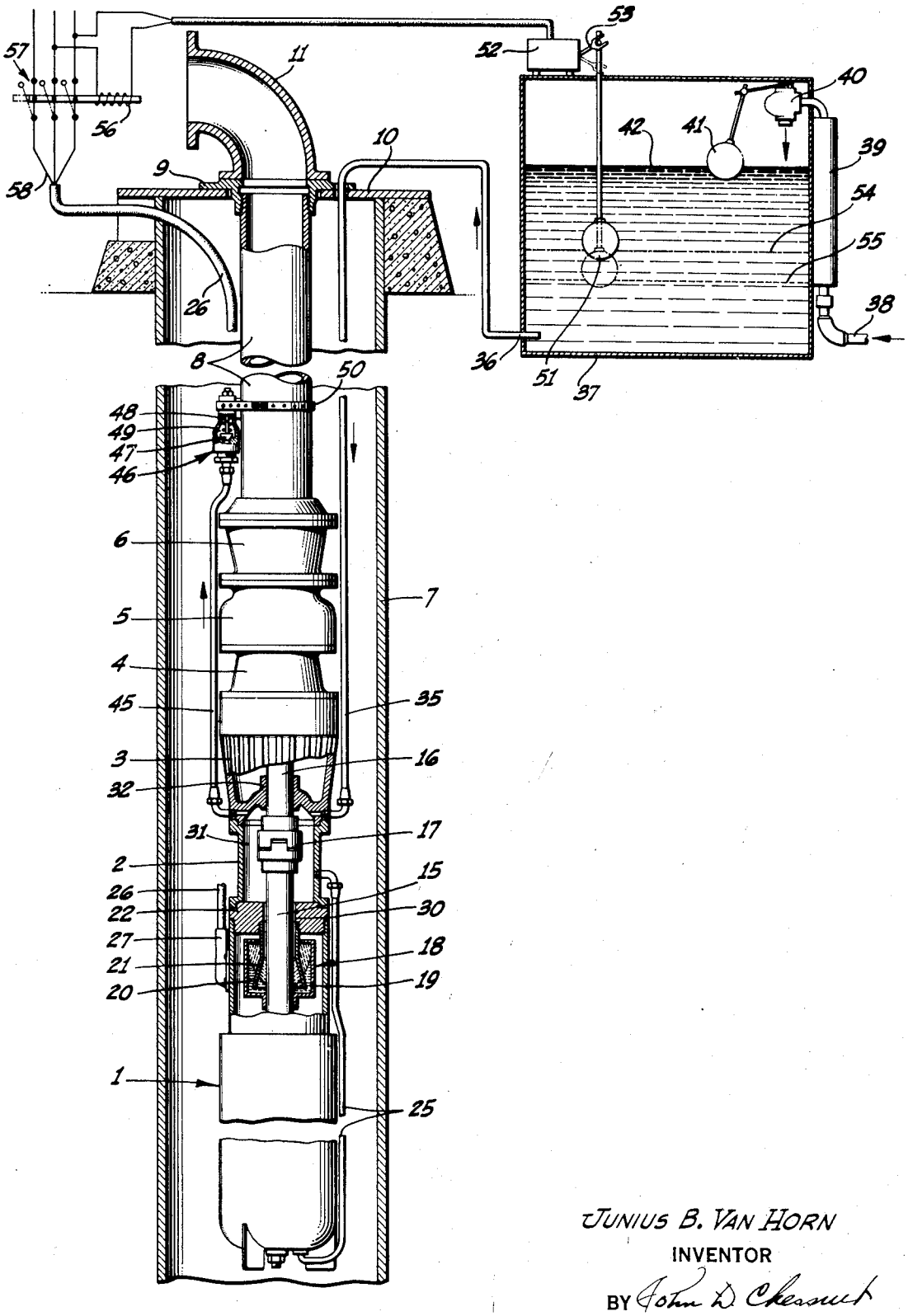
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SUBMERSIBLE MOTOR STRUCTURE

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SUBMERSIBLE MOTOR STRUCTURE

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This invention relates generally to submersible electric motors, and pertains particularly to improved means for protecting the shaft seals of such motors from the detrimental action of the ambient fluid in which the motor is immersed. The invention is particularly directed, although not necessarily limited, to the protection of a fluid-packed shaft seal of a submersible motor immersed in a fluid which, if allowed to contact the seal, would adversely affect its operation.

