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TWO-PHASE SPRAY SYSTEM FOR FILLING TANKS

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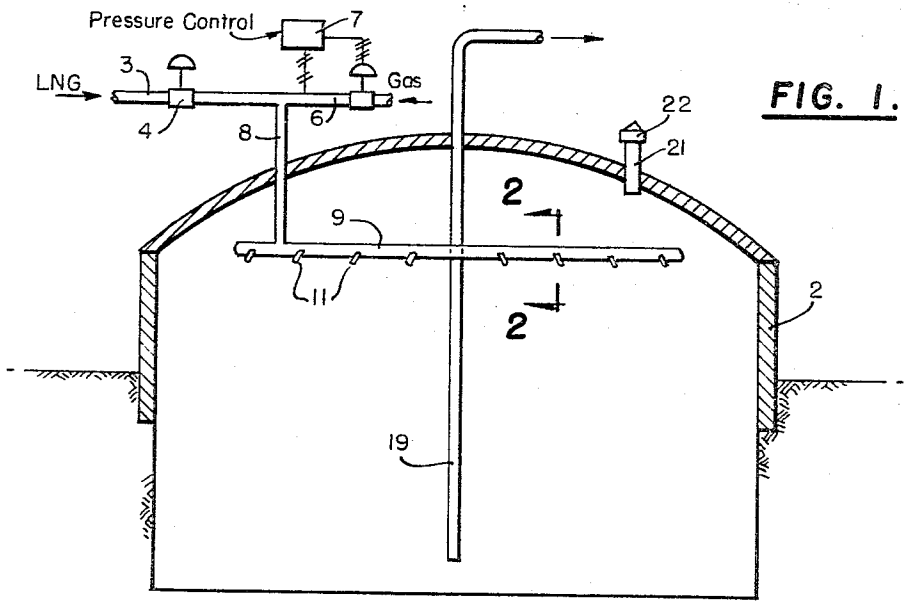



FIG. 1.

FIG. 2.

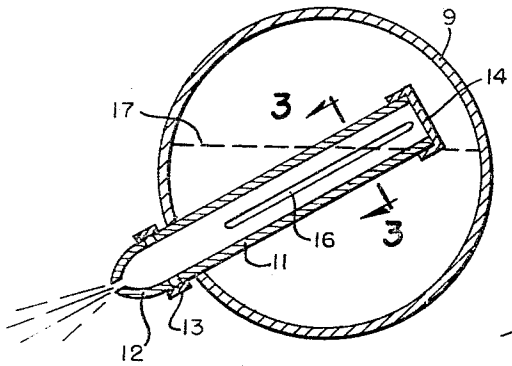
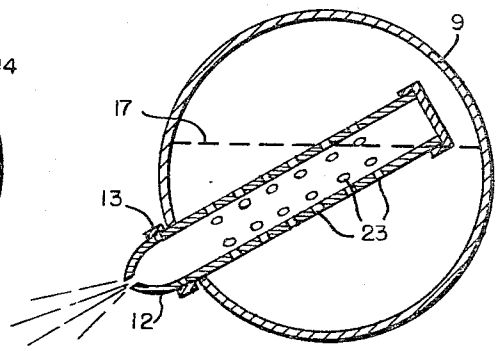



FIG. 4.



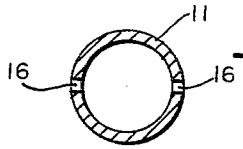




FIG. 3.

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# TWO-PHASE SPRAY SYSTEM FOR FILLING TANKS

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3 Claims. (Cl. 239—200)

This invention relates to a system for filling tanks with liquid, and more particularly to a system which is adapted for filling tanks with low-temperature liquids such as liquefied gases.

The increasing use of liquefied gases such as liquefied natural gas, which must be stored at very low temperatures, typically in the order of —260° F., in very large reservoirs, requires that the liquid be introduced into the reservoir for storage in a very particular manner. Since initially, the reservoir walls are at a much higher temperature than the liquid, it is desired to rapidly cool down the walls as the liquid is introduced, which is preferably done by spraying the liquid onto the walls as it is introduced into the reservoir, and thus rapidly cooling the walls down to the temperature of the liquid, so that a stable temperature condition within the reservoir will be attained as quickly as possible, for retention of the maximum amount of the introduced liquid in the liquid form. For this purpose, it is desired that the liquid be sprayed against the walls of the tank in fairly large droplets, generally similar to those issuing from an ordinary bathroom shower. If the spray issues in the form of a fine mist, it will not effectively reach the walls of the reservoir, while if it issues in a solid stream, the maximum amount of effective contact between the liquid and the wall will also not be obtained. It has been proposed to use spray nozzles, which are supplied with gas under pressure, preferably the same gas which is being introduced in liquid form, to a header which feeds the spray nozzles within the tank, while the liquefied gas is also introduced into the same header, so that the gas pressure is effective to produce a fairly vigorous spray as required. The gas pressure can readily be maintained constant, but the amount of liquid which is introduced varies with the conditions, being sometimes at a higher rate than at other times. This introduces a problem, with ordinary spray nozzles, of providing adequate momentum to the spray at low liquid flow rates. A normal spray nozzle operating far below its design capacity will tend to merely produce a dribble of fluid without sufficient momentum to carry the fluid to the wall as required. This results from the fact that the header pressure will have dropped to some low value dictated by the liquid condition throughout and by the pressure drop across the nozzles at that throughput. The present invention prevents this from occurring by maintaining the header at a constant pressure, thus providing sufficient momentum to the spray at all liquid throughput rates.

In practice, it has also been found that ordinary spray nozzles used as described above tend to produce a different type of spray, depending upon the rate at which the liquid is being introduced, and varying from the desired droplet, form, to a fine mist, which is not desirable.

