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FILLING RATE CONTROL

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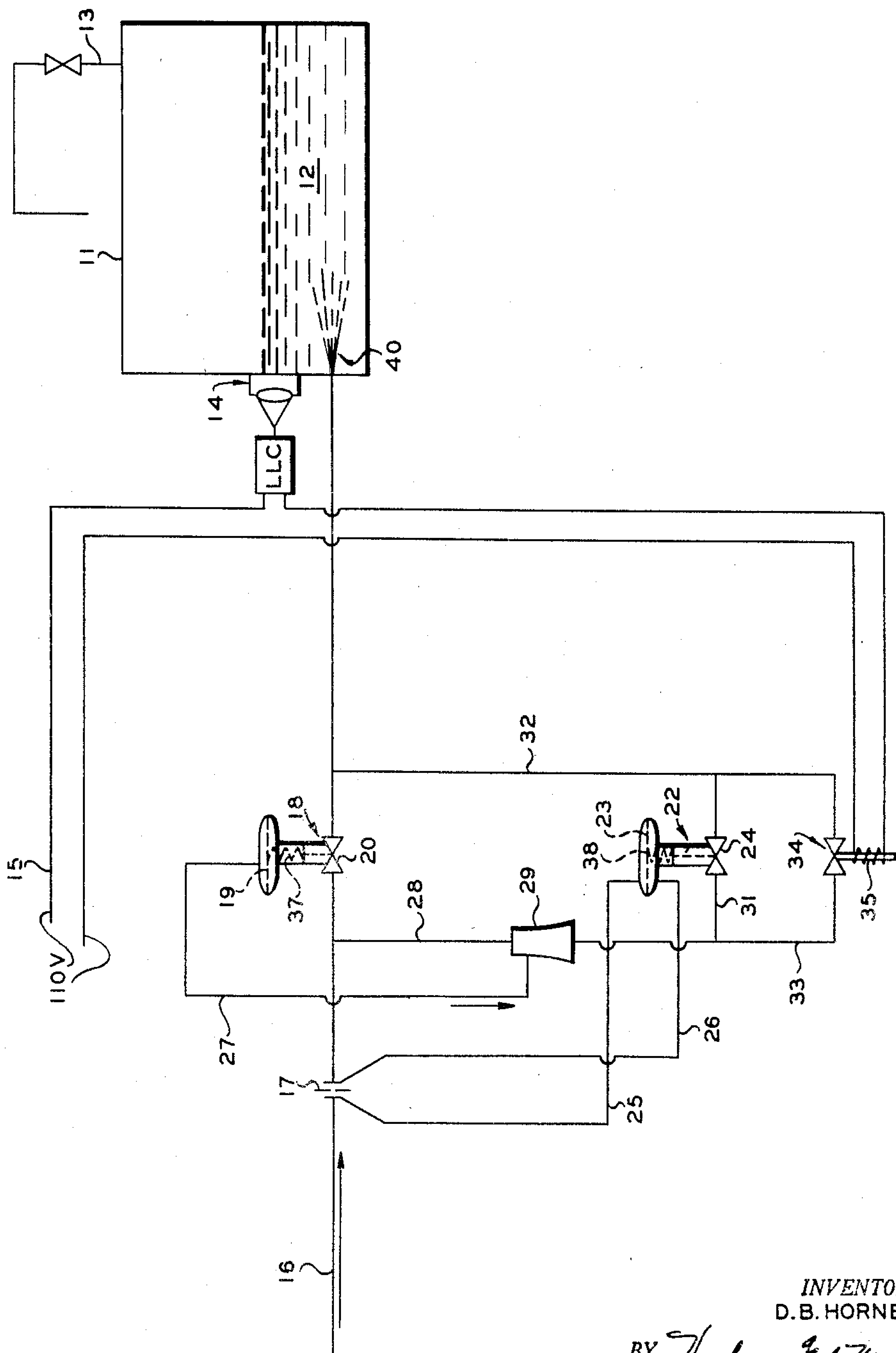

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FILLING RATE CONTROL

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This invention relates to apparatus and method for safely filling a tank with a liquid, the vapors of which form an explosive mixture with the atmosphere. In one aspect it relates to apparatus and method for minimizing danger of explosion while filling an open tank with a liquid, the vapors of which form explosive mixtures with air at ambient temperatures.

