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LIQUID STORAGE TANK VENTING DEVICE FOR ZERO GRAVITY ENVIRONMENT

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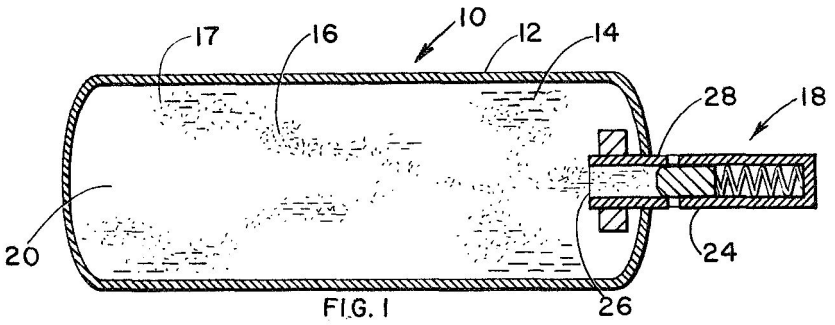

FIG. 1

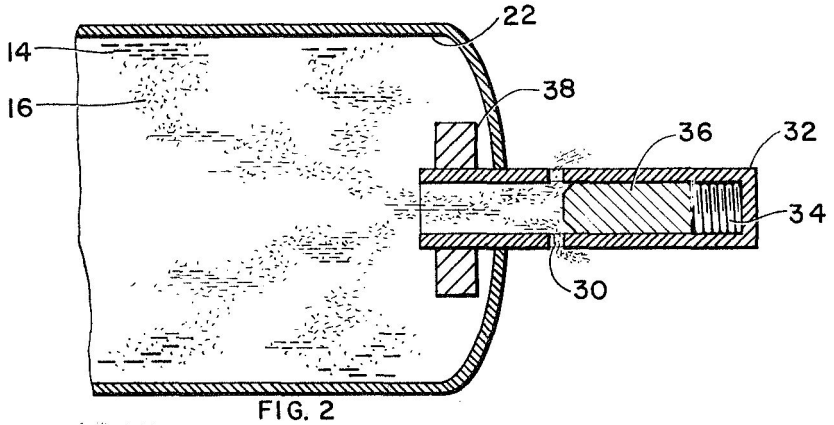

FIG. 2

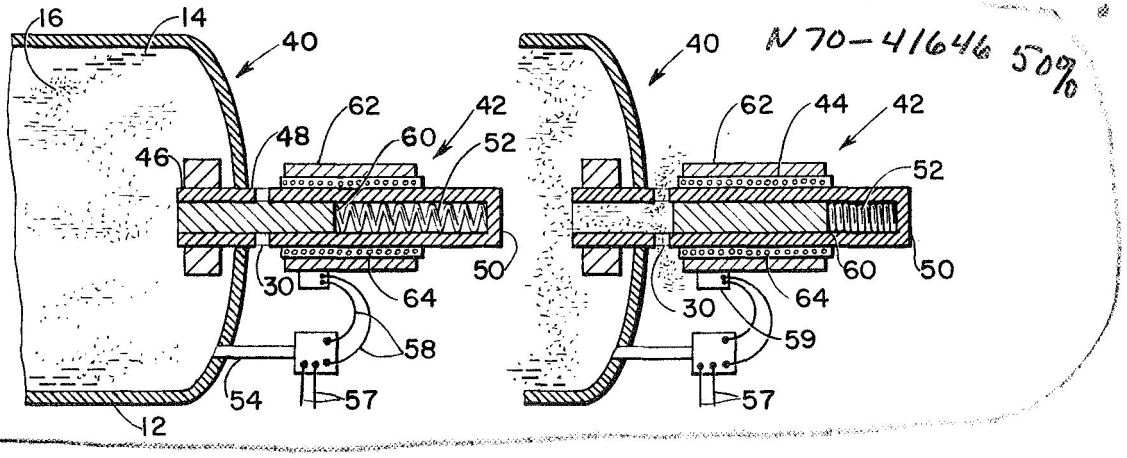

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FIG. 3

FIG. 4

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LIQUID STORAGE TANK VENTING DEVICE FOR ZERO GRAVITY ENVIRONMENT

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1 Claim. (Cl. 137—197)

The present invention relates, generally, to a venting device and, more particularly, to a zero-gravity venting device for vessels or tanks storing magnetic fluids such as those disclosed in co-pending application Serial No. 315,096 filed October 9, 1963 now Patent No. 3,215,572, issued November 2, 1965, and having a common assignee.

