

Sept. 20, 1971

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3,605,436

CENTRIFUGAL ABSORPTION AIR CONDITIONER

Original Filed March 6, 1968

6 Sheets-Sheet 1

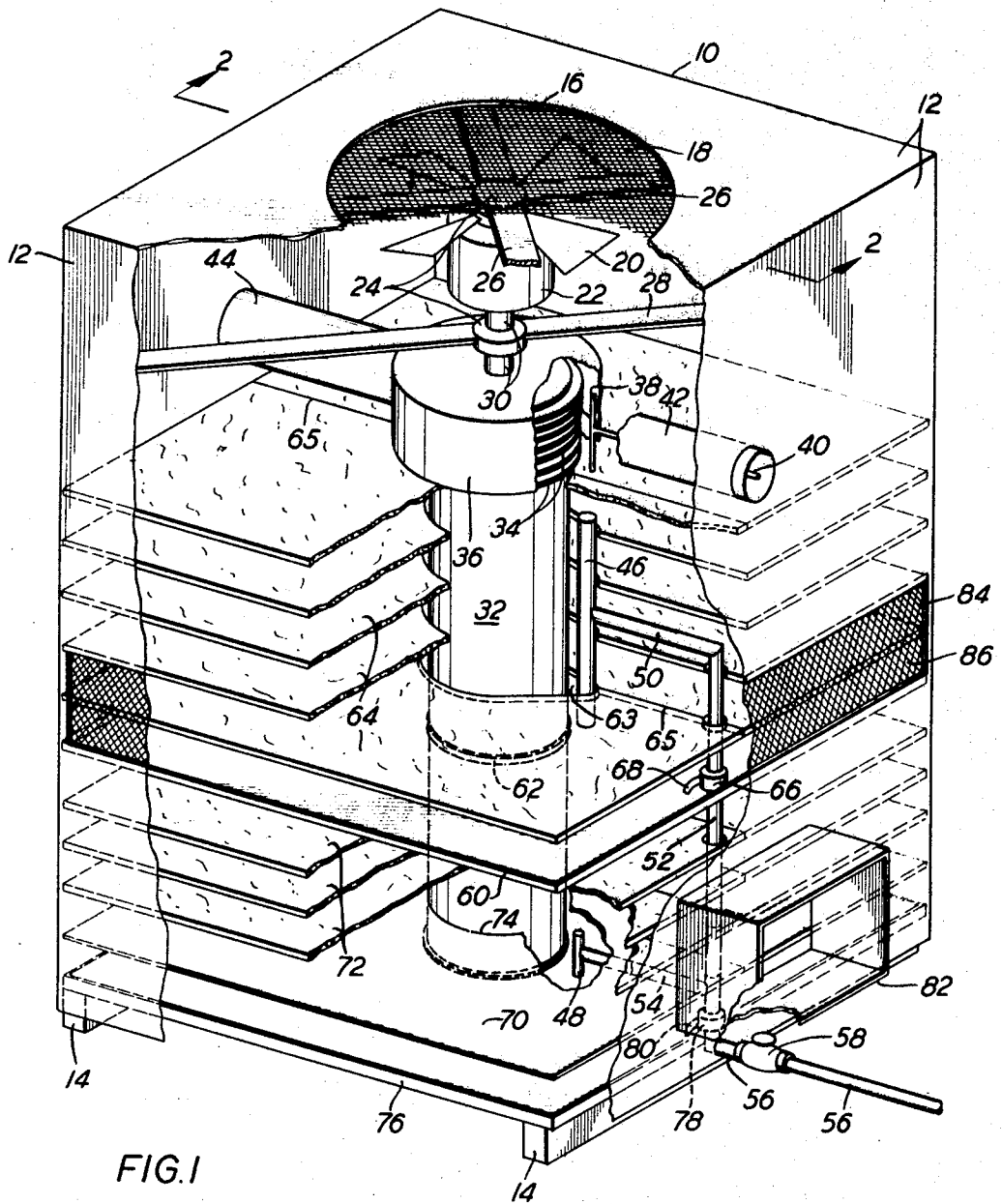


FIG. 1

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6 Sheets-Sheet 2

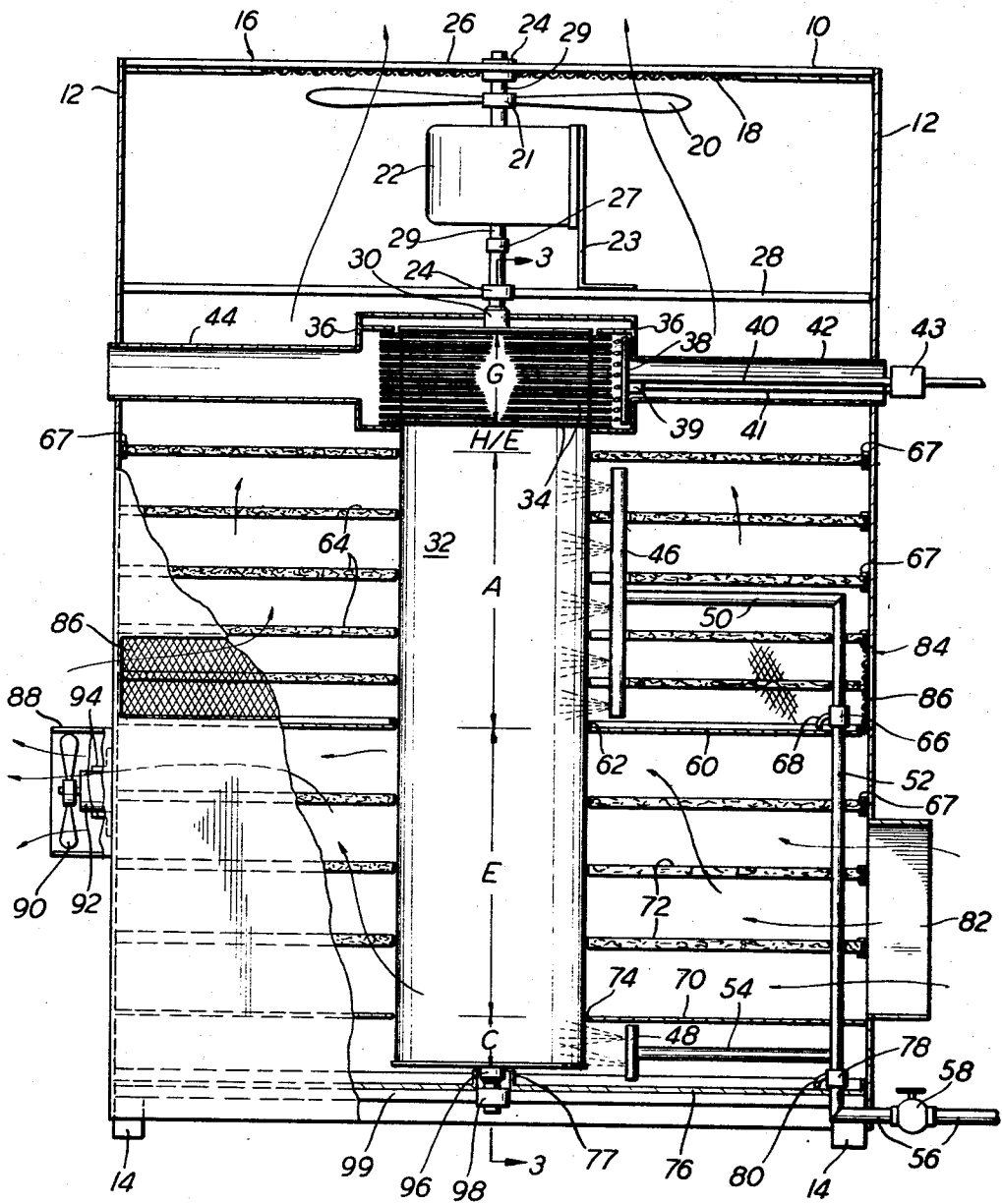


FIG. 2

