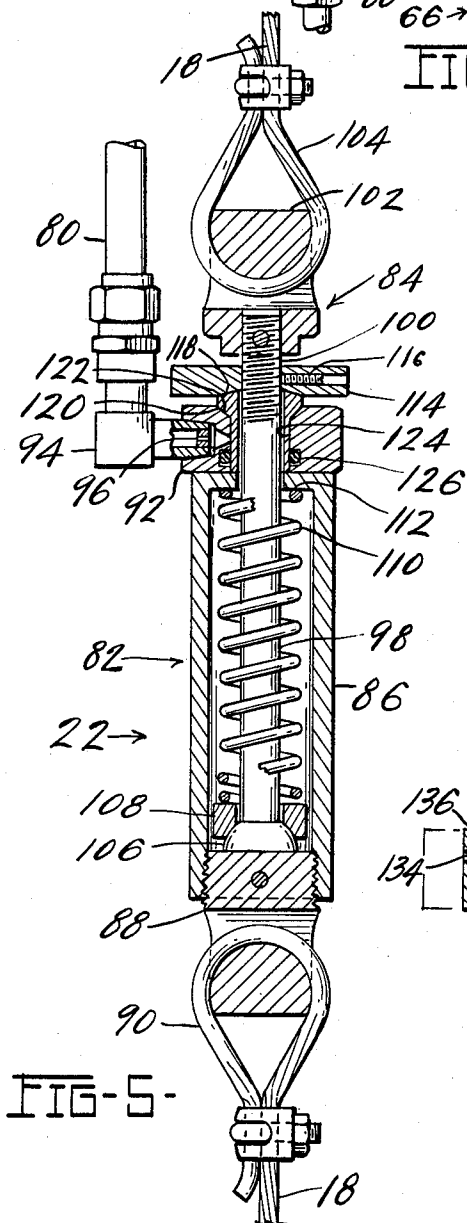


FIG-5-

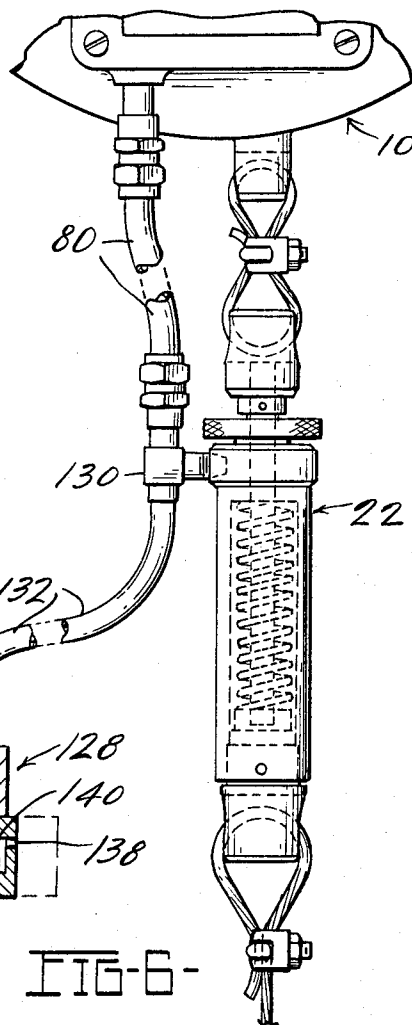


FIG-6-

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PNEUMATICALLY-OPERATED DEVICE FOR MANIPULATING HEAVY LOADS

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Filed Sept. 22, 1966, Ser. No. 581,326
10 Claims. (Cl. 254—172)

ABSTRACT OF THE DISCLOSURE

A pneumatically-operated device such as a balancer for aiding in supporting a heavy load includes an air chamber for causing rotation of a cable drum having a cable connected to the load. Air is supplied to the chamber by an air regulator, the output pressure of which is determined by a pilot air regulator. The pilot air, in turn, is controlled through a valve connected directly to the cable. When the tension on the cable is increased above a certain amount, the valve is opened and relieves pilot air which causes the pressure in the chamber to be reduced and enables the load to be lowered more easily.

This invention relates to a pneumatically-operated device for aiding in manipulating loads and particularly to a hoist or balancer with a load-responsive control therefor which facilitates the handling of heavier loads.

