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[54] **BALANCING APPARATUS WITH SERVO RELIEF VALVE**

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Related U.S. Application Data

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[52] **U.S. Cl.** ..... **254/168,** 251/347, 251/353, 254/150 FH, 254/186 R

[51] **Int. Cl.** **B66d 1/44**

[58] **Field of Search** ..... 254/150 FH, 168, 186, 189; 251/340, 344, 347, 353

[56] **References Cited**

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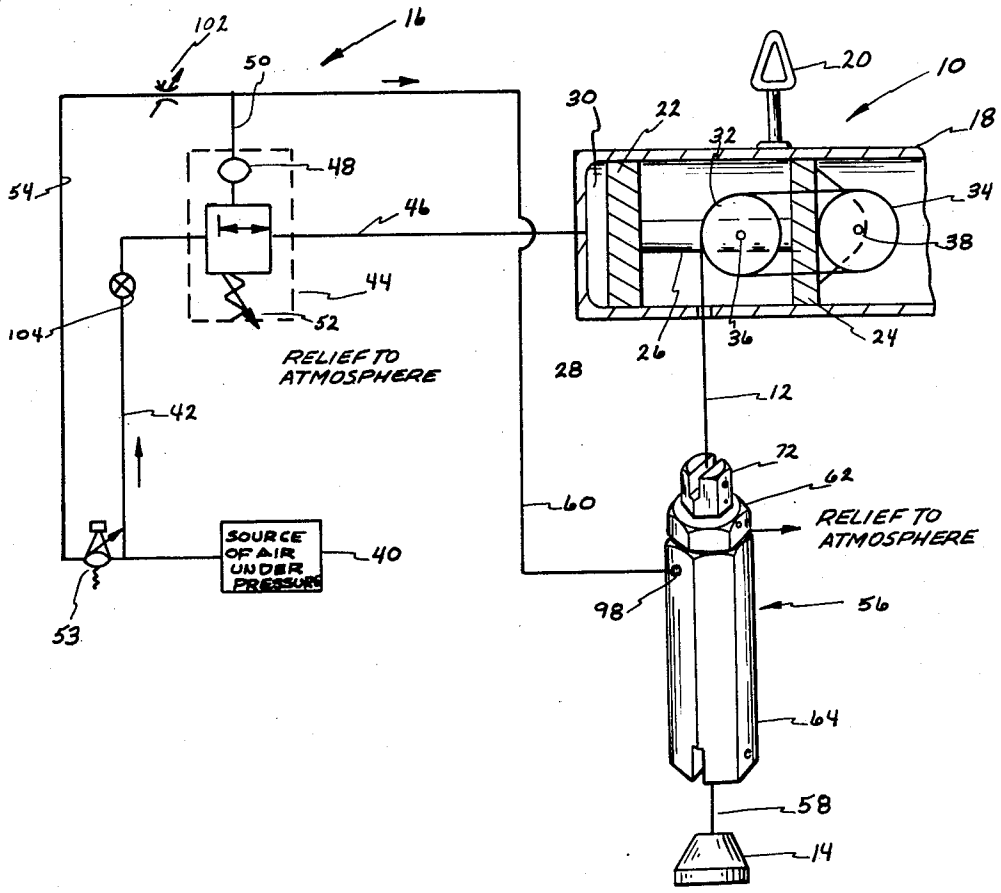
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[57] **ABSTRACT**

A pneumatic balancing apparatus for supporting, a load, such as a tool, on the lower end of a hoisting cable. A pneumatic hoist balances the load in a suspended position by air pressure supplied by a pilot-operated regulator, and a servo relief valve carried on the cable is so attached to the load as to allow the operator to temporarily change the balancing pressure by manipulating the load to a different height. The regulator automatically restores the balancing pressure to a controlled value when the operator has finished adjusting the height of the load.

