

Nov. 17, 1959

A. J. LOEPSINGER
HUMIDIFYING SYSTEM

2,913,183

Filed July 17, 1956

3 Sheets-Sheet 1

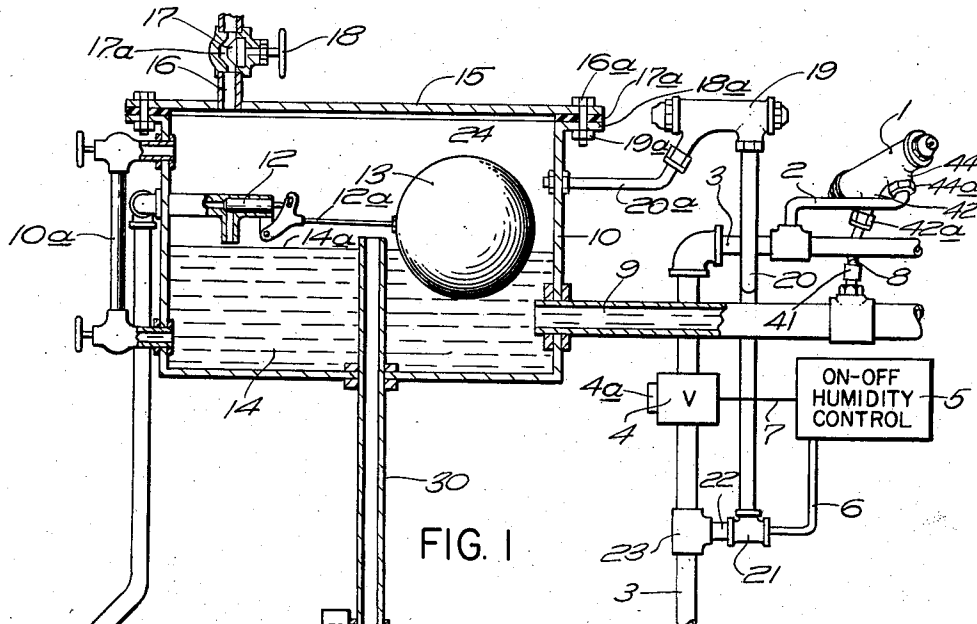


FIG. 1

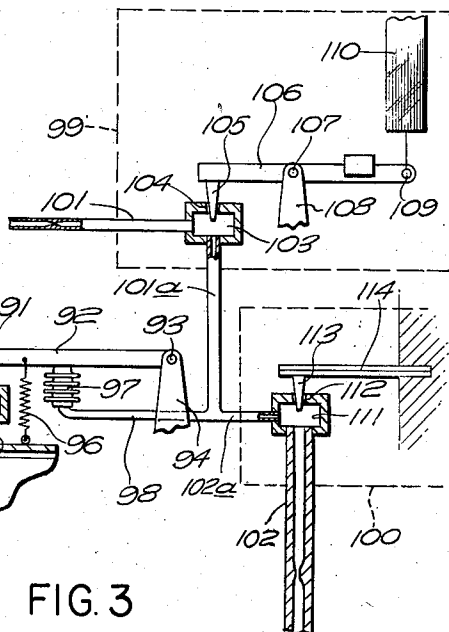
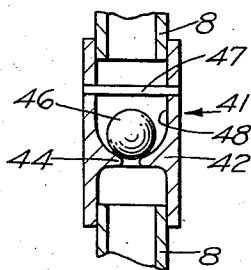