A pneumatic device of the type under consideration includes a housing with a chamber or cylinder to which fluid, usually air, is supplied under pressure. This air pressure acts through a piston on a rotatable drum which is mounted by means of a ball screw nut assembly on a ball screw. The drum, in turn, carries a line or cable which is arranged so that the drum moves along the ball screw toward the chamber as the load is lowered and moves away from the chamber as the load is raised. When the air in the chamber is maintained under a particular pressure, most of the load carried by the cable is offset or balanced by the pressure so that only a small force exerted by the operator can raise or lower the load, with this force usually being no more than about ten percent of the actual weight of the load. The operator can thereby manipulate the load, including raising and lowering it, as though it weighed but a few pounds. Hence, the operator uses the same muscles he would otherwise use if carrying the full load, but without undue strain and exertion. Perhaps more important, even an inexperienced operator has complete control over the load and can move it about rapidly.

The pneumatically-operated device has particular utility for balancing a heavy tool used by an operator, particularly over an extended period of time. The device can be designed to enable the tool to have an effective weight of only a small percentage of its actual weight and thereby relieve fatigue of the operator and increase his productivity. The tool has a sense of feel to the operator similar to that of the tool when not balanced at all and the feel does not vary over a wide range of vertical positions. This is in contrast with a spring balancer used to partially offset the weight of the tool, with the spring balancing more of the weight of the tool when it is in a lower position and less when in an upper position.

The pneumatically-operated device can also be provided with separate controls which enable the device to function as a hoist to raise and lower loads with the aid of air pressure, without any direct handling of the load by the operator. In this manner, the hoist operates similarly to a conventional hoist but has the additional advantages that the load can be physically raised or lowered directly by the operator by an appropriate setting of the controls.

When the air pressure in the chamber is set to balance

a load carried by the pneumatically-operated device, the operator can manipulate the load, raising and lowering it, as though the load weighed a fraction of the actual weight, up to about ten percent, the percentage depending on the friction inherent in the device. Hence, a fifty pound load can be manipulated as though it weighed but only five pounds, with a five-pound force required to raise the load and substantially the same force required to lower it, since the friction will be similar in either direction. If the air pressure in the device were increased slightly, the force required to raise the load would be decreased but the force required to lower the load would be increased, and the load may tend to creep up if it is released entirely by the operator.

When the device is employed as a hoist for heavy loads or particularly when designed as a balancer to help offset the weight of heavy tools, such as large riveters or welders, the force required by the operator to manipulate the load may be excessive. For example, with a five hundred pound load, a force of fifty pounds may be required by the operator to raise and lower the load. This may be unduly tiresome to the operator, particularly when manipulating the load over a period of time.

The present invention enables heavy loads to be handled with the pneumatically-operated device without the use of excessive force to either raise or lower the loads. The invention provides a load-responsive valve which enables the air pressure to be established high enough to urge the load upwardly and thus reduce or eliminate the force required by the operator to raise the load. The valve also automatically exhausts fluid to reduce the pressure in the device to enable the operator to easily lower the load with little force. To accomplish this, the valve can be incorporated into the cable between the device and the load, and has means for urging the valve toward a closed position. When the combination of the weight of the load and the relatively small force exerted downwardly by the operator on it exceeds the force urging the valve shut, the valve thereby opens sufficiently to exhaust some of the air and decrease the pressure in the device and enable the load to easily move downwardly.

It is, therefore, a principal object of the invention to provide a pneumatically-operated device with a load-responsive valve capable of handling heavy loads with facility.

Another object of the invention is to provide a sensitive, load-responsive valve for use with a pneumatically-operated device.

Numerous other objects and advantages of the invention will be apparent from the following detailed description of preferred embodiments thereof, reference being made to the accompanying drawing, in which:

FIG. 1 is a somewhat schematic view in perspective of a pneumatically-operated device functioning as a tool balancer and a load-responsive valve embodying the invention;

FIG. 2 is a view in perspective similar to FIG. 1 with the pneumatically-operated device functioning as a hoist, with the load-responsive valve mounted in a slightly different manner;

FIG. 3 is a somewhat schematic view in longitudinal cross section through the pneumatic device of FIG. 1 or 2;

FIG. 4 is a schematic view in section of a controller used with the device of FIGS. 1-3;

FIG. 5 is an enlarged view in vertical section taken through the load-responsive valve shown in FIG. 1; and

FIG. 6 is a view partly in elevation and partly in section showing the load-responsive valve employed in combination with a hand-operated control valve.

