United States Patent

[11] 3,630,639

[72] Inventors **Paul P. Duron**
Anaheim;
Thomas A. Carter, Jr., Whittier, both of Calif.

[21] Appl. No. **872,849**
[22] Filed **Oct. 31, 1969**
[45] Patented **Dec. 28, 1971**

[73] Assignee **Air Reduction Company Incorporated**
New York, N.Y.

[54] **SUCTION LINE VENT VALVE FOR RECIPROCATING PUMPS**
14 Claims, 3 Drawing Figs.

[52] **U.S. Cl.** **417/53,** 417/435, 417/901, 62/53, 62/55
[51] **Int. Cl.** **F04b 15/08,** F04b 21/02, F17c 7/02
[50] **Field of Search** 417/299, 435, 439, 901, 53; 62/53, 55

[56] **References Cited**
UNITED STATES PATENTS

2,362,724	11/1944	Shea	417/299
2,775,211	12/1956	Lahoda	417/901
2,978,987	4/1961	Bessiere	417/299
3,263,622	8/1966	Tyree	417/901

Primary Examiner—Carlton R. Croyle
Assistant Examiner—John J. Vrablik
Attorneys—Francis B. Henry, Edmond W. Bopp and H. Hume Mathews

ABSTRACT: This invention relates to an automatically controlled vent valve in a vent line connected to the suction line in a cryogenic pumping system. The vent valve is in an open position during the cooldown cycle and is moved to a closed position after the system has reached desired operating conditions. Blowby gas which leaks around the piston of the pumping system provides the pressure for closing the vent valve. The vent valve contains an orifice through which the blowby gas bleeds and returns to the storage vessel for the cryogenic fluid being pumped.