When jet airplanes fuels, kerosenes and other petroleum products having vapor pressures similar to those fuels just mentioned, are stored in tanks open to the atmosphere, the vapor in the space above the liquid is frequently within the inflammable range over a wide temperature range. It is known that for such liquid fuels the rates of vaporization are such that the vapors produced therefrom at ambient temperatures form with the air normally contained in the vapor space of the tank mixtures the compositions of which are within the explosive limits. Liquids having lower vapor pressures usually do not evolve vapors at sufficient rates to form explosive mixtures with the air in a tank, that is, the compositions of the mixtures of fuel vapors and air are lower in fuel vapor content than the lower explosive limits. Higher vapor pressure fuels evolve vapors at sufficiently high rates that the compositions of the mixtures of vapors and air in the vapor space in the tank are higher in the fuel vapor contents than the upper explosive limit. Thus, liquid fuels having higher or lower vapor pressures than the above-mentioned jet fuels, kerosene, and other petroleum products having vapor pressures similar thereto, do not present the hazards which jet fuels and the like do present.

Explosions within storage tanks being filled with the above-mentioned jet fuels, kerosene and other petroleum products having vapor pressures similar to those of jet fuels and kerosenes, sometimes occur when the static charge which has been generated at the surface of the liquid while the tank is being filled is released to the vapor space above the liquid. It is well known that one of the normal operations which contributes to the generation of such a static charge is filling the tank at such a rate as to cause more or less violent agitation of the liquid within the tank. Such agitation can be avoided by controlling the linear velocity of the stream entering the tank to a velocity below about 3 feet per second until the level of the liquid in the tank reaches a depth of about 6 feet. To my knowledge such a type of control for filling a tank with such fuels has not been accomplished and the present invention relates to an automatic control system and method for regulating the filling of a tank so as to eliminate or at least minimize the danger of explosion from a static charge within the tank.

One object of my invention is to provide a simple method for filling a tank with jet fuels, kerosenes and other petroleum products having vapor pressures similar to those of jet fuels and kerosenes, to avoid the hazard of explosion while filling the tank due to static charge.

Another object of my invention is to provide an apparatus automatic in its operation for carrying out this stated method.

Still another object of my invention is to provide such an apparatus which is relatively inexpensive to construct and to operate.

Yet other objects and advantages of my invention will be realized upon reading the following description which, taken with the attached drawing, forms a part of this specification.

The drawing illustrates in diagrammatic form an assembly of apparatus parts suitable for carrying out the method of my invention.

Broadly, my invention provides a flow controller assembly for controlling flow of liquid into a vessel comprising, in combination, a vessel for storage of liquid, a conduit for supplying liquid to said vessel, a normally open motor valve in said supply conduit for regulating flow of liquid to said vessel, first flow indicating means in said supply conduit, second means for operating said motor valve, said second means being responsive to said first means, a liquid level indicator assembly operatively disposed in said vessel, third means operatively communicating said liquid level indicator assembly and said second means, said second means also being responsive to said liquid level controller assembly, said liquid level controller assembly and said third means being adapted to override said flow indicating means to open said motor valve for unrestricted flow of liquid in said supply conduit to said vessel when said liquid level indicator assembly indicates liquid in said vessel is at level above a predetermined level.

Furthermore, my invention provides a method for minimizing the danger of an explosion resulting from a static electric charge generated at the surface of liquid hydrocarbon introduced into an open storage tank, the vapors of said hydrocarbon forming an explosive mixture with the atmosphere in said storage tank, comprising the steps of introducing said liquid hydrocarbon into said tank at a flow rate below which a static charge is built up at the surface of the liquid in the tank until the level of liquid in said tank reaches a predetermined level, and subsequently increasing the flow rate of liquid introduced into said tank.