3 Claims, 4 Drawing Figures



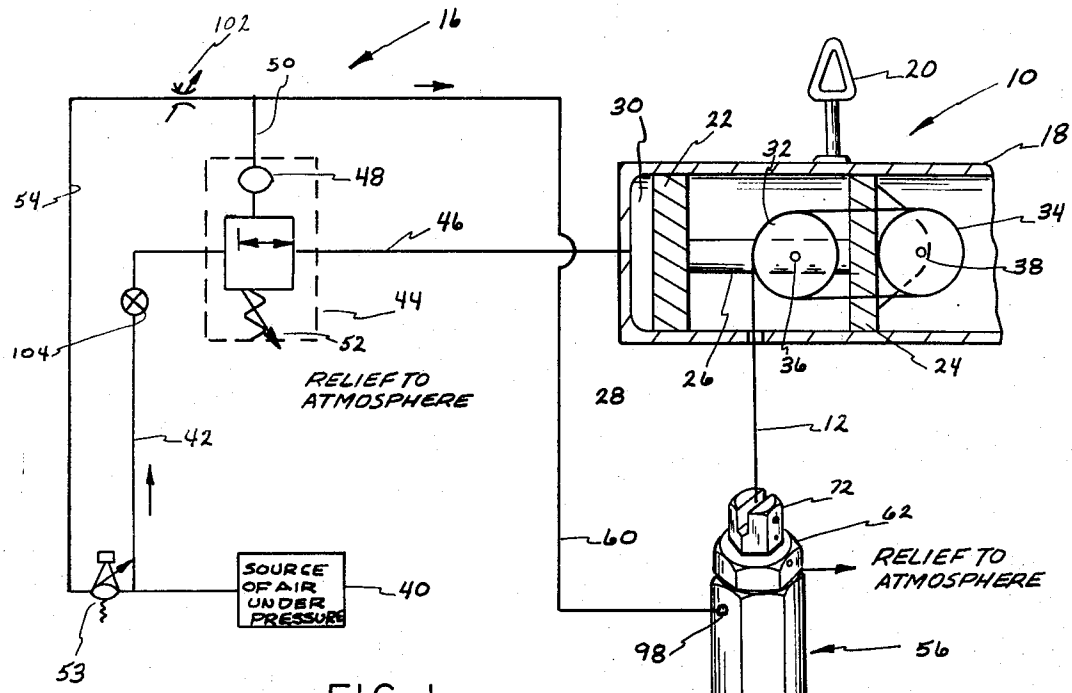


FIG-1

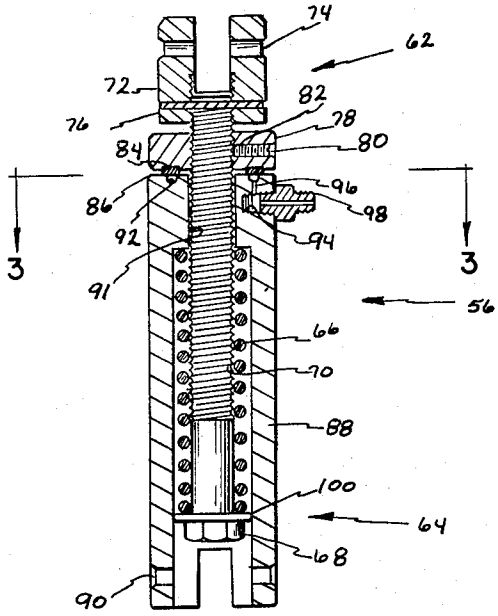


FIG-2

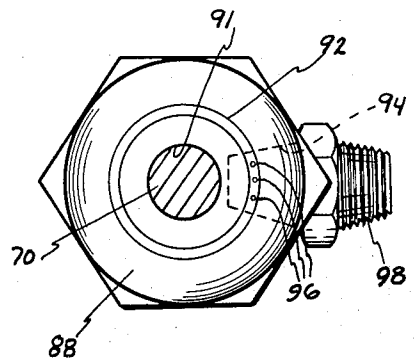


FIG-3

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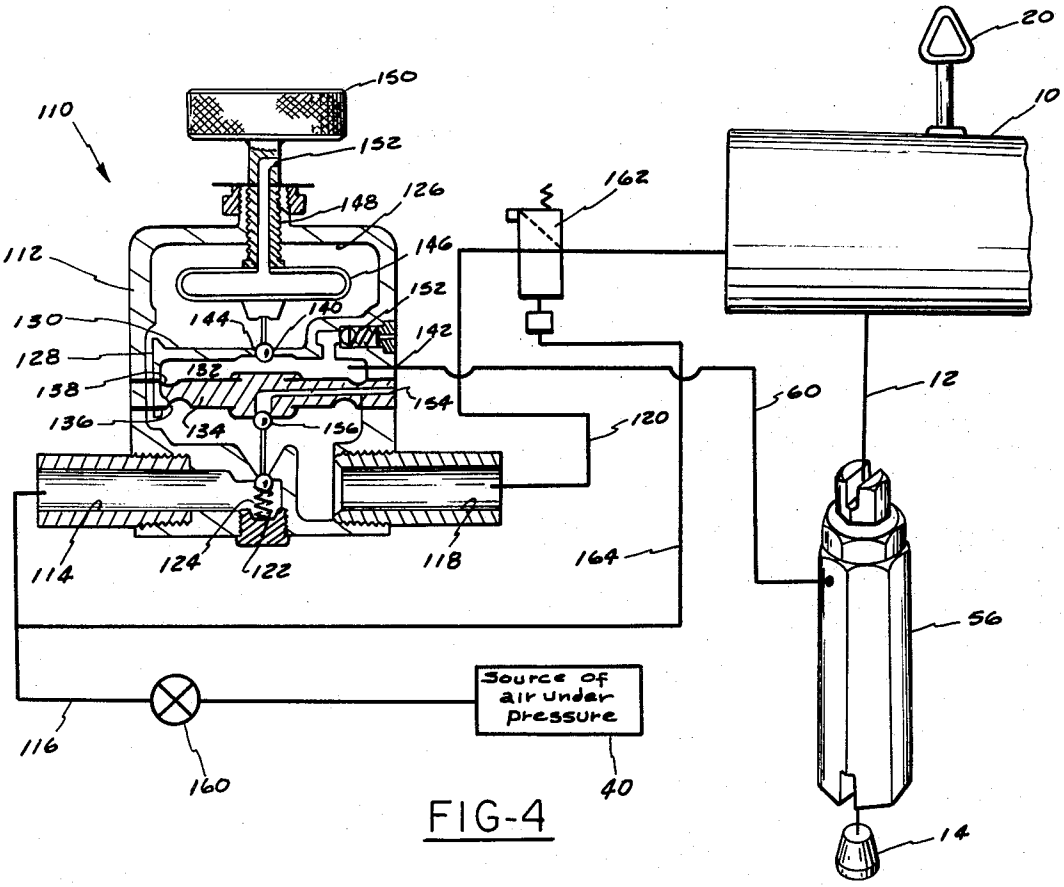


FIG-4

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BALANCING APPARATUS WITH SERVO RELIEF VALVE

This is a continuation of application Ser. No. 13,272 filed Feb. 24, 1970.

BACKGROUND OF THE INVENTION

I. Field Of The Invention

This invention is related to pneumatic hoists and balancers, and more particularly to a hoist having a relief valve carried on the hoist cable which allows the operator to temporarily reduce the air pressure balancing the load by applying a downward effort on the load.

II. Description Of The Prior Art

Air-balanced hoists are useful in many industrial applications in which a relatively heavy load, such as a tool, is suspended at a certain height and is manually repositioned by the operator. In general, such devices have a piston and means connecting a cable to the piston so that the cable is raised or lowered according to the direction of piston motion. A regulator controls air pressure to bias the piston according to whether the load is being raised, lowered or balanced.

Since the motion of the cable depends upon the bias of the air pressure, certain hoists of the prior art have regulators for adjusting the air pressure to balance the load in a suspended position. The operator of such a hoist can easily manipulate a suspended load even though it weighs several hundred pounds. One form of such hoist, disclosed in U.S. Pat. No. 2,384,774 to C. D. P. Smallpeice, operates on the principle that as the operator applies a downward effort on the load, and the initial movement of the piston increases the pressure of the balancing air a regulator automatically responds by opening a vent to exhaust the increased pressure to allow the operator to continue to adjust the position of the load. The regulator then automatically closes the vent to restore the air to its balancing pressure when the operator has finished his adjusting motion.

In U.S. Pat. No. 3,384,350, to E. R. Powell a similar balancing system is disclosed in which the regulator includes a relief valve carried on the hoisting cable adjacent the load.