Referring to FIGS. 1 and 2, a pneumatically-operated

device embodying the invention is indicated at 10 and is suspended from a conveyor rail 12 by a suitable trolley 14. A heavy load 16, such as a large tool, is supported from the device by a cable or line 18. A single cable can be used as shown in FIG. 1, with the load being supported by a hook or loop 20 and with a load-responsive valve 22 embodying the invention being connected directly into the cable 18.

In the embodiment of FIG. 2, the cable 18 is reeved, having a pulley 24 carrying a hook 26 for the load 16, and with a slightly modified load-responsive valve 28 connected to the cable 18, in this instance being located between the end of the cable and the device 10. With the reeved cable, the device can handle still heavier loads and the load may be raised higher since the load-responsive valve is not connected into an intermediate point of the cable thereby to constitute an upper limit beyond which the load cannot be raised.

Referring more particularly to FIG. 3, the basic pneumatically-operated device 10, as shown in cross section, is similar to that of my Patent No. 3,260,508 and even closer to that shown in my co-pending applications, Ser. No. 518,287, filed January 3, 1966 and Ser. No. 564,295, filed July 11, 1966. The device has a housing 30 with end walls 32 and 34 and ball screw 36 extending longitudinally through the housing and supported by the end walls. A ball screw nut assembly 38 is mounted on the ball screw 36 and moves longitudinally in the housing when turned relative to the ball screw. A cable drum 40 is mounted on the ball screw nut assembly 38 and moves with this assembly to rotate and move longitudinally relative to the screw 36. The drum 40 has a shallow helical groove 42 on which the cable 18 is wound when the load is raised, and vice versa. One end of the cable 18 can be suitably affixed to the drum at the appropriate end of the helical groove 42.

The position of the drum 40 relative to the ball screw 32 is controlled by air pressure. For this purpose, a thrust bearing 44 is located adjacent the drum 40 and bears against a hub portion 46 thereof. The bearing 44 extends beyond the drum so as to be engageable with a piston 48 movable longitudinally in the housing 30, in gas-tight relationship therewith. The second end wall 34, the right-hand portion of the housing 30, and the piston 48 form a power chamber 50 to which air or other suitable fluid under pressure is supplied for operating the device. An O-ring seal 52 is located in the piston 48 to enable the piston to be supported in slidable but sealing contact with a sleeve 54 around the right end portion of the ball screw 36.

When air supplied to the power chamber 50 is under sufficient pressure, the piston 48 is pushed toward the left and causes the drum 40 and the ball screw nut assembly 38 to move in the same direction. This movement causes the drum 40 to rotate in a manner such as to raise the cable 18 and the load 16. When the load is sufficiently heavy to overcome the air pressure, the piston 48 moves toward the right and forces air out of the power chamber 50.

The air supply for the power chamber 50 is regulated by a controller 56 communicating with a supply opening 58 in the end wall 34. The controller 56 is shown and described more fully in my co-pending application, Ser. No. 564,295 and will be discussed only briefly in connection with FIG. 4. Air is supplied from a line 60 (FIG. 4) to a chamber 62 containing a filter 64. From here, the main air is supplied through a main air regulator indicated at 66 which controls the pressure of the air supplied to the power chamber 50. The regulated air is then supplied to the chamber 50 when an air-operated check valve 68 is opened. Air from the supply chamber 62 also passes through a pilot air regulator 70 which controls the pressure of pilot air which is subsequently supplied to a pilot air bonnet or chamber 72 of the main air regulator 66. The pressure of this air in the chamber

72 controls the output pressure of the air regulated by the regulator 66, with the pressure of the pilot air supplied to the chamber 72, in turn, being controlled by the pilot air regulator 70. An externally-operated screw 74 controls the pilot air pressure and, hence, the pressure of the main air supplied to the power chamber. Trim valves 76 and 78 can control the flow of pilot air to control the speed at which the hoist responds to the controls. Since the details of the components of the controller 56 do not constitute part of the instant invention, and since they are discussed fully in my aforementioned co-pending application, they will not be described further.

