Sept. 3, 1968 H. N. SHAW 3,399,696

DIFFERENTIAL BY-PASS VALVE

Filed April 22, 1966

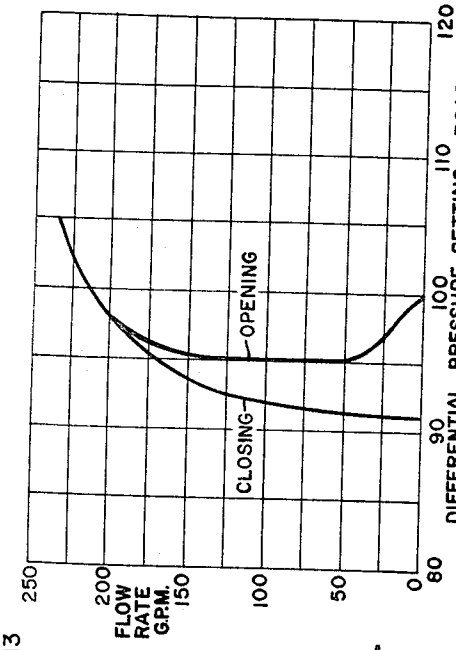

FIG. 4.

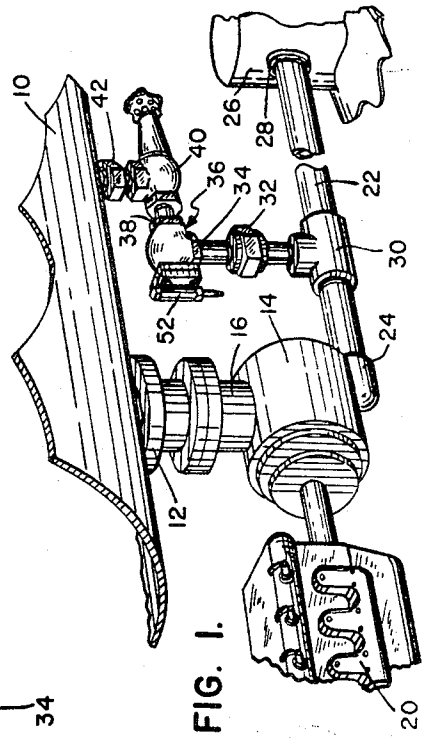

FIG. 1.