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6 Sheets-Sheet 3

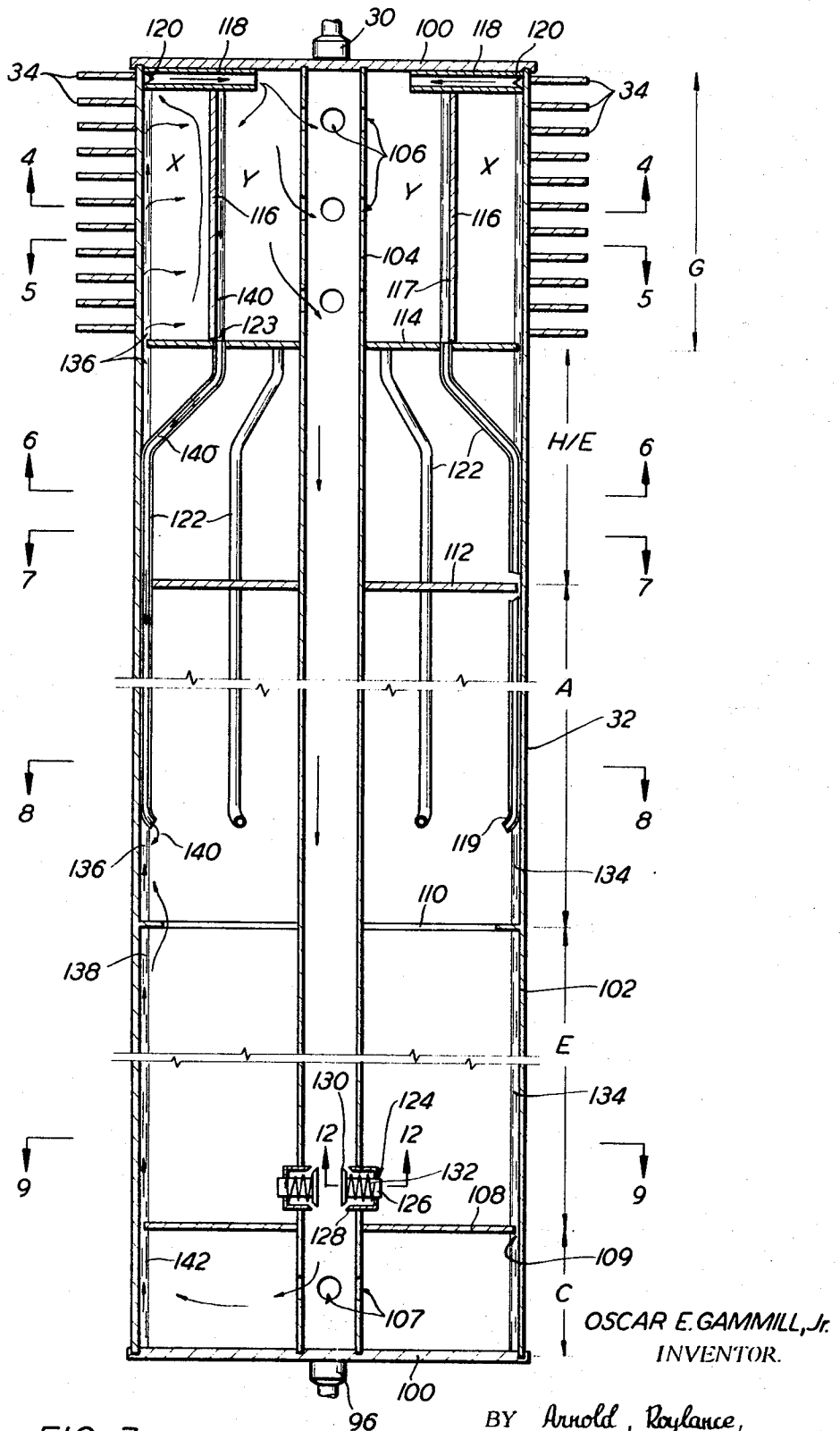


FIG. 3

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FIG. 4

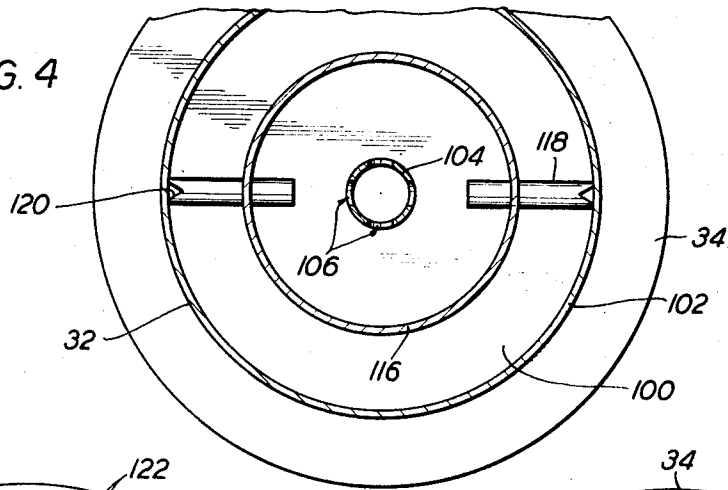


FIG. 5

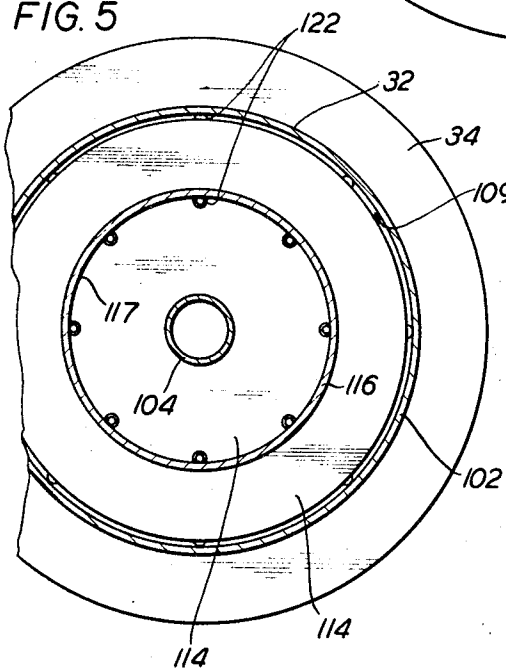


FIG. 6

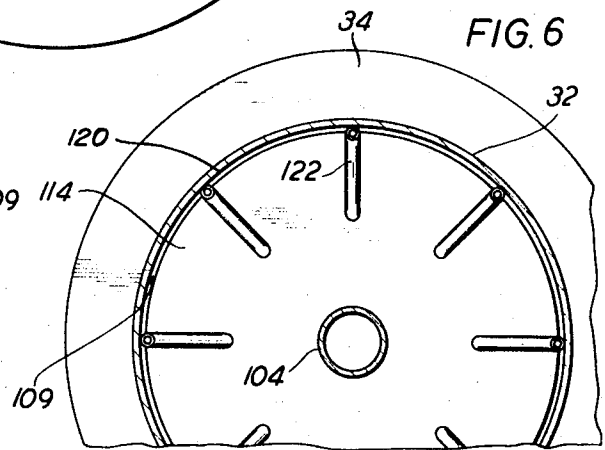


FIG. 7

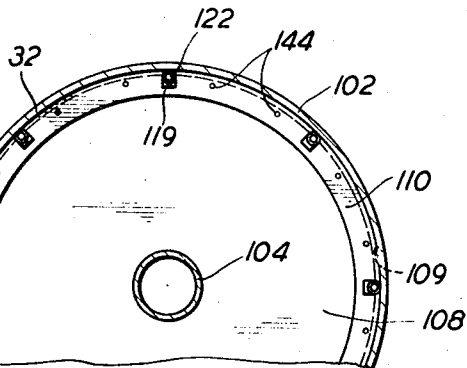