Ordinarily, when the pneumatically-operated device is designed as a tool balancer, the air pressure substantially balances the load or tool 16 so that it can be raised and lowered by an operator with a small effort, as though the load actually weighed no more than about ten percent of its actual weight, this percentage depending on the friction inherent in the device. With a very heavy load, however, the effort required to manipulate the load may be excessive, particularly if the load is in the form of a tool which is operated over long periods during the course of a workday.

The load-responsive valve 22, however, enables the operator to manipulate the load with very little effort. With the valve 22, the pressure of the air supplied to the power chamber 50 can be set to cause the load to be urged upwardly slightly so that if the load is unattended, it will rise very slowly. The pilot air is connected to the load-responsive valve 22 through a line 80 to vent the pilot air, decreasing the pressure thereof, and consequently, the pressure of the air supplied to the power chamber. Rather than venting the pilot air, the main power air could be vented. However, this would require venting of substantially larger quantities of air and greater waste. Therefore, pilot air venting is preferred. The valve 22 is designed to open and vent the pilot air when the downward force or tension on the cable 18 increases slightly above that normally exerted by the load 16. This enables the operator, when desiring to move the load downwardly, to simply push or pull downwardly on the load slightly, causing the valve 22 to open and the pressure in the power chamber 50 to be decreased, thus enabling the load to be moved downwardly under only the relatively light pressure on behalf of the operator needed to open the valve. A heavy load thereby can be operated as easily as a light load since the air for the device can be maintained above that normally required to balance the load, thereby to aid in moving the load upwardly, and the load can be moved downwardly by the exertion of only enough force to open the valve 22.

A preferred construction of the valve 22 is shown in FIG. 5. The valve includes two main separate and separable parts 82 and 84 connected to respective portions of the cable 18. It is to be understood that the two parts can be reversed with the lower part 82 connected to the upper portion of the cable and the upper part 84 connected to the lower portion of the cable, if desired. The lower part 82, in this instance, includes a cylindrical housing 86 connected at its lower end to a cable eye 88 through which a loop 90 of the lower portion of the cable 18 passes. The lower part 82 also includes a valve seat body 92 which can be a part of the cylindrical housing 86 but preferably is separate so that the housing 86 can rotate or pivot with the lower portion of the cable 18 relative to the body 92 and the exhaust line 80 which is connected thereto. The valve seat body 92 is threaded to receive a fitting 94 to which the vent line 80 is attached, the fitting 94 having an orifice 96 therein to restrict flow of air through the line 80. Without the orifice 92 to restrict flow of air through the line 80, the valve 22 can chatter as the load is pulled downwardly. If desired a variable orifice can be employed in place of a fixed orifice.

The upper part 84 includes a long rod 98 extending into the housing 86, the rod having an upper threaded

portion 100 to which an upper cable eye 102 is connected and through which a cable loop 104 passes. The rod 98 has a spherical enlargement 106 at its lower end upon which a seating ring 108 is mounted, with a coiled spring 110 located between the seat 108 and an upper end flange or shoulder 112 of the housing 86. The spring 110 is under compression and urges the rod 98 into the housing 86. A long spring is desired because less additional force applied to the load is then required to compress the spring further by a desired amount.

The threaded portion 100 of the rod 98 carries a large knurled adjusting nut 114 which is frictionally held in place by a nylon pin 116. The nut 114 is urged by the spring 110 toward the valve body 92 and engages a valve sleeve or member 118 which has a conical valve ring 120 urged toward a conical valve seat 122 formed by the body 92. The adjusting nut 114 has a shallow, spherical recess cooperating with a spherical upper face on the sleeve 118 to accommodate any misalignment of the components. The valve ring 120 and the valve seat 122 control escape of air from the line 80 which communicates with a thin annular chamber 124, the lower end of which is sealed by an O-ring 126 engaging the outer surface of the sleeve 118.