FIG. 3



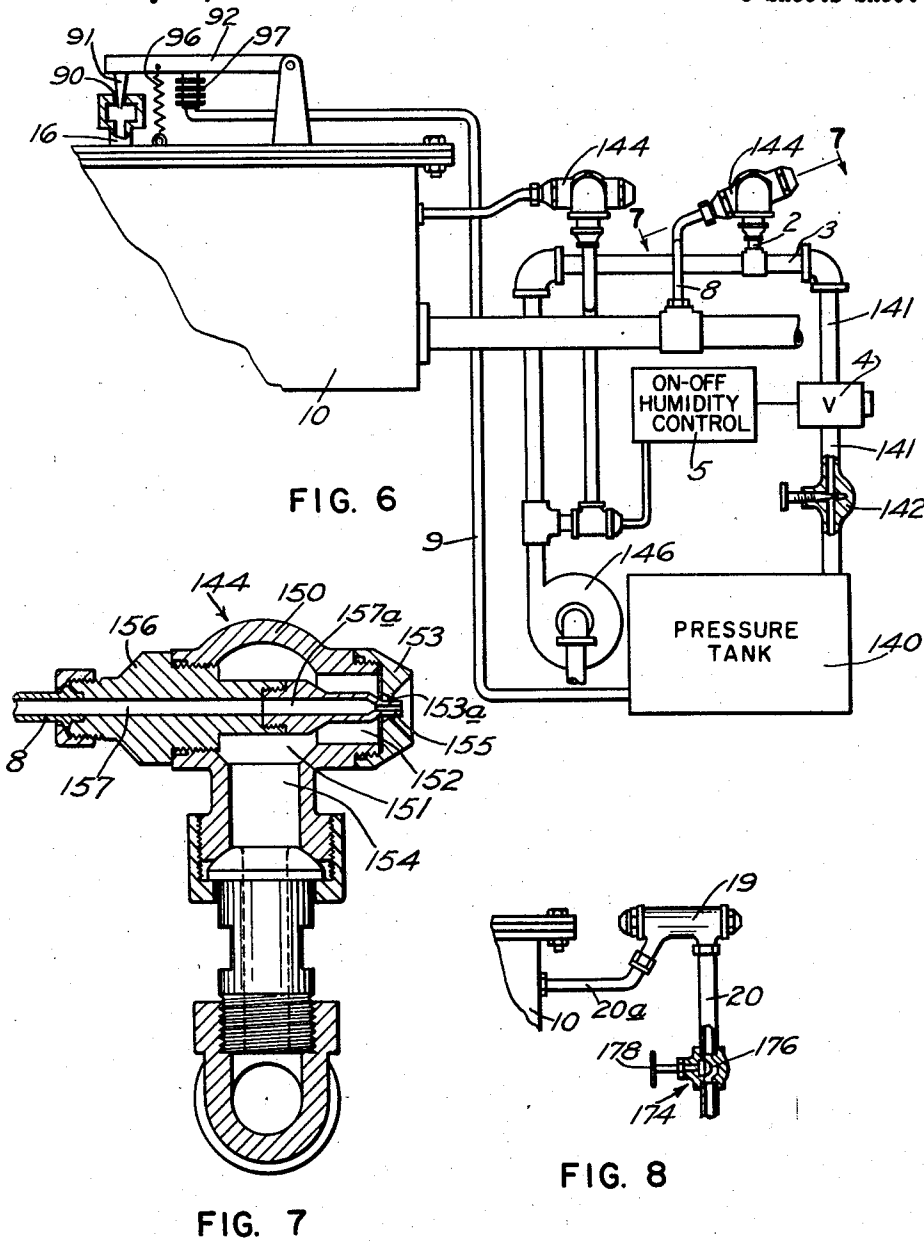
Nov. 17, 1959

A. J. LOEPSINGER
HUMIDIFYING SYSTEM

2,913,183

Filed July 17, 1956

3 Sheets-Sheet 3



INVENTOR.
ALBERT J. LOEPSINGER
BY
David O. McInnes
ATTORNEYS

1

2,913,183

HUMIDIFYING SYSTEM

Albert J. Loepsinger, Providence, R.I., assignor to Grinnell Corporation, Providence, R.I., a corporation of Delaware

Application July 17, 1956, Serial No. 598,267

21 Claims. (Cl. 236—44)

The present invention relates to systems for humidifying the atmosphere in an enclosure. More particularly it has to do with such systems employing suction-type atomizers and with apparatus for regulating the rate of discharge therefrom by regulating, modulating or varying in accordance with variations in the condition of the atmosphere, the pressure on the surface of the liquid to be atomized in a reservoir tank or like supply between a pressure substantially less than atmospheric pressure and a higher pressure which is not substantially greater than atmospheric pressure.

The application of such a vacuum on the surface of the liquid in the reservoir or supply decreases the rate at which flow of the gas (usually air) through the atomizer can draw the liquid (usually water) from the reservoir and project it into the atmosphere, and accordingly the atomizers have a lower rate of water discharge than they would if no such vacuum were applied in the reservoir. By varying the amount of this vacuum in accordance with variations in the condition of the atmosphere the rate of atomizer water discharge is correspondingly varied. Thus, a system is provided having that number of atomizers which can take care of the atmospheric conditions of maximum moisture demand when no vacuum is applied in the reservoir and then by merely applying such a vacuum during lesser demand conditions and by varying the amount of vacuum as the demand changes, the rate of moisture discharge is more nearly in accordance with the rate at which the atmosphere can evaporate the water particles during such lesser demand conditions than in suction-type atomizer systems heretofore known.

The regulation of discharge by such a regulated vacuum, in addition to providing a more efficient system in which discharge is alternately turned on and off, makes possible a commercially feasible suction-type atomizer humidifying system in which discharge is substantially continuous. It also makes possible a commercially feasible suction-type humidifying system employing a non-lubricated rotary type pump for compressing the gas flowing through the atomizer and employing substantially lower pressures than in conventional humidifying systems.

Accordingly it is one object of the present invention to provide apparatus for regulating the rate of liquid discharge from suction-type atomizers by regulating a vacuum imposed on the supply of the liquid.

Another object is to provide apparatus of the kind described in which the vacuum is regulated in accordance with the conditions of the atmosphere.

Another object is to provide apparatus of the kind described in which the vacuum is regulated in accordance with changes in a condition of the atmosphere which affects the relative humidity.

Another object is to provide apparatus of the kind described in which the atomizers are turned on and off and in which the vacuum is varied in accordance with the relative durations of the on and off periods.

2

Another object is to provide apparatus employing a vacuum as described in which the atomizers are on substantially continuously and in which the vacuum is regulated in accordance with atmospheric conditions.

5 Another object of the invention is to provide a commercially feasible suction-type humidifying system employing a vacuum as described, employing a non-lubricated rotary type pump for compressing the gas flowing through the atomizer and employing substantially lower pressures than in conventional humidifying systems and in which the vacuum is regulated in accordance with atmospheric conditions.

10 Another object is to provide an improved and more efficient system employing suction-type atomizers and control apparatus for use with the same.

Other objects will appear hereinafter.

The accompanying drawings show and the following specification describes preferred embodiments of the present invention. They are merely illustrative of the invention and it is not intended that it be limited thereto.

15 In the accompanying drawings:

Fig. 1 is a somewhat diagrammatic view in elevation and partly in section of apparatus embodying the present invention;

25 Fig. 2 is a top view of the apparatus of Fig. 1;

Fig. 3 is a somewhat diagrammatic view in elevation and partly in section of a mechanism for automatically controlling the rate of liquid discharge from the apparatus of Fig. 1;

30 Fig. 4 is a somewhat diagrammatic view in elevation and partly in section, of another embodiment of the present invention;

Fig. 5 is a diagrammatic elevation view, in section, of a check valve in the water pipe to the atomizer in Fig. 1;

35 Fig. 6 is a somewhat diagrammatic view like Fig. 4 but showing still another embodiment of the invention;

Fig. 7 is a cross-section view taken on line 7—7 of Fig. 6; and

40 Fig. 8 is a fragmentary view showing another way in which the vacuum may be varied.

Referring now more particularly to Figs. 1 and 2 of the drawings, the numeral 1 designates one of a plurality of atomizers which are distributed about an enclosure and which have air inlets 44 communicating through pipes 2 with a distributing pipe 3. Pipe 3, in turn, communicates with a source (not shown) of air or other fluid under a pressure of, for example, 20 to 30 pounds per square inch, gauge. The distributing pipe 3 is provided in a conventional manner with an on and off blow-through valve 4 controlled by a humidity controller 5 in which a humidity sensitive element (not shown) acts on compressed air flowing thereto from pipe 3 through T 23, pipe 22, T 21 and feed pipe 6. This air pressure, in turn, actuates an actuator which is shown diagrammatically at 7 and which turns the valve 4 on or off in accordance with the condition of the atmosphere inside the enclosure.

Also communicating with pipe 3 at a point thereon upstream of valve 4 and through T 23, pipe 22, T 21 and pipe 20 is an aspirator 19 the suction side of which communicates through suction pipe 20a with the interior of a tank 10. This tank has a cover 15 attached thereto in an air tight manner by means of flange 18a, gasket 17a, bolts 16a and nuts 19a. Cover 15 has a bleed pipe 16 which provides communication between the interior of the tank 10 and the atmosphere and which has a bleed valve 17 with a restriction 17a. The size of this restriction is manually adjustable by a handwheel 18.

