

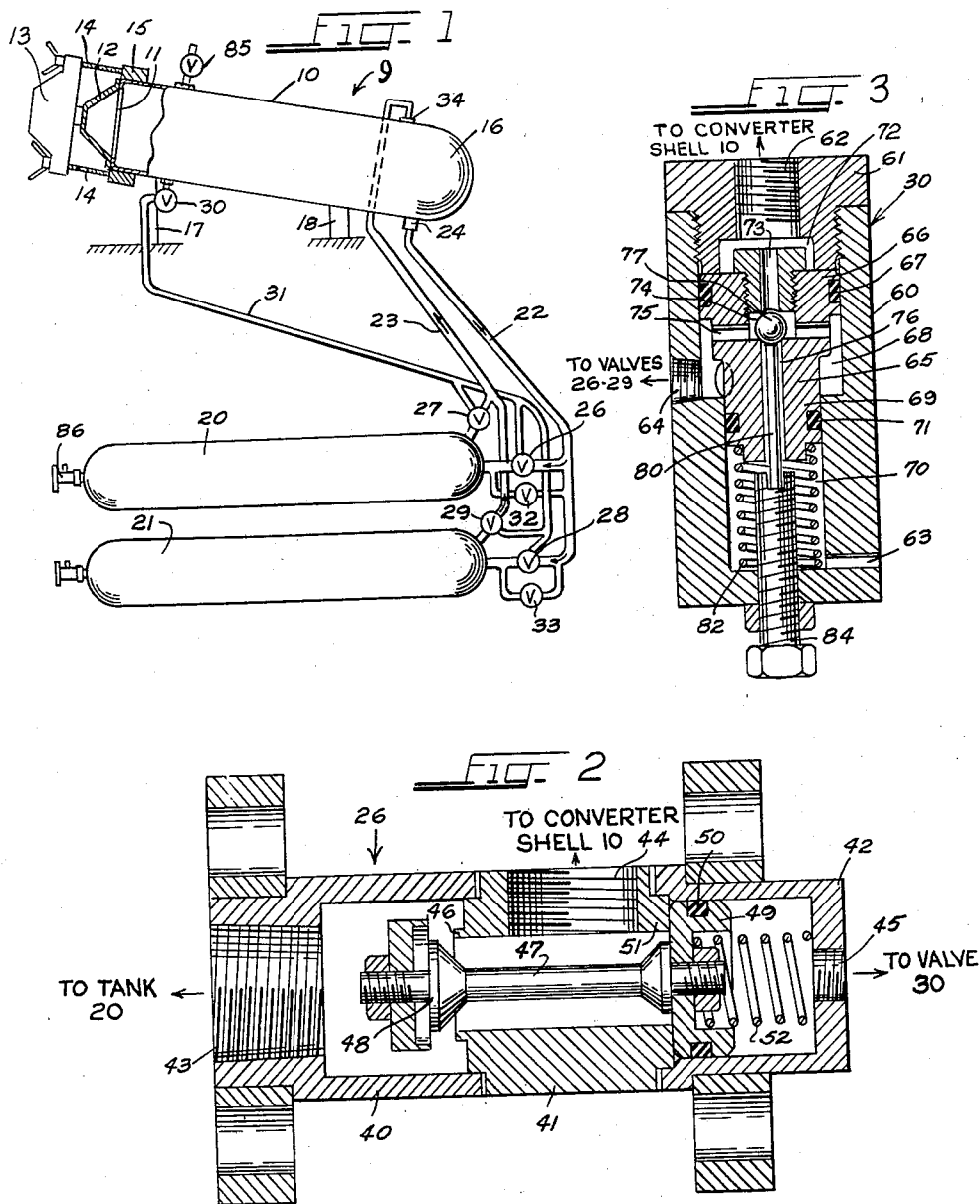
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CONTROL APPARATUS

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CONTROL APPARATUS

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6 Claims. (Cl. 137—102)

This invention relates to a new and improved snap-action control device which may be employed as a part of a system for converting materials from solid to fluid phase. This application is a division of application Serial No. 657,772, filed May 8, 1957.