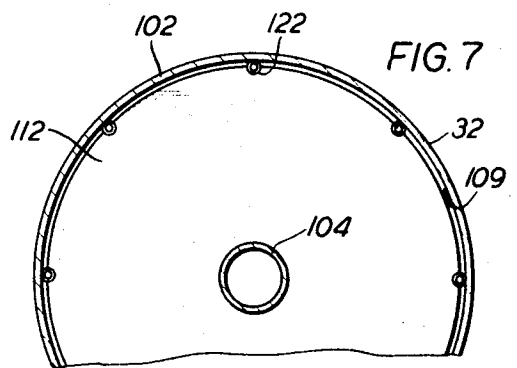


FIG. 8

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CENTRIFUGAL ABSORPTION AIR CONDITIONER

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FIG. 9

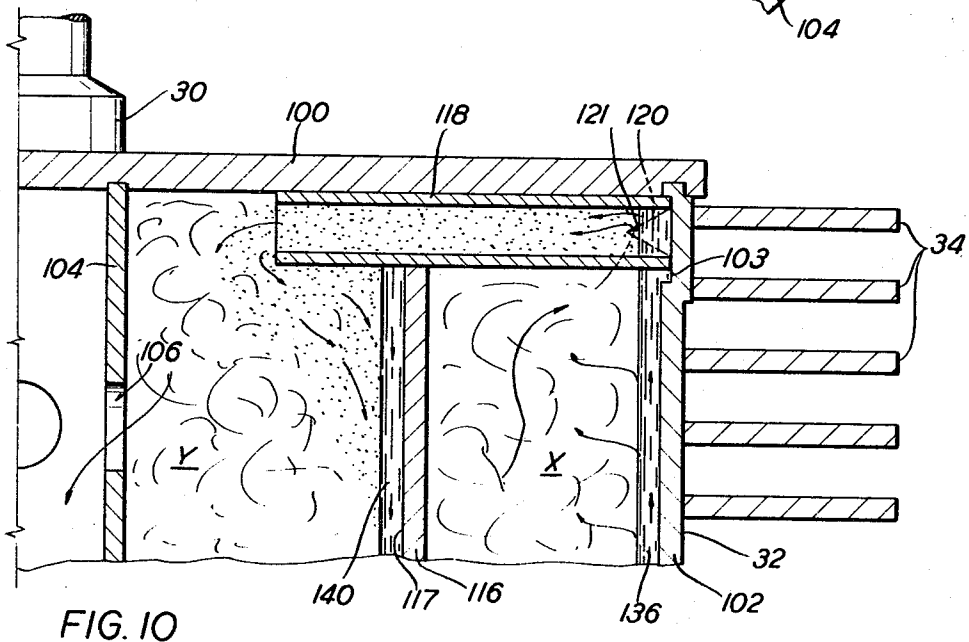
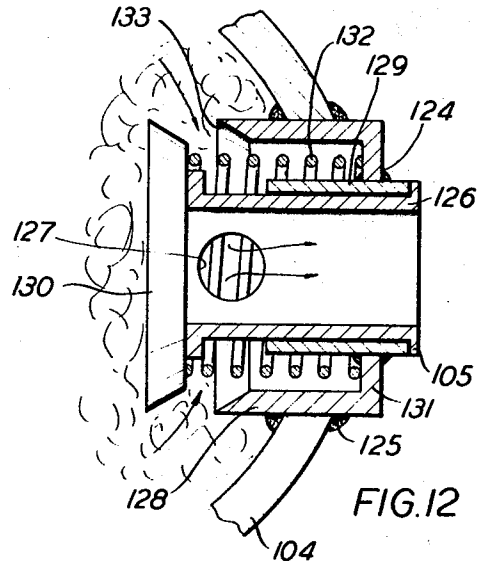
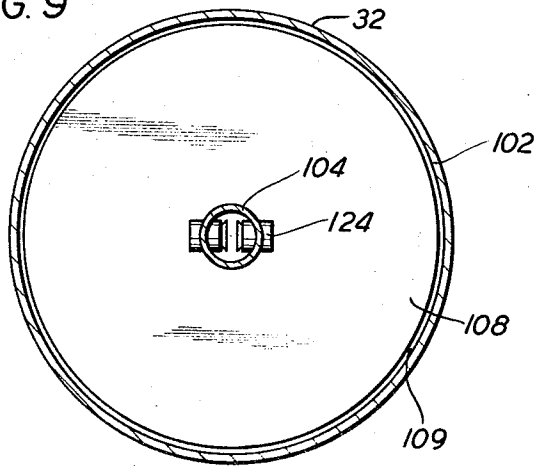
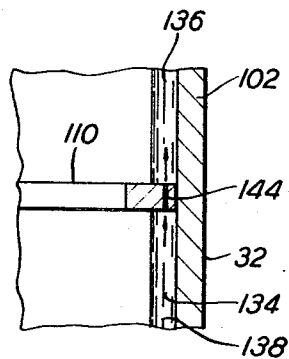