One problem with prior art balancing devices employing such pressure responsive valves is due to the tendency of pressure responsive valves to hunt and overcontrol because of their dependency on air pressure. In addition, such valves are affected by vibrations from the surrounding environment. When mounted on the hoisting cable, they are often affected by the weight and change in rigidity of the air hose connecting the valve to the regulator.

SUMMARY OF THE INVENTION

One of the broad purposes of the present invention is to provide a pneumatic balancing apparatus having a relief valve connected directly with the load and which opens in response to changes in the downward force produced by the load rather than to the pressure of the air being vented. In the preferred embodiment of the invention, the relief valve is carried by the hoisting cable and has a spring biased member attached to the load. An air hose connects a venting port on the valve to a pilot-operated regulator that controls the balancing air pressure.

When the preferred apparatus is employed as a balancer, the regulator adjusts the bias of the air pressure on the piston to balance the weight of the load. When the operator manually applies a downward effort on the load, the relief valve is so constructed that its initial motion opens the port to vent the pilot air which controls the regulator. The regulator responds by reducing the balancing pressure to allow the operator to continue lowering the load, and then restores the balancing pressure when the downward motion has been completed.

The preferred relief valve provides several advantages over prior art devices. For instance, since the operation of the valve is independent of pilot air pressure, the fluttering and hunting associated with fluctuations in air pressure are avoided. In addition, the valve allows the pilot pressure to stabilize more quickly after each pressure relief.

The preferred balancing system also employs a novel regulator for controlling the balancing pressure. The regulator has an aneroid that is adjusted to a control pressure by the operator according to the weight of the load. The aneroid governs the air pressure in a pilot chamber so as to automatically open a supply valve when the balancing air pressure is less than the control pressure and to open a relief valve when the balancing pressure is greater than the control pressure.

The servo relief valve is connected to the outlet of the pilot chamber to change the control pressure without adjusting the aneroid. When the servo relief valve is closed, the supply valve operates according to the control pressure established by the aneroid. However, when the servo relief valve is opened the pilot chamber pressure is reduced thereby closing the supply valve. The regulator then vents the balancing air until the operator releases the load and the regulator returns to the control pressure established by the aneroid.

A hand-operated relief valve, instead of a servo valve, is connected to the outlet of the pilot chamber when the operator is to adjust the height of the load without manually positioning it.

Still further objects and advantages of the invention will become apparent to those skilled in the art to which the invention pertains upon reference to the following detailed description.

DESCRIPTION OF THE DRAWINGS

The description refers to the accompanying drawings in which like reference characters refer to like parts throughout the several views and in which:

FIG. **1** is a schematic illustration of a pneumatic balancing apparatus illustrating a preferred embodiment of the invention;

FIG. **2** is a longitudinal cross-section of a preferred servo relief valve;

FIG. **3** is an enlarged sectional view of the servo relief valve as viewed along lines **3—3** of FIG. **2**; and

FIG. **4** is a schematic illustration showing another preferred balancing apparatus.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Now referring to the drawings, a preferred pneumatic balancing apparatus is illustrated in FIG. **1** as comprising a pneumatic hoist **10** having a cable **12** for raising or lowering a load **14** that is attached to the lower end of the cable. A pneumatic system, generally indicated at **16,** is connected to the hoist **10** for balancing the load **14** in a hoisted position.

The hoist 10 comprises a tubular housing 18 having an eyebolt 20 for attaching the housing to an overhead beam, a trolley or other suitable support. A pair of spaced pistons 22 and 24 are slidably disposed in the housing 18, and are connected together by a pair of piston rods 26 (only one shown). The housing 18 has a closed end 28 forming a power chamber 30 adjacent piston 22. The power chamber 30 receives compressed air from the pneumatic system 16 to bias the piston 22 in a manner that will be more fully described.

A pair of cable sheaves 32 and 34 are also disposed in the housing 18. Sheave 32 is rotatably supported by an axle 36 mounted in the housing 18 between piston 22 and piston 24. The other sheave 34 is rotatably supported by an axle 38 that is mounted on piston 24. Thus the sheave 34 is moved either toward or away from sheave 32 depending upon the direction of motion of the two pistons 22 and 24. Although only two sheaves are shown, axle 36 could be formed to support several sheaves, and similarly a number of sheaves could be mounted on a suitably modified axle 38.