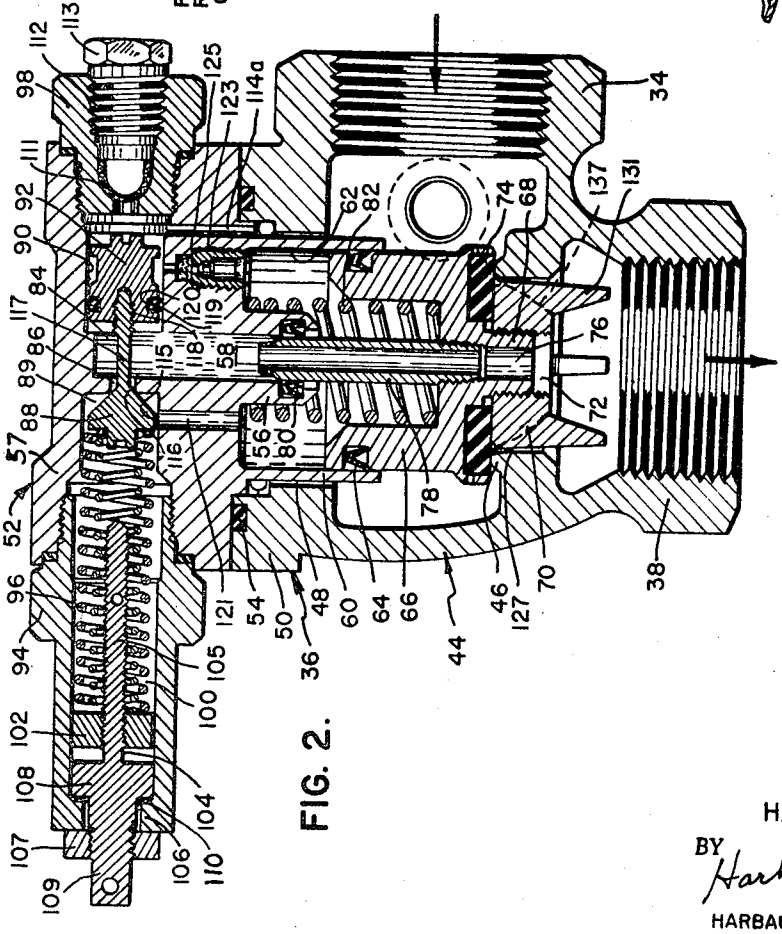

FIG. 2.

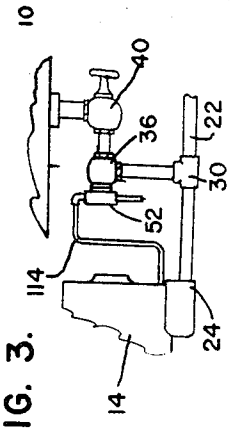

FIG. 3.

INVENTOR.
HARRY N. SHAW
BY Harbaugh and Thomas
HARBAUGH AND THOMAS ATTYS

United States Patent Office

3,399,696

Patented Sept. 3, 1968

3,399,696

DIFFERENTIAL BY-PASS VALVE

Harry N. Shaw, Chicago, Ill., assignor to The Bastian-Blessing Company, Chicago, Ill., a corporation of Illinois

Filed Apr. 22, 1966, Ser. No. 544,499
14 Claims. (Cl. 137—563)

The present invention relates to the filling of pressure containers by a pump with liquid, and more particularly to transferring liquefied gas to a storage tank by a high volume pump wherein the pump is protected against pressure output overload.

In replenishing widely distributed, rural, industrial and residential storage tanks with liquefied gases having low boiling points, a supply tank truck must have means such as a high volume positive displacement pump for the rapid transfer of the liquefied gases at each stop as a matter of economy of time and delivery cost.

To those confronted with problems involved, it is to be noted that at the start of a liquefied gas transfer pumping operation, the supply tank and receiving tank pressures may be at substantially the same tank pressure at the start because of like temperatures. However, as the pump starts up with the output conduit closed or as it continues, the pressure drops in the supply tank with evacuation and slow vaporization in the tank while the pressure may rapidly mount in the receiving tank with gas already present being compressing therein faster than it can liquefy. Thus, the pump can be subjected to excessive pressures which are not detected by operators. Damage to the pump occurs frequently and such is generally of a substantial extent and cost.

Many manufacturers of pumps of the type concerned provide bypass conduits in the pump body itself from the output to the input, to prevent damage, but this is a direct recycling of liquefied gas and heats it. This heat generates bubbles of vapor which cause greater damage to liquid pumps than otherwise and this is true particularly when the pumps are overloaded for long periods of time. Moreover, many pumps so equipped overthrottle, vibrate and pulse under excess differential pressures.

In the present invention, a pressure differential by-pass valve discharging back to the supply tank is provided. It is connected between the pump outlet and the supply tank so that excess liquefied gas is returned to the supply tank before it again reaches the pump. A pressure differential actuated valve is located in a conduit branching from the conduit to the receiving tank so that when the pressure differential across the pump, i.e., between the inlet and outlet of the pump approaches a dangerous level, the excess liquid being pumped which would cause an excess differential is diverted and by-passed back to the supply tank regardless of the pressure in the receiving tank.

The invention in accomplishing this is characterized by a piston type check valve in the branch conduit that is closed by a spring in the direction of relief flow. The output pressure of the pump assists in this closing over an area equal to the area of the valve port with the lower supply tank pressure effective over the opposing port area as indicative of the inlet pressure at the pump. Then when the outlet pressure rises high enough to move the pilot valve piston against an adjustable control spring with the output and input pressures effective against opposite equal working areas of the pilot piston, the pilot valve is opened

to reduce the pressures to inlet pressure on the spring side of the main valve piston to permit opening of the main valve by the higher output pressure effective over an area fractionally greater than the area of the valve port with a hunting action that permits proportional bleeding of the pump output enough to prevent excessive back pressure differentials developing on the pump, regardless whether the build up is gradual or rapid.