Submersible electric motor-pump units have been developed to meet a wide variety of pumping services and conditions. They are widely used for pumping oil, water, or oil-water mixtures from deep wells, also in oil refinery and pipe line service for pumping hydrocarbons, and their use in industrial processes for pumping various chemical mixtures is rapidly increasing. It has been ascertained, however, that certain liquids to be pumped contain components which may have an adverse effect on the shaft seal of the submersible motor, and consequently the field of application of submersible motor-pump units has heretofore been limited to those services in which the liquid to be pumped has no detrimental effect on the shaft seal.

A principal object of this invention is to provide a novel and thoroughly dependable protective system for the shaft seal of a submersible motor, which is capable of rendering the operation of the seal wholly independent of the nature of the liquid in which the motor is immersed.

A further object is to provide a seal protecting system which is equally effective over an extended period of time, and which is fully automatic and requires no manual attention.

A more specific object is to provide a seal protecting system wherein the seal is isolated from the surrounding medium by a confined body of protecting liquid which has no detrimental effect on the seal, and wherein cumulative contamination of the protecting liquid by the external liquid is avoided by continuously circulating clean protecting liquid from a suitable source through the chamber containing the confined body of protecting liquid.

A still further object is to provide, in conjunction with a seal protecting system of the aforementioned character, an auxiliary protecting system operable to de-energize the motor in the event the seal protecting system should fail to function properly due to failure of the supply of protecting liquid or from other unforeseen causes.

The manner in which the foregoing and other objects are attained will be apparent from the following detailed description of an illustrative embodiment of the invention, reference being had to the accompanying drawing wherein the single figure illustrates the application of the invention to a deep well submersible motor-pump unit.

Referring to the drawing, the submersible motor-pump unit shown therein is generally of a well-known construction, and comprises a submersible electric motor, generally indicated at 1, secured to and supported by an adapter 2, which in turn is suspended from a pump assembly consisting of a strainer 3, a suction piece 4, a pump bowl 5, and a discharge piece 6. The unit is suspended in the well casing 7 by a discharge column 8, which is supported at the surface of the well by a collar 9 resting on a cover plate 10. An elbow fitting 11 is secured to the collar 9, and is connected to a suitable discharge line (not shown).

The motor is connected in driving relation with a pump impeller mounted in the bowl 5, by sectional shafting including a motor shaft 15 and a pump shaft 16 coupled thereto by a coupling 17. In the particular embodiment illustrated, the interior of the motor contains a dielectric liquid, which is isolated from the liquid filling the adapter 2 by a fluid-packed seal, generally indicated at 18. The seal is of well-known construction and hence it will suffice to state that it comprises generally a cup-shaped member 19 secured to the shaft 15 to rotate therewith and containing a body of mercury or other sealing liquid 20, and a stationary annular baffle member 21 secured at its upper end to the end closure plate 22 of the motor housing. The baffle 21 extends downwardly into the cup member 19 to a point below the surface of the sealing liquid, thus effectively isolating the dielectric liquid in the motor housing from the liquid in the adapter 2.

In order to provide for thermal expansion and contraction of the internal liquid in the motor housing, the lower end of the motor housing is connected in open communication with the adapter by a balance tube 25. In this manner, the pressures in the motor housing and in the adapter are equalized independently of the fluid seal, thus avoiding displacement of the sealing liquid which would result from a preponderance of pressure on one side thereof.

Electrical energy for operating the motor 1 is conducted from a suitable source at the surface through an armored conductor cable 26 extending downwardly to a terminal box 27 secured in fluid-tight relation to the motor housing, and from which suitable leads extend into the motor

housing and are connected to the motor in a well-known manner.