Referring now to the drawing, reference numeral **11** identifies a tank to be filled with, for example, a jet fuel, kerosene or other petroleum product having such a vapor pressure or volatility that the fuel vapors in the tank form an explosive mixture with atmospheric air in the tank. Reference numeral **12** identifies the quantity of such a liquid fuel in tank **11**. Pipe **13** is a vent having a valve which is, of course, opened during filling and emptying of the tank. A pipe **16** conduits liquid, from a source not shown, to tank **11**. This pipe is provided with a normally closed throttle motor valve **18** for control of the rate of flow of liquid fuel into the tank. This motor valve **18**, by way of example, is illustrated as being a diaphragm operated valve. A tension spring **37** is provided below the diaphragm **19** in such a manner as to tend to pull diaphragm **19** downward, which movement closes the valve. The space below diaphragm **19** in the motor is vented to the atmosphere through an opening, not shown. An orifice plate assembly **17** is provided in pipe **16** as illustrated. A by-pass conduit, comprising pipes **28**, **31** and **32**, extends from a point upstream of motor valve **18** to a point downstream of this valve as regards flow of liquid into tank **11**. The portion of this by-pass conduit, identified by reference numeral **31**, is provided with a normally open throttle motor valve **22**. As illustrated, motor valve **22** is provided with a motor containing a diaphragm **23** for pneumatic operation. The valve portion **24** can be any suitable type valve desired. A compression spring **38** is disposed below diaphragm **23** and this spring tends to open the valve so that the valve is a normally open valve. A tube **25** connects the upstream side of the orifice plate assembly **17** with the space above diaphragm **23** while tube or pipe **26** connects the downstream side of the orifice plate assembly with the space on the under side of the diaphragm **23**. A second by-pass or tube **33** provides a by-pass around normally open motor valve **22**. This valve **34** is an open-closed snap-action valve. As illustrated in the drawing, it is a solenoid operated valve, the solenoid being identified by reference numeral **35**.

A pair of electrical wires **15** conduct ordinary 110 volt electric current, from a source not shown, to the apparatus of my invention. One lead of these wires is connected with a liquid level float controller assembly **14** installed operatively in tank **11** as illustrated. This liquid level controller apparatus is intended to operate in such a manner that when the float rises to a predetermined level, the circuit through leads **15** is closed and the solenoid **35** operates to open valve **34**.

As illustrated in the drawing, a venturi **29** is inserted in line **28** as shown. This venturi is intended to receive a small stream of the liquid flowing through supply pipe **16** upstream of valve **20** of the motor valve **18** and to discharge this small stream either to pipes **31** or **33** depending on whether motor valve **22** or motor valve **34** is open. The suction opening of venturi **29** communicates by way of pipe **27** to the space above diaphragm **19** in motor valve **18**.

Liquid leaving supply pipe **16** and entering tank **11** is identified by reference numeral **40**.

As stated hereinabove, to avoid the possibility of an explosion in such a tank by discharge of a static charge from the surface of the liquid to the vapor it is merely necessary to restrict the velocity of the inflowing stream of liquid fuel **40** to a velocity of less than 3 linear feet per second until such time as the surface of the liquid **12** reaches a height of about 6 feet in the tank. At this time the velocity of the liquid **40** entering the tank appears not to form a static charge of sufficient magnitude to be hazardous. Thus, the operation of my invention is specifically directed to restricted flow of liquid fuel into the tank at a low rate until a considerable volume of fuel is in the tank. Then liquid can be introduced into the tank at any desired flow rate.

The operation of the specific apparatus illustrated is as follows: Liquid fuel, from a source not shown, is pumped through pipe **16** and through valve **20** into the tank. While the level of liquid in the tank is low, that is, below about 6 feet, and if the rate of flow of liquid into the tank is greater than about 3 feet per second, there is a large pressure drop on passage of the liquid through the orifice plate assembly **17** and a relatively great pressure differential is produced between pressures in pipes **25** and **26**. Thus, under this condition pressure above diaphragm **23** is greater than the pressure below the diaphragm and the compression spring **38** is compressed with the downward movement of diaphragm **23** and the valve **24** is throttled, that is, partially closed so as to restrict the flow of liquid through pipe **31**. With the flow of liquid restricted through pipe **31** the flow of liquid from pipe **28** through venturi **29** is accordingly restricted. Restriction of liquid flow through venturi **29** similarly restricts the suction produced in pipe **27** and the pressure on the diaphragm **19** increases thereby cooperating with tension spring **37** to throttle and to partially close valve **20** thereby restricting the rate of liquid flow through valve **20** into tank **11**.

If the flow of liquid through pipe **16** into tank **11** is appreciably below, for example, 3 feet per second, the pressure drop across orifice plate assembly **17** is small with the result that motor valve **22** opens somewhat to allow a larger flow of liquid through pipes **28**, **31** and **32** which increased flow increases the suction in pipe **27** thereby reducing the pressure in the space above diaphragm **19** which operation allows valve **20** to open somewhat.