70 The water inlets 42 of atomizers 1 communicate in a conventional manner through water pipes 8 and water distributing pipe 9 with the tank 10 which is supplied with

water through a water supply pipe 11. This pipe 11 communicates with a source of water, such as a municipal water main (not shown) and has a float valve 12 operated through a linkage 12a by a float 13 to maintain the desired level 14a of the water 14 in tank 10, this water level usually being about four inches below the discharge orifices of the atomizers 1, being above the open end of pipe 9 and being below the open end of pipe 20a.

Tank 10 is also provided with a liquid level gauge 10a and an overflow pipe 30, the latter preferably being made of a transparent material and having its lower end in communication with an overflow tank 31 containing water 35 which is supplied thereto through a pipe 32. This pipe 32 is connected to pipe 11 and is provided with a float valve 33 controlled through linkage 33a by a float 34 to maintain the water level 35a above the open lower end of pipe 30, thereby providing a means for measuring the amount of vacuum in tank 10 and an effective water seal which prevents air from being drawn upwardly by the vacuum through pipe 30 and into tank 10.

The overflow pipe 30 is necessary because of the possibility that the float valve 12 might fail to function properly and allow water to enter tank 10 in excess of the requirements of the system. If this condition continued and there were no overflow pipe 30 the level in the tank 10 would rise and might reach a level above the orifices of the atomizers 1 in which case a solid stream of water would issue from each of these atomizers.

Tank 31 is necessary to provide a place for the overflow from tank 10 to go without disrupting the vacuum in tank 10. The valve 33, connection 33a and float 34 are similar in construction to valve 12, connection 12a and float 13 previously described. Pipe 30 is provided with a scale 37 having graduations marked thereon for measuring in inches of water 40 the amount of vacuum in the tank 10. Tank 31 has its own overflow pipe 36.

Atomizer 1 is of conventional design, for example like that shown in U.S. Patent No. 2,594,045, issued April 22, 1952, on my invention in Atomizer. Such an atomizer has a built-in water valve which closes when the air passing through the atomizer is turned off to stop atomization, and this valve prevents the vacuum in the tank from pulling air back through the atomizer down pipe 8 and along pipe 9 into the tank. If another type of atomizer is employed which does not have this built-in valve a single check valve may be located in pipe 9 upstream of the first atomizer permitting downstream flow only or a separate check valve 41 may be located in each pipe 8 to perform the same function. Such a valve 41 is shown in Fig. 5. It is of the ball check type, having a body portion 42 with an orifice 43 surrounded by a seat 44 on which a ball member 46 seats when flow is downwardly (upstream) and from which this ball member rises when flow is upwardly (downstream). Preferably this ball member is made of a material having a density only slightly greater than the density of the liquid, for example, nylon. A pin 47 retains the ball near the seat. Portions of the water pipe 8 are shown connected at opposite ends of the valve.

In the operation of the arrangement of Fig. 1 compressed air flows continuously during both the on and the off periods from the source thereof through T 23, nipple 22, T 21 and pipe 20 into and through the aspirator 19 (which is like the atomizer 1) thereby aspirating air from the space 24 above the water 14 in tank 10. The amount of vacuum thus produced depends upon the capacity of the aspirator 19 and the rate at which air from the atmosphere is allowed to bleed into the tank through bleed conduit 16. This rate of bleeding depends upon the size of the opening of bleed valve 17, which can be adjusted manually by handwheel 18. If the valve 17 is wide open, the vacuum produced by aspirator 19 is substantially neutralized and the pressure in tank 10 is atmospheric. If valve 17 is completely shut off a maximum vacuum is obtained in the tank.

When the humidity of the atmosphere of the enclosure decreases below a particular desired amount, humidity controller 5 acts on compressed air introduced thereto through pipe 6 to open valve 4 through actuator 7. When valve 4 is opened air under pressure passes from the source thereof through valve 4, distributor pipe 3, pipe 2 and finally through atomizer 1 which draws water from tank 10 through distributing pipe 9 and pipe 8 and which atomizes and discharges this water into the atmosphere. The rate of flow of the water is dependent upon the amount of vacuum in the space 24 in tank 10. When the amount of vacuum in tank 10 is increased by decreasing the size of the opening of valve 17 the rate of water flow is decreased. When the amount of vacuum in tank 10 is decreased by increasing the size of the opening of valve 17, the rate of water flow is increased. The flow of water 14 from tank 10 causes valve 12 to open and admit more water into the tank at a rate which is approximately the same as the rate at which water is withdrawn therefrom and discharged by the atomizers.

Water continues to be discharged until the relative humidity of the atmosphere is increased to substantially the desired relative humidity value whereupon humidity controller 5 closes valve 4 which shuts off the supply of compressed air to the atomizers 1 and exhausts the pipe 3 on the downstream side of valve 4 through a port 4a therein.

Movement of water from tank 10 into the stream of air passing through atomizer 1 is caused by the difference between the pressure on the water surface 14a in tank 10 and the lower pressure on the water at the atomizer 1, this lower pressure being created by the flow of air through the atomizer. In conventional humidifying systems employing suction type atomizers the tank 10 is open to the atmosphere so that the pressure on the surface 14a is always that of the atmosphere and the pressure differential which causes movement of the water from the tank to the atomizer is the difference between the relatively constant pressure of the atmosphere and the relatively constant, but lower pressure produced at the atomizer. By providing a vacuum on the surface of water in tank 10 with aspirator 19, the pressure differential of such conventional systems is reduced, and it is this reduction in pressure differential which reduces the rate of flow and discharge of the water. When the amount of vacuum is increased the pressure differential is further decreased and the flow rate of the water is correspondingly decreased.

The bleed valve 17 can be adjusted from the full open position, in which the pressure in tank 10 is substantially atmospheric and the atomizers discharge water at their maximum rate, to the fully closed position, in which a maximum vacuum is produced in tank 10 and the slowest flow rate is obtained. By selecting an aspirator or aspirators having sufficient capacity to produce a vacuum in tank 10 equal to the suction on the water in the atomizers 1 caused by the flow of compressed air through these atomizers, adjustment of bleed valve 17 to fully closed position can result in a vacuum in tank 10 sufficient to neutralize completely the suction effect of the atomizers, and the flow of, and hence the discharge of, water will be shut off entirely, even while the valve 4 is open. It is pointed out, however, that if the rate of discharge is reduced to the rate at which moisture is being removed from the enclosure the valve 4 will remain open continuously and the atomizer will discharge continuously. Consequently, when atomizers are used of the so-called self-cleaning type which require shutting off and turning on the rate should not be reduced so as to prevent this on and off action. The level of the liquid column 40 (Fig. 1) in the transparent overflow pipe 30 indicates the amount of vacuum in tank 10.