The upper end of cable 12 passes into the housing 18 and around the sheaves 32 and 34 in such a manner that as they are moved away from one another, the cable 12 is retracted up into the housing a distance equal to the piston stroke multiplied by the number of sheaves. Similarly, as the sheaves 22 and 24 are moved toward one another, the cable 12 is extended down from the housing 18.

The pneumatic system 16 includes a source of air under pressure 40 connected by a fluid line 42 to a pilot-operated regulator 44. Regulator 44 functions to maintain power chamber pressure at a constant value. The line pressure received by the regulator 44 from the source 40 typically ranges between 80 psi and 100 psi. The air in line 42 is passed through the regulator 44 to a line 46 for delivery to the power chamber 30. The regulator 44 reduces the air pressure from line pressure to a controlled balancing pressure that depends upon a suitable operator 48 which is controlled by the air pressure in a pilot line 50. Since power chamber pressure tends to vary with the motion of the piston 22, the regulator 44 automatically compensates for such motion. If the piston 22 is moved so as to enlarge the power chamber 30, the regulator 44 responds to the resulting pressure drop by supplying air from the source 40 to the power chamber. Conversely if the piston 22 is moved so as to compress the power chamber air, the regulator 44 responds to the resulting pressure increase by opening a relief passage 52 to the atmosphere and by closing the connection between the source 40 and the power chamber 30. The regulator 44 is a commercially available component and a typical unit is described in greater detail in my copending patent application Ser. No. 640, filed Jan. 5, 1970, now abandoned in favor of continuation Ser. No. 187,870. filed Oct. 8, 1971 and now U.S. Pat. No. 3,773,296 for "Pneumatic Balancing Hoist."

A remotely located pilot regulator 53 is adjusted to establish the control pressure in line 50, and is connected in a fluid control line 54 to receive line pressure from the source 40. The pilot regulator 53 is adjusted to reduce the line pressure to a control pressure that depends upon the weight of load 14.

Since the regulator 44 operates according to the air pressure in pilot line 50, the pressure in power chamber 30 can be changed by changing the pilot air pressure. For example, assuming the control pressure of the pilot air has been so adjusted by the regulator 53 that the power chamber pressure on the piston 22 balances the load 14 and the connecting cable components, then the load 14 can be suspended in a hoisted position. If then, the pilot air pressure is gradually reduced below the control pressure, the load 14 will overbalance the piston causing it to move to lower the cable 12.

A servo relief valve 56 is connected to the pneumatic system 16 to allow the operator to lower the load 14 by temporarily reducing pilot air pressure below the control pressure. The servo valve 56 is carried on the lower end of the cable 12. A short connecting cable 58, or a suitable hook, is carried by the valve 56 and is attached to the load 14 so that it is raised and lowered with the cable 12. A wire braided hose 60 connects the valve 56 to the pilot line 50.

Referring to FIG. 2, the servo valve 56 comprises what will be referred to as an upper valve unit 62, a lower valve unit 64 and a spring 66, however, it is to be understood that the relative positions of the valve units could be reversed when connected to the cable without affecting their pilot air venting function.

The upper valve unit 62 comprises a steel bolt 68 having a threaded rod 70. A connector 72 is mounted on the upper end of the rod, and has an eye 74 for receiving the looped end of the cable 12. A pin 76 prevents the connector 72 from being unthreaded from the rod 70. A knurled steel nut 78 is also threadably mounted on the rod 70 adjacent the connector 72. A lock screw 80 is carried by the nut 78 in contact with a brass pad 82 which engages the rod 70. The position of the nut 78 on the rod 70 can be adjusted by backing off the screw 80, turning the nut, and then tightening the screw 80 against the pad 82 to lock the nut in place. The bottom of the nut 78 has an annular seat 84. An annular seal 86 is cemented in the seat 84 so as to extend below the nut.

The lower valve unit 64 comprises an elongated hollow body 88 having an eye 90 for receiving the lower cable 58, and a bore 91 slidably receiving the rod 70. As best shown in FIG. 3, the upper end of the body 88 has an annular groove 92 facing the seal 86. A threaded relief valve port 94 adjacent the upper end of the body 88, is connected by three drilled passages 96 to the groove 92. A fitting 98 in the port 94 connects the lower end of the hose 60 to the body 88 for the passage of pilot air. Referring again to FIG. 2, the groove 92 forms an outlet for the port 94 when the seal 86 is disengaged from the body 88. The seal 86 engages the groove 92 to block air flow through the port 94 as the body 88 is moved toward the nut 78.