When the liquid entering tank **11** under the above described conditions has reached a level of approximately 6 feet, it is then safe to increase the rate of liquid flow into the tank. The liquid level controller **14** is so disposed in tank **11** that when the surface of the liquid reaches the approximate 6 foot level the float operates a switch in the control box of the controller to close the circuit in leads **15** thereby causing the solenoid **35** to open the valve of motor valve **34**. When the valve **34** is thus fully opened, there is no restriction of flow of liquid through pipes **28**, **33** and **32**, thus resulting in a full velocity of liquid through the venturi **29**. This full flow through venturi **29** creates a maximum of suction in pipe **27** and this operation fully opens valve **20** of motor valve **18** which operation allows full velocity flow of liquid fuel from pipe **16** into tank **11**.

While I have described merely as examples the use of an orifice plate assembly **17** in conduit **16** and a venturi **29** in conduit **28**, the use of these specific pieces of apparatus is not critical because other suitable apparatus operating on the same principles can, when desired, be used. For example, orifice plate assembly **17** can be replaced by a venturi similar to venturi **29** with a suction line leading from the venturi to one side of a valve more or less similar to valve **22** in pipe **31**. Likewise, venturi **29** in pipe **28** can be replaced by an orifice plate assembly similar to assembly **17** with two pressure pipes leading to opposite sides of a motor valve similar to motor valve **18**. Also, if desired, both of these pressure responsive pieces of apparatus can in one installation be orifice plate assemblies or both can be venturis. The selection of the specific types of apparatus to be used in a given application can be dictated in many cases upon local conditions, for example, orifice plate assemblies may already be available at a given plant in which this installation is desired.

Such liquids as would normally be handled by this apparatus ordinarily do not possess corrosive properties. Thus, equipment may not need to be selected to resist corrosion.

While I have disclosed a liquid inlet velocity of about 3 feet per second and a liquid level of about 6 feet in the storage tank, the specific values are merely examples. The critical velocity and critical height of liquid in a tank being filled will vary depending among other things on the specific fuel, its vapor pressure, ambient conditions, etc. Regarding vapor pressure of the liquid being passed into the tank, the intended vapor pressure is that which the given fuel ordinarily possesses.

While certain embodiments of the invention have been described for illustrative purposes, the invention obviously is not limited thereto.

I claim:

1. A flow controller assembly for controlling flow of liquid into a vessel comprising, in combination, a vessel for storage of liquid, a conduit for supplying liquid to said vessel, a motor valve in said conduit for regulating flow of liquid to said vessel, a flow sensing means in said conduit, means for operating said motor valve, said means for operating said motor valve being responsive to said flow sensing means in such a manner that said motor valve throttles upon an increase in the sensed differential by said flow sensing means and opens wider upon a decrease in sensed differential so as to maintain a substantially constant flow rate, a liquid level controller assembly operatively disposed in said vessel, means operatively communicating said liquid level controller assembly and said means for operating said motor valve so that said means for operating said motor valve is also responsive to said liquid level controller assembly, said liquid level controller assembly and said means operatively communicating said liquid level con-

troller assembly and said means for operating said motor valve being adapted to override said flow sensing means to open said motor valve for unrestricted flow of liquid in said supply conduit to said vessel when said liquid level controller assembly indicates liquid in said vessel is at a level above a predetermined level.

2. A flow controller assembly for controlling flow of liquid to a vessel comprising, in combination, a vessel to hold liquid, a supply conduit for passage of liquid to said vessel, a first motor valve in said supply conduit, a flow sensing device in said supply conduit, a second and by-pass conduit communicating said supply conduit on opposite sides of said first motor valve, said second conduit comprising a venturi, said venturi being disposed to pass liquid flowing through said second conduit from said supply conduit on the side of said first motor valve opposite said vessel to said supply conduit on the side of said first motor valve adjacent said vessel, a second motor valve in said second conduit downstream of said venturi, means for operating the motor of said second motor valve, said means being responsive to said flow sensing device, a third conduit communicating said second conduit intermediate said venturi and said second motor valve with said supply conduit intermediate said first motor valve and said vessel, a third motor valve in said third conduit, and a fourth conduit means communicating the motor of said first motor valve with the throat of said venturi in such a manner that upon sensing an increase in flow said sensing device throttles said second motor valve thereby restricting flow through said venturi whereupon said first motor valve throttles, and upon sensing a decrease in flow said sensing device opens said second motor valve thereby increasing flow through said venturi whereupon said first motor valve opens so as to maintain a substantially uniform flow rate, a liquid level controller assembly disposed operatively in said vessel, said liquid level assembly communicating with the motor of said third motor valve in such a way as to open said third motor valve and such opening will in turn effect the full opening of the first motor valve when the level of liquid in said vessel is above a predetermined level.