FIG. 11



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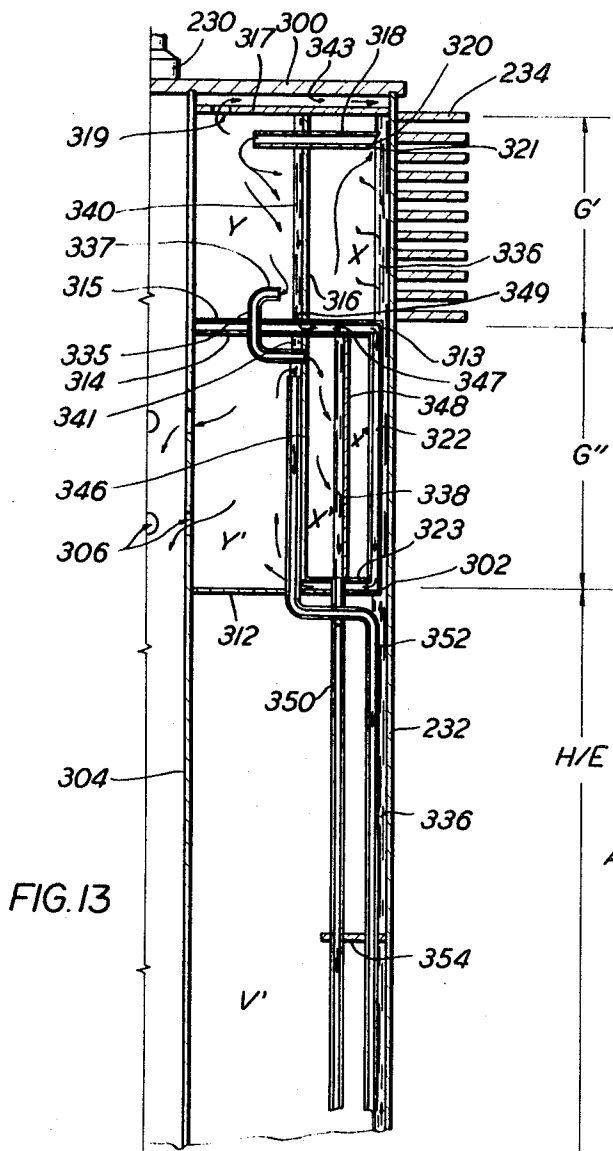


FIG. 13

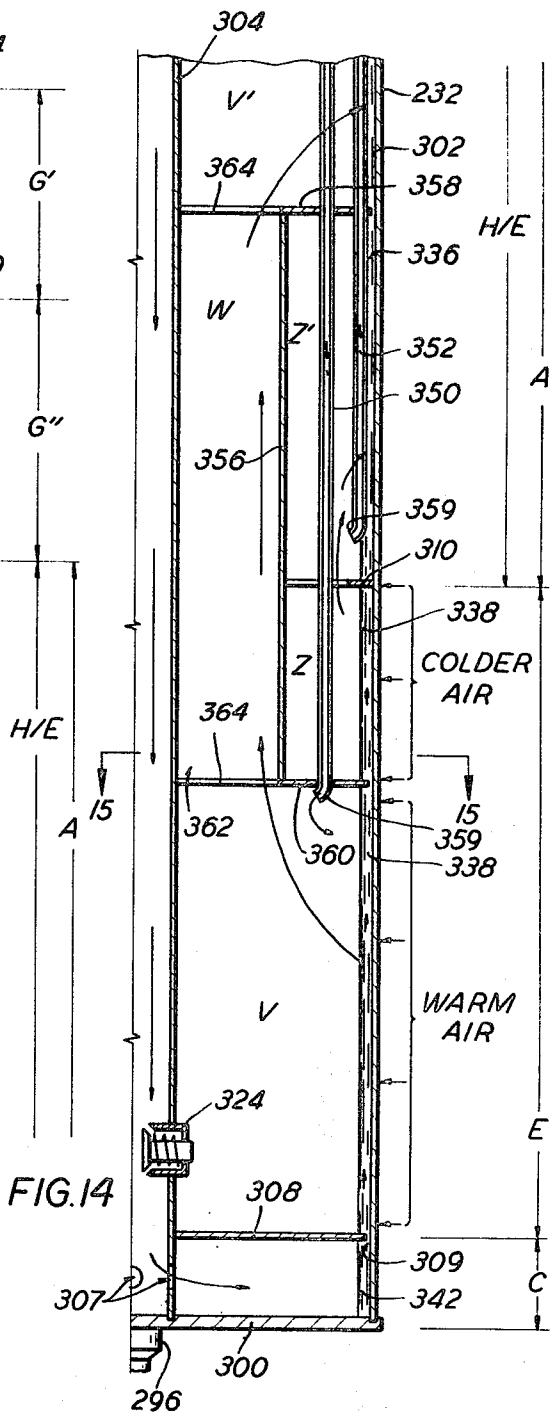


FIG. 14

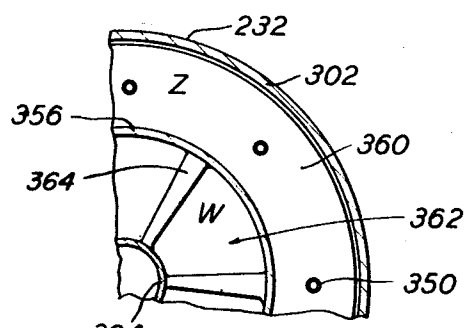


FIG. 15

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3,605,436  
**CENTRIFUGAL ABSORPTION AIR CONDITIONER**  
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Continuation of application Ser. No. 711,037, Mar. 6,  
1968. This application Aug. 29, 1969, Ser. No. 858,559  
Int. Cl. F25f 15/04  
U.S. Cl. 62—476 30 Claims

## ABSTRACT OF THE DISCLOSURE

In one exemplar embodiment, a gas heated absorption air conditioning system is disclosed, utilizing a rotating cylindrical vessel in which the functions essential to the absorption cycle are performed and heat rejection is effected between a heating or cooling medium and a portion of the outer wall of the cylindrical vessel. The cylindrical vessel, containing a predetermined quantity of an absorptive fluid, is evacuated and sealed and then rotated at a predetermined rotational velocity. The centrifugal and velocity forces created by the rotating vessel evenly distribute the absorptive fluid over the inner walls of the cylinder and provide the motive force to cause circulation of the fluid during the absorption cycle without the need for pumps to maintain such fluid circulation.

This is a continuation of application Ser. No. 711,037, filed Mar. 6, 1968, now abandoned.

## BACKGROUND OF THE INVENTION

This invention relates to air conditioning apparatus, and more particularly to air conditioning systems of the absorption type operated by heat.

"Air conditioning" as the term is used herein is defined in its broad sense, i.e., the cleaning and control of the humidity and temperature of the air within a defined enclosure, including heating and cooling. In present air conditioning systems of this type, in order to circulate absorption liquid through and between a generator, heat exchanger and absorber, either mechanical devices, such as pumps must be employed or a vapor-lift action must be utilized in the generator to cause the liquid to flow to the absorber and return to the generator by gravity. While the use of pumps to circulate the absorption liquid is commonly utilized, various disadvantages are also encountered including the need for fluid level control devices, added cost of pumping devices, additional costs of operating the pumps, increased possibility of equipment failure, and the danger of leakage of the highly corrosive absorptive liquid through the many pump seals and tubing connections.

