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PISTON LOCKING MEANS

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2 Sheets-Sheet 1

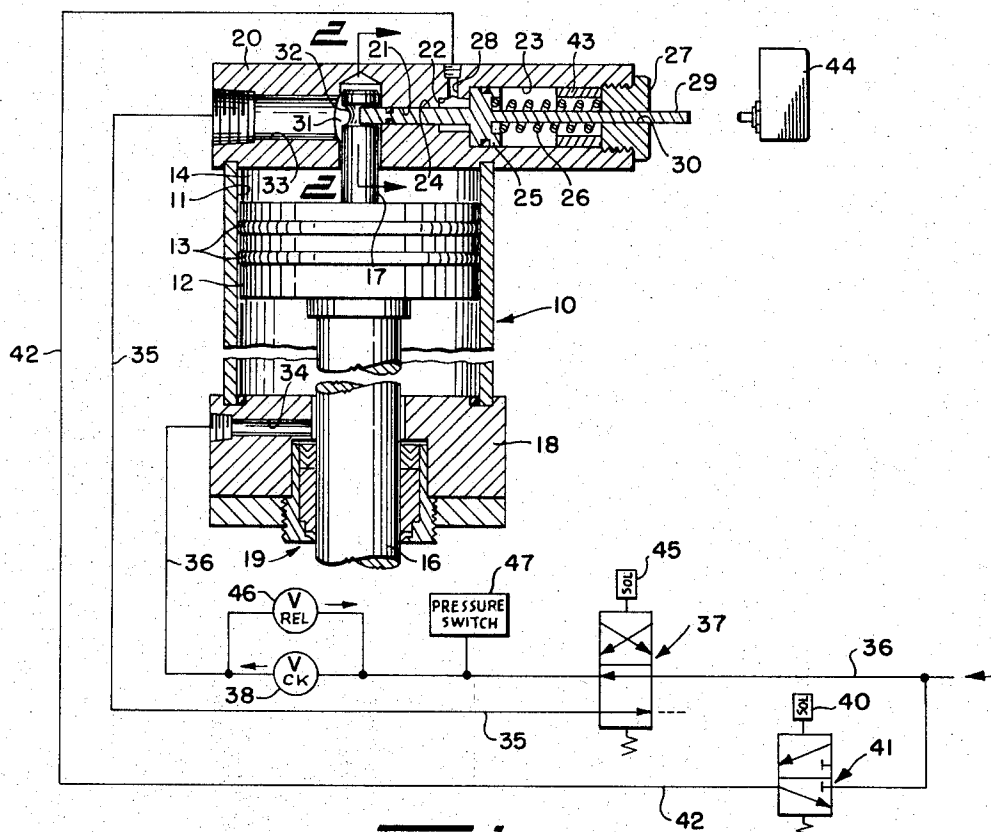


FIG. 1

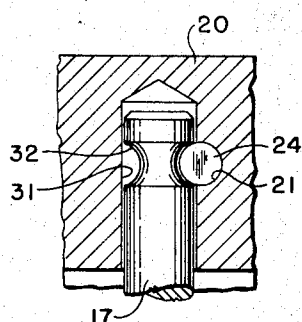


FIG. 2

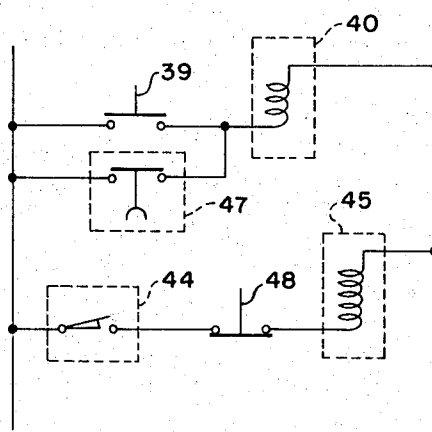


FIG. 3

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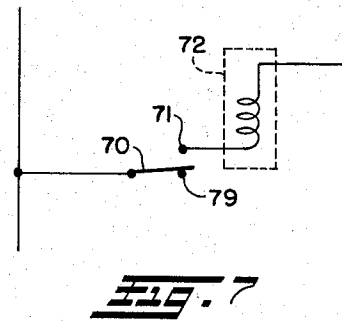
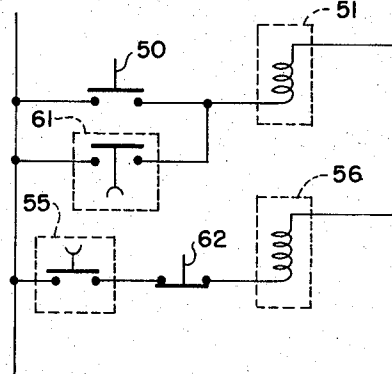
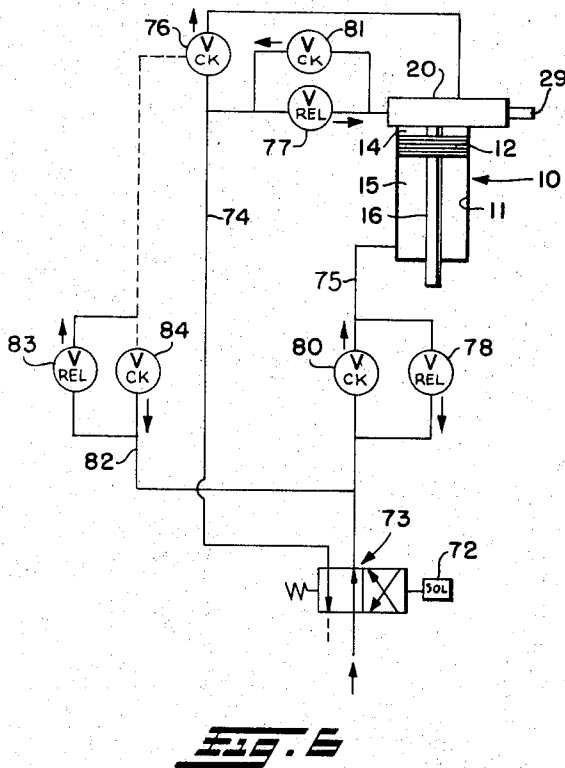
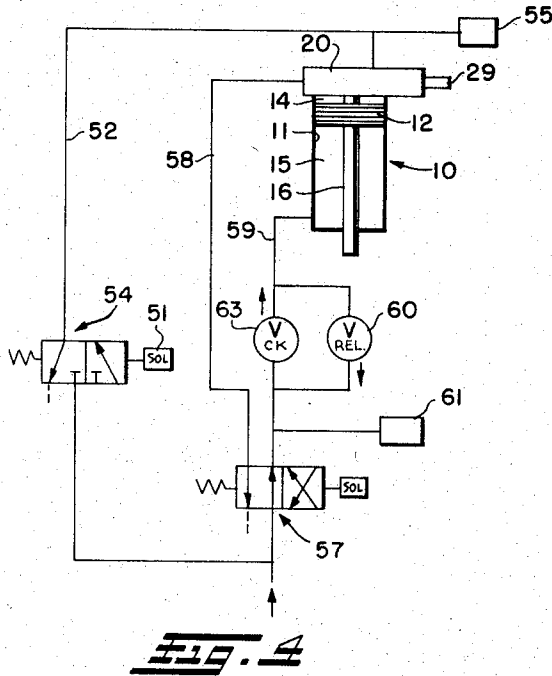
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PISTON LOCKING MEANS

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This invention relates to a locking device and, more particularly, to a device for locking a piston relative to its cylinder.

In many applications it is necessary to provide a fluid-operated cylinder with a locking means to insure that the piston will remain in its retracted position in the event there is a sudden drop in the fluid pressure which holds the piston in that position. For example, in aluminum smelting operations, it is frequently necessary to suspend a fluid-operated cylinder having a mechanical element, such as a crust breaker, over the surface of the molten metal to perform certain operations during the smelting process. When such operations are not being performed, the piston and its attached mechanical element are held in a retracted position by fluid pressure applied to the rod end of the cylinder. If this fluid pressure should fail, the piston would advance and drop its mechanical element into the bath of molten metal, thereby creating a hazardous splashing condition.

It is, therefore, a principal object of the present invention to provide a locking device for a fluid-actuated cylinder which will positively lock the piston in a predetermined position with the cylinder and which will permit the evacuation of the fluid holding the piston in its retracted position only in response to the disengagement of the locking mechanism from the piston. According to this invention, means are provided to retain the locking mechanism in its released or unlocked condition until the piston is once again retracted by fluid pressure and which will once again lock the piston after the retracting pressure attains a predetermined value which is at least sufficient to move the piston to a preselected retracted position within the cylinder.