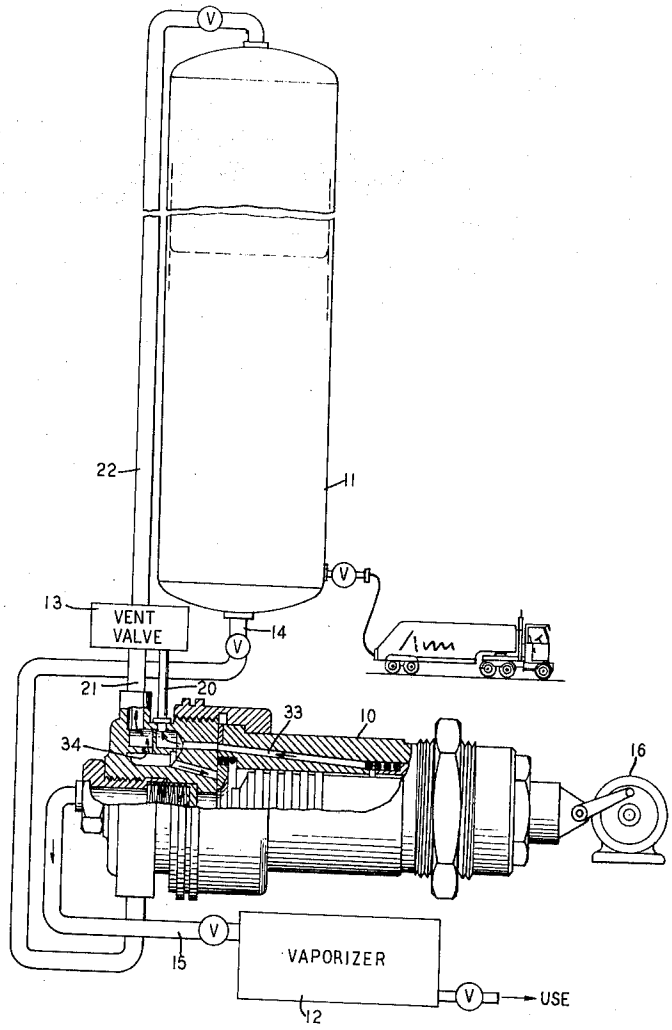


FIG. 1

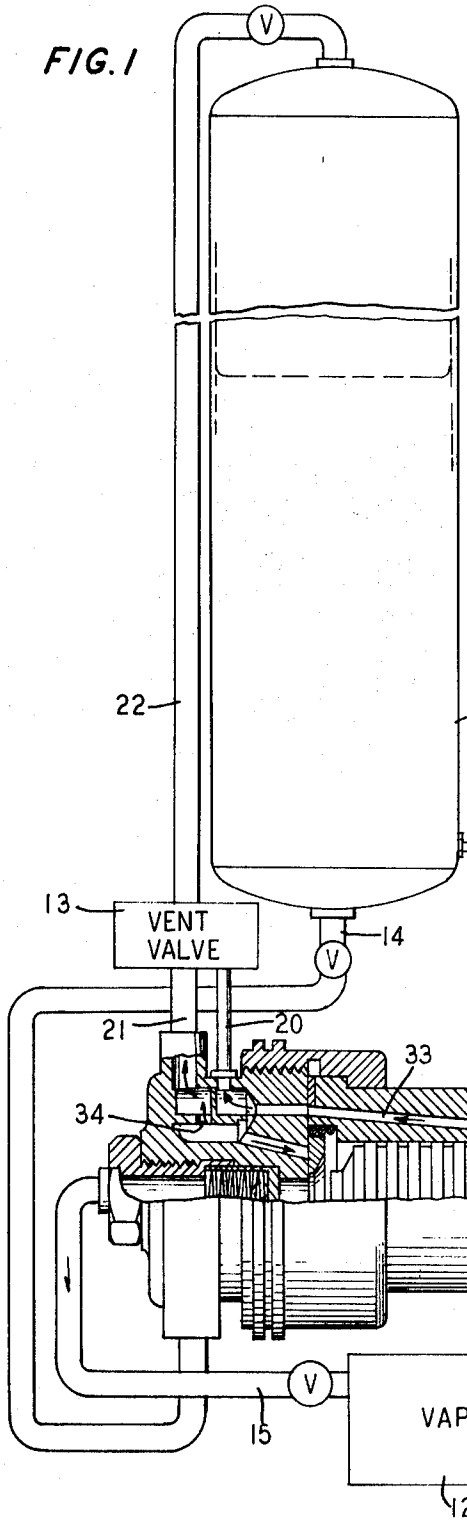
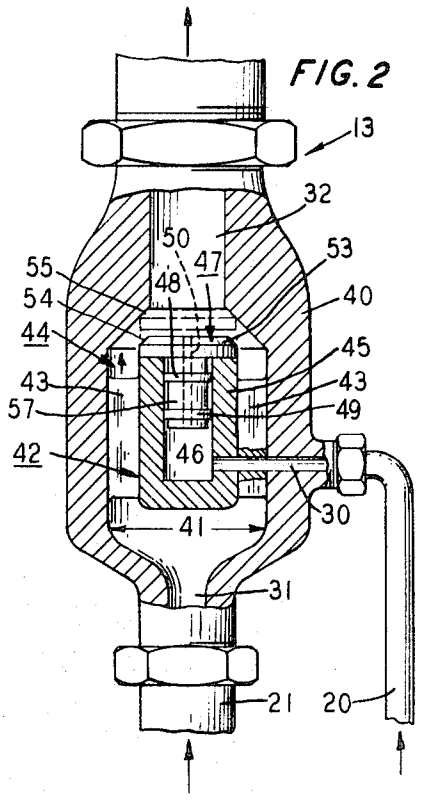
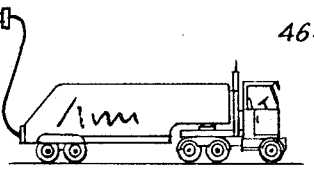


FIG. 2





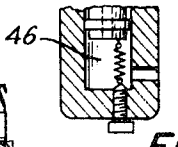


FIG. 3

INVENTORS
THOMAS A. CARTER, JR.
PAUL P. DURON
BY
ATTORNEY

SUCTION LINE VENT VALVE FOR RECIPROCATING PUMPS

SUMMARY OF THE INVENTION

The problems related to cavitation in high pressure cryogenic pumping systems are discussed at length in U.S. Pat. No. 3,181,473. In general the invention disclosed in that patent was directed to avoiding the introduction of vapor into the piston chamber of the pump, to avoiding the retention of blowby gases in the piston chamber and to avoiding retention of gases in the chamber after the compression stroke. The pump described in the patent was highly successful in solving these problems. For example vapor which forms in the suction line leading to the intake valve is vented before it reaches the intake valve. The vapor so vented returns to the cryogenic storage vessel in gaseous phase. Similarly blowby gas is vented to the cryogenic storage vessel. The Duron piston, intake valve and piston chamber were also designed to have a minimum clearance volume so as to reduce the amount of cryogenic liquid in the clearance volume and to thereby reduce flashing at the start of the intake stroke.