Some materials which are ordinarily utilized in their gaseous or liquid state in commercial, industrial, and other processing are most conveniently transported in their solid state. The most important of these materials, from an economic standpoint, is carbon dioxide. Inasmuch as transportation costs are very much less if carbon dioxide is transported in its solid form, sometimes referred to colloquially as "Dry Ice," rather than in its gaseous form, it is customary to ship the carbon dioxide in solid phase and to convert it to fluid phase at the location where it is to be utilized.

One form of a converter for carbon dioxide or like material comprises a low pressure container for receiving a charge of solid material and a high pressure fluid storage tank. A pair of conduits interconnect the low pressure container and the storage tank, one of these conduits being adapted to drain liquid material from the low pressure container into the storage tank. A pair of valves are interposed in these conduits, these valves being actuable from a normal open condition to a closed condition. The converter further includes means for actuating the valves from open condition to closed condition in response to an increase in pressure within the low pressure container to a predetermined threshold value effectively exceeding the triple-point pressure of the material being stored.

Operation of the converter apparatus is dependent to some extent upon the pressure developed within the converter system. For most efficient operation, and to prevent loss of more than a very minor portion of the converted material, it is highly desirable that the low pressure container be cut off from the storage tank or tanks of the system as soon as all of the material has been changed to fluid phase. Otherwise, a substantial portion of the material may be left in the low pressure container and is lost when the container is subsequently open to receive the next charge of solid material. Conventional pressure-sensitive valves are not particularly well suited for the control of the converter, since they tend to close gradually with increases in pressure.

It is therefore a primary object of the invention to construct a new and improved snap-action control device which acts rapidly to effect a control operation when subjected to pressures above a predetermined threshold value.

Another object of the invention is to construct a new and improved snap-action control device which remains essentially unaffected by pressures up to a given threshold value but which changes its operating condition virtually instantaneously when subjected to a pressure above that value.

A corollary object of the invention is a snap-action pressure responsive control device which is simple and

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economical in construction yet which affords a positive and rapid control action.

A snap-action control device constructed in accordance with this invention comprises a cylinder having a pressure port and a vent port. A piston is disposed within the cylinder and defines therewith three separate chambers; these chambers include a pressure chamber opening into the pressure port, a vent chamber opening into the vent port, and a transition chamber which is interconnected with the pressure and vent chambers by fluid passageways extending through the piston. The piston is movable from a normal position through an intermediate position toward an actuated or control position in response to an increase in fluid pressure in the pressure chamber. A valve closure member is disposed within the fluid passageways of the piston. The valve closure member is actuatable between a normal position in which the transition chamber is connected to one of the vent and pressure chambers and is sealed off from the other and an actuated position in which the transition chamber connections are reversed. The control device further includes means for actuating the valve closure member toward its actuated position in response to movement of the piston to its intermediate position to increase the effective piston area of the vent chamber and thereby accelerate movement of the piston toward its second operating position when the pressure within the pressure chamber reaches a given threshold value. And to incorporate the foregoing structural features in a novel snap-action control device so as to function in the manner described is yet another object of this invention.

Other and further objects of the present invention will be apparent from the following description and claims and are illustrated in the accompanying drawing which, by way of illustration, shows a preferred embodiment of the present invention and the principles thereof and what is now considered to be the best mode for applying those principles. Other embodiments of the invention embodying the same or equivalent principles may be used and structural changes may be made as desired by those skilled in the art without departing from the present invention and the purview of the appended claims.

In the drawings:

Fig. 1 is a simplified elevation view, partly schematic, of a solid-to-fluid converter;

Fig. 2 is a cross sectional view of one type of control valve which may be employed in the converter illustrated in Fig. 1; and

Fig. 3 is a sectional view of a snap-action control device constructed in accordance with one embodiment of this invention and which may be utilized to control the operation of the valve illustrated in Fig. 2.

In Fig. 1 there is illustrated a converter 9 for carbon dioxide or like materials. The converter 9 comprises a low pressure container or converter shell 10 having a relatively large opening 11 at one end to permit introduction of a charge of solid carbon dioxide thereinto. The open end 11 of the converter shell is closed by a lid 12 which is releasably sealed to the converter shell by suitable means such as a clamping member 13 and a plurality of clamp bolts 14 which extend from the member 13 and are threaded into a collar or other bearing portion 15 of the low pressure container. As indicated in Fig. 1, the converter shell 10 is preferably mounted at an angle such that the end 16 of the shell opposite opening 11 is somewhat lower than the opening. In the illustrated embodiment, the converter shell is supported upon a pair of brackets 17 and 18 and is inclined only at a slight angle from the horizontal; this angle is not critical, however, as is explained more fully hereinafter.