The spring 66 is mounted in the body 88 around the rod 70. The lower end of spring 66 is seated on a washer 100 to bias the body 88 toward the nut 78 and the servo valve 56 toward a closed position.

Considering the operation of the preferred balancing apparatus, the spring 66 is chosen to accommodate the weight of the load 14. When the load 14 is in a hoisted position, its weight applies a downward bias tending to open the relief port 94 through the orifices 96 and the groove 92 but the spring 66 is sufficiently strong to prevent separation of the body 88 and the nut 78 and keeps the port 94 closed. The port 94 remains closed until an additional downward effort, as by the operator, moves the body 88 away from the nut 78. The position of the nut 78 on the rod 70 is chosen to accommodate

the desired pilot air flow rate through the groove **92** and past the seal **86.**

As the port **94** of the servo valve **56** opens, pilot air is vented through the hose **60** to the atmosphere thereby reducing the air pressure in pilot line **50.** As the pilot pressure is reduced below control pressure, the power chamber responds by opening the relief passage **52** of the regulator **44** to the atmosphere. As the power chamber pressure is vented, the downward bias of the load together with the additional downward effort of the operator overbalances the piston **22** so that it moves to lower cable **12** from its housing. When the operator removes his downward effort, the servo relief valve **56** is automatically closed by the spring **66** thereby restoring the pressure of the pilot air to the control pressure established by the regulator **52.** The load **14** then remains suspended at its lowered height.

To raise the load from its suspended position, the operator applies an upward effort on the load **14.** The piston **22** is then temporarily overbalanced by the power chamber pressure and retracts the cable **12** up into its housing. As the piston **22** is moved away from the housing end **28,** the volume of the power chamber **30** increases and temporarily lowers the power chamber pressure. The regulator **44** responds by delivering air at line pressure to the power chamber **30** to maintain the power chamber air at the balancing pressure. When the operator releases the load it remains at its raised height, balanced by the power chamber pressure.

A variable orifice flow control valve **102** is connected in the control line **54** adjacent the pilot line **50** to control the manner in which the pilot-operated regulator **48** responds to a sudden opening of the servo valve **56.** The valve **102** provides an inherent time delay in the pneumatic system that obviates the possibility of the hoist lowering the load at an unsafe rate if the pilot air pressure should be suddenly changed.

A one-way check valve **104** is connected in the line **42** adjacent the inlet of the regulator **44.** The valve **104** is normally closed in the absence of line pressure from source **40,** but when open, passes air to the regulator **44.** This arrangement provides a fail-safe feature should the source **40** suddenly lose pressure when the load **14** is in a hoisted position. The valve **104** then automatically closes to trap the air in the power chamber **30** thereby preventing the load **14** from being dropped at an uncontrolled rate.

It is to be understood that I have described an improved pneumatic hoist system having a servo valve **56** carried on the hoisting cable such that the operator can manipulate a load of several hundred pounds with a slight effort. The preferred servo relief valve provides a positive means for reducing pilot air pressure because the valve opens and closes in response to the initial motion of the load by the operator instead of in response to the pressure of the air being vented.

FIG. **4** illustrates a modified balancing apparatus in which the pilot-operated regulator **44** has been replaced by a manually adjustable regulator or manostat **110.** The manostat **110** functions to maintain the power chamber air at a controlled balancing pressure. If the power chamber pressure is raised above the control pressure, a relief passage is opened to vent power chamber air to the atmosphere. If the power chamber pressure is reduced below the control pressure, the manostat **110** opens a connection to the source **40** to supply additional line air.

The manostat **110** is preferably a commercially available component that is connected in a novel manner to the servo relief valve **56.** The manostat **110** includes a body **112** having an inlet **114** connected by a conduit **116** to the source **40** for receiving air at line pressure. An outlet **118** provides a passage for supplying air received from the inlet **114** to a conduit **120** and the power chamber of the hoist **10.** A supply valve **122** is disposed between the inlet **114** and the outlet **118** to open a connection for passing air to the hoist **10.** A spring **124** biases the supply valve **122** toward its closed position.