Similarly, in utilizing the vapor-lift technique it is necessary to provide ample gas and liquid contact surfaces for the refrigerant vapor and absorption liquid making it desirable to utilize a "film" type of absorber in which the piping, upon which the film of absorption liquid is maintained to provide ample gas and liquid contact surfaces for the refrigerant vapor and absorption liquid, requires a sufficient length to achieve the desired result. In air conditioning systems of large capacity, increasing the size of the absorber unduly results in a system of increased size, and this is undesirable because of the importance of keeping air conditioning systems as small as possible, so that they will occupy a minimum amount of space. In many instances, particularly in small business establishments and dwellings, the amount of space available for the installation of a refrigeration system is limited and a deciding factor in the ultimate selection of a particular type of air conditioning system.

Gas heated absorption air conditioners presently utilized

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are more expensive than comparable compressor-type air conditioners due to the requirements for additional pumps or the large "film" type absorbers necessary in vapor-lift systems with the attendant increase in size. Absorption units are generally larger and bulkier and require more space for installation than do conventional compressor units. However, the operating cost of the absorption units is generally less, but is offset by the additional initial cost.

## SUMMARY OF THE INVENTION

The disadvantages of the prior art are overcome by the present invention and a gas heated absorptive air conditioning unit for summer cooling and winter heating is provided utilizing a rotating cylindrical vessel within which the entire absorption cycle is accomplished without the need for pumps or fluid level control devices and having means to accomplish heat exchange between a desired fluid medium and the walls of the cylinder for heating or cooling. The cylindrical vessel is evacuated and contains a predetermined quantity of refrigerant and absorptive medium. The various functions of the absorption cycle are performed within discrete sections of the cylinder, the circulation of the absorptive fluid being maintained by centrifugal and velocity forces produced by the rotating cylinder. A fluid medium, either water or air, is passed over the outer wall of the rotating cylinder adjacent the longitudinal section of the cylinder within which the evaporative function of the absorption cycle is performed for heating or cooling the medium. Heat rejection means, utilizing a combination of air and water cooling, are provided to cool the condenser and absorber sections of the cylinder during its refrigeration cycle.

The utilization of centrifugal and velocity forces to circulate the absorptive fluid readily permits the use of multi-staging to increase efficiency and lower costs since the only additional needs are for more functional sections within the cylinder and no additional pumping or distributing means is necessary.

Accordingly, it is a feature of the present invention to provide an absorption air conditioning unit in which the absorptive fluid is distributed between the essential elements of the absorptive cycle solely by centrifugal and velocity forces.

It is another feature of the present invention to provide an absorption air conditioner permitting the use of water or air for heat rejection or as the fluid cooling medium.

It is another feature of the present invention to provide an absorption air conditioning unit that permits the use of multiple generator, evaporator, and absorber stages to reduce the fuel energy required and provide a higher overall heat transfer efficiency.

Another feature of the present invention is to provide a compact absorption air conditioning unit wherein the elements essential to accomplish the absorption cycle are sealed within one structural unit having a minimum of joints and seams for permitting leakage of the corrosive absorptive fluid.

Yet another feature of the present invention is to provide an absorption air conditioning unit having heat rejection surfaces that are self-cleaning and reduce the amount of fouling normally associated with the use of liquid cooling mediums.

## BRIEF DESCRIPTION OF THE DRAWINGS

In order that the manner in which the above-cited advantages and features of the invention are attained, as well as others that will become apparent, can be understood in detail, a more particular description of the invention may be had by reference to specific embodiments thereof which are illustrated in the appended drawings, which drawings form a part of this specification. It is to be noted, however, that the appended drawings illustrate

only typical embodiments of the invention and therefore are not to be considered limiting of its scope, for the invention may admit to other equally effective embodiments.

In the drawings:

FIG. 1 is a perspective view, partly in cross-section, of an embodiment of the absorption air conditioner according to the present invention.

FIG. 2 is a vertical cross-sectional view of the apparatus according to the present invention taken along lines 2—2 of FIG. 1.

FIG. 3 is a vertical cross-sectional view of an embodiment of the rotatable absorption cylinder of the apparatus according to the present invention shown in FIGS. 1 and 2 and taken along lines 3—3 of FIG. 2.

FIG. 4 is a horizontal cross-sectional view of the cylinder shown in FIGS. 2 and 3, taken along lines 4—4 of FIG. 3.

FIG. 5 is a horizontal cross-sectional view of the cylinder shown in FIGS. 2 and 3, taken along lines 5—5 of FIG. 3.

FIG. 6 is a horizontal cross-sectional view of the cylinder shown in FIGS. 2 and 3, taken along lines 6—6 of FIG. 3.

FIG. 7 is a horizontal cross-sectional view of the cylinder shown in FIGS. 2 and 3, taken along lines 7—7 of FIG. 3.

FIG. 8 is a horizontal cross-sectional view of the cylinder shown in FIGS. 2 and 3 taken along lines 8—8 of FIG. 3.

FIG. 9 is a horizontal cross-sectional view of the cylinder shown in FIGS. 2 and 3, taken along lines 9—9 of FIG. 3.

FIG. 10 is a detailed cross-sectional view of a portion of the generator section of the cylinder shown in FIG. 3.

FIG. 11 is a detailed cross-sectional view of the separating ring of the cylinder shown in FIG. 3.

FIG. 12 is a detailed cross-sectional view of a centrifugal action valve of the cylinder shown in FIG. 3.

FIG. 13 is a partial vertical cross-sectional view of the upper portion of another embodiment of the rotatable absorption cylinder of the apparatus according to the present invention shown in FIGS. 1 and 2.

FIG. 14 is a partial vertical cross-sectional view of the lower portion of another embodiment of the rotatable cylinder of the apparatus according to the present invention shown in FIGS. 1 and 2.

FIG. 15 is a partial horizontal cross-sectional view of the cylinder shown in FIGS. 13 and 14, taken along lines 15—15 of FIG. 14.

#### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to FIGS. 1 and 2, one embodiment of the absorption air conditioner according to the present invention is shown. Absorption air conditioner 10 is contained in a housing 12 comprising removable side and top panels. Legs 14 support the housing structure 12 and aid in the installation and moving of the air conditioner unit. A circular opening 16 is disposed centrally in the top panel of housing 12 and is covered with a screen 18 to prevent the entry of foreign materials and large objects that may damage the unit. A fan 20 is driven by a variable or multi-speed motor 22, supported by mounting bracket 23, to exhaust air utilized in the heat exchange process when the air conditioner is used in its cooling cycle as will be hereinafter described. The drive shaft 29 of motor 22 is coupled to a fan by means of a centrifugal clutch 21 which engages and operates the fan as will be hereinafter described. Drive shaft 29 of motor 22 is also coupled by coupling 27 to the shaft 30 of a rotatable cylinder 32 for rotating the cylinder at one of the desired motor speeds for purposes to be hereinafter described. Shafts 29 and 30 are supported for rotation by conventional bearing assemblies 24 supported by a structural brace member 28.