By manually adjusting the opening of bleed valve 17 the rate of discharge of all the atomizers may be simultaneously varied. This is desirable because ordinarily dur-

5

ing certain times of the year, for example in the winter, less moisture is needed to maintain the desired relative humidity than at other times, for example, in the summer. Valve 17 makes it possible to effect this seasonal adjustment very easily and without having to adjust each of the atomizers 1 individually.

The on and off valve 4 and humidity controller 5 with its air line 6 and actuator 7 are conventional. One humidity controller and valve arrangement which is satisfactory for use in the present invention is the one shown and described in U.S. Patent No. 2,697,553. This controller may be used as shown in Fig. 2 of that patent or as shown in Fig. 2 but with the end of bar 96 clamped firmly between screws 164 and 168 so that the bar 96 is held stationary. In the case of humidity controllers of the type described in Figs. 1 and 2 of that patent, having a switch 110 operating a solenoid valve 120, the numeral 7 in Fig. 1 herein diagrammatically represents the electrical connections leading from the controller 5 to the valve, and the numeral 4 herein represents such a solenoid valve. In the case of a controller 5 which is pneumatically connected with valve 4, then the numeral 5 represents diagrammatically this pneumatic connection. Although a pipe 6 is shown in the drawings leading fluid pressure from pipe 3 to controller 5, humidifier controllers may be used which do not utilize such a fluid.

Any conventional aspirator 19 can be used for withdrawing gas from tank 10. An atomizer of the same construction as atomizers 1 is preferred. Furthermore, more than one aspirator can be attached to the tank 10 to produce the vacuum therein. Although aspirator 19 is shown as being connected to the pipe 3, any independent source of gas can be used for actuating the aspirator 19.

Whatever the source of gas used to actuate the aspirator the vacuum produced in tank 10 may be varied in the arrangement of Fig. 1, and in the other arrangements shown in the drawings, by a valve located in the conduit 20 carrying such gas to the aspirator or located in the conduit 20a. For example, Fig. 8 shows a valve 174 in the line 20 leading to the aspirator 19, this valve having a passage 176 which can be restricted more or less by turning the handwheel 178. When the size of the passage 176 is decreased the flow of air through the atomizer 19 takes place at a decreased rate and the rate at which air is being aspirated from the tank 10 through pipe 20a is decreased. Accordingly the amount of the vacuum is decreased. Conversely, when the size of the passage 176 is increased the rate of flow through pipe 20 and the atomizer 19 is increased, the rate at which air is being aspirated from the tank 10 is increased, and the amount of vacuum increases.

Instead of the aspirator which is shown in the drawings and which is preferred, any means may be used for thus providing a vacuum in tank 10, for example, a reciprocating or rotary vacuum pump.

It has already been stated that in Fig. 1 the height of the atomizer may be four inches above the liquid level or surface 14a, this four inches being the height which the atomizer lifts the water at the highest rate of discharge, which rate is achieved when the pressure in the tank is atmospheric. It is noted also in Fig. 1 that the vacuum in the tank is eight inches of water. Assuming that this is the greatest vacuum produced, the range of pressure regulation is eight inches of water and the atomizer is well below a height which is above the liquid surface 14a a distance equal to the range of pressure regulation in space 24 measured in inches of water (eight inches) plus the height (four inches) which the atomizer lifts the liquid at the highest rate of discharge. This is true regardless of the magnitude of the range of regulation. Put in another way, the sum of the range of pressure regulation in inches (eight inches) and the height (four inches) which the atomizer lifts the water at maximum rate of discharge is twelve inches so that in Fig. 1

6

twelve inches is the height which is above the liquid surface a distance equal to the range of pressure regulation in inches of liquid plus the height which the atomizer lifts the liquid at maximum discharge and the atomizer is well below that height.

In Fig. 3 there is shown an apparatus for automatically regulating the amount of vacuum in tank 10 and consequently the rate of water discharge from atomizers 1 in response to changes in atmospheric conditions.

In this embodiment, the bleed conduit 16 communicating between the atmosphere and the interior of tank 10 has a restricted opening 90 the size of which is adapted to be varied by a conical shaped pin valve 91 which is attached to the end of a lever 92 the other end of which is pivotally attached at 93 to a stationary support 94 which may be fixed to cover 15. A tension spring 96 attached at one end to cover 15 of tank 10 and at the other end to a middle portion of arm 92 biases the pin 91 into closed position with respect to opening 90. Also attached to the middle portion of lever 92 is the actuator of a bellows 97. Changes in the pressure in these bellows produce movement of the actuator, and these pressure changes are caused to be in accordance with variations in the relative humidity by an indoor modulating thermostat 100 and an outdoor modulating humidistat 99, both shown diagrammatically. Although any conventional modulating humidistat is suitable, a device like that shown in Fig. 2 of U.S. Patent No. 2,697,553 is preferred. The air inlet connection 101 of the humidistat and the air inlet connection 102 of the thermostat are connected with a source of air or other gas under pressure (for example, with pipe 3 upstream of valve 4) and the air outlets 101a and 102a of the humidistat and thermostat, respectively, are connected to pipe 98.

In the operation of the modulating thermostat 100 compressed air is admitted through passage 102 into a chamber 111. This chamber has an air outlet 102a and a restricted opening 112 the size of which is controlled by a conical pin valve 113 attached to one end of a thermostatic element 114. The other end of this element 114 is fixed. Preferably the thermostat is located inside the enclosure which is being humidified and operates in the following manner: When the dry bulb temperature within the enclosure is high element 114 bends to move the pin valve 113 in the direction which tends to close opening 112, whereupon the pressure in chamber 111, passages 102a and 98 and bellows 97 tends to increase and to move pin 91 out of restriction 90 against the force of spring 96, whereby the vacuum in tank 10 tends to be decreased and the rate of atomizer discharge tends to be increased. Conversely, when the dry bulb temperature decreases the thermostatic element 114 bends the other way to move pin valve 113 in the direction which tends to increase the size of opening 112 and consequently to reduce the pressure in chamber 111, passages 102a and 98 and bellows 97, which tends to allow spring 96 to move pin 91 further into opening 90, thereby decreasing the size thereof, increasing the vacuum in tank 10 and decreasing the rate of discharge.