The system disclosed in the above-mentioned patent and in other systems being used in the cryogenic field have however certain drawbacks. During pump start-up, when the pump is called upon to deliver high pressure liquid, considerable flashing of the liquid takes place in the suction line and in the pump itself. This is due to relatively warm temperature of the lines and the pump. During start-up, which is also referred to as the "cooldown cycle," the vent line to the storage vessel must be kept open to allow the vapor to vent and to allow the pump to draw liquid into the pumping chamber. If the vapor in the suction line were not vented easily, vapor lock in the suction line and pump would occur, no liquid would be pumped, and a possible pump failure might occur.

Thus venting during cooldown is essential. It has been found, however, that after cooldown, continued venting of this suction line serves no useful purpose, or is in fact detrimental. Cooldown is generally completed when the pump parts have been cooled to their operating temperatures, as indicated by frost on the parts and when the discharge pressure is up to that desired. Little, if any, vaporization or flashing of the liquid passing though the suction line occurs after cooldown. Thus it has been found that there is really no need for continued venting of the suction line. Furthermore, it has been found that continued venting results in lowering the efficiency of the pumping operation by allowing some of the liquid to vaporize and return to the storage tank as vapor. This vapor is essentially lost since it cannot be pumped effectively or efficiently by the pumping system. Furthermore, continuous venting builds up pressure in the tank beyond the desired pressure and thus a pressure relief valve must activate to prevent destruction of the tank. In order to prevent this continued venting, users have installed a shutoff valve in the vent line in order to be able to close the vent line to prevent continuous venting of the suction line. In the event that the pump loses prime during its normal operation, it has been found necessary to open the said vent line to assist in repriming of the pump. When the pump has been reprimed, the shutoff valve must again be manually operated to close the vent line.

The inclusion of a manual shutoff valve in the vent line necessitates the addition of a separate blowby gas vent line to vent blowby gas to the storage tank. It is evident that the blowby gas must be allowed to vent at all times to avoid vapor buildup in the piston chamber. A certain small amount of blowby gas is usually generated when high pressures (up to 15,000 p.s.i.) are involved. Blowby occurs when liquid passes around the piston rings to a region of lower pressure.

The present invention utilizes a unique automatically actuated valve in the vent line to shut off the vent from the suction line while allowing the blowby gases to vent. The valve is operated automatically when the cooldown cycle is completed and returns to an open position when the pump is shut down or when it loses prime.

It is therefore the principal object of this invention to allow the venting of the suction line during the cooldown cycle, and when the pump loses prime, and to terminate the venting when cooldown is complete.

Another object of the invention is to maintain the venting of blowby gases from the piston chamber during cooldown and normal operation of the cryogenic pump.

A further object is to utilize the pressure of the blowby gases to position a vent valve which controls the venting of the suction line.

Yet a further object of the invention is to improve the overall efficiency of a cryogenic storage and pumping system.

Yet a further object of the invention is to control the venting of a cryogenic pumping system automatically.

Still another object of the invention is to utilize a single vent line to vent blowby gas and suction line gas to a storage tank and to position a shutoff valve in said vent line which will shut off the flow of suction line vent gas but not the blowby vent gas to the storage tank.

The novel features which are believed to be characteristic of the invention, both as to its organization and method of operation, together with further objects and advantages thereof will be better understood from the following description considered in connection with the accompanying drawings. It is to be expressly understood, however, that the drawings are for the purpose of illustration and description only and are not intended as a definition of the limits of the invention.

FIG. 1 shows schematically a cryogenic pumping system;

FIG. 2 illustrates schematically a vent valve according to the present invention, positioned in the vent line from the cryogenic pump; and

FIG. 3 illustrates a modified form of vent valve which is adjustably spring loaded.

Reference is now made to FIG. 1 where the general form of a system incorporating the various features of the invention is shown. The principal parts of the invention are the pump **10**, the storage tank **11**, the vaporizer **12**, and the vent valve assembly **13**. The figure illustrates also the suction line **14** connecting the storage tank **11** and the pump intake. A discharge line **15** leads from the pump exhaust valve to a vaporizer **12**.