The valve 22 will be described further in connection with its operation. With a load or tool of a given weight suspended by the cable 18, the adjusting nut 116 is turned toward the valve body 92 until the conical valve ring 120 closes off the conical valve seat 122. Actually, it is not essential that the valve be completely closed since a very small leakage can actually increase the sensitivity of the overall valve and improve its operation. The pilot air also is adjusted so that the main air supplied to the power chamber is sufficient to raise the load very slowly, causing the load to move slowly to its highest position if left alone. Very little effort on behalf of the operator is then required to hold the load at a given level or to raise it. A small downward force on the load is sufficient to lower the load by moving the housing 86 downwardly relative to the rod 98, thereby moving the valve seat 122 and the sleeve 118 downwardly away from the adjusting nut 114. The pressure of the air in the annular chamber 124 will then force the valve sleeve 118 upwardly and move the conical valve ring 120 away from the valve seat 122, allowing air from the line 80 to escape. This vents the pilot air and decreases the pilot air pressure in the regulator chamber 72, thereby decreasing the pressure of the air supplied to the power chamber 50 by the main air regulator 66.

Only a very small relative movement between the first and second valve parts 82 and 84 is necessary to open the valve sufficiently, with this movement being as little as 0.0001 inch. With a five hundred pound load, a two-and-one-half pound downward force exerted on the load can be sufficient to open the valve and move the load downwardly, in contrast to a force of perhaps fifty pounds required when the air pressure in the pneumatically-operated device is used to directly balance the load without the employment of the valve 22. Further, even though a very small movement of the valve parts is necessary to effect proper venting, it has been found that once the valve 22 is properly adjusted, the adjusting nut 116 can be turned as much as 270° without affecting the operation of the valve significantly. Hence, the adjustments can be made by a person of limited skill.

The conical valve ring 120 can be of a plastic material, but can also be of metal with a ground, metal-to-metal contact provided between the ring 120 and the seat 122. With the valve ring 120 and the seat 122 close to the axis of the parts 82 and 84, the effect of misalignment therebetween also is minimized so that even if some misalignment of the parts exists, nevertheless the pre-load applied to the valve ring by the adjusting nut 116 can be maintained at a minimum to achieve maximum sensitivity for the valve.

Referring to FIG. 6, the load-responsive valve 22 can

be operated in combination with a hand-operated control valve 128 to enable the pneumatically-operated device to function more as a hoist than as a balancer. In this instance, a T-fitting 130 is substituted for the L-shaped fitting 94 with a control line 132 connecting the fitting 130 and the control valve 128. The pilot air, in this instance, can be vented through the load-responsive valve 22, the hand-control valve 128, or both. The valve 128 has three positions as shown schematically. In one position, shown in solid lines, the control line 132 is not vented at all so that the load 16 can be controlled the same as with the arrangement of FIG. 5. This position of the control valve is employed when the heaviest load is manipulated. The control valve 128 has a second position in which an exhaust opening 134 communicates with the line 132, with air vented through the opening 134 controlled by a needle valve 136. The needle valve 136 preferably is adjusted so that a load of intermediate weight to be manipulated will be slightly over-balanced so that the hoist will slowly raise this load when left alone, in the same manner as for the heavier load. With the control valve 128 in this position, the intermediate weight load can be lowered and manipulated in the same manner as for the heavier weight load with the control line 132 blocked. The control valve 128 has a third position in which a second vent opening 138 communicates with the line 132, with flow controlled by a needle valve 140. The needle valve 140 is set so that maximum pilot air will be vented through the opening 138, with the venting in this instance being sufficient so that pressure in the hoist power chamber only balances the hoist hook. In this instance, when the hook is raised and lowered, most of the air vented will be through the hand control valve 128 with the load-responsive valve 22 having little effect on the operation.

An example in which the combination of the hand-controlled valve 128 and the load-responsive valve 22 is particularly effective is as follows: Large cylinders of metal are to be turned down on a lathe to a predetermined shape with the unmachined pieces weighing four hundred fifty pounds and with twenty pounds removed therefrom by the turning operation. In this instance, the pieces are picked up and carried to the lathe by the hoist with the pressure in the power chamber regulated to enable the piece to rise slowly when left alone. The operator can then easily move the piece to the lathe and through minor forces on the piece, move it into the proper position, by virtue of the load-responsive valve 22. After the piece is machined and it is twenty pounds lighter, the hoist hook is again attached to the piece and the hand-controlled valve moved to the intermediate position which is set to vent sufficient air that the lighter piece will again slowly rise if left alone. Hence, the machined, lighter piece can be handled exactly as before. When the hook of the hoist is not engaged with the piece or is to be disengaged, the hand control is moved to the vented or third position so that the hook can readily be raised and lowered when empty, as desired.