Such a modulating thermostat is employed in the enclosure for the control of relative humidity therein because changes in dry bulb temperature within the enclosure customarily provide a reliable indication of the changes in the demand for moisture. There are, however, occasional days, particularly in the summer, when the indoor dry bulb temperature is high, which would normally indicate a large demand for moisture, but the outdoor relative humidity is also high, which means that there is actually little or no demand for moisture. Accordingly for such conditions a modulating humidistat is employed outside the enclosure and arranged to add its control to that of the thermostat in the enclosure.

In the operation of this humidistat compressed air is admitted through passage 101 into chamber 103, which has a restricted opening 104 the size of which is ad-

justed by a pin valve 105 attached to one end of an arm 106 the middle portion of which is pivotally supported at 107 to a support 108 and the other end of which is attached at 109 to an end of a humidity sensitive element 110 which contracts when the atmosphere is drying and expands when the atmosphere is becoming more moist. When restriction 104 is fully closed the pressure in chamber 103, passages 101a and 98 and bellows 97 tends to increase and to force pin 91 out of opening 90 against the force of spring 96, thereby tending to increase the size of the opening 90 and to neutralize the vacuum in tank 10 so that the atomizer discharge tends to increase. This occurs when the relative humidity of the air outside the enclosure is decreasing and, because this air is entering the enclosure, a higher rate of discharge is desired to maintain the proper humidity therein. When the relative humidity outside the enclosure is increasing so that a decreased rate of discharge is required to maintain the desired relative humidity inside the enclosure, the element 110 automatically lengthens thereby moving pin 105 to increase the size of opening 104. This tends to decrease the pressure in chamber 103, passages 101a and 98 and bellows 97, which tends to decrease the upward force exerted by bellows 97 and 92, whereby spring 96 tends to force pin 91 further into opening 90, decreases the size thereof and increase the vacuum in tank 10. Thus the rate of discharge tends to be automatically reduced in accordance with the increased humidity which actuated the humidistat.

By use of the automatic control apparatus of Fig. 3 the vacuum in tank 10 and consequently the rate of discharge from atomizers 1 is automatically responsive to changes both in humidity and temperature, so that the proper rate of discharge is obtained for any particular condition of the atmosphere.

Fig. 4 shows another manner of automatically controlling the vacuum in tank 10, and consequently the rate of discharge, in response to variations in atmospheric conditions.

In this embodiment the line 98, instead of being connected to a humidistat and thermostat as shown in Fig. 3, communicates with a tank 140 which in turn communicates through a pipe 141 with distribution pipe 3, preferably at the end thereof downstream of the atomizers 1 mounted thereon. Line 141 has therein a conventional needle valve 142 which is manually controlled by a handle 143 to vary the size of the opening thereof.

With the use of this type of apparatus the vacuum in tank 10 and consequently the rate of discharge is controlled in accordance with the relative durations of the on and off periods, which in turn depend upon the conditions of the atmosphere. Thus, during each on period valve 4 is open and gas under pressure passes from distributor pipe 3 through pipe 141 and needle valve 142 into tank 140, the amount of gas passing into tank 140, and consequently the pressure which builds up in tank 140 and hence in line 98 and bellows 97 at the end of each on period, being determined by the duration of that period, by the differential between the air pressure in line 3 (which is usually 20 pounds) and the air pressure already in tank 140 and by the size of the opening of needle valve 142. During off periods gas flows from tank 140 back through needle valve 142, pipes 141 and 3 and out into the atmosphere via valve 4 which exhausts pipe 141 and the portion of pipe 3 beyond valve 4 when this valve is actuated to shut off the supply of gas pressure. The amount of gas passing out of tank 140 during these off periods and hence the pressure in tank 140, in line 98 and in bellows 97 at the end of each off period is dependent upon the duration of the such period, by the size of needle valve 142 and by the differential between the pressure in the tank and of the atmosphere. Since the pressures of the atmosphere and of the gas source do not change substantially and since the size of the opening of needle valve 142 remains the same, the

pressure in tank 140, line 98 and bellows 97 depends primarily upon the relative durations of the on and off periods, and for any particular period of time during which atmospheric conditions do not vary appreciably the relative durations of the on and off periods will not vary appreciably and an average pressure will be built up and maintained in tank 140, line 98 and bellows 97.

Under dry, hot conditions humidity controller 5 will normally cause valve 4 to remain open for relatively long periods and closed for relatively short periods. In such a case the average pressure in tank 140, line 98 and bellows 97 is relatively high causing valve pin 91 to be raised far enough out of opening 90 to have substantially reduced the vacuum in tank 10. Accordingly, the vacuum in the tank 10 is small and water is discharged at a high rate. When the demand for moisture decreases the durations of the on periods decrease and accordingly the average pressure in tank 140, line 98 and bellows 97 drops, which decreases the size of opening 90. This increases the vacuum in tank 10, and the rate of discharge decreases in accordance with the change in atmospheric conditions.

Needle valve 142 dampens fluctuations in pressure in tank 140. The smaller the opening of the needle valve 142 the smaller are the pressure fluctuations above and below the average pressure for any particular atmospheric condition and the longer it will take for a given change to take place in the average pressure in the tank due to changes in the condition of the atmosphere. The size of the opening of valve 142 should be adjusted so as to be small enough to cut out excessive fluctuations above and below average pressure and to prevent too rapid changes in average pressure, but it should not be so small that changes in average pressure in tank 140, line 98 and bellows 97 in response to changes in the relative durations of the on and off periods are too sluggish.

Although Fig. 4 shows only a single needle valve in pipe 141, an additional conduit may be used communicating between the atmosphere and the interior of tank 140 with a second needle valve therein so that during off periods, gas travels through the additional conduit as well as through 141. In such case the second needle valve provides added means for controlling pressure fluctuations. Furthermore, the needle valve 142 can include a check valve permitting gas to pass into the tank only, and the second needle valve can also include a check valve, permitting gas to pass only out of the tank.