The construction described thus far is well known, and is capable of functioning satisfactorily for an indefinite period of time, provided the liquid in which the unit is immersed is of such a nature that it has no detrimental effect on the seal 18. However, it has been ascertained from extensive tests that certain liquids encountered contain components which adversely affect the operation of the seal. For example, if the pump liquid contains even a very small percentage of sulfur of the order of 0.5 of one percent, and if such a sulfur-containing liquid is permitted to contact the mercury in the seal, it has been found that the sulfur combines with the mercury to form a sludge which is detrimental to the operation of the seal. Inasmuch as crude petroleum usually contains a higher percentage of sulfur than that mentioned above, it is not feasible to employ a pumping unit such as that described for pumping an oil well, unless means are provided for protecting the seal from the detrimental effect of the pump liquid. Certain petroleum refinery products, such as fuel oil, often contain sulfur in harmful percentages, and hence similar protective measures must be taken when pumping them with a unit such as described. Other instances have been found where components other than sulfur adversely affect the seal, and for this reason the utility of a seal protecting system, such as that about to be described, is not limited to submersible units employed in pumping oil wells or in handling petroleum products generally.

In the present instance, the well liquid in which the motor-pump unit is immersed is prevented from contacting the seal 18 by interposing a body of clean liquid, which has no detrimental effect on the seal, between the seal and the well liquid. It will be observed, with reference to the drawing, that the portion of the seal chamber between the baffle 21 and the shaft 15 is in open communication, through the narrow annular passage 30, with the chamber 31 formed within the adapter 2. This chamber is substantially fluid-tight but is not completely so because of the possibility of infiltration of well liquid downwardly along the pump shaft 16 past the bearing hub 32 in the strainer 3. For this reason, it has been found that if the chamber 31 were filled with a body of clean protecting liquid, in the course of time the protecting liquid would become contaminated by the external liquid and would then be incapable of performing its intended function—that of isolating the seal from the external liquid.

By the present invention, the aforementioned difficulties are overcome and a seal protecting system is provided which is capable of functioning indefinitely without attention. This is accomplished by delivering protecting liquid to the chamber 31 at a pressure higher than that of the external liquid, whereby any leakage between the shaft 16 and the bearing 32 will be outwardly rather than inwardly. Provision is also made for limiting the excess pressure in the chamber to an amount sufficient to cause outward flow past the bearing at a rate which prevents infiltration of well liquid downwardly along the shaft.

In the embodiment illustrated in the accompanying drawing, a supply conduit 35 is connected at its lower end to the chamber 31 and extends upwardly to the top of the well, where it is connected to the outlet 36 of a liquid supply tank 37. The protecting liquid, which may be clean water or other suitable liquid, is supplied to the tank 37 from a suitable source through a supply conduit 38, a filter 39, and a float controlled inlet valve 40 which is controlled by a float 41 to maintain the liquid level in the tank substantially at the level indicated at 42.

If the clearance between the shaft 16 and the bearing 32 were to remain constant during the life of the installation, so as to provide a restricted discharge orifice of definite and constant cross-sectional area, it would be possible to maintain a predetermined excessive pressure in the chamber 31 simply by the selection of the proper size of supply conduit 35 with relation to the length of the conduit and the depth of submergence of the adapter 2 beneath the surface of the well liquid. Unfortunately, however, the bearing 32 is subject to wear, so that the clearance between the shaft and the bearing gradually increases, and as a consequence the flow resistance decreases and allows a greater volume of flow therethrough under a given pressure head. Any increase in the rate of discharge from the chamber 31 obviously decreases the pressure in the chamber, since the frictional resistance in the supply conduit 35 increases with increased flow. Consequently, if the discharge from the chamber were confined solely to that escaping past the bearing 32, it would be necessary to select a conduit 35 of a size which would provide an unduly high initial pressure in the chamber when the bearing 32 is new and relatively tight in order to be certain that when the bearing becomes worn and the clearance increases, the pressure in the chamber will be sufficiently high to maintain a rate of outward flow past the bearing which will prevent migration of internal liquid downwardly along the shaft.