A blowby gas vent line **20** and a suction line vent line **21** lead from the pump to a vent valve assembly **13**. A single vent line **22** leads from the assembly **13** to the tank **11** wherein it communicates with the vapor space above the cryogenic liquid.

The structural details of the storage tank **11** will not be described in detail in view of the fact that they are not significant to the disclosure of this invention. The tank may be mobile or stationary. Generally speaking, tanks or vessels of this type are vacuum insulated and have suitable connections for filling and discharge and have instrumentation for indicating the quantity, pressure and temperature of the contents. Suitable pressure relief valves are installed to protect the tank from exploding. Tank pressures are usually slightly above atmospheric pressure but not generally higher to minimize construction costs, etc. Generally speaking, the discharge or suction line **14** communicates with the very bottom of the tank so that only liquid is withdrawn. The pump is usually located below the level of liquid in the tank and is sometimes positioned in a housing directly under the tank.

The vaporizer **12** may be of the ambient air variety or may utilize the heat from an external source such as a jet engine, air-fuel burner, hot water heater, etc. The details of the vaporizer are not described in that they form no part of the present invention.

Generally the pumping system as shown in FIG. 1 is used to supply high pressure gas to a use point. The cryogenic liquid is pumped to a high pressure in liquid phase due to the fact that this is considerably easier than trying to compress gas. The high pressure liquid is then vaporized and supplied to a user at a desired pressure. If the user requires liquid, then the vaporizer is not used. The tank is filled periodically by means

of a transport vehicle **16** (not to scale). High pressure gases of the type delivered by the above-described system have a multitude of uses in industry. The gas may be oxygen for use in metallurgical operations (BOF, etc.). It may be nitrogen for use in creating an inert atmosphere or supplying an oil well, etc. The invention although especially suited for use in handling cryogenic liquids, which are liquefied gases having a boiling temperature at atmospheric pressure at or below about −100° F., may be utilized in handling various other liquids which have a tendency to vaporize or flash during distribution and pumping.

With regard to the details of the pump **10**, reference may be had to the Duron U.S. Pat. No. 3,181,473. Instead of combining the blowby gas which comes through ports **33** and the vent gas from the suction line which comes through port **34**, however, the applicants maintain the two sources of vent gas separate in conduits **20** and **21**. The internal details of the pump are not critical to the instant invention, it being only necessary to provide for venting the blowby gas and the suction line gas by known means and to direct the separate streams to the vent valve assembly **13**.

The details of the vent valve assembly are illustrated in FIG. **2**. The ring blowby gas is passed through conduit **20** into a passage **30** drilled into the housing **40** of the assembly. The housing has a generally cylindrical shape and contains inlet passages **30**, **31** and an exhaust passage **32**. The vent gas from the suction line passes through conduit **21** and enters the housing **40** through passage **31**. As shown in FIG. **2** the passage **31** widens at **41** and the gas passes around a central valve block **42** which is supported by a plurality of spiderlike members **43**. The openings defined by the members **43** allow the suction line vent gas to enter the cavity **44**.

The valve block **42** comprises a cylindrical wall portion **45** defining a central chamber **46**. The wall portion slidably guides a valve **47** having a pistonlike member **57** for reciprocating movement. Annular sliding seals **48**,**49** are fitted in annular recesses in the pistonlike member and contact the wall portion. The seals are designed to substantially prevent fluid communication between the piston **57** and the wall **45**. An opening **50** has been drilled through the piston **57** and presents a restriction to the passage of fluid from the chamber **46** to the exhaust passage **32**.

Valve **47** has at one end a valve head **53** with an annular face **54** adapted to contact a mating valve seat **55** formed in the housing **40**. When the valve **47** is in its uppermost position, as shown in dotted lines in FIG. **2**, it prevents the vent gas from the suction line from passing through the vent valve assembly. When the valve is in the position shown in solid lines the said vent gas passes through the assembly and out the exhaust passage **32** to the storage tank.

In the embodiment shown in FIG. **2**, the valve **47** is gravity loaded and must be forced upward to shut off the venting of the suction line **14**.