Fig. 6 shows another embodiment of the present invention which is similar to the arrangement of Fig. 4 except that a low pressure atomizer 144 is employed, gas at a relatively low pressure is pumped through pipe 3, risers 2 and atomizers 144 continuously by means of a low pressure, non-lubricated rotary pump 146, three way valve 4 is located in pipe 141, discharge is substantially continuous and the desired humidity is maintained by regulating the discharge so that moisture is delivered into the enclosure at approximately the same rate at which moisture is being removed. Valve 4 in this embodiment is turned on and off by the modulating humidistat 5 in the same manner as described above with reference to Fig. 4 and although it does not control the flow of gas to the atomizers 144 and hence does not turn discharge on and off, because it is downstream of the atomizers, it controls the flow of gas from pipe 3 through pipe 141 and needle valve 142 to tank 140 and hence controls the pressure in tank 140 in the manner described above in discussing Fig. 4. In turn, the pressure in tank 140 regulates the vacuum in tank 10 and hence the rate of discharge as in the arrangement of Fig. 4. The low pressure atomizer 144 (see Fig. 7) comprises body 150 having a central air chamber 151 which is in communication with air outlet port 152 and through which air passes from air inlet port 154. Port 152 is covered by a cap member 153 having a central aperture 153a. Concentrically located in this aperture and extending therethrough from the interior of the body

is a nozzle member 155 which is mounted on a plug 56 and which forms with aperture 153a an atomization orifice. Air passing through this orifice draws water from the supply tank 10 through riser 8 and passages 157 and 157a of plug 156 and nozzle 155 into the air stream where it is atomized and discharged into the enclosure.

146 is a non-lubricated, rotary type, low pressure pump or blower, as for example, a centrifugal pump. It has been found when such pumps are used that deposits do not form to any appreciable extent in the orifices of the atomizers and consequently relatively cheap, low pressure atomizers can be used like those shown in Figs. 6 and 7 which do not have self cleaning elements operated to remove deposits by turning on and off the flow of gas thereto.

In the device shown in Fig. 6 discharge is controlled wholly by the application of a modulating vacuum on a surface of the liquid supply so that the flow of gas to the atomizers need not be turned off for regulation purposes. Consequently, the use of the low pressure, non-lubricated, rotary pump is practical. The only time that discharge does not occur in the arrangement of Fig. 6 is when the relative humidity which is desired for the enclosure exists naturally. Otherwise, discharge is continuous and is not intermittent.

The device shown in Fig. 6 provides a low pressure, humidifying system employing a relatively inexpensive, low pressure, non-lubricated, rotary type pump, relatively inexpensive low pressure atomizers which do not employ self cleaning elements and low pressure piping and fittings in the gas line.

The bellows 97, spring 96 and opening 90 are arranged so that the range of the positions of pin 91 from full open to full closed will generally correspond with the range of pressures created in the bellows and accumulator tank by the range of variations of atmospheric conditions.

The term "fluid conduit" as used in the claims hereof, is intended to include the part of pipe 141 in Fig. 6 which is upstream of off and on valve 4 and in which valve 4 is located so that in the Fig. 6 embodiment the off and on valve 4 is located in the fluid (compressed air) conduit downstream of atomizer 144 whereas in Fig. 1 it is located in the fluid conduit upstream of atomizer 1.

The capacity of the atomizer 19 in Fig. 6 is sufficient so that when the valve 91 is substantially closed, the rate of discharge is zero.

I claim:

1. Apparatus for use with a suction type atomizer for humidifying the atmosphere within an enclosure in which the flow of fluid effects movement of the liquid to be atomized from a liquid supply downstream to the region where atomization occurs, said apparatus comprising means for regulating the rate of discharge of said atomizer over a range of rates, said means comprising means for producing pressures below atmospheric pressure in an enclosed space bounded by a surface of said liquid supply and means for regulating the magnitude of said pressures below atmospheric pressure to regulate the rate of discharge over said range, said means for producing pressures below atmospheric pressure being remote from said fluid downstream of the atomization region, said atomizer being below a level which is above said liquid surface a distance equal to the range of pressure regulation in said space measured in inches of liquid plus the height which the atomizer lifts the liquid at the highest rate of discharge.

2. Apparatus for use with a suction type atomizer for humidifying the atmosphere within an enclosure in which the flow of a fluid effects movement of the liquid to be atomized from a liquid supply to the region where atomization occurs, comprising means for establishing in an enclosed space bounded by a surface of said liquid supply a pressure ranging between a pressure substantially be-

low atmospheric pressure and a higher pressure not substantially greater than atmospheric pressure, means for regulating said pressure over said range, said pressure establishing means being remote from said fluid downstream of the atomization region said atomizer being below a level which is above said liquid surface a distance equal to the range of pressure regulation in said space measured in inches of liquid plus the height which the atomizer lifts the liquid at the highest rate of discharge.

3. Apparatus for use with a suction type atomizer for humidifying the atmosphere within an enclosure in which the flow of a fluid from a fluid source through a conduit for said fluid to an atomizing region effects the movement of the liquid to be atomized from a chamber forming a reservoir for said liquid through a conduit for said liquid to said atomization region, comprising means for regulating the rate of discharge of said liquid over a range of rates, said means including means for producing pressure below atmospheric pressure in said chamber on a surface of said liquid and means for regulating the magnitude of said pressures below atmospheric pressure produced by said last mentioned means to regulate the rate of discharge over said range, said means for producing said pressures below atmospheric pressure being remote from said fluid downstream of the atomization region said atomizer being below a level which is above said liquid surface a distance equal to the range of pressure regulation in said chamber measured in inches of liquid plus the height which the atomizer lifts the liquid at the highest rate of discharge.

4. Apparatus for use with a suction type atomizer for humidifying the atmosphere within an enclosure in which the flow of a fluid from a fluid source through a conduit for said fluid to an atomization region effects the movement of the liquid to be atomized from a chamber forming a reservoir for said liquid through a conduit for said liquid to said atomization region, comprising means for regulating the rate of discharge of said liquid over a range of rates, said means including means for producing pressures below atmospheric pressure in said chamber on a surface of said liquid and means for regulating the magnitude of said pressures below atmospheric pressure produced by said last mentioned means to regulate the rate of discharge over said range, and means responsive to variations in atmospheric conditions for automatically controlling said pressure regulating means to automatically regulate the magnitude of said pressures below atmospheric pressure and consequently the rate of discharge in accordance with said variations said atomizer being below a level which is above said liquid surface a distance equal to the range of pressure regulation in said chamber measured in inches of liquid plus the height which the atomizer lifts the liquid at the highest rate of discharge.