The converter apparatus further includes at least one high pressure fluid storage tank; in the embodiment of

Fig. 1, two such storage tanks 20 and 21 are provided. A pair of conduits 22 and 23 interconnect the low pressure container 10 with the storage tank 20 and, in the illustrated multi-tank storage arrangement, with the additional storage tank 21. The conduit 22 is positioned to drain liquid material from the low pressure container 10 to the storage tanks, the inlet opening 24 for this conduit being located at the bottom of the lower end 16 of the low pressure container.

A pair of valves 26 and 27 are interposed in the conduits 22 and 23 respectively between the converter shell 10 and the first storage tank 20. Similarly, a pair of valves 28 and 29 are interposed in the conduits 22 and 23 between the low pressure container and the high pressure storage tank 21. Each of the valves 26-29 is actuatable from a normal open condition to a closed condition, as is explained more fully hereinafter. The converter system of Fig. 1 further includes a means for actuating each of the valves 26-29 from its normal open condition to its closed condition in response to an increase in pressure within the converter shell 10 to a predetermined threshold value. This means comprises a pressure-responsive snap-action control valve 30 which is connected by a conduit 31 to each of the valves 26-29. The embodiment of Fig. 1 also includes a bleeder valve 32 which is connected in the system in parallel with the valve 26 and a similar bleeder valve 33 which may be employed to bypass the valve 28.

In the use of the converter 9 the solid material to be converted is deposited in the low-pressure converter shell 10. The converter shell is then sealed by closing the lid 12 and clamping the lid in place by means of the clamping member 13 and the clamp bolts 14. The carbon dioxide or other like material begins to sublime and to melt; usually both of these actions take place at the same time. The melted carbon dioxide is drained into a second container, which in this instance may constitute the storage tank 20. The melted material also tends to vaporize within the tank 20.

It is essential that both of the containers 10 and 20 be maintained approximately at the triple-point pressure and temperature of the material being stored during the conversion operation in order that most of the material may be melted and deposited in the storage tank 20 in liquid form. Consequently, vaporized carbon dioxide is continuously drained from the second container or storage tank 20 to refrigerate that container and maintain both of the containers 10 and 20 at the triple-point pressure and temperature. In the apparatus illustrated in Fig. 1 this is accomplished by draining the vaporized carbon dioxide from the tank 20 through the conduit 23. To avoid loss of this vaporized carbon dioxide, it is preferably returned to the first container 10 and condensed upon the solid carbon dioxide remaining in the converter shell. For this purpose, the outlet opening 34 for the conduit 23 is preferably located immediately adjacent the inlet opening 24 for the conduit 22.

The conversion process continues, without mechanical pumping or other application of external pressure to the system, until all of the solid carbon dioxide has melted. When this has been accomplished, virtually all of the carbon dioxide is deposited in the tank 20 in liquid form, although a certain minor portion is present in the tank and the remainder of the system in vapor phase. This being the case, it is no longer possible to maintain the system at the triple-point pressure and temperature without external refrigeration. Consequently, the liquid material in the tank 20 continues to vaporize and the internal pressure of the converter increases substantially. As soon as the pressure increases to an extent sufficient to afford a positive indication that the conversion process has been completed, it is desirable that the storage tank 20 be sealed off from the container 10 by closing valves 26 and 27, leaving the major portion of the carbon dioxide stored in the tank 20 in fluid phase. Eventually, continued

vaporization of the liquid portion of the fluid carbon dioxide in tank 20 may raise the internal pressure of that tank to a value many times higher than the triple-point pressure; for example, the ultimate gas storage pressure may be of the order of 1000 pounds per square inch as compared to the triple-point pressure of approximately 75 pounds per square inch absolute.