The valve **47** is forced upward by pressure generated by the blowby gas from conduit **20**. This gas enters chamber **46** and then must pass through opening **50** in the valve. The opening is sized to restrict the flow of the blowby gas and therefore pressure is built up in chamber **46**. When the pressure is sufficient to lift the valve it forces it upward into contact with valve seat **55**. Opening **50** allows blowby gas to continue to vent even when it is in its seated position. When the pressure drops in chamber **46** to a predetermined level, the valve will drop down and again allow the suction line to vent to the tank. Thus in the event the pump loses prime, its discharge pressure will drop and the pressure of the blowby gas will also correspondingly drop. When this occurs the valve drops down opening up the vent line **21** thereby assisting in the repriming of the pump.

It is apparent that while a gravity loaded valve is especially suited for this type of an operation, a spring-loaded valve could also be utilized. By adjusting the spring loading in such a valve, as shown in FIG. **3**, the desired pressure for activation could be varied.

A description of the start-up operation of a pumping system incorporating the features of the present invention will now be given.

When the pumping system is called upon to deliver high pressure gas various steps must occur in sequence. Manual valves controlling the flow of liquid from the tank **11** must be opened to allow the liquid to reach the pump **10**. Similarly any manual valves in conduit **22** must be opened to allow the vent gases to return to the tank.

It is the common practice to keep the manually controlled valves in the conduit **15** leading to the vaporizer closed until the discharge pressure of the pump is up to a desired pressure.

The power source **16** for the pump **10** is then started up causing the piston in the pump to reciprocate and pull a suction on the suction line **14**. The head of the liquid in the tank or the pressure in the tank may also assist in priming the pump. Due to the low boiling temperature of the cryogenic liquid coming through the suction line **14**, a considerable amount of it vaporizes during the time that the suction line **14** and the cold end of the pump is being cooled down. The vapor which is formed in the suction line and in the cold end of the pump adjacent the inlet valve passes through port **34**, conduit **21** and through valve assembly **13** into conduit **22** and then to the vapor space in tank **11**. Similarly a portion of the cryogenic liquid which enters the piston chamber of the pump flashes and therefore the pump discharge is not entirely in liquid phase. This may be observed by disconnecting the conduit **15** from the vaporizer and venting the discharge to the atmosphere. During the cooldown cycle, frost will appear on the suction line **14** and also on the cold end of the pump. During the initial operation, the pressure of the blowby gas which passes around the piston sealing rings and which passes through conduit **20** will be insufficient to lift the valve **47**. The blowby gas therefore will pass through opening **50** and join with the vent gas from the suction line and pass through conduit **22** back to the tank. After a relatively short period of time, however, the cold end of the pump will cool down and thereafter relatively little of the cryogenic liquid which enters the pumping chamber will be vaporized. The pressure of the blowby gas will therefore increase as the discharge pressure increases; that is, when the pump starts discharging pure liquid. When the pressure discharge increases, the manual valve leading to the vaporizer is opened so that the liquid can enter the vaporizer. Due to the fact that the pressures caused by pumping pure liquid in this type of pump are relatively high, the blowby gas pressures will also be high. When the pressure of the blowby gas increases in the chamber **46**, sufficient to cause the lifting of valve **47**, it will seat in the manner shown in FIG. **2** in dotted lines and prevent the passage of vent gas from the suction line to the tank. As mentioned above, it is at this time no longer desirable to vent the suction line back to the tank in view of the fact that the suction line has been cooled down and little, if any, vaporization occurs in the suction line thereafter. Thus there is no necessity for venting this line and in fact if the line is maintained in a vented condition, it will only serve to increase vaporization losses in the line with consequent pressure buildup in the storage tank.

Thus during normal continuous running operation of the pumping system, the valve **47** shuts off the vent from the suction line while allowing the blowby gasses to vent back to the tank.

If the pumping operation is ceased, the power source **16** for the pump **10** is shut down and the manual valve in the suction line from the tank is also closed. When the pump ceases to operate, the blowby gas pressure drops as the blowby gas passes through the opening **50** and the valve **47** drops back to the full line position shown in FIG. **2**. This again allows the vent gas from the suction line of **14** to vent. This venting is necessary due to the fact that the liquid which is trapped in the suction line when the pump is shut off vaporizes and must be allowed to vent in order to prevent excess pressure occurring in the suction line and in the intake area of the pump. Similarly, when the pump loses prime the vent valve will open when the blowby pressure drops.