5. Apparatus for regulating the rate of discharge from a suction type atomizer for humidifying the atmosphere within an enclosure in which the flow of a fluid from a fluid source through a conduit for said fluid to and through an atomizing region effects the movement of a liquid from a chamber which forms a reservoir for said liquid through a conduit for said liquid to the region where atomization occurs, said apparatus comprising, means for regulating the rate of discharge of said liquid over a range of rates, said means including means for producing pressures below atmospheric pressure in said chamber on a surface of said liquid, said last mentioned means including means for withdrawing gas from said chamber and means for regulating said pressures below atmospheric pressure in said chamber produced by said gas withdrawal means to regulate the rate of discharge over said range, said means for producing said pressures below atmospheric pressure being remote from said fluid downstream of the atomization region said atomizer being below a level which is above said liquid surface a distance equal to the range of pressure regulation in said cham-

ber measured in inches of liquid plus the height which the atomizer lifts the liquid at the highest rate of discharge.

6. In combination a suction type atomizer for humidifying the atmosphere within an enclosure, a chamber forming a liquid reservoir for said liquid and having means for admitting liquid thereto at substantially the same rate at which liquid is withdrawn therefrom, the level of the liquid in said chamber being below said atomizer, a conduit for said liquid providing communication between said chamber and said atomizer, a source of fluid, a conduit for said fluid providing communication between said atomizer and said fluid source, said atomizer, conduits, source and chamber being so arranged that the flow of said fluid from said fluid source through said fluid conduit and to the region where atomization occurs effects atomization, discharge and movement of said liquid from said chamber through said conduit for said liquid to said atomization region, and means for regulating the rate of discharge of said liquid over a range of rates, said last mentioned means including means for producing pressures below atmospheric pressure in said chamber on a surface of said liquid and also including means for regulating said pressures below atmospheric pressure to regulate said liquid discharge over said range, said means for producing said pressures below atmospheric pressure being remote from said fluid downstream of the atomization region said atomizer being below a level which is above said liquid surface a distance equal to the range of pressure regulation in said chamber measured in inches of liquid plus the height which the atomizer lifts the liquid at the highest rate of discharge.

7. In combination a suction type atomizer for humidifying the atmosphere within an enclosure, a chamber forming a liquid reservoir for said liquid and having means for admitting liquid thereto at substantially the same rate at which liquid is withdrawn therefrom, the level of the liquid in said chamber being below said atomizer, a conduit for said liquid providing communication between said chamber and said atomizer, a source of fluid, a conduit for said fluid providing communication between said atomizer and said fluid source, said atomizer, conduits, source and chamber being so arranged that the flow of said fluid from said fluid source through said fluid conduit and to the region where atomization occurs effects atomization, discharge and movement of said liquid from said chamber through said conduit for said liquid to said atomization region, means for regulating the rate of discharge of said liquid over a range of rates, said last mentioned means including means for producing pressures below atmospheric pressure in said chamber on a surface of said liquid and also including means for regulating said pressures below atmospheric pressure to regulate said liquid discharge over said range, and means responsive to variations in atmospheric conditions for automatically adjusting said pressure regulating means in accordance with said variations said atomizer being below a level which is above said liquid surface a distance equal to the range of pressure regulation in said chamber measured in inches of liquid plus the height which the atomizer lifts the liquid at the highest rate of discharge.

8. Apparatus according to claim 1, including a check valve located between said liquid supply and said atomization region.

9. Apparatus according to claim 3, including a check valve located between said liquid reservoir and said atomization region.

10. Apparatus according to claim 5 wherein said means for regulating said pressures below atmospheric pressure comprises means for regulating the rate at which gas is withdrawn from said chamber by said gas withdrawal means.

11. Apparatus for use with an atomizer for humidifying the atmosphere within an enclosure in which the flow of

a fluid to and through an atomization region effects the movement of the liquid to be atomized from a chamber forming a reservoir for said liquid to said atomization region, said apparatus comprising means for regulating the rate of discharge of said liquid from said atomizer, said last mentioned means including means for producing a vacuum in said chamber and means for regulating the amount of vacuum produced by said vacuum producing means, means responsive to variations in atmospheric conditions for automatically controlling said vacuum regulating means to automatically regulate the amount of said vacuum and consequently the rate of discharge in accordance with said variations, said means for automatically controlling said vacuum regulating means comprising pneumatically controlled movable means responsive to changes in pressure applied thereto for actuating said vacuum regulating means in accordance with said pressure changes, conduit means for transmitting pressure between said pneumatically controlled means and a first source of fluid at a first pressure and between said pneumatically controlled means and a second source of fluid at a second pressure different in magnitude than said first pressure, means for restricting the rate at which pressure is transmitted between said first source and said pneumatically controlled means, a valve in said conduit means between said first source and said means for restricting the rate of pressure transmission, said valve being responsive to variations in atmospheric conditions to alter the transmission of pressure between said first source and said pneumatically controlled means to vary the pressure applied to said pneumatically controlled means in accordance with said variations in atmospheric conditions.

12. An apparatus according to claim 11 in which said conduit also has a pressure tank located between said pneumatically controlled means and said means for restricting the rate of pressure transmission between said pneumatically controlled means and said first source of fluid.

13. An apparatus according to claim 12, wherein said first source of fluid comprises a source of compressed air, said second source is the atmosphere and said valve comprises an on and off valve responsive to variations in atmospheric conditions to alternately shut off and turn on communication between said pneumatically controlled means and said first and second sources whereby fluid alternately flows from the first source through said on and off valve and said means for restricting rate of flow to the pressure tank and from the pressure tank through said means for restricting rate of flow to the second source, said means restricting rate of flow being located in a conduit between said on and off valve and said pressure tank.

14. Apparatus for use with a suction type atomizer for humidifying the atmosphere within an enclosure in which the flow of a fluid from a fluid source through a conduit for said fluid to an atomizing region effects the movement of the liquid to be atomized from a chamber forming a reservoir for said liquid through a conduit for said liquid to said atomization region, comprising means for regulating the rate of discharge of said liquid, said means including means for producing a vacuum in said chamber and means for regulating the amount of vacuum produced by said vacuum producing means, means responsive to variations in atmospheric conditions for automatically controlling said vacuum regulating means to automatically regulate the amount of said vacuum and consequently the rate of discharge in accordance with said variations, means for intermittently shutting off and turning on the discharge of said liquid in response to said variations in atmospheric conditions, whereby the duration of each off and on period depends upon said atmospheric conditions, and said means for automatically controlling said vacuum regulating means being responsive to the relative durations of said on and off periods.