I prefer, however, to avoid the necessity of maintaining an initially high pressure in the chamber 31, by providing an auxiliary discharge port in the chamber. Referring to the drawing, it will be observed that a second conduit 45 is connected at its lower end to the chamber 31 at the side thereof opposite the conduit 35. The conduit 45 extends upwardly to a point above the pump discharge piece 8, and to the upper end thereof there is connected a mechanism exerting a predetermined back pressure on the flow through the conduit. Any suitable means may be employed for this purpose, and I have shown, for purpose of illustration, a spring-loaded pressure relief and check valve generally designated 46, having a valve member 47 yieldingly pressed downwardly on its seat by an adjustable compression spring 48, and having an outlet 49 above the valve seat. Any suitable means, such as plumber's tape 50, may be used to secure the valve to the discharge column 8. It will be understood, of course, that the auxiliary outlet need not embody an upwardly extending conduit. For example, the pressure relief valve or other back-pressure means may, if desired, be connected directly to the adapter 2, or it may be connected to the balance tube 25.

It will be apparent that the adjustment of the spring 48 in the valve 46 will predetermine the magnitude of the excess pressure which will be maintained in the chamber 31. While the bearing 32 is relatively tight, only a relatively small quantity of protecting liquid can escape past the bearing, the remainder flowing outwardly through the conduit 45 and the valve 46. As the bearing becomes worn, a greater proportion

of the liquid will flow past the bearing, and less will flow through the valve. However, it is obvious that, irrespective of the amount of clearance between the bearing and the shaft, the total discharge from the chamber will remain constant, because the pressure is maintained constant by the spring-loaded valve, and a constant pressure in the chamber produces a constant rate of flow in the supply conduit 35. In this manner, a stable operating condition is established at the outset and is maintained throughout the operation of the pumping unit. Even material changes in the pumping level of the well liquid have no effect on the rate of flow of protecting liquid, inasmuch as the relation of the internal pressure in the chamber to the external submergence pressure is predetermined by the adjustment of the valve spring, and is independent of the absolute submergence pressure.

It will be apparent that the foregoing arrangement provides adequate protection for the seal 18 against any detrimental effect of the well liquid thereon, provided a constant supply of protecting liquid is maintained in the tank 37. However, I prefer to provide added protection to avoid damage to the motor which might result from unforeseen failure of the supply of protecting liquid to the tank. It will be observed that, in addition to the float 41, a second float 51 is mounted in the tank 37 at a lower level than the float 41, and is connected to a switch mechanism designated 52. When the supply of liquid to the tank functions properly, the liquid level therein is maintained by the inlet valve 40 and its float 41 approximately as indicated at 42, and the float 51 and the switch lever 53 connected thereto assume the position indicated in solid lines in the drawing. If, however, the inlet valve 40 should fail to function properly, or the supply of liquid to the inlet pipe 38 should be inadvertently cut off, the liquid level will slowly descend. When the suface of the liquid reaches the level indicated by the dot-and-dash line 54, further lowering thereof causes the float 51 to descend, and, if it should reach the level indicated by the dotted line 55, the switch mechanism 52 is actuated.

The switch mechanism 52 is preferably connected in a relay circuit, in series with a relay, which is shown schematically at 56, for actuating a switch 57 in the motor circuit 58. The arrangement is such that when the liquid level in the tank 37 is at or above the line 54, the main switch 57 is closed, permitting operation of the motor under the control of the usual manual switch and automatic control devices (not shown). Should the liquid level drop to the line 55, however, the motor is automatically de-energized while sufficient protecting liquid still remains in the tank to insure flow thereof through the chamber 31 for a substantial period of time following shut-down of the motor. This continued flow is desired, principally for the following reasons:

(1) When pumping ceases, the level of the well liquid rises in the well, increasing the submergence pressure, and forcing dielectric liquid upwardly within the conductor cable 26 to a higher point than during pumping. The dielectric liquid displaced from the motor housing is replaced by liquid flowing from the chamber 31 through the balance tube 25 and into the lower portion of the motor housing. By maintaining a sufficient supply of protecting liquid after pumping ceases, the transfer of liquid from the chamber 31 to the lower portion of the motor housing may be effected without drawing well liquid into the chamber 31.