It is highly desirable to afford some means for automatically and instantaneously sealing off the storage tank 20 from the remainder of the system as soon as the pressure in the system reaches a predetermined threshold value only slightly higher than the triple-point pressure of the carbon dioxide, since in this way the converter may be operated most simply and efficiently. For this reason, the line valves 26 and 27 are preferably constructed as fluid-pressure controlled devices and are actuated by a pressure-responsive control valve 30 to seal off the container 20 as soon as the tank 10 reaches a pressure effectively exceeding the triple-point pressure. This may best be understood by first considering the valve structures illustrated in Figs. 2 and 3.

Fig. 2 shows the line valve 26 in cross sectional detail; this figure may also be considered to represent any of the other similar valves 27, 28, and 29. The valve 26 comprises a casing including a first end section 40, a central section 41, and a further end or control section 42. In valves 26 and 28, end section 40 comprises the inlet section of the valve and central section 41 the outlet portion thereof; in valves 27 and 29 this inlet-outlet relationship is reversed. The outlet section 40 of the valve 26 is preferably provided with a threaded opening 43 which may be connected to the portion of the conduit 22 leading to the storage tank 20. The central portion 41 of the valve is provided with a similar threaded opening 44 to afford a convenient means for connecting the valve to that portion of the conduit 22 leading to the converter shell 10. The other end section 42 of the valve 26 is provided with a threaded opening 45 into which the conduit 31 from the control valve 30 may be fitted.

The central section 41 of the valve 26 is of somewhat smaller internal diameter than the end sections 40 and 43 and is provided at one end with a valve seat comprising a shoulder 46 facing the end section 40 of the valve. A valve stem 47 extends longitudinally through the central portion of the valve section 41. One end of the valve stem 47 supports a suitable valve head 48 which is adapted to engage the valve seat 46 and thereby seal off the central portion 41 of the valve 26 from the end portion 40 thereof. A piston 49 is affixed to the other end of the valve stem 47. The piston 49 is preferably provided with a suitable sealing ring or packing 50 engaging the internal surface of the valve section 42. With the valve 26 in its normal open condition, as illustrated in Fig. 2, the piston 49 is in engagement with a shoulder 51 on the central valve section 41, being biased toward that position by means of a suitable spring 52 which extends from the piston 49 into engagement with the rear wall of the valve section 42.

As indicated in Fig. 2, the valve 26 is a normally open one but may be actuated to a closed condition by movement of the valve stem and piston structure therein to bring the valve head 48 into engagement with the valve seat 46. The spring 52 is effective to maintain the valve in the illustrated open condition so long as the pressure within the three valve sections 40, 41, and 42 is substantially equal. If, on the other hand, the pressure within the valve sections 40 and 41 exceeds that in section 42 by a substantial amount, the piston 49 is driven to the right, as seen in Fig. 2, bringing the valve head 48 into engagement with the valve seat 46 and thereby sealing off the valve section 40 from the valve section 41.

Fig. 3 shows in cross sectional detail a snap-action control valve 30 constructed in accordance with this invention. The valve 30 comprises a cylinder 60 which is closed at one end by a cap member 61 threaded into the

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main cylinder member. A pressure port comprising a threaded opening 62 is provided in the cap member 61 and leads into the cylinder 60; the pressure port 62 is utilized to connect the control valve to the converter shell 10. The cylinder 60 is also provided with a vent port 63 which in this embodiment of the device is vented directly to the atmosphere. Cylinder 60 is further provided with an opening 64 which connects the control valve to the conduit 31 leading to the valves 26-29.

A piston member 65 is disposed within the cylinder 60. The large-diameter or head portion 66 of the piston is provided with a suitable packing or sealing ring 67 which seals this portion of the piston to the internal wall of a large diameter opening 68 in the cylinder 60. The lower portion 69 of the piston is similarly sealed to the internal surface of a reduced diameter section 70 of the cylinder by means of a suitable packing or sealing ring 71. Thus, the piston and the cylinder effectively define three separate chambers within the cylinder, a pressure chamber 72 above the head portion 66 of the piston, the vent chamber 70 at the opposite end of the piston, and the transition chamber 68 adjacent the central portion of the piston.