One of the objects of the invention is to protect against damage a liquid transfer pump driven by a mover of torque power so great that the pump could be destroyed without the excessive load being detected in an appreciable reaction slow down of the prime mover.

A further object of the invention is to provide a pump which operates at full pumping output within a predetermined pressure differential range that is independent of atmospheric pressure, and is irrespective of, (1) the vapor pressure of the liquid being transferred, (2) the ambient temperatures, and (3) the relative storage and receiving tank pressures.

Another object of the invention is to provide a by-pass for a pump overloaded by a high pressure differential which unloads the condition proportionately with respect to the differential excess and closes at a pressure appreciably below the predetermined differential level.

Another object of the invention is to take heat due to excess pressures developing in the pump and expend it in the supply tank where it helps serve as latent heat of vaporization for relieving pressure drop therein, and by the same increment help reduce any differential in pressure.

A further object resides in a pressure differential pump by-pass valve normally held closed by a bonnet spring acting directly on the main valve even when the pump is started, whereupon the pump differential pressure assists the spring to hold the valve closed within a predetermined differential of pressures across the main valve as directly related to intake and output pressures of the pump.

A further object is to provide a pilot valve responsive to intake-output pump differential pressures which is operated by and operates with a liquid solid fluid for instant and proportional response to any pressure at the output that is higher than a predetermined pressure differential over the intake.

These being among the objects of the invention, other and further objects reside in the simplicity of construction, adjustment and operation, for both production and maintenance, of a pressure by-pass valve for a pump transferring a liquefied gas. Other and further objects will become apparent from the claims appended hereto, and the description relating to the drawing herein which:

FIG. 1 is a perspective view of a pump and excess pressure differential relief apparatus embodying the invention;

FIG. 2 is a sectional view of the preferred valve construction of the invention;

FIG. 3 is a schematic view of a modification of the invention where the capacity of the valve used is well above the capacity of the pump and where the control may be most critically operative; and

FIG. 4 is a chart representing the performance characteristics of a typical embodiment as shown in FIG. 1.

Referring to FIG. 1 a liquefied gas transfer device is shown including a dispensing tank **10** having a liquid transfer valve **12** such as shown in my co-pending application Ser. No. 394,590; a positive displacement pump **14** supported at its inlet **16** in the outlet **18** of the transfer valve and driven by prime mover **20** whose power capa-

bilities are much greater than pump requirements, such as the road engine of a tank transport truck; and, an outlet conduit 22 connected to the pump output 24 leading to service or receiving tank 26 through a back flow check valve 28 thereon. Adjacent to the pump outlet 24 a reducing T 30 is provided a branch conduit connected through a union coupling 32 to the inlet 34 of the pressure differential by-pass valve 36, whose outlet 38 is connected through a hand shut-off valve 40 and back pressure check valve 42 to the dispensing tank 10.

The by-pass valve is more particularly shown in FIG. 2 in which the body 44 is shaped similar to a T with a valve seat 46 between the inlet 34 and outlet 38 facing the third opening 48 which is externally flanged as at 50 to support a bonnet 52 thereon in a relationship sealed by an O-ring.

The bonnet carries all of the working parts and comprises a body 57 which has a boss 56 with an opening 58 therethrough coaxial with the valve seat 46. The boss is surrounded by a cylindrical shell portion 60 telescoping into said body opening 48 and defining a working cylinder 62 which receives a main valve piston 66 reciprocably therein as sealed by a block V packing or seal 64 with its edges directed towards the valve seat 46.

The piston 66 has an externally threaded boss 68 secured to the valve member or valve disk holder 70 in an opening 72 therethrough and carries a valve seal or disk 74 held in place by the holder 70 to engage the valve seat 46 as guided thereby.