(2) When the motor is de-energized, the column of liquid, extending between the pump and the top of the well, flows back down the discharge column and causes reverse rotation of the pumping element and of the rotor of the motor. If a check valve with a restricted bleeder passage is mounted at the lower end of the discharge column, this reverse flow may be relatively slow and may require a substantial period of time. It is very desirable that the circulation of protecting liquid through the chamber 31 continue during this period.

From the foregoing detailed description of one embodiment of the invention, it will be apparent that I have provided a simple and inexpensive, but nevertheless very effective and dependable, system for protecting the shaft seal of a submersible motor from any detrimental effect of the external liquid in which the motor is immersed. The continuous circulation of fresh protecting liquid through a chamber interposed between the seal and the external liquid avoids the possibility of cumulative contamination of the protecting liquid by infiltration of external liquid into the chember. By maintaining a slightly higher pressure in the protecting chamber than that prevailing externally of the chamber, leakage of external liquid into the chamber along the shaft opening therein is reduced to a minimum. Also, by providing an auxiliary outlet from the chamber, equipped with means for exerting a predetermined back pressure on the protecting liquid, a constant back pressure is maintained irrespective of the rate of leakage outwardly along the shaft opening in the chamber.

I claim:

1. A submersible electric motor structure comprising a motor housing containing a dielectric liquid and having a shaft opening in a wall thereof, rotor and stator elements in said housing, and shafting connected to said rotor element and extending through said opening, a fluid-packed seal surrounding said shafting and sealing said opening, said shafting being adapted to extend into a body of external liquid which is detrimental to said seal, and means for protecting said seal from the detrimental effect of the external liquid, said means comprising walls surrounding said shaft opening and forming a chamber interposed between the external side of said seal and the external liquid, a source of supply of a third liquid, means for continuously delivering third liquid from said source to said chamber at a pressure greater than that of the external liquid, an outlet for discharging third liquid from said chamber into the external liquid, and means associated with said outlet for regulating the discharge of third liquid to maintain a predetermined greater pressure in said chamber.

2. A submersible motor structure as set forth in claim 1, and including passage means connecting said chamber with the interior of said motor housing independently of said seal, whereby the seal is subjected on opposite sides thereof to the pressure prevailing in said chamber.

3. A submersible electric motor structure comprising a motor housing containing a lubricant and having a shaft opening in a wall thereof, rotor and stator elements in said housing and including shafting connected to said rotor element

and extending through said opening, a liquid seal surrounding said shafting and sealing said opening, said shafting being adapted to extend into a body of external liquid which is detrimental to said seal, and means for protecting said seal from the detrimental effect of the external liquid, said means comprising walls forming a chamber isolating the external side of said seal from the external liquid, means for supplying a third liquid to said chamber at a pressure greater than that of the external liquid, an outlet from said chamber, and back-pressure means associated with said outlet for maintaining a predetermined greater pressure in said chamber.

4. In a submersible motor structure, the combination of a motor housing adapted to be immersed in an external liquid and containing an internal liquid, motor elements in said housing including shafting projecting from the housing, a fluid-packed seal for sealing the juncture of the housing and shafting, said external liquid containing components detrimental to said seal, and means protecting said seal from the detrimental effect of the external liquid, said means comprising walls surrounding the projecting portion of said shafting at its juncture with the housing and forming a compartment communicating with the outer side of said seal, a source of supply of a third liquid having no detrimental effect on said seal, means for delivering said third liquid from said source to said compartment at a pressure exceeding the pressure of said external liquid, a discharge outlet connection from said compartment to the external liquid, and means in said outlet connection for exerting a predetermined back pressure on said third liquid.