The piston 65 is provided with a first fluid passageway 73 which leads from the pressure chamber 72 into a central valve chamber 74 within the piston. The valve chamber 74, in turn, communicates with the transition chamber 68 by means of one or more fluid passageways 75 and with the vent chamber 70 by means of a further fluid passageway 76. A valve closure member 77 is disposed within the chamber 74 and normally is biased toward the position shown in Fig. 3, in which the closure member is seated at the opening of the fluid passageway 76 into the valve chamber. In the illustrated embodiment, this biasing effect is achieved simply by mounting the valve in the position shown so that gravity maintains the valve closure ball 77 in the desired position, sealing off the vent chamber 70 from the transition chamber 68 and from the pressure chamber 72. Suitable spring biasing means may be utilized for this purpose if desired.

The snap-action control valve 30 is also provided with an actuating means comprising a rod 80 which is mounted in adjustable fixed relation to the cylinder 60 and which extends upwardly through the fluid passageway 76 toward valve closure member 77. When the valve 30 is in its normal or unactuated condition, the rod 80 does not contact the ball but is spaced a relatively small distance therefrom. The piston 65 of the valve is biased toward the normal or unactuated position as shown in Fig. 3 by means of a suitable spring 82 which engages the lower end of the piston and the rear wall of the cylinder 60.

The snap-action control valve 30 affords an extremely rapid control action in response to an increase in the pressure within the pressure chamber 72 above a predetermined threshold value. In considering the operation of this device, it may be assumed at the outset that the pressure within chamber 72 is equal to that within the transition chamber 68, since the converter shell 10 is maintained at the same pressure as the storage tanks 20 and 21 and therefore at the same pressure as the internal pressure of the valves 26-29 during operation of the converter of Fig. 1. The effective piston area facing the pressure chamber 72, however, is substantially larger than that facing the transition chamber 68. Consequentially, the piston 65 may be moved downwardly through the cylinder 60, as seen in Fig. 3, by an increase in pressure in the chamber 72 with respect to the atmospheric pressure of vent chamber 70, despite the fact that the pressure within the transition chamber 68 may increase by the same amount. Consequently, when the converter is placed in operation and the solid carbon dioxide begins to vaporize, the consequent increase of pressure within the converter system causes the piston 65 to move down-

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wardly against the biasing force afforded by the spring 82. The spring 82, however, is made strong enough to prevent the piston 66 from moving through a distance sufficient to bring the valve closure member 77 into contact with the actuating rod 80 so long as the pressure within the converter does not substantially exceed the triple-point pressure of the carbon dioxide. Thus, although the piston is moved to some extent during the initial stages of operation of the converter, it does not change materially from the normal or unactuated condition illustrated in Fig. 3 as long as the system remains approximately at the triple-point pressure.

As soon as the pressure within the container 10 rises substantially above the triple-point pressure, however, as occurs when all of the carbon dioxide has been converted to fluid phase, the piston 65 again starts to move in a downward direction through the cylinder 60. This continued movement of the piston brings the valve closure member 77 into contact with the actuating rod 80 and unseats the valve closure member from its normal position. As a consequence, the transition chamber 68 is opened to the vent chamber 70, materially reducing the pressure within the transition chamber, and, in effect, increasing the piston area facing the vent chamber. This effective increase in the piston area markedly accelerates the movement of the piston 65 towards its actuated position. The piston continues its downward movement at a much greater speed and brings the valve closure member 77 into engagement with the lower end of the fluid passageway 73, sealing off that passageway from the remainder of the valve. Consequently, there is no longer any means for maintaining a pressure differential between the transition chamber 68 and the vent chamber 70, and the transition chamber 68 and its connecting conduit 31 (Fig. 1) are reduced to atmospheric pressure.

It is this reduction in pressure in the transition chamber 68 of control device 30 which actuates the valve 26 of Fig. 2 and the corresponding valves 27-29 of the converter system. As indicated hereinabove in the description of valve 26, the line valve 26 is actuated from its normal open condition to closed condition by a reduction in the pressure within the valve section 42 relative to the pressure within the valve sections 40 and 41. As soon as the conduit 31 is vented to the atmosphere as described hereinabove, the internal pressure of the converter system closes the valve 26 and effectively seals off the converter shell 10 from the tank 20, the valve 27 being similarly and simultaneously closed.