3. A flow controller assembly comprising, in combination, a vessel for storage of liquid, a supply conduit for passage of liquid to said vessel, a first motor valve in said supply conduit, a flow sensing device in said supply conduit, a first by-pass conduit communicating with said supply conduit on opposite sides of said first motor valve, a second by-pass conduit also communicating with said supply conduit on opposite sides of said first motor valve, a portion of said first by-pass conduit being common to a portion of said second by-pass conduit, second and third motor valves in said first and second by-pass conduits respectively, a venturi in the common portion of said by-pass conduits, a fourth conduit communicating the throat of said venturi operatively with the motor of said first motor valve, said flow sensing device being connected operatively with the motor of said second motor valve in such a manner that upon sensing an increase in flow said sensing device throttles said second motor valve thereby restricting flow through said venturi whereupon said first motor valve throttles, and upon sensing a decrease in flow said sensing device opens said second motor valve thereby increasing flow through said venturi whereupon said first motor valve opens so as to maintain a substantially uniform flow rate, a liquid level controller operatively in said vessel, and a fifth conduit operatively connecting said liquid level controller with the motor of said third motor valve in such a manner that when the liquid in said vessel reaches a predetermined level the third motor valve will be opened and such opening will in turn effect the full

opening of the first motor valve for unrestricted flow into the vessel.

4. A flow controller assembly comprising, in combination, a vessel adapted to hold liquid under atmospheric pressure, a supply conduit for passage of liquid into said vessel, a first motor valve in said supply conduit, an orifice plate flow sensing device in said supply conduit, a first by-pass conduit communicating with said supply conduit on opposite sides of said first motor valve, a second by-pass conduit communicating with said supply conduit on opposite sides of said first motor valve, a second normally open motor valve in said first by-pass conduit, a third motor valve in said second by-pass conduit, a portion of said first by-pass conduit being common to a portion of said second by-pass conduit, a venturi in the common portion of said by-pass conduits, said venturi being disposed to discharge liquid in the direction of flow of liquid to said vessel, a fourth conduit communicating the throat of said venturi and the motor of said first motor valve, a separate conduit communicating said supply conduit on each side of said flow sensing device with the motor of said second motor valve in such a manner that upon sensing an increase in flow said sensing device throttles said second motor valve thereby restricting flow through said venturi whereupon said first motor valve throttles, and upon sensing a decrease in flow said sensing device opens said second motor valve thereby increasing flow through said venturi whereupon said first motor valve opens so as to maintain a substantially uniform flow rate, a liquid level controller disposed operatively in said vessel, and a fifth conduit communicating said liquid level controller with the motor of said third motor valve for passage of motive power thereto in such a manner that when the liquid in said vessel reaches a predetermined level the third motor valve will be opened and such opening will in turn effect the full opening of the first motor valve for unrestricted flow into the vessel.

5. A method for minimizing the danger of an explosion resulting from a static electric charge generated at the surface of liquid hydrocarbon introduced into an open storage tank, the vapors of said hydrocarbon forming an explosive mixture with the atmosphere in said storage tank, comprising the steps of introducing said liquid hydrocarbon into said tank directly at a level near its bottom at a velocity below which a static charge is built up at the surface of the liquid in the tank until the level of liquid in said tank reaches a level above which a static charge fails to build up at high liquid inlet velocity, and subsequently automatically increasing the velocity of liquid being introduced into said tank.

6. A method for minimizing the danger of an explosion resulting from a static electric charge generated at the surface of liquid hydrocarbon of the nature of jet fuels and kerosene introduced into an open storage zone, the vapors of said jet fuels and kerosene forming explosive mixtures with atmospheric air in said storage zone, comprising the steps of introducing said liquid hydrocarbon into said storage zone directly at a level near its bottom at a velocity below which a static charge is built up at the surface of the liquid in said zone until the level of liquid in said zone reaches a level above which a static charge fails to build up at high liquid inlet velocity and subsequently automatically increasing the velocity of liquid being introduced into said zone.

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