5. In a submersible structure, walls forming a chamber containing an internal liquid and having a shaft opening in a wall thereof; a shaft projecting through said opening, and a liquid seal for sealing the juncture of said shaft and said opening; said shaft being adapted to extend into a body of external liquid which is detrimental to said seal; and means isolating said seal from said external liquid, said means comprising: walls surrounding the projecting portion of said shaft and forming a second chamber, means for supplying a third liquid to said second chamber at a pressure exceeding that of the external liquid, said third liquid having no detrimental effect on said seal, passage means communicating said second chamber with the outer side of said seal and other passage means communicating said second chamber with said internal liquid whereby opposite sides of the seal are subjected to the pressure of said third liquid, an outlet from said second chamber, and means associated with said outlet for exerting a predetermined back pressure on the third liquid in said second chamber.

6. A submersible structure comprising walls forming a main chamber containing a first liquid, and an auxiliary chamber containing a second liquid; a shaft extending from said main chamber through said auxiliary chamber and into a body of third liquid; a liquid seal surrounding said shaft and separating the first liquid in the main chamber from the second liquid in the auxiliary chamber; said third liquid being detrimental to said seal; a source of supply of said second liquid, means for delivering second liquid from said source to said auxiliary chamber at a pressure greater than that of said third liquid, a discharge outlet from said auxiliary chamber, and pressure relief means associated with said outlet permitting discharge of said second liquid from said auxiliary chamber only when the pressure therein exceeds that of the third liquid by a predetermined amount.

7. A submersible structure comprising walls forming a main chamber containing a first liquid, and an auxiliary chamber containing a second liquid; a shaft extending from said main chamber through said auxiliary chamber and into a body of third liquid; a liquid seal surrounding said shaft and separating said first and second liquids, said third liquid being detrimental to said seal; means forming a semi-effective seal around said shaft between said second and third liquids; means for delivering second liquid to said auxiliary chamber at a pressure greater than that of the third liquid to cause discharge of second liquid from the auxiliary chamber through said semi-effective seal; an auxiliary outlet from said auxiliary chamber; and back pressure means associated with said auxiliary outlet and permitting discharge therethrough only when the pressure in said auxiliary chamber exceeds that of the third liquid by a predetermined amount.

8. In a submersible electric motor, a motor housing adapted to be submerged in an external liquid and having a shaft opening in a wall thereof, a motor in said housing including a shaft extending through the opening, a shaft seal for sealing the shaft opening, walls forming a chamber adjacent said shaft opening and interposed between the external side of said seal and the external liquid, a source of supply of a second liquid, means for delivering said second liquid from said source to said chamber, and motor control means operable to de-energize said motor in response to interruption of the supply of second liquid.

9. A submersible electric motor as set forth in claim 8, in which said source of supply of second liquid includes a liquid container having an inlet, and an outlet communicating with said chamber, and in which said control means includes relay means controlled by the liquid level in said container and operably connected to the motor circuit.

10. A submersible electric motor as set forth in claim 8, in whic said source of supply of second liquid includes a liquid container having an inlet, and an outlet communicating with said chamber, float valve means controlling said inlet for maintaining a predetermined liquid level in said container, and in which said motor control means includes relay means controlling the supply of current to said motor, and means, operable when the liquid in said container reaches a predetermined low level, to actuate said relay means to de-energize the motor.

11. In a submersible electric motor, a motor housing adapted to be immersed in an external liquid and having a shaft opening in a wall thereof, a motor in said housing including a shaft extending through said opening, shaft sealing means for sealing said opening, walls forming a chamber surrounding said opening and interposed between the external side of said shaft sealing means and the external liquid, a source of supply of a second liquid, means for delivering second liquid from said source to said chamber, and means for automatically stopping said motor in response to a pending interruption of the supply of second liquid before said supply is exhausted.

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