In the processing of carbon dioxide, as indicated above, the triple-point pressure at which the converter system is operated during transfer of the carbon dioxide from the shell 10 to the storage tank 20 is approximately 75 pounds per square inch absolute or approximately 60 pounds per square inch gauge, the triple-point temperature being -69.9° F. The threshold value for actuation of the snap-action control valve 30 may be established at any desired value effectively above triple-point pressure; satisfactory operating results have been achieved with the control valve set for actuation at approximately 100 pounds per square inch absolute. This setting of the valve may be readily adjusted by varying the extent to which the actuation rod 80 projects into the fluid passageway 76; for this reason, the actuation rod is preferably affixed to a mounting member 84 which is threaded into the rear or bottom wall of the valve cylinder to afford a convenient means for adjusting the valve.

As illustrated in Fig. 1 the converter 9 may include a safety valve 85 as well as a bleeder valve 32. Thus, a control valve constructed in accordance with this invention affords an extremely rapid control action in response to an increase in pressure above a predetermined threshold value. The control valve of this invention is especially well adapted for operation in a converter for carbon dioxide and like materials wherein it is desirable to connect a low pressure container from a storage con-

tainer whenever the conversion process in the low pressure container has been substantially completed, as evidenced by a rise in pressure in the low pressure container.

Hence, while I have illustrated and described the preferred embodiment of my invention, it is to be understood that this is capable of variation and modification, and I therefore do not wish to be limited to the precise details set forth, but desire to avail myself of such changes and alterations as fall within the purview of the following claims.

I claim:

1. A snap-action control device comprising: a cylinder having a pressure port and a vent port; a piston disposed within the cylinder and defining therewith a pressure chamber opening into the pressure port, a vent chamber opening into the vent port, and a transition chamber and having fluid passageways therein interconnecting the transition chamber with the pressure and vent chambers, said piston being movable from an unactuated position through an intermediate position toward an actuated position in response to an increase in fluid pressure in the pressure chamber and having an effective piston area in the pressure chamber greater than the effective piston area in the transition chamber; bias means for normally maintaining said piston in said unactuated position; a valve closure member disposed within the fluid passageways and actuatable between an unactuated position in which the transition chamber is connected to one of the vent and pressure chambers and is sealed off from the other chamber and an actuated position in which the transition chamber connections are reversed; and means for actuating said valve closure member toward its actuated position in response to movement of the piston to its intermediate position to increase the effective area of said piston acted upon by fluid under pressure within said pressure chamber and thereby accelerate movement of the piston toward its actuated position when the pressure within the pressure chamber reaches a given threshold value sufficient to move the piston to said intermediate position against the biasing force exerted by said bias means.

2. A snap-action control device comprising: a cylinder having a pressure inlet port and a vent port and an outlet port; a piston disposed within the cylinder and defining therewith a pressure chamber opening into the pressure port, a vent chamber opening into the vent port, and a transition chamber opening into the outlet port, and having fluid passageways therein interconnecting the transition chamber with the pressure and vent chambers, said piston being movable from an unactuated position through an intermediate position toward an actuated position in response to an increase in fluid pressure in the pressure chamber and having an effective piston area in the pressure chamber greater than the effective piston area in the transition chamber; bias means for normally maintaining said piston in said unactuated position; a valve closure member disposed within the fluid passageways and actuatable between an unactuated position in which the closure member is effectively seated in the opening of the fluid passageway leading to one of the vent and pressure inlet chambers and an actuated position in which the closure member is effectively seated in the opening of the other of the vent and pressure inlet chambers; and means for actuating said valve closure member toward its actuated position in response to movement of the piston to its intermediate position to increase the effective area of the piston acted upon by fluid under pressure within said pressure chamber and thereby accelerate movement of the piston toward its actuated position when the pressure within the pressure chamber reaches a given threshold value sufficient to move the piston to said intermediate position against the biasing force exerted by said bias means.

3. A snap-action control device comprising: a cylinder

having a pressure port and a vent port; a piston disposed within the cylinder and defining therewith a pressure chamber opening into the pressure port, a vent chamber opening into the vent port, and a transition chamber, and having fluid passageways therein interconnecting the transition chamber with the pressure and vent chambers, said piston being movable from an unactuated position through an intermediate position toward an actuated position in response to an increase in fluid pressure in the pressure chamber and having an effective piston area in the pressure chamber substantially greater than the effective piston area in either of the other two chambers; bias means for normally maintaining said piston in said unactuated position; a valve closure member disposed within the fluid passageways and actuatable between an unactuated position in which the transition chamber is sealed off from the vent chamber and an actuated position in which the transition chamber is open to the vent chamber; and means for actuating said valve closure member toward its actuated position in response to movement of the piston to its intermediate position to increase the effective piston area of the vent chamber and thereby accelerate movement of the piston toward its actuated position when the pressure within the pressure chamber reaches a given threshold value sufficient to move the piston to said intermediate position against the biasing force exerted by said bias means.