Absorption cylinder 32 has a lower support shaft 96 that rotates within and is supported by a suitable bearing assembly 98 also supported by a lower structural brace member 99.

Cylindrical vessel 32 has affixed to an upper portion thereof a series of extending rings or fins 34. A cylindrical housing 36 encloses the finned upper portion of cylindrical vessel 32. A gas burner 38 is disposed longitudinally adjacent radial fins 34 and is located within housing 36 which acts as a closed firebox to contain the combustion elements emanating from burner 38 and distribute the hot burning gases around and between fins 34. Air intake duct 42 is connected to firebox 36 to provide an air intake source to support combustion within box 36. Burner 38 is attached to a fuel supply line 40 passing through duct 42 that provides combustion fuel, preferably natural gas, from an outside source. An exhaust flue 44 attached to the opposite side of cylindrical firebox 36 from air intake duct 40 provides a means for exhausting the combustion gases from firebox 36 to the atmosphere.

Located longitudinally parallel and adjacent to the cylinder 32 is a spray head 46 for directing a fine spray of pressurized water onto a predetermined section of the outer surface of cylinder 32. Similarly, a spray head 48 is located longitudinally parallel and adjacent to the base end of vessel 32 for directing a fine spray of pressurized water onto a predetermined lower portion of the cylindrical vessel 32. Spray heads 46 and 48 are coupled to a water supply line 56 from an outside source by pipe sections 50, 52 and 54. Water flow from the outside source through pipe 56 is controlled by shut-off valve 58.

Spaced below spray head 46 and encircling cylinder 32 is a water pan 60. Pan 60 has a flanged rim 62 closely spaced to the outer surface of cylinder 32 to prevent the water from head 46 from being sprayed downwardly between the outer surface of cylinder 32 and the rim of collar 62. However, the space between collar 62 and cylinder 32 is such that a small amount of water may trickle down the side of the cylindrical surface and pass between collar 62 and the surface of cylinder 32. Longitudinally disposed along the cylinder between firebox 32 and pan 60 are several filter elements or pads 64 in a parallel arrangement that completely surrounds cylinder 32 and are coextensive within housing 12. The filter pads 64 are sectioned to facilitate removal for maintenance and for changing the filter elements after they have become clogged and soiled. It may be seen in FIG. 1, that the filter elements are half-sections which have edges joining along lines 65 to completely encircle cylinder 32 and are supported by brackets 67 (see FIG. 2). It will also be noted that there is a triangular cut-out area 63 that provides a suitable opening to allow the water spray from head 46 unhindered access to the outer surface of cylindrical vessel 32. The air that is drawn through elements 64 by fan 20 enters housing 12 on four sides through air intake slots 84 and a filter screen 86.

In operation, the water spray from head 46 strikes the rotating cylinder 32 which throws the water circularly outward where it falls upon and is absorbed by the filter elements 64. When the filter elements 64 are saturated, excess moisture will drip down through the filter pads 64 and be collected by water pan 60. The water that collects in pan 60 is recirculated to spray head 46 by means of a conventional water siphon 66 disposed in pipe section 52. Siphon 66 has a projecting tube 68, the end of which extends below the surface of the water collected in pan 60 and siphons the water into pipe sections 52 and 50 for recirculation to spray head 46. Filter elements 64 may be composed of glass fibers or any other conventional air filtering and wetting material.

Spaced below water pan 60 is a sheet metal plate 70 that surrounds cylindrical vessel 32 and is coextensive within the interior of housing 12. Plate 70 has a slight downward and inward slant from its outside edge to its



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inner circular edge surrounding the outer surface of vessel 32 for reasons to be hereinafter described. Disposed in parallel arrangement in the space between plate 70 and water pan 60 are several filter elements or pads 72 similar to elements 64 hereinbefore mentioned. These filter pads 72 are also half-sectioned for easy removal and maintenance and are held in place by brackets 67. The air that is to be conditioned (heated or cooled) is drawn through air duct 82 and is directed against a predetermined outer portion of cylindrical vessel 32 where a heat exchange function is accomplished. The air passes through various filter pads 72 to be filtered, cooled and dehumidified and then is expelled through the conditioned air duct 88 (see FIG. 2) by the action of an exhaust fan 90 and is re-directed to the room or enclosure that is being air conditioned. Fan 90 is driven by a motor 92 conventionally mounted by brackets and bolts 94.

Moisture is absorbed by the filter elements 72 and when the elements are saturated the water will drip down onto the top surface of plate 70 where, because of its downward and inward slant, the moisture in the form of water will drain towards edge 74, closely spaced to the outer surface of cylindrical vessel 32. The water will flow onto the surface of vessel 32 from the edge 74 of plate 70. As will be noted, plate 70 is located just above the top of water spray head 48.

Spaced below plate 70 and just below the bottom end spray head 48 is another water pan 76. Water pan 76 has an inner collar 77 that encircles lower support shaft 96 of cylindrical vessel 32 to trap any water that may be sprayed under the base of cylinder 32 or that may accumulate by condensation. Pan 76 collects the water that is sprayed upon the narrow lower section of cylindrical vessel 32 by spray head 48 and drips down or is circularly thrown out from the cylinder 32. The water that seeps downwardly between plate rim 74 onto the lower surface of cylindrical vessel 32 is also collected by pan 76. Disposed in pipe section 56 below the interconnection of pipe section 54 is a second conventional water siphon 78. Siphon 78 has a downwardly protruding tube 80, the end of which extends below the surface of the water collected in pan 76 to siphon the water back into the distribution system to be redistributed to sprayer heads 46 and 48.

During operation in the cooling or heating cycle, motor 22 rotates cylinder 32 at a predetermined speed to achieve a desired rotational velocity. Within cylindrical vessel 32, which has been sealed and from which the atmosphere has been evacuated, is a predetermined quantity of fluid refrigerant and absorbing medium suitable for accomplishing a conventional absorption refrigeration cycle. The centrifugal forces generated by the rotating vessel 32 distribute the absorbing medium evenly over the inside walls of the vessel for accomplishing the absorption cycle. The cylindrical vessel 32 is divided internally into several compartments or sections to accomplish the absorption cycle. The interior section of the cylinder adjacent the external radial fins 34 is the generator compartment or boiler heating section of the cycle, indicated at G in FIG. 2. The absorber compartment is disposed within cylinder 32 directly adjacent the outer surface of cylinder 32 that is cooled by water from spray head 46, and indicated by A in FIG. 2. In the interval between the top limit of the absorber compartment A and the lower portion of the generator compartment G marked by the lowermost fin 34 is the heat exchanger compartment indicated by H/E. The longitudinal section of cylindrical vessel 32 that corresponds to the interval between water pan 60 and plate 70 corresponds to the evaporator compartment utilized in the absorption cycle, and indicated at E in FIG. 2. The lowermost section of cylindrical vessel 32, located between plate 70 and water pan 76 and cooled by the spray head 48 and the water which flows downwardly from plate 70, is the condenser compartment of the absorption cycle, indicated by C.