The manostat body **112** has a control chamber **126** connected by a passage **128** to the outlet **118** to receive air at outlet pressure. An internal wall **130** forms one side of a pilot pressure chamber **132.** A spacer **134,** movably supported by diaphragms **136** and **138,** forms the opposite side of the chamber **132.** The position of the spacer **134** depends upon the differential in pressure of the outlet air and the air in the pilot pressure chamber **132.** The motion of the spacer **134** is caused by a change in such a differential.

The pilot pressure chamber **132** has an inlet **140** for receiving air from control chamber **126,** and an outlet **142** for passing pilot air to the hose **60.** A pilot valve **144** is disposed in the inlet **140** for controlling air flow into the chamber **132.** An aneroid **146** is disposed in the control chamber **126** for moving the pilot valve **144** between open and closed positions with respect to the inlet **140.** The aneroid **146** is a hollow pressure sensitive device supported by a threaded adjusting stem **148** that is mounted on the body **112.** A knob **150** is mounted on the stem **148** to position the pilot valve **144** relative to the inlet **140.** A passage **152** in the stem **148** connects the interior of the aneroid **146** with the atmosphere.

The aneroid **146** is so formed that it tends to collapse as the control chamber pressure reaches a certain value. As the aneroid **146** collapses, it moves the pilot valve **144** toward its closed position. Similarly, as the control chamber pressure is reduced, the pressure differential between the interior of the aneroid **146** and the control pressure causes the aneroid to expand and thereby move the pilot valve **144** to an open position. The pilot valve **144** thereby controls the passage of air into the pilot pressure chamber **132.**

It is apparent then that the servo relief valve **56** controls the passage of air out of the pilot pressure chamber **132** depending upon whether port **94** is open or closed. Consequently, the air pressure in pilot chamber **132** depends upon whether or not the servo relief valve **56** is venting pilot air. A safety valve means **152** provides another outlet for venting air from the pilot chamber **132.**

The spacer **134** also has a relief passage **154** for passing air from the outlet **118.** A relief valve **156** is carried at the upper end of the supply valve **122** for opening or closing the relief passage **154.** The spacer **134** is disposed such that as it is moved toward the supply valve **122,** the supply valve is moved toward its open position while the relief valve **156** closes the relief passage **154.** However, when the spacer **134** is moved in the opposite direction, it remains engaged with the relief valve **156** until the supply valve has been seated in its closed position. Continued motion of the spacer **134** then opens

the relief passage **154.** Thus the relief passage **154** is only opened when the connection between the inlet **114** and the outlet **118** is closed.

The operation of manostat **110** is as follows. Assume the servo valve **56,** the supply valve **122** and the relief valve **156** are each closed, that the aneroid **146** has been adjusted such that the power chamber pressure balances the load **14,** and that the air pressure in the outlet **118** corresponds to the power chamber pressure. With the load **14** balanced in a suspended position, air pressure in pilot chamber **132** equals outlet pressure to maintain the spacer **134** in a balanced position. As the operator applies a downward effort on the load **14** to open the servo valve **56,** the pressure in the pilot chamber **132** begins to drop below the outlet pressure. The spacer **134** is then in an unbalanced position and starts to move away from the relief valve **156.** As the relief passage **154** is opened, the outlet air vents to the atmosphere thereby reducing the outlet pressure. The resulting reduction in outlet and power chamber pressure allows the operator to continue to lower the load **14** to a different height.

When the operator releases the load **14,** the servo valve **56** closes and the spacer **134** returns to its balanced position as the power chamber pressure is restored to the balancing pressure to balance the load. When the operator raises the load **14,** the resulting increase in outlet pressure also creates a pressure differential across the spacer **134** that moves it to open the relief passage **154.** As the operator removes his upward effort, the spacer **134** closes the relief passage **154** as the outlet pressure drops to the controlled balancing pressure.

Thus it can be seen that manostat **110** is responsive to the outlet pressure as the load **14** is being raised, and responsive to the pressure in pilot chamber **132** as the load is being lowered by the operator. The operator can easily and manually adjust the height of the load **14** even though it weighs several hundred pounds because of the manner in which the manostat **110** responds to the initial vertical adjustment of the load.