These and other objects and advantages of the invention will be apparent from the following description and drawings, in which:

FIG. 1 is a partly schematic, fragmentary, cross sectional view of a fluid cylinder and its fluid circuit according to one aspect of the invention;

FIG. 2 is a fragmentary, cross sectional view, the plane of the section being indicated by the line 2-2 in FIG. 1;

FIG. 3 is a schematic illustration of an electrical control circuit which may be employed to operate the device illustrated in FIG. 1;

FIG. 4 is a schematic illustration of a fluid cylinder and its fluid circuit according to a further aspect of this invention;

FIG. 5 is a schematic illustration of an electrical circuit which may be employed to operate the device illustrated in FIG. 4;

FIG. 6 is a schematic illustration of a fluid cylinder and its fluid circuit according to a still further aspect of this invention; and

FIG. 7 is a schematic illustration of an electrical circuit which may be employed to operate the device shown in FIG. 6.

Referring now to the drawings, and particularly to FIGS. 1, 2, and 3, a fluid-operated cylinder 10 is illustrated. The cylinder 10 comprises a cylindrical chamber 11 wherein which a piston head 12 is slidably mounted. The piston head 12 is provided with circumferential sealing rings 13, and the piston head divides the chamber 11 into first and second pressure chambers 14 and 15 respec-

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tively. The piston head 12 is further provided with a piston rod 16 which extends from one of its faces and a locking rod 17 which extends from its other face. The lower end of the chamber 11 is closed by a block 18, and the piston rod 16 is slidably received in a sealing sleeve assembly 19 which is provided in the block 18.

The chamber 11 is closed at its upper end by a block 20 and the blocks 18 and 20 may be tied together by tie rods (not shown). The block 20 is provided with a bore 21 and, extending inwardly from one end thereof, with a first counterbore 22 and a second counterbore 23. A piston rod 24 is slidably received in the bore 21 and projects axially from a piston head 25 which is slidably received in the second counterbore 23. The piston head 25 is biased to the left by a spring 26 which extends between the piston head 25 and a plug 27 which is threaded into the second counterbore 23. A fluid port 28 is drilled into the block 20 so that it communicates with the first counterbore 22. The piston head 25 is provided with a stem 29 which extends through an axial bore 30 in the plug 27. There is provided a loose sliding fit between the stem 29 and the surrounding bore 30.

When the piston head 25 is urged to the position shown in FIG. 1, the stroke of the piston head 25 is limited by a shoulder formed between the first counterbore 22 and the second counterbore 23. In this position, the piston rod 24 extends through the bore 21 and into a transverse bore 31. As may be seen most clearly in FIG. 2, the axis of the bore 21 is substantially tangent to the bore 31 so that only an approximately semi-cylindrical portion of the piston rod 24 is exposed to the bore 31. When the rod 24 is in the position illustrated in FIG. 1, it engages a portion of a circumferential groove 32 on the rod 17 to mechanically lock the rod 17, the piston head 12, and the piston rod 16 in their retracted positions. The semi-cylindrical engagement of the rod 17 by the piston rod 24 provides a rigid mechanical link between these elements since at least one of these elements must be sheared if the link is to part by mechanical failure.

A port 33 is drilled into the block 20 and communicates with the first pressure chamber 14 through the bore 31. A port 34 is provided in the block 18 and the port 34 communicates with the second pressure chamber 15. A first fluid pressure conduit 35 is connected to the port 33 and a second fluid pressure conduit 36 is connected to the port 34.

In the position shown in FIG. 1, fluid pressure is applied to the second pressure chamber 15 from a source of fluid pressure through a reversing valve 37, a one-way check valve 38, and through the port 34. The fluid in the first pressure chamber 14 is exhausted to the atmosphere or to a reservoir through the port 33, the conduit 35, and the valve 37.

The piston head 12 may be advanced downwardly by unlocking the piston head and applying fluid pressure to the first pressure chamber 14 while exhausting fluid from the second pressure chamber 15. To accomplish this objective, a switch 39 is manually and momentarily closed (FIG. 3). Closure of the switch 39 energizes a solenoid 40 which reverses a valve 41 from the position shown in FIG. 1. The reversal of the valve 41 connects a conduit 42 to the source of fluid pressure and applies the fluid pressure to a chamber formed by the first counterbore 22. The pressure in the counterbore 22 drives the piston 25 to the right against the bias of the spring 26 until the piston head 25 abuts a sleeve 43 which is press-fitted into the second counterbore 23. The retraction of the piston head 25 retracts the rod 24 from the bore 31 to thereby unlock the rod 17. Air, which otherwise would be trapped behind the piston 25, is exhausted through the clearance which is provided between the bore 30 and the stem 29. The re-

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traction of the piston 25 drives the rod 29 to the right and, when the piston 25 is in its fully retracted position against the sleeve 43, the rod 29 operates a limit switch 44.