Various modifications of the above described embodiments of the invention will be apparent to those skilled in the art, and it is to be understood that such modifications can be made without departing from the scope of the invention, if they are within the spirit and the tenor of the accompanying claims.

I claim:

1. In combination, a pneumatically-operated device having a line and means including a power fluid chamber cooperating with said line to raise and lower said line according to fluid pressure in said chamber, regulator means for supplying fluid under pressure to said chamber, pilot fluid regulator means for controlling pressure of fluid supplied to said regulator means to control the pressure of the fluid supplied by said regulator means to said chamber, and valve means responsive to the pulling force of a load carried by said line for venting pilot fluid to

reduce the pressure of fluid supplied by said regulator means to said chamber.

2. In combination, a pneumatically-operated device having a housing, a drum, means rotatably carrying said drum for rotational and axial movement relative to said housing, a line on said drum, means including a power fluid chamber in said housing to effect rotation of said drum to move said line into and out of said housing, control means for controlling the pressure of power fluid to said chamber, and valve means comprising at least two parts movable relative to one another, with at least one of said parts connected to and movable with said line to cause said valve means to be responsive to the pulling force on said line for causing said control means to reduce the pressure of the fluid supplied to said chamber when the pulling force on said line exceeds that exerted normally by a load carried on said line.

3. In combination, a pneumatically-operated device having a housing, a drum, means rotatably carrying said drum for rotational and axial movement relative to said housing, a line on said drum, means including a power fluid chamber in said housing adjacent an end of said drum to effect rotation of said drum to raise and lower said line, means for supplying fluid under pressure to said chamber, a valve connected with said line and responsive to the tension on said line, said valve being opened when the tension on said line exceeds a predetermined amount, means urging said valve toward a closed position, and means connecting said valve to the power fluid to vent a portion of the power fluid and reduce the fluid pressure in said chamber when said valve is opened.

4. The combination according to claim 3 characterized by said valve means including a valve member associated with one portion of said line and means forming a valve seat associated with the other portion of said line and arranged so that said valve member and said seat tend to separate when the tension on the line exceeds a predetermined value.

5. The combination according to claim 3 characterized by said valve means including a valve member associated with one of said housing and said line and means forming a valve seat associated with the other of said housing and said line, said valve member and said valve seat being

effective to separate when the tension on the line exceeds a predetermined value.

6. The combination according to claim 3 characterized by said valve including two separate and separable parts, one of said parts comprising a spring housing and means forming an annular valve seat, said connecting means comprising a vent line connecting the power fluid with said valve seat, the other part of said valve comprising a rod extending into said spring housing, a spring carried by said rod and maintained under compression to urge said rod toward the spring housing, a valve sleeve around said rod and effective to close said valve seat, and means carried by said rod and cooperating with said sleeve to urge said sleeve toward said seat.

7. The combination according to claim 6 characterized by said last-named means comprising a ring threadedly engaged with said rod to enable movement of said ring longitudinally of said rod when said ring is turned.

8. The combination according to claim 6 characterized by the means forming said annular valve seat also forms an annular chamber adjacent said seat and located around said rod, said annular chamber communicating with said vent line.

9. The combination according to claim 3 characterized further by said connecting means comprising a vent line connecting power fluid with said valve and an orifice in said vent line.

10. The combination according to claim 3 characterized by said connecting means comprising a vent line connecting power fluid with said valve, and a second vent line connecting power fluid with a hand controlled valve, said control valve having a plurality of positions for venting a particular volume of power fluid from the line in each of the positions.

References Cited

UNITED STATES PATENTS

1,319,601 10/1919 Miller ----- 254—172

EVON C. BLUNK, *Primary Examiner*.

H. C. HORNSBY, *Assistant Examiner*.

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,384,350

May 21, 1968

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It is certified that error appears in the above identified patent and that said Letters Patent are hereby corrected as shown below:

In the heading to the printed specification, lines 4 to 6, cancel "Birmingham, Mich., assignor to D. W. Zimmerman Mfg., Inc., Toledo, Ohio, a corporation of Ohio" and insert -- 7358 St. Auburn Drive, Birmingham, Mich. 48010 --.

Signed and sealed this 30th day of September 1969.

(SEAL)

Attest:

Edward M. Fletcher, Jr.

Attesting Officer

WILLIAM E. SCHUYLER, JR.
Commissioner of Patents