Under the zero-gravity environment of outer space, fluids such as cryogenic fluids or liquid propellants become disoriented with the result that, the liquid and vaporous phases of the fluid are free to disperse and intermix throughout the storage tank. From this condition ensues the problem of proper tank venting since radiant heat gain to the storage tank from space causes a dangerous pressure build-up within the tank which must be compensated for in order to prevent tank rupture and to insure that pump inlet pressures are within design limitations so that pumping may be successfully carried out. Of course, the storage tank or pump could be built with thickened containing walls and heavier moving parts, but the excessive weight caused thereby would engender a large energy penalty, necessitating heavier and more cumbersome lower stage boosters or lowered payload. A more advantageous solution to this problem would seem to be the use of a tank venting device to bleed off excess pressure. However, since the gaseous and liquid phases of fluid are intermixed, the use of normal venting devices would result in the loss of large amounts of usable liquid.

Accordingly, it is an object of the invention to provide a venting device which is operative under zero-gravity conditions.

It is another object of the invention to provide a venting device which orients the fluid by magnetic force.

It is still another object of the invention to provide a venting device which selectively vents only the gaseous phase of fluid from the storage tank.

It is yet another object of the invention to provide a venting device for use with a magnetic propellant such as disclosed in the aforementioned co-pending application.

A more complete appreciation of the invention and many attendant advantages thereof will be more readily appreciated as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawing wherein like numerals are used to identify like parts in both embodiments.

In the drawings:

FIG. 1 is an elevation view in section of one embodiment of the invention showing the vent port closed.

FIG. 2 is a view of the venting device of FIG. 1 in larger scale showing the vent port open.

FIG. 3 is an elevation view partly in cross section of an alternate embodiment of the invention showing the vent port in closed position.

FIG. 4 is a view of the venting device of FIG. 3 with the vent port open.

According to the present invention, the foregoing and other objects are obtained by providing a novel venting device for a fluid storage means in which the liquid and vaporous phases of the fluid are selectively separated and the gaseous phase vented to space. A magnet is utilized to orient and separate the two phases of the fluid while a movable valve element mounted in the venting device permits the separated vaporous phase to exhaust to space. Additionally, a pressure sensitive means is provided to control operation of the valve element. In a further refinement of the invention, the movable valve element is solenoid operated and is disposed as to clear the venting device of entrained liquid, returning it to the storage tank by a piston-like motion. In this embodiment a timing means is also provided to regulate the time sequencing operation of the solenoid.

Referring now to the drawings, where throughout like numerals are used to indicate like elements, there is shown in FIGS. 1 and 2 one embodiment of the invention wherein a tank and venting assembly **10** is provided with a storage tank **12** in which the liquidous phase **14** and gaseous phase **16** of the fluid **17** are stored. Because of the absence of any gravitational force on these phases, they are randomly dispersed and intermixed throughout the tank **12** (as best seen in FIG. 1). Venting device **18**, fixed to the tank, provides an exit flow passageway from the tank interior **20** to control excess pressure build-up caused by the boil-off of the stored fluid.

This venting device is sealingly attached to tank wall **22** by welding or the like to insure that there is no unwanted leakage of the stored fluid to space, and is formed from a pipe **24** having an inner portion **26**, an intermediate port portion **28**, and an end portion **32**. The inner portion **26** of the vent pipe **24** extends into the tank interior **20** and is open thereto to provide communication for the gaseous phase of the fluid to the venting device, while the ports **30** in the intermediate portion **28** are capable of being alternately opened and closed by valve element **36** to permit exhaust of this vaporous phase to space. End portion **32** made integral or separate from the remainder of the vent pipe closes the end of the pipe **24** to seal the tank and venting assembly from space. Attached between the end portion **32** and the valve element **36** is compressed spring **34**, this spring being preloaded to resist a selected pressure safely with the design limitations of the tank **12**. On the inner portion **26** of the vent pipe **24**, magnet **38** is mounted so as to surround the vent pipe and trap the magnetized liquid and prevent its escape to space.