The boss 68 has an opening 76 internally threaded at the top to receive a sleeve 78 which telescopes into opening 58 as sealed by a block V seal 80. The sleeve 78 is surrounded by a spring cavity and a light compression spring 82 is received therein as supported at the top around the boss 56. Thus, as the piston reciprocates the valve, the piston 66, the sleeve 78 and the valve move as a unit subject to the effort of the spring 82 to urge closure of the valve.

The openings 72, 76, 58 and the sleeve 78 provide an open passage from the outlet opening 38 to a cross-passage 84 in the top of the bonnet body 57 which has a valve port 86 at one side closed by pilot valve member 88 reciprocable in a valve chamber 89, and a cylinder 90 receiving a pilot piston 92. The outer end of the valve chamber 89 is enlarged and internally threaded to receive a holder assembly 94 for compression springs 96 which urge closure of the valve. The outer end of the cylinder 90 is internally threaded to receive a bushing 98.

The holder assembly has a hex section cavity 100 slidably receiving a hex nut 102 therein that bears against the free ends of the springs 96. An adjusting screw 104 having a threaded shank 105 at one end engages the nut and extends outwardly through a flanged opening 106 at the other end 109 where it receives a lock nut 107 bearing against the flange 106.

The adjusting screw 104 has intermediate its ends a radial flange 108 which rotatably engages the flange 106 with a seal washer 110 between them. Thus, when the outer end is turned for adjustment, the nut 102 is advanced or retracted to adjust the valve closing tension on the springs 96.

The bushing 98 receives a strainer 111 in it and has a threaded opening 112 which receives either a plug 113 or a conduit connection 114 (FIG. 3) which leads directly to the output 24 of the pump 14 when a high degree of differential pressure control accuracy is desired.

The pilot valve 88 has a hex-section head 115 with a valve seat 116 closing the valve port. The seat terminates in a stud 117 which extends through the valve port 86 and is terminally threaded to interthread as at 118 with the pilot piston 92 to operate therewith as a unit. The pilot piston carries a split seal ring 119 in a groove 120 sealing it with the cylindrical wall 90.

A drilled conduit 121 interconnects the valve chamber 89 and the cylinder 62 to vent the cylinder 62 to supply tank pressure when the valve 88 is open; a conduit connection 114*a* of a small size interconnects the cylinder 90 and the inlet 34 to supply the cylinder 90 with output pump pressure effective on the pilot piston and a threaded passage 123 between the cylinders 90 and 62 carries an orifice insert 125 to meter a supply of output pump pressure to the cylinder 62 effective on the main valve piston 66 to close it.

It will be observed that the main valve seat defining the mouth of the port is provided downstream with a cylindrical wall portion 127 of substantial length, a length about 30% of the diameter of the port and the valve body or disk holder 70 is provided with a close clearance therewith at the top of approximately .0156" in the example being described. Guide legs 131 are provided on the bottom of the holder 70 with a taper of 5° included angle. Between the guide legs the holder 70 tapers with a parabolic curve indicated in dotted lines at 137 over a distance greater than the length of the wall portion 127 to provide an aspirating action at the opening 76.

Referring now to the chart, FIG. 4 having the opening and closing curves 133 and 135, respectively, for a pressure differential setting of 100 pounds per square inch gauge on one ordinate against the flow rate of propane on the other ordinate, it will be observed by way of example that the opening and closing is very accurate at high volume levels while at lower volumes it is within plus zero and minus eight pounds of the setting of the differential pressure up to the capacity of the valve.

In operation when the pump 14 is turned on, after connection is made to the receiving tank 26, the main valve 74 is being held closed by the light spring 82. This exerts a pressure just enough to assure closing the valve against the possible drag of seals 64 and 80 thereon. Thereafter the output pressure then builds up and becomes effective in the main valve chamber and the pilot cylinder 90 through passage 114 (FIG. 3) or 114*a* (FIG. 2). In the pilot cylinder 90 the pressure is effective against the pilot piston 92 for urging an opening of the pilot valve 88 against the setting of the spring 96 tension. The other side of the pilot piston 92 is subjected to supply tank pressure at 84.