Referring once again to FIG. 3, when the limit switch 44 is closed in the previously described manner, a solenoid 45 is energized. The solenoid 45 reverses the valve 37 from the position illustrated in FIG. 1 to thereby supply fluid to the first fluid pressure chamber 14 and, simultaneously, exhaust fluid from the second pressure chamber 15. The piston rod is therefore driven downwardly. The downward stroke of the piston rod 16 may be cushioned by passage of the exhausted fluid through a relief valve 46 which is provided in a line by-passing the check valve 38.

Since the switch 39, which may be spring-biased to an open position, is closed only momentarily, means are provided to ensure that the solenoid 40 will remain energized in order to ensure that the piston rod 24 will remain in its retracted position. To this end, there is provided a pressure switch 47 in the conduit 36. The pressure switch 47 remains open so long as there is a predetermined pressure in the second pressure chamber 15 and, therefore, the conduit 36. After the solenoid 45 has been operated in the previously described manner, however, this predetermined pressure in the second pressure chamber 15 is relieved to close the pressure switch 47 and thereby hold the solenoid 40 in the circuit.

The piston head 12 may be raised by opening a manual switch 48 to thereby de-energize the solenoid 45. When the solenoid 45 is de-energized, the valve 37 returns to the position illustrated in FIG. 1, and pressure is applied to the second pressure chamber 15 and exhausted from the first pressure chamber 14. When the pin 17 has been driven into the bore 31, the pressure in the second pressure chamber increases to thereby open the pressure switch 47. When the switch 47 is opened, the solenoid 40 is de-energized to return the valve 41 to the position illustrated in FIG. 1, and the fluid pressure is exhausted from the first counterbore 22, permitting the spring 26 to drive the piston rod 24 into the bore 31, thereby locking the rod 17.

In order to fully retract the piston head 12, the switch 48, which may be spring-biased to a closed position, must be held open until the piston rod 24 enters the bore 31. When the piston head 25 is driven to the left by the spring 26 and the rod 29 opens the limit switch 44, however, the solenoid 45 will remain de-energized even though the switch 48 is then released and permitted to close.

The cylinder 10 may be provided with conventional cushioning means at its ends to decelerate the piston head 12 as it approaches the limits of its stroke. Such cushioning means may provide a positive stop for the piston head 12 when the rod 17 reaches its predetermined locking position in the bore 31.

Referring now to FIGS. 4 and 5, the fluid-operated cylinder 10 is illustrated schematically. It is to be understood that the cylinder 10 corresponds precisely to the cylinder illustrated in greater detail in FIGS. 1 and 2. The fluid cylinder 10 is illustrated with its piston head 12 and, therefore, the piston rod 16, in their retracted and locked positions within the chamber 11. The piston head 12 may be unlocked and lowered by closing a manually operated switch 50 (FIG. 5). When the switch 50 is closed, a solenoid 51 is energized to reverse a valve 54 from the position illustrated in FIG. 4. The reversal of the valve 54 connects a fluid conduit 52 to a source of fluid pressure to thereby pressurize the chamber formed by the first counterbore 22 to drive the piston head 25 to the right and unlock the rod 17. When the conduit 52 is connected to the source of fluid pressure, a pressure switch 55 is closed. The closure of the switch 55 energizes a solenoid 56 to reverse a valve 57 from its position illustrated in FIG. 4. The reversal of the valve 57 connects the first pressure chamber 14 to the source of fluid pressure through a conduit 58 and connects the second pressure chamber 15 to an exhaust port through a conduit

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59 and a relief valve 60. The relief valve 60 tends to cushion the downward stroke of the piston head 12 and its piston rod 16. When the conduit 59 is exhausted, a pressure switch 61 is closed to prevent the solenoid 51 from dropping out of the circuit when the switch 50 is released.