4. A snap-action control device comprising: a cylinder having a pressure port and a vent port; a piston disposed within the cylinder and defining therewith a pressure chamber opening into the pressure port, a vent chamber opening into the vent port, and a transition chamber and having fluid passageways therein interconnecting the transition, pressure and vent chambers with a common valve chamber within the piston, said piston being movable from an unactuated position through an intermediate position toward an actuated position in response to an increase in fluid pressure in the pressure chamber and having an effective piston area in the pressure chamber substantially greater than the effective piston area in either of the other two chambers; bias means for normally maintaining said piston in said unactuated position; a valve closure member disposed within the valve chamber and actuatable between an unactuated position in which the closure member is seated in the fluid passageway opening from the vent chamber and an actuated position in which the closure member is seated in the fluid passageway opening from the pressure chamber; and means for actuating said valve closure member toward its actuated position in response to movement of the piston to its intermediate position to increase the effective piston area of the vent chamber and thereby accelerate movement of the piston toward its actuated position, said means comprising a valve actuation rod affixed to the cylinder and extending through the fluid passageway from the vent chamber toward engagement with the valve closure member.

5. A snap-action control device comprising: a cylinder having a pressure section, a vent section, and a transition section; a piston disposed within the cylinder and defining therewith a pressure chamber within the pressure section of the cylinder, a vent chamber within the vent section, and a transition chamber within the pressure section and having fluid passageways therein interconnecting the transition, pressure and vent chambers with a common valve chamber, said piston being movable from an unactuated position through an intermediate position toward an actuated position in response to an increase in fluid pressure in the pressure chamber and having an effective piston area in the pressure chamber greater than the effective piston area in the transition chamber; bias means for normally maintaining said piston in said unactuated position; a valve closure member comprising a ball disposed within the valve chamber actuatable between an unactuated position in which the

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ball is seated in the opening of the vent chamber passageway and an actuated position in which the ball is seated in the opening of the pressure chamber passageway; and an actuating member affixed to the cylinder and extending through the vent chamber passageway for actuating said ball toward its actuated position in response to movement of the piston to its intermediate position to increase the effective piston area of the vent chamber by venting the transition chamber and thereby accelerate movement of the piston toward its actuated position when the pressure within the pressure chamber reaches a given threshold value sufficient to move the piston to said intermediate position against the biasing force exerted by said bias means.

6. A control device for actuating control valve apparatus to disconnect a low pressure container from a storage container whenever the pressure within the low pressure container exceeds a predetermined threshold value, said control device comprising; a cylinder formed with a pressure port connectable to a low pressure container, a vent port, and a third port connectable to a control valve apparatus; a piston slidably disposed within the cylinder and including a first surface forming a pressure chamber within said cylinder in communication with said pressure port, said piston also including a second surface forming a transition chamber within said cylinder in communication with said third port, said second surface being of

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lesser area than said first surface, said piston additionally including a third surface forming a vent chamber in said cylinder which communicates with said vent port; said piston having conduit means formed therein for communicating said pressure chamber with said transition chamber and said transition chamber with said vent chamber; valve means disposed within said conduit means for regulating fluid flow therethrough; and biasing means effective to maintain said piston in a first position wherein the valve means block fluid flow from said transition chamber to the vent chamber while permitting fluid flow between the pressure chamber and the transition chamber so long as the pressure within said low pressure chamber does not exceed a threshold value, said biasing means being related to the differential areas of said first and second surfaces so that a pressure exceeding the threshold value in said pressure chamber shifts the piston to a second position wherein the valve means unblock the conduit means between the transition and vent chambers to relieve the pressure in said transition chamber and enable the piston to move rapidly to a third position wherein the valve means block flow between the pressure and transition chambers.

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