13

15. Apparatus according to claim 14 wherein said means for alternately shutting off and turning on said discharge comprises off and on valve means in said conduit for said fluid and wherein said means for automatically controlling said vacuum regulating means includes pneumatically controlled means responsive to changes in pressure thereon for operating said vacuum regulating means in accordance with said changes in pressure, a control conduit for transmitting pressure between said pneumatically controlled means and said conduit for said fluid downstream of said off and on valve means and a restriction in said control conduit.

16. Apparatus for use with a suction type atomizer for humidifying the atmosphere within an enclosure in which the flow of a fluid from a fluid source through a conduit for said fluid to an atomization region effects the movement of the liquid to be atomized from a chamber forming a reservoir for said liquid through a conduit for said liquid to said atomization region, comprising means for regulating the rate of discharge of said liquid over a range of rates, said means including means for producing a vacuum in said chamber and means for regulating the amount of vacuum produced by said vacuum producing means to regulate the rate of discharge over at least the major portion of said range, and means responsive to variations in atmospheric conditions for automatically controlling said vacuum regulating means to automatically regulate the amount of said vacuum and consequently the rate of discharge in accordance with said variations, said discharge being continuous, said means for automatically controlling said regulating means comprising an on and off valve in said conduit for said fluid downstream of said atomizer, said on and off valve being adapted to be turned on and off intermittently in response to variations in the condition of the atmosphere, a pressure tank communicating with the downstream side of said on and off valve, a restriction between said on and off valve and said tank and means for automatically controlling said regulating means in accordance with the pressure in said tank.

17. Apparatus for regulating the rate of discharge from a suction type atomizer for humidifying the atmosphere within an enclosure in which the flow of a fluid from a fluid source through a conduit for said fluid to and through an atomizing region effects the movement of a liquid from a chamber which forms a reservoir for said liquid through a conduit for said liquid to the region where atomization occurs, said apparatus comprising means for producing a vacuum in said chamber, said vacuum producing means including means for withdrawing gas from said chamber, means for regulating the vacuum producing effect in said chamber of said gas withdrawal means, said regulating means comprising a bleed passage providing communication between said chamber and the atmosphere, said passage having an adjustable restriction therein, the vacuum in said chamber being increased when the size of said restriction is decreased, means responsive to variations in atmospheric conditions for automatically adjusting the size of said restriction and consequently the rate of flow of gas through said bleed passage in accordance with atmospheric conditions, said means for automatically adjusting the size of said restriction means including pneumatically operated means movable in response to pressure changes thereon to adjust the size of said restriction means in accordance with said pressure changes, on and off valve means in said conduit for said fluid, a control conduit communicating between said pneumatically operated means and said conduit for said fluid downstream of said on and off valve means, a restriction in said control conduit, and tank means located between said last mentioned restriction and said pneumatically operated means.

18. An apparatus according to claim 5 also including on and off valve means in said conduit for said fluid upstream of said atomizer, means responsive to variations

14

in atmospheric conditions within the enclosure into which liquid is discharged for alternately shutting off and turning on said on and off valve means and consequently the discharge of said liquid, whereby the duration of each off and on period depends upon atmospheric conditions.

19. In combination a suction type atomizer for humidifying the atmosphere within an enclosure, a chamber forming a liquid reservoir for said liquid and having means for admitting liquid thereto at substantially the same rate at which liquid is withdrawn therefrom, the level of the liquid in said chamber being below said atomizer, a conduit for said liquid providing communication between said chamber and said atomizer, a source of fluid, a conduit for said fluid providing communication between said atomizer and said fluid source, said atomizer, conduits, source and chamber being so arranged that the flow of said fluid from said fluid source through said fluid conduit and to the region where atomization occurs effects atomization, discharge and movement of said liquid from said chamber through said conduit for said liquid to said atomization region, and means for regulating the rate of discharge of said liquid, said last mentioned means including means for producing a vacuum in said chamber and also including means for regulating said vacuum, means responsive to variations in atmospheric conditions for automatically adjusting said vacuum regulating means in accordance with said variations, on and off valve means in said fluid conduit for alternately shutting off and turning on the flow of said fluid to said atomizer in response to said variations in atmospheric conditions, thereby alternately shutting off and turning on the discharge of said liquid, said means for automatically adjusting said vacuum regulating means comprising pneumatically controlled movable means responsive to changes in pressure thereon for actuating said vacuum regulating means in accordance with said pressure changes, a control conduit communicating between said movable means and said fluid conduit downstream of said on and off valve means, a restriction in said control conduit and tank means in said control conduit between said movable means and said restriction.

20. In combination a suction type atomizer for humidifying the atmosphere within an enclosure, a chamber forming a liquid reservoir for said liquid and having means for admitting liquid thereto at substantially the same rate at which liquid is withdrawn therefrom, the level of the liquid in said chamber being below said atomizer, a conduit for said liquid providing communication between said chamber and said atomizer, a source of fluid, a conduit for said fluid providing communication between said atomizer and said fluid source, said atomizer, conduits, source and chamber being so arranged that the flow of said fluid from said fluid source through said fluid conduit and to the region where atomization occurs effects atomization, discharge and movement of said liquid from said chamber through said conduit for said liquid to said atomization region, and means for regulating the rate of discharge of said liquid, said last mentioned means including means for producing a vacuum in said chamber and also including means for regulating said vacuum, means responsive to variations in atmospheric conditions for automatically adjusting said vacuum regulating means in accordance with said variations, said source of fluid comprising a low pressure, non lubricated rotary pump for continuously pumping said fluid at a relatively low pressure through said atomizer.

21. A combination according to claim 20 wherein said means for automatically adjusting said vacuum regulating means comprises an on and off valve in said fluid conduit downstream of said atomizer, said on and off valve being responsive to said variations in atmospheric conditions, a pressure tank communicating with the downstream side of said on and off valve, a restriction between said on and off valve and said tank and means for auto-

atically adjusting said vacuum regulating means in accordance with pressure in the pressure tank.

References Cited in the file of this patent

UNITED STATES PATENTS

400,758	Easton	Apr. 2, 1889
1,270,159	Hodge	June 18, 1918
2,014,906	Munoz	Sept. 17, 1935
2,086,957	Peet	July 13, 1937

5

2,127,162
2,255,639
2,295,728
2,401,004
2,675,217
2,782,992

10

555,336
151,500

Beauregard Aug. 16, 1938
Annin Sept. 9, 1941
Gess Sept. 15, 1942
Lehane May 28, 1946
Slason Apr. 13, 1954
Gustafson Feb. 26, 1957

FOREIGN PATENTS

Germany July 21, 1932
Switzerland Mar. 1, 1932