Pressure in the pilot cylinder 90 bleeds through orifice 125 to the main valve cylinder 62 and assists in holding the valve 66 closed and the pressure in the main valve cylinder is immediately effective through conduit 121 on the back side of the pilot valve over the valve port area 86 thereof.

When the pressure in conduit 22 (FIG. 1) exceeds the pressure in the outlet 38 by a differential determined by the setting of the spring, the pressure against the pilot piston dominates the springs and opens the pilot valve thereby releasing the pressure behind it to vent the cylinder 62 to the supply tank pressure. This latter is instantaneous since the pressure is hydraulic. Thereupon the pressure in the main valve chamber which is effective over the differential of the sizes of the main piston, whose effective pressure response area is approximately 40% greater than the valve seat area which is enough to overcome the counter effort of the spring 82 even when fully compressed and main valve will begin to open.

The pilot valve will continue to be forced open, since the pressure therebeyond is lowered by its opening and the flow of liquid from the cylinder 62 begins to be a factor wherein the bleed 125 is effective to control liquid flow to the cylinder so that the throttling action of the valve 88 is a steady and stable influence as long as the by-pass flow through the valve to the supply tank maintains an adequately reduced excess pressure differential.

As the liquid flows through the clearance between the main valve and the valve port this flow causes an aspirating effect on the liquid in the passage 58 which assists in opening the pilot valve further and the withdrawal of liquid from the main valve cylinder. The end result is a stabilizing effect of interrelated forces which dampen any

tendency of one force to oscillate. Thus providing a constant output pressure effect on the pump with the results characterized by the curves.

Having thus described the invention and preferred embodiments thereof, it will be apparent to those skilled in the art how the objects of the invention are attained and how various adjustments of parts and relative sizes can be made for various sizes of pumps and flow characteristics without departing from the spirit of the invention, the scope of which is commensurate with the appended claims.

What is claimed is:

1. In a liquefied gas transfer system, the combination comprising a supply tank having liquefied gas therein under pressure, a displacement pump connected to the outlet of the supply tank, an outlet conduit for the pump connected to a point of use having a gauge pressure, a pressure differential by-pass valve interconnecting said conduit and said supply tank including a check valve closing in the direction of flow of liquefied gas to the supply tank, a main pressure differential responsive means for actuating said check valve, open conduit means for applying pump outlet pressure to one side of said main pressure responsive means to close the check valve, means for venting said one side of the main pressure responsive means to the pressure in the supply tank including a spring closed pilot valve, a pilot pressure differential responsive means controlling said pilot valve, means for continuously applying pump output pressure to one side of the pilot pressure responsive means to urge the pilot valve to its open position, means for continuously applying supply tank pressure to the other side of the pilot pressure responsive means and to one side of the pilot valve, conduit means interconnecting the other side of the pilot valve to said one side of said main pressure responsive means to reduce the pressure upon said one side of said main pressure responsive means for opening said main valve.

2. The combination called for in claim 1 in which said open conduit means includes a flow restricting conduit interconnecting said one side of both of said pressure differential responsive means.

3. The combination called for in claim 1 in which said means for applying pump output pressure comprises a direct connection from the pump output to said one side of the pilot pressure responsive means.

4. The combination called for in claim 1 in which said venting means and supply tank pressure applying means includes an open conduit through said responsive means and the check valve.

5. The combination called for in claim 1 including a light spring urging said main pressure responsive means to close said check valve, and said main pressure responsive means having a pressure responsive area on the other side thereof for overcoming said spring above a predetermined pressure differential between pump output pressure and supply tank pressure.