The piston head 12 and its rod 16 may be raised by opening a manually operated switch 62 to thereby de-energize the solenoid 56. When the solenoid 56 is de-energized, the valve 57 returns to the position illustrated in FIG. 4 to thereby connect the second pressure chamber 15 to the source of fluid pressure through the conduit 59 and through a one-way check valve 63. The valve 57 also connects the first pressure chamber 14 to exhaust to thereby drive the piston head 12 and its piston rod 16 upwardly. During the upward travel of the piston head 12 and its rod 16, the manually operated switch 62 must be held in its open position until the piston head 12 drives the rod 17 into the bore 31. When the rod 17 is driven into its bore 31 and the pressure in the second pressure chamber 15 reaches a predetermined value, the pressure switch 61 is opened to thereby de-energize the solenoid 51. When the solenoid 51 is de-energized, the valve 54 returns to the position illustrated in FIG. 4 to thereby exhaust the conduit 52 and the first counterbore 22 to spring 26 to drive the piston head 25 to the left so that the rod 24 enters the bore 31 to lock the rod 17 in its raised position. The pressure drop in the conduit 52 opens the pressure switch 55 to ensure that the solenoid 56 will remain de-energized when the manually operated switch 62 is released.

Referring now to FIGS. 6 and 7, a cylinder control circuit according to a further aspect of this invention is illustrated. In FIG. 6, a fluid-operated cylinder 10 is shown only schematically but may be identical to the cylinder 10 shown in greater detail in FIGS. 1 and 2. The cylinder 10 is shown in FIG. 6 in a raised and locked condition. To lower the piston head 12 and its piston rod 16, a manually operated toggle switch is closed against a contact 71. When the switch 70 engages the contact 71, a solenoid 72 is energized. When the solenoid 72 is energized, a valve 73 is reversed from the position illustrated in FIG. 6 to connect a fluid conduit 74 to a source of fluid pressure and to connect a conduit 75 to an exhaust port. When the conduit 74 is pressurized, fluid pressure is immediately transmitted through a one-way, pilot-operated check valve 76 to the first counterbore 22 to thereby release the rod 24 from its locking position within the bore 31. When the pressure in the conduit 74 reaches a value which is sufficient to overcome a relief valve 77, fluid pressure is applied to the first pressure chamber 14 while, simultaneously, fluid is exhausted from the second pressure chamber 15. It should be appreciated that the rod 24 is retracted from the bore 31 prior to the application of fluid pressure to the first pressure chamber 14, since fluid pressure is applied to the first counterbore 22 prior to the time that the fluid pressure in the conduit 74 overcomes the relief valve 77. The piston head 12 is thereupon driven downwardly and the fluid in the second pressure chamber 15 is exhausted through the conduit 75 through a relief valve 78 and to an exhaust port.

The piston head 12 and its rod 16 may be driven upwardly by reversing the position of the switch 70 to an open contact 79 to thereby de-energize the solenoid 72. When the solenoid 72 is de-energized, the valve 73 is returned to the position illustrated in FIG. 6. The conduit 75 is then connected to the source of fluid pressure through a one-way check valve 80 to apply fluid pressure to the second pressure chamber 15. The fluid pressure in the first pressure chamber 14 is exhausted through a one-way check valve 81 and the conduit 74 to an exhaust port. Fluid is trapped in the first counterbore 22 by the pilot check valve 76, and the rod 24 is held in its retracted position. When the rod 17 reaches its locking position within the bore 31, the fluid pressure in the conduit 75 in-

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creases and this pressure is transmitted through a conduit 82 and a relief valve 83, to the pilot-operated check valve 76 to thereby open the check valve 36 and permit the fluid in the first counterbore 22 to be exhausted through the conduit 74. The spring 26 drives the rod 24 to the left to lock the rod 17 in its retracted position. The fluid pressure holding the one-way check valve open is relieved through a check valve 84 and the conduit 82 when the conduit 75 is connected to the exhaust port by once again lowering the piston head 12 and its piston rod 16.

Many additional modifications and variations of the invention will be apparent to those skilled in the art in view of the foregoing detailed disclosure. Therefore, it is to be understood that, within the scope of the appended claims, the invention may be practiced otherwise than as specifically shown and described.