In operation, as boil-off of the fluid progresses, pressure increases in tank **12** forcing the valve element **36** against the preloaded spring **34**. As the spring compresses, the valve element **36**, within the vent pipe **24**, moves away from sealing engagement with ports **30** towards the end portion **32** to thereby permit the gaseous phase **16** of the fluid to escape from the tank in sufficient amounts to permit the valve element to again seal the ports **30**. As set out in the aforementioned co-pending applications, the liquidous phase of the fluid **17** has colloidally suspended therein metal particles having magnetic properties. Magnet **38** attracts and holds this liquidous phase to form a slug which by a process of adhesion or surface tension remains held adjacent to the magnet while the non-magnetic gaseous phase bubbles through the slug and passes out the exit ports.

Referring now to the embodiment of the invention illustrated in FIGS. 3 and 4, wherein the venting device includes a valve element having solenoid actuation.

The tank and vent assembly, indicated generally by the numeral **40**, is provided with a venting device **42**, similar in many respects to the venting device of the first embodiment. It includes a vent pipe **44** having an inner portion **46** in sealing communication with the tank in-

terior **20** and port and end portions **48**, **50**, respectively, extending outwardly from the tank **12**. The vent portion **48**, similarly to the first embodiment, is provided with ports **30** through which the gaseous phase of the fluid exhausts to atmosphere.

End portion **50** made either integral or separate from the remainder of the vent pipe seals the end of the pipe and provides one of the connections for a spring **52**. The opposite end of this spring is connected to a valve element **60** and is always under slight compression so as to urge the valve element into sealing engagement with the ports **30**. A pressure tap **54** which is sealingly affixed to the tank **12** at one end, adjacent to the vent pipe **44**, has its opposite end connected to a pressure transducer **56** set for a predetermined pressure safely within the design limitations of the tank **12**. Leads **57** provide connection to an outside power source (not shown) while leads **58** connect the transducer **56** to a timer **59**, for example, a time delay relay, which actuates the valve element **60** through solenoid **62** having windings **64**. The timer **59** holds the valve element open a predetermined time to permit exhaust of the gaseous propellant **16** and to prevent too rapid sequencing of the valve element and then switches off the solenoid to permit the valve element **60** to return to the closed position illustrated in FIG. 3. As can be easily seen in this figure, this position of the valve element **60** discharges any liquid phase **14** of the magnetic fluid back into the tank to prevent a large build-up of liquid in the venting device itself.

The operation of this embodiment of the invention is similar to that of the embodiment illustrated in FIGS. 1 and 2 but, because of the positive solenoid actuation and consequent purging of the venting device by the valve element, provides somewhat better control over extended periods of operation.

It is clear from the foregoing that the present invention may be effectively utilized for venting any stored magnetic fluid, and that, obviously, many modifications and variations of the present invention are possible in the light of the above teachings. It is to be understood, therefore, that within the scope of the appended claims, the invention may be practiced other than as specifically described.

What is claimed is:

A venting device for use with a storage tank adapted to contain a magnetic fluid having a liquid phase and a gas phase and subject to zero gravity conditions, said venting device comprising a vent pipe connected to said tank in sealing communication therewith, said vent pipe having an inner portion extending into said tank and outer portion disposed outwardly of said tank, said inner portion having an open end and said outer portion having a closed end; port means in said outer portion of said vent pipe; magnetic means disposed around said inner portion of said vent pipe to prevent passage of the liquid phase of said magnetic fluid from said tank to said port means; a plunger-like valve element slidably disposed in said vent pipe and having sufficient travel so that the end of said valve means facing the interior of said tank can move between a point inward of said magnetic means and a point outward of said port means; a preloaded spring means disposed between said valve element and said closed end of said outer portion of said vent pipe, said valve means compressing said spring means to unblock said port means thereby venting a portion of the gas phase of said magnetic fluid when pressure in said tank exceeds a predetermined magnitude, said spring means biasing said valve means to a position at which the end of said valve means facing said interior of said tank is normally positioned inwardly of said magnetic means whereby after each venting action, said valve means forces magnetic liquid from said vent pipe into said tank thereby preventing a build-up of magnetic liquid in said vent pipe.

References Cited by the Examiner

UNITED STATES PATENTS

1,553,737	9/1925	Allingham	55—3
2,305,519	12/1942	Dunmire	137—538
2,556,906	6/1951	Del Mar	137—487.5 XR
2,575,906	11/1951	Bullard	251—65 XR

FOREIGN PATENTS

561,861	4/1957	Italy.

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