6. In a liquefied gas transfer system having a supply tank and a receiving tank storing liquefied gas therein under pressure, a transfer valve in the supply tank and a positive displacement pump connected to the outlet of the transfer valve, the combination of an output conduit from the pump connected to said receiving tank, a pressure differential bypass valve interconnecting said output conduit and said supply tank including a check valve closing in the direction of flow of liquefied gas to the supply tank, a main piston and cylinder for actuating said check valve, restricted flow conduit means for applying pump output pressure to said cylinder on one side of said main piston to urge closure of the check valve, means for venting said cylinder on said one side of the piston to the pressure in the suply tank including a spring closed pilot valve, pilot piston and cylinder controlling said pilot valve, said conduit means continuously applying pump output pressure to the pilot cylinder on one side of the pilot piston to urge it to open the pilot valve, means for continuously applying supply tank pressure to the pilot cylinder on the other side of the pilot piston and to one side of the pilot valve, conduit means interconnecting the other side of the pilot valve to said main cylinder on said one side of said main piston to vent the pressure upon said one side of said main piston to said supply tank pressure for opening said main valve.

7. The combination called for in claim 6 in which said venting means and said supply tank pressure applying means include a conduit portion in common extending through said main piston and said check valve.

8. In a pump by-pass valve a valve body having a central chamber passage having three openings, a valve seat in one of two adjacent openings and facing the third opening, a pilot valve assembly closing said third opening and including a body with a cylindrical chamber coaxial with said valve seat and a conduit portion, a piston valve reciprocable in said chamber for closing said valve seat, a conduit means by-passing said valve seat placing said conduit portion in open communication with said one opening, pilot valve means including a passage interconnecting said conduit portion and said chamber and a pilot valve closing said passage, adjustable spring means urging closure of said pilot valve, piston means including a pilot cylinder in communication with said conduit portion at one end and in communication with the other of said two openings at its other end, flow restricting means between said other end and said chamber, a pilot piston in said pilot cylinder subjected to pressure in said other end thereof, means interengaging said pilot valve and pilot piston for urging the pilot valve to open position against said adjustable spring.

9. The combination called for in claim 8 in which said pilot cylinder and pilot valve means are coaxial and the last mentioned means extends through the port of said pilot means to reduce the effective area thereof.

10. The combination called for in claim 8 in which said by-pass conduit means is coaxial with said cylindrical chamber and valve seat, and said cylindrical chamber has a diameter a fraction greater than that of the valve seat.

11. The combination called for in claim 8 in which said valve seat is at the entrance of a substantially cylindrical elongated valve port and said piston valve includes a valve seal retaining head telescoping into said valve port and defining a tapering surface of revolution with a close clearance with said valve port having an included angle of approximately 5°.

12. The combination called for in claim 8 in which said piston valve is cup-shaped having a threaded boss on the bottom with a passage therethrough, a resilient valve disk around said boss, a disk retainer on said boss telescoping in said valve seat and securing said disk in place, a sleeve secured in the upper end of said passage telescoping in sealed relationship with said conduit means, and spring means urging said piston and valve disk against said valve seat.

13. The combination called for in caim 8 in which said spring means includes a holder having a cavity, a compression spring engaging the pilot valve at one end and a nut at the other end, means slidably supporting the nut in the cavity against relative rotation, an internal flange on the outer end of said holder, an adjusting screw means threaded in said nut and exposed for manual adjustment beyond the flange, said screw means having a shoulder engaging said flange in rotatably sealed relationship.

14. A pilot valve assembly comprising a body having a boss defining a cylindrical chamber, means around said boss for securing said body to a main valve housing, a piston valve member reciprocably carried in said chamber having a piston conduit therethrough, a central conduit in said body concentric with said chamber in sealed relationship with said piston conduit, a cross conduit in the body in communication with said central conduit, a valve port and valve in one portion of said cross conduit,

a cylinder having a piston in the other portion of said cross conduit, passages interconnecting both portions with said chamber, passage means connecting said other portion to a point on the said body outside said boss and within the confines of said securing means, spring means including a holder closing the outer end of said one portion and urging said valve to its closed position, the outer end of said other portion being threaded to receive a strainer and a plug.

References Cited

UNITED STATES PATENTS

2,580,128	12/1951	Renick	137—489
2,807,274	9/1957	Evans	137—108
2,945,515	7/1960	Zimmerman	137—563

M. CARY NELSON, *Primary Examiner.*

R. J. MILLER, *Assistant Examiner.*