It is a major object of the present invention to provide a spray system and special spray nozzles which overcome this disadvantage and which produce substantially the same type of droplet in the spray over a wide range of filling rates.

Another object is to provide a spray nozzle arangement which effectively filters out from the spray nozzle small particles tending to plug the nozzle and interfere with its operation, without interfering with the effectiveness of the spray nozzle.



Still another object is to provide an apparatus which permits a steady two-phase liquid-vapor flow through the spray nozzle. A further object is to provide a spray system which is not sensitive to the level of liquid in the header, but produces the same desired type of spray over a wide range of liquid levels.

The specific nature of the invention, as well as other objects and advantages thereof, will clearly appear from a description of a preferred embodiment as shown in the accompanying drawings, in which:

FIG. 1 is a diagrammatic view of a cross-section taken taken through an in-ground storage reservoir, showing a filling system according to the invention;

FIG. 2 is a sectional view taken on line **2**—**2** of FIG. 1;

FIG. 3 is a sectional view taken on line **3**—**3** of FIG. 2; and

FIG. 4 is a view similar to FIG. 2 showing a modified form of the invention.

In FIG. 1, the invention is shown for use in connection with an in-ground storage reservoir **2**, although the invention is also applicable to use with other types of large storage reservoirs. The liquid natural gas in introduced via pipeline **3** controlled by a suitable valve **4**, while pressure gas in introduced on line **6** through an automatic pressure control valve **7**, which may be of any known type, to maintain the gas pressure at a constant value. The gas in line **6** is preferably the vaporized form of the same gas as is introduced on line**3**. The mixture of gas and vapor passes down line **8** to header **9** located in the vapor space of the reservoir **2**. Header **9** is shown as a single large tube, but may be ring-shaped, or may be a grid of such tubes for the purpose of distributing the spray uniformly throughout the tank, as desired. Protruding from the header are a number of tubular members **11** terminating at their lower ends in a suitable spray nozzle **12**, which may be a standard commercial spray nozzle of any suitable type. The spray nozzle **12** is attached to the tubular member **11** in any convenient manner, as by a coupling **13**. Members **8**, **9**, **11**, **12** and **13** should be made of suitable materials, e.g., stainless steel, which can withstand extremely low temperatures involved, in the order of —258° F. Tubular member **11** is terminated at its upper end in the interior of the header by a cap **14**, although in some instances this cap may be omitted and the end of the tubular member left open. The tubular member is provided with at least one slot **16**, and preferably with two or more such slots, as best shown in FIG. 3, the slots being sufficiently long to extend from above the highest liquid level **17** in the header to the lowest liquid level contemplated in normal operation, which can be adjusted by the setting of valve **4**, and by the conditions of filling required by external circumstances. Under the expected conditions of use, the LNG flow rate through the reservoir will vary between 5 and 20 gallons per minute, and the number of spray nozzles, together with the suitable design of the slots, should be made such as to accommodate this range of liquid flow, which can readily be done.

It will be seen that under the above conditions of operation, liquid will enter the tubular element **11** through the slots, and gas will be supplied at all times through the top part of the slot (or through the open end of the tube, if the cap **14** is omitted). The gas pressure is therefore available at all times to force the liquid through the nozzle, and some of the gas, being entrapped in the liquid, will issue together with the liquid, the action being such that the liquid issues as a spray of substantially-sized droplets which are directed preferably against the sides of the reservoir to rapidly cool them during the filling operation. It has been found that this arrangement provides a smooth, constant two-phase spray which does not sputter or cycle, and that it is not particularly sensitive to the

level of liquid within the header, provided that this is maintained within the very substantial range permitted by the linear dimensions of the slots. The width of each individual slot should be made smaller than the orifice in the spray nozzle, so that no particles can get into the tubular element which would plug the nozzle. However, a few particles trapped along the length of the nozzle will do very little harm, nor will they interfere substantially with the desired operation of the spray system. Except for this limitation, the sizing of the slot is not critical.

A suitable gas pressure for the above operation has been found to be 25 p.s.i.g.

Since the device is not very sensitive to liquid level within a wide range, a moderate amount of deviation of the header from strict horizontality can be tolerated, which is an advantage in installing the system. The reservoir **2** can be provided with the customary tube **19** for withdrawing the liquid from the reservoir, and also with a venting means **21** provided with an automatic pressure control **22**, since it is usually desired to maintain the vapor in the vapor space at very slightly above atmospheric pressure, to prevent the possibility of air entering this space and producing an explosive or otherwise dangerous mixture.

FIG. 4 shows a modification of the spray device, in which the slot **16** is replaced by a series of small holes **23** preferably dimensioned to provide the same effective area as the slots, and generally serving the same purpose.

It will be apparent that the embodiments shown are only exemplary and that various modifications can be made in construction and arrangement within the scope of the invention as defined in the appended claims.

I claim:

**1.** Means for filling a liquefied gas reservoir comprising



(a) a generally horizontal header within the reservoir,
(b) means for supplying pressure gas to the header at constant pressure,
(c) means for supplying fluid to the header at various rates of flow over a limited range,
(d) a tubular element passing through the wall of the header,
(e) a spray nozzle at the end of the tubular element exterior of the header, said nozzle being below the level of liquid in the header,
(f) the portion of the tube within the header extending to above the level of liquid in the header, said portion having restricted fluid passage means through the tubular wall thereof, said passage means extending along the length of the tube from below the liquid level to above the liquid level to provide restricted access of fluid and gas under pressure, from the header to the interior of the tube and thence to the nozzle.

**2.** The invention according to claim **1**, said restricted fluid passage means being a narrow slot.

**3.** The invention according to claim **1**, said restricted passage means being a series of small holes.

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