A check valve **160** is disposed in the conduit **116** at the outlet of the source **40.** The valve **160** closes at a high flow rate that is above normal operating flow. An air-operated safety valve **162** is disposed in conduit **120** and connected by a line **164** to the conduit **116** to automatically close and trap the power chamber air when the line pressure from the source **40** is reduced below a normal level. The valve **162** provides a safety feature by preventing the load **14** from being dropped from a hoisted position when the source pressure is suddenly dropped.

Having described my invention, I claim:

1. In a pneumatic hoist for raising and lowering a load including a pneumatic device having a fluid power chamber and a piston movably disposed within the power chamber, a hoisting cable connected to the piston to be raised and lowered according to movement of said piston, a source of air under pressure and regulator means for connecting the source to the power chamber to urge movement of the piston in a direction shortening the cable, valve means carried by the cable so as to be raised and lowered with it, said valve means having a fluid port connected to the regulator means and being operable to open said port to change fluid pressure in the power chamber as the valve means is moved from a closed position toward an open position, means connecting the load to the valve means to move said valve means from said closed position toward said open position as the load is manually lowered from a hoisted position, said valve means comprising an elongated housing member, said port formed in said housing member and connected with the outlet of said regulator means, a passage connected with said port and extending through said housing member to one end thereof, said passage being parallel to and spaced from the axis of said elongated housing member, said passage connecting said port to an annular recess formed in the end of said housing member, a valve closure member mounted to said housing member and including a seal member fixed to said valve closure member, said valve closure member and said seal member adapted for relative movement toward and away from said annular recess, whereby said seal member is moved into and out of said annular recess upon separation of said valve closure member and said housing member to thereby open and close said port for the passage of air from said regulator means through said valve means to atmosphere and a spring carried by said housing member and urging said housing member and said valve closure member toward a position closing said annular recess.

2. A hoist as defined in claim **1** and in which the pneumatic device comprises an elongated cylindrical housing, said piston being slidably disposed in said elongated cylindrical housing, and including a sheave mounted in said last mentioned housing so as to be rotated by the cable as the piston is being moved.

3. A hoist as defined in claim **1** and in which the regulator means is a pilot operated valve comprising: means defining an inlet for receiving air from said source of air under pressure, means defining an outlet communicating through said pilot operated valve with said inlet, said outlet operatively communicating with the fluid power chamber of the pneumatic device to provide pressurized air thereto, means defining a control chamber, means defining a passage connecting said control chamber to said outlet so that outlet pressure is communicated to said control chamber, means defining a pilot chamber having a passage to the atmosphere, a wall disposed between said control chamber and said pilot chamber having an opening which connects said control chamber to said pilot chamber, a hollow pressure-sensitive aneroid housed in said control chamber having its hollow interior operatively connected to said source of air under pressure between said source of air and said power chamber so that the interior of said aneroid is subjected to said air pressure from said source and the outer surface of said aneroid is exposed to the outlet pressure in said control chamber so that said aneroid expands and contracts in response to a differential pressure between the outlet pressure in said control chamber and the air pressure in the interior of said aneroid, said inlet of said pilot operated regulator valve being operatively connected to the source of air under pressure, a valve operatively connected to the outer surface of said aneroid, said valve being disposed in said wall between said control chamber and said pilot chamber to control the communication between said control chamber and said pilot chamber to close said opening in said wall when said aneroid expands due to a relative increase in internal pressure, and to open said opening when said aneroid contracts due to a relative increase in pressure on its outer surface, a spacer forming a movable wall between said outlet and said wall,

said pilot chamber being defined by said spacer and said wall, said spacer having a relief passage connected to the atmosphere, a valve disposed in said relief passage to control the opening and closing of said relief passage, a valve disposed between said inlet and said outlet to close and open communication therebetween so that when the outlet pressure is less than either the pilot pressure or the inlet pressure the air pressure in said control chamber is equal to the outlet pressure causing said aneroid to open said valve disposed in said opening in said wall between said control chamber and said pilot chamber, and as the outlet pressure increases the pressure in said control chamber increases to a value greater than the air pressure interior to said aneroid causing said aneroid to contract closing said valve in said opening in said wall between said control chamber and said pilot chamber, said fluid port of said valve means being connected to the hollow interior of said aneroid.

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