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During the cooling cycle of the absorption air conditioner 10, fan 20 is engaged by clutch 21 to draw air into housing 12 through the screened heat rejection air intake 84. The air is then circulated around the outer surface of cylindrical vessel 32 and is drawn upwardly through the filter elements 64 and around firebox 36 to be discharged through opening 16 by the action of fan 20. The combination of the water spray upon cylinder 32 and the movement of the air which is being wetted and cooled on contact with the moist filter elements 64, provide the means for cooling the absorber section A and providing the necessary heat rejection necessary in accomplishing the absorption cycle.

Burner 38, utilizing natural gas or other suitable fuel, directs combustion materials against radial fins 34 and into firebox 36 to provide heat for the generator section G of cylinder 32. Radially extending fins 34 provide a maximum heating surface for conducting heat from the burning fuel to the generator section G of cylindrical vessel 32. As was previously mentioned, the atmosphere to support the combustion within firebox 36 is drawn in through air duct 42 and the consumed combustion gases are expelled from firebox 36 through the exhaust flue 44. A thermocouple 39 monitors burner 38 during operation and signals a safety shut-off valve 43 via conductor 41 to shut-off the gas flow in the event the flame from burner 38 is extinguished.

The warm air to be cooled is drawn in through air intake duct 82 by the action of fan 90, and is distributed against and around the outer wall of cylindrical vessel 32 between upper water pan 60 and plate 70 adjacent evaporator section E. A heat exchange between the warm incoming air and the evaporator section of the absorption cycle is effected to cool the air before it is discharged by fan 90 through vent 88. Of course, the condenser section E of cylindrical vessel 32 between plate 70 and lower water pan 76 is cooled by the action of the water spray from head 48 and the cool water trickling from plate 70 over the outer surface of vessel 32. The water or condensate draining from plate 70 is particularly useful in the condenser cooling process since it has been cooled prior to contact with the surface of cylinder 32 by the action of the air flow through filter elements 72.

In the heating cycle, clutch 21 disengages and fan 20 is inoperative, thereby shutting off the flow of heat rejection air through intakes 84, around cylinder 32, and upwardly through filter elements 64 to be discharged through exhaust opening 16. Shut-off valve 58 is closed to shut-off the supply of water to spray heads 46 and 48. Thus, none of the cooling means for heat rejection employed during the cooling cycle are utilized in the heating cycle.

The cold air to be warmed is drawn in through intake duct 82 by the action of fan 90 and is distributed against and around the outer wall of vessel 32 between upper water pan 60 and plate 70 adjacent evaporator section E. The cold incoming air gains heat from the evaporator section's cylindrical wall and the heated air is discharged for distribution by fan 90 through vent 88.

From the foregoing descriptions of the absorption air conditioner unit 10 as shown in FIGS. 1 and 2, it may be seen that a relatively simple apparatus, employing only one motor to drive the entire apparatus, may be employed to accomplish both cooling and heating by a single unit without need for modification. The apparatus as shown may utilize low cost natural gas or other suitable fuels to heat the generator section of the absorption cylindrical vessel 32. The motor 22 may be of a low horsepower rating since its only load is the rotation of the cylinder 32 and heat rejection fan 20, thus, contributing to an extremely low electrical power requirement contrasted to the power requirements necessary in conventional compressor-type units.

The cylindrical vessel 32 performs its heating and cooling cycles by utilization of the stable, low cost absorption cycle. All of the functions of the absorption refrigeration

tion cycle are accomplished within the rotating cylinder 32 without the need for power consuming pumps or water control devices as will be hereinafter described.

As shown in FIGS. 1 and 2, an air conditioning unit 10 having a capacity of approximately 3 to 4 tons would likely have the following approximate dimensions: height, 45 inches; width and length, 32 inches. As previously mentioned, the fuel for heating the generator section would require an external source of gas and a water line for providing the cooling water spray. Electrical power may be supplied by a 115-volt source for energizing motor 22 in contrast to the 220-volt source normally required in presently used conventional units of this capacity.

Of course, it may be seen by those skilled in the art, that either air or water alone could be utilized in accomplishing heat rejection in the the system illustrated in FIGS. 1 and 2, instead of the combination of water and air shown. Water or another cooling medium may be chilled or heated and distributed remotely to accomplish heat exchange and condition the air in a desired location. Other structural features may be utilized in routing the air flow, positioning the water spray heads 46 and 48, and providing means for heating the generator section of cylinder 32. The cylinder 32 does not have to be rotated in a vertical position, but it may be slanted to any side or rotated horizontally and accomplish the desired absorption cycle for reasons that will be hereinafter explained. It will be noted that since the vessel is rotating, its outer surface tends to be self-cleaning as the water is sprayed thereon, preventing a build up of scale and foreign material as is common in present systems where the water filters or flows slowly over absorber and evaporator surfaces. Of course, vessel 32 need not be cylindrical, but may advantageously take a conical shape for accomplishing the solution flow. Other symmetrical vessels may be utilized as long as absorption flow by use of centrifugal forces is maintained.

Referring now to FIG. 3, a vertical cross-sectional view of the cylindrical vessel 32 is shown. Cylindrical vessel 32 comprises two circular end plates 100 and an outer cylindrical shell 102 suitably attached by welding or brazing to form a sealed compartment. Shafts 30 and 96 are fixed to the opposite circular end plates 100 through the axis of cylindrical vessel 32 and provides a means for rotating the vessel as hereinbefore described. Concentrically disposed within outer cylinder 102 is a small inner cylinder or pipe 104 interconnected to end plates 100 in a similar manner as outer cylinder 102. Pipe 104 has several rings of apertures 104 disposed symmetrically in its upper end adjacent the top plate 100. A ring of apertures 107 is disposed symmetrically about the lower end of pipe 104.

A circular plate 108 is spaced above and parallel to base plate 100 and fixed to inner cylinder 104 to provide a condenser compartment section, indicated at C in the drawing. Note that there is a narrow annular space 109 between the outside edge of circular plate 108 and the inner surface of cylinder 102 for reasons to be hereinafter described. Disposed above condenser plate 108 is a flat circular ring 110 attached to the inner surface of outer cylinder 102. Ring 110 is a separating ring that provides a fluid barrier between the adjacent evaporator and absorber compartments within vessel 32, while allowing the two compartments to have a vapor communication. The evaporator compartment of cylindrical vessel 32 is located between condenser plate 108 and separating ring 110 as indicated by the section shown as E in the drawing.

Located above separating ring 110 and parallel to condenser plate 108 is a second plate fixed to inner cylinder 104 and defines a compartment between plates 112 and 108 separated centrally by separating ring 110. Plate 112 has a narrow annular space between its outer edge and the inner surface of cylinder 102, identical to space 109 associated with plate 108, for reasons to be hereinafter described. The absorber compartment of the cylindrical vessel 32 is defined by the space between ring 110 and plate 112 as shown by the section marked A in FIG. 3.