If the cryogenic pumping system is to operate relatively frequently, it is not necessary to close the manual valve in the suction line each time the pump is shut down. If, on the other hand, the pump is not going to be operated for a fairly long period of time, it is best for reasons of economy to close the manual valve so that excess vaporization does not take place. Although the preferred embodiment of the valve assembly is illustrated in FIG. 2, other variations in the valve structure will become readily apparent to those skilled in the art. For example, the vent valve assembly may be included as an integral part of the cold end assembly of the pump.

Accordingly, it will be understood that the scope of the invention is to be construed only by reference to the appended claims, since the description herein covers features with an extremely broad range of equivalents.

We claim:

1. A method of automatically controlling the venting of a suction line supplying a pump for liquid having a low boiling temperature during pump start-up, comprising venting the suction line until the pump cools down and the discharge pressure of the pump reaches a normal level, and then utilizing pressure developed by the blowby gas of said pump to terminate said venting.

2. A high pressure pump for liquid having a low boiling temperature comprising a pumping chamber, a piston mounted for reciprocating movement in said chamber, exhaust valve means for said chamber, intake means communicating with said chamber, means to vent vapor from said intake means, further vent means to vent blowby gas which has passed around said piston, control means to continue the venting of vapor in said first vent means during pump cooldown and to terminate said venting upon the completion of cooldown, said control means being operative in response to an operating condition of the pump attained when cooldown is completed.

3. A pump for liquid having a low boiling temperature comprising a pump housing having means therein for raising the pressure of said liquid, intake means for said pump housing, vent means for venting vapor from said intake means before the vapor reaches the pressure raising means, valve means to control said vent means dependent on the discharge pressure of said pump.

4. A high pressure pump for liquid having a low boiling temperature comprising a suction line, a discharge line, means to vent vapor formed in said suction line during the cooldown cycle, means to vent blowby gas from said high pressure pump, further means responsive to the pressure of said blowby gas for regulating the first-mentioned vent means.

5. A high pressure pump for liquified gases having low boiling temperatures comprising a pumping chamber, intake means to direct low pressure liquified gas to the pumping chamber, discharge means to direct high pressure liquified gas from the pumping chamber, means to vent vapor from said intake means, further means to control said vent means dependent on the discharge pressure of said pump.

6. A pump as defined in claim 5 further comprising additional vent means for venting blowby gas from said pumping chamber, said further means including valve means in said first vent means, said additional vent means directing blowby gas to actuate said valve means to close said first vent means when a predetermined blowby gas pressure is reached.

7. A pumping system for a liquid having a low boiling temperature comprising storage means for said liquid, a pump, a suction line connected to said storage means for supplying liquid to said pump, first vent means for passing gas formed in said suction line back to said storage means, further vent means to pass blowby gas back to said storage means, means to close and open said first vent means dependent on pressure created by the blowby gas.

8. A pumping system according to claim 7 in which said closure means is a valve adapted to close said first vent means.

9. A pumping system according to claim 8 in which said further vent means communicates with said valve, said valve having an opening to restrict the passage of blowby gas therethrough.

10. A pumping system according to claim 9 in which the valve is gravity loaded and is moved by a predetermined pressure created by the blowby gas.

11. A pumping system according to claim 10 said opening in the valve allowing the blowby gas to continuously pass back to the storage means.

12. A reciprocating pump for liquid having a low boiling temperature comprising a piston chamber and a piston within, a suction line for said pump, a discharge line for said pump, valve means controlling the entrance and the exhaust of the liquid from said pump, a first vent passage for said suction line to remove gas therefrom, a second vent passage for removing blowby gas from said piston chamber, vent valve means in the first vent passage to control flow therethrough, said second vent passage communicating with said vent valve means to actuate the same.

13. A pump according to claim 12, in which said vent valve means comprises a gravity loaded valve having an orifice therein for restricting the flow of blowby gas therethrough.

14. A pump according to claim 12 in which the vent valve means is adjustably spring loaded.

* * * * *

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,630,639 Dated December 28, 1971

Inventor(s) PAUL P. DURON and THOMAS A. CARTER, JR.

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

Col. 6, line 13 (Claim 7) after "for" delete "a".

Signed and sealed this 6th day of June 1972.

(SEAL)
Attest:

EDWARD M.FLETCHER, JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents

FORM PO-1050 (10-69)

USCOMM-DC 60376-P69
* U.S. GOVERNMENT PRINTING OFFICE : 1969 O—366-334