What is claimed is:

1. A fluid-operated cylinder having a piston slidably mounted therein for movement between first and second positions within said cylinder, said piston dividing said cylinder into first and second pressure chambers, first and second conduit means respectively connected to and in fluid communication with said first and second pressure chambers, connecting means for selectively and alternately connecting said first and second conduits to a pressure line and an exhaust port so that when one of said conduits is connected to the pressure line, the other conduit is connected to the exhaust port, means operative to lock the piston in a preselected position within the cylinder, means for operating said locking means alternately into and out of locking relationship with said piston, said connecting means including means operable only after the locking means has been operated to unlock the piston for connecting the first pressure chamber to the pressure line and the second pressure chamber to the exhaust port to move the piston away from the locking means, means to retain the locking means in its unlocked condition, means to operate said connecting means so that the connecting means connects the second pressure chamber to the pressure line and the first chamber to the exhaust port to move said piston toward said locking means, means responsive to a preselected pressure increase in said second chamber to release said retaining means and to cause the locking means to operate into locking relationship with the piston, said preselected pressure being at least sufficient to move the piston to said preselected position within the cylinder.

2. A fluid-operated cylinder having a piston slidably mounted therein for movement between first and second positions within said cylinder, said piston dividing said cylinder into first and second pressure chambers, first and second conduit means respectively connected to and in fluid communication with said first and second pressure chambers, valve means for selectively and alternately connecting said first and second conduits to a pressure line and an exhaust port so that when one of said conduits is connected to the pressure line the other conduit is connected to the exhaust port, means operative to lock the piston at a preselected position within the cylinder, means for operating said locking means alternately into and out of locking relationship with said piston, said valve including means operable only in response to the disengagement of the locking means from the piston for connecting the first pressure chamber to the pressure line and the second pressure chamber to the exhaust port and to move the piston away from the locking means, means to retain the locking means in its unlocked condition, means to operate said valve so that the valve connects the second pressure chamber to the pressure line and the first chamber to the exhaust port to move said piston toward said locking means, means responsive to a preselected pressure increase in said second chamber to release said retaining means and to cause the locking means to operate into locking relationship with the piston, said preselected pressure being at least sufficient to move the piston to said preselected position within the cylinder.

3. A fluid-operated cylinder having a piston slidably mounted therein for movement between first and second positions within said cylinder, said piston dividing said cylinder into first and second pressure chambers, first and second conduit means respectively connected to and in fluid communication with said first and second pressure chambers, a first valve for selectively and alternately connecting said first and second conduits to a source of fluid pressure and an exhaust port so that when one of said conduits is connected to the source of fluid pressure the other conduit is connected to the exhaust port, a plunger slidably mounted in a bore for movement into and out of locking relationship with said piston to lock the piston at a preselected position within the cylinder, spring means mounted in said bore at one side of the plunger and urging said plunger into locking relationship with said piston, third conduit means connected to the bore at the other side of the plunger to admit fluid pressure to said bore to urge said plunger out of locking relationship with said piston, second valve means for selectively and alternately connecting said conduit means to the source of fluid pressure and an exhaust port, means to operate said second valve to connect the third conduit to the source of fluid pressure and to thereby release said locking means, means responsive to the release of the locking means from the piston to operate said first valve means so that the first valve means connects the first pressure chamber to the pressure line and the second chamber to the exhaust port to move the piston away from the locking means, means responsive to a predetermined pressure drop in said second chamber to retain the locking means in its unlocked condition, means to operate said first valve so that the first valve connects the second pressure chamber to the pressure line and the first chamber to the exhaust port to move said piston toward said locking means, means responsive to a preselected pressure increase in said second chamber to release said retaining means and operate said urging means to urge the locking means into locking relationship with the piston, said preselected pressure being at least sufficient to move the piston to said preselected position within the cylinder.

4. The cylinder according to claim 3 wherein said first valve is operated by a solenoid and connects the first pressure chamber to the source of fluid pressure and connects the second pressure chamber to the exhaust port when the solenoid is energized and wherein the means responsive to the release of the locking means comprises a limit switch which is closed by said locking means to connect said solenoid to a source of electrical energy.

5. The cylinder according to claim 3 wherein said first valve is operated by a solenoid and connects the first pressure chamber to the source of fluid pressure and connects the second pressure chamber to the exhaust port when the solenoid is energized and wherein the means responsive to the release of the locking means comprises a pressure switch which is closed in response to an increase in pressure in said bore to connect said solenoid to a source of electrical energy.

6. The cylinder according to claim 1 wherein said connecting means includes a pressure relief valve which opens only after the locking means has been operated to unlock the piston to admit fluid pressure to said first pressure chamber.

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