Disposed parallel to plate 112 and end plate 100 is a third circular plate 114 fixed to inner cylinder 104 and having an identical annular space between its outer edge and the inner surface of wall 102 as hereinbefore described for plate 108. The interval between plates 112 and 114 defines the heat exchanger compartment of the unit as indicated at H/E in FIG. 3. The section defined by the interval between plates 100 and 114 is the generator compartment of the unit, as indicated by G in FIG. 3. The generator compartment G is divided into two lateral compartments X and Y by a cylindrical wall 116 concentrically disposed between outer cylinder wall 102 and the inner cylinder 104. Wall 116 defines an outer compartment which is the generator compartment of the unit as indicated at X, and the inner compartment is a separator compartment, Y, for separating the steam generated in compartment X from other fluid components as will be hereinafter described. Velocity tubes 118 are fixed adjacent to top circular plate 100 and provide a path for steam communication between compartments X and Y. Velocity tube 118 has a notched end 120, the extreme points of which contact the inner surface of outer cylinder 102. The other end of tube 118 terminates centrally in compartment Y. Drain tubes 122 are symmetrically disposed within cylindrical vessel 32 and provide a means of fluid communication between compartment Y and the absorber section A. The end of drain tube 122 in compartment Y is disposed immediately adjacent the inner surface 117 of cylindrical wall 116 for reasons to be hereinafter described.

Disposed in the walls of inner cylinder 104 and adjacent to and spaced above the condenser plate 108 and within the evaporator section E is a centrifugal action valve 124. Centrifugal valve 124 is comprised essentially of a hollow valve plunger 126 having a flanged head with seating surfaces 130 around its outer edge. A valve seat member 128 is provided for mating with seating surfaces 130 to seal the valve. Plunger spring 132 urges valve plunger 126 inwardly toward the axis of vessel 32. When a desired rotational velocity of vessel 32 is achieved, the centrifugal force acting outwardly on valve plunger 126 overcomes the resistance of plunger spring 132 allowing plunger seating surfaces 130 to mate with valve seat 128, thereby closing the valve and preventing communication between the interior of inner cylinder 104 and the evaporator compartment E.

A predetermined quantity of suitable refrigerant and absorbing medium are placed within the cylindrical vessel 32 and it is then sealed and partially evacuated. In the present invention, the refrigerant utilized is distilled water and the absorbing medium utilized is lithium bromide, although other absorbing mediums such as lithium chloride, a mixture of lithium bromide, calcium bromide and calcium chloride, or a water solution of sodium hydroxide or ethylene glycol and water could be used. Of course, ammonia or another suitable refrigerant in liquid form could be utilized. As the cylinder is rotated at a predetermined speed to obtain a desired rotational velocity, the absorptive solution of distilled water and lithium bromide is distributed evenly over the entire inner surface of the cylinder 102. In other words, the absorptive solution contained in the cylinder will distribute itself over the inner walls in the cylinder as a "sheet" of fluid solution taking the shape of the outside walls of the cylindrical vessel 32. This "sheet" or "wall" of the absorptive solution containing water and lithium bromide is indicated at 134 in FIG. 3.

When cylinder 32 is not in motion, the solution 134 will be accumulated in the condenser section C in the bottom of the cylinder. When the unit is initially started and cylindrical vessel 32 begins to rotate, the centrifugal forces acting on the absorptive solution will cause it to be distributed uniformly over the inner surface of cylinder 102 up to the lower side of separating ring 110. Separating ring 110 has a radial series of "pin-sized" apertures 144 (see FIG. 11) symmetrically distributed around the ring for providing fluid communication between the evapora-

tor section E and the absorber section A on opposite sides of ring 110.

The forces acting upwardly on the absorptive solution 134 and forcing the solution against the bottom of ring 110 are sufficiently great to cause the absorptive solution 134 to be forced through apertures 144, as shown in FIG. 11, under pressure thereby rapidly transferring a portion of solution 134 to the inner surface of wall 102 above ring 110 where solution 134 is distributed evenly over the remainder of the inner wall surface. This transfer of solution 134 from the area below the ring 110 to the area above ring 110 continues until the depth of the fluid above and below ring 110 is equalized at which time the pressure differential across apertures 144 drops to zero and the flow of the solution ceases. The narrow annular space 109 between circular plates 108, 112 and 114 and the inner surface of cylinder 102, as hereinbefore described, allows the absorptive fluid 134 to flow evenly over the inner surface of cylinder wall 102 and from one compartmented functional section to another without hinderance. The width of the annular space 109 is predetermined so that the depth of the absorptive fluid 134 will exceed the width of the space and effectively seal the condenser, evaporator-absorber, heat exchanger, and generator sections into vapor tight compartments while allowing fluid intercommunication between all compartments along the inner surface of cylinder wall 102.

Referring now to FIGS. 1, 2 and 3, with absorptive solution 134 distributed evenly over the inner walls of outer cylinder 102 and cylindrical vessel 32 rotating at a predetermined speed to achieve a desired rotational velocity during the cooling cycle, the absorptive solution is properly disposed for beginning and maintaining the absorptive refrigeration cycle. When heat is applied to radial fins 34 by the burning gases from burner 38, heat is transferred through fins 34 and the upper portion of cylinder wall 102 associated with the first compartment or generator section G where the absorptive solution is heated. As the temperature of the absorptive solution in contact with wall 102 in compartment X is heated, the water in the solution begins to vaporize and collect within the confines of compartment X. The temperature of the solution 134 continues to rise and more vapor is given off and eventually the solution reaches a boiling point causing water in solution 134 to be rapidly released as water vapor or steam which continues to collect and pressurize compartment X, the steam begins to move through the aforementioned that the apex of each V-notch extends slightly above the level of solution 134, thereby allowing a very small opening above the level of the solution that communicates with the interior of velocity tube 118.

As the steam pressure builds up in generator compartment X, the steam begins to move through the aforementioned narrow aperture in the apex of the V-shaped notch 120 and moves through the velocity tube 118, in the direction shown by the arrow, into a second compartment or separator compartment Y. As the steam pressure within generator compartment X increases, the velocity of the steam through the narrow aperture into velocity tube 118, as hereinbefore described, correspondingly increases. The velocity of the steam through notch 120 increases until it is sufficient to cause the narrow aperture to become a venturi tube creating sufficient suction to draw minute droplets of solution 134 into the flow of steam through velocity tube 118.

In separator compartment Y, the steam leaving the velocity tube spills downwardly into the compartment where an insignificant portion of the steam is condensed. The steam passes through upper apertures 106 of inner cylinder 104 and moves downwardly through the interior of cylinder 104 as shown by the arrows in FIG. 3. The fine mist or spray of solution 134 that is drawn into separator compartment Y is forced outwardly by the centrifugal forces created by the rotating cylinder 32 against the inner surface 117 of generator cylinder wall 116 along with any condensed water vapor to form an evenly dis-

tributed layer of solution 140 over the entire inner surface 117. The solution 140 is a "strong" lithium bromide solution since an appreciable quantity of distilled water contained in the original solution 134 has been evaporated and the steam has been transferred out of separator cylinder Y.

As will be noted in FIG. 3, the opening 123 of drainage tubes 122 passing through generator plate 114 is immediately adjacent the inner surface 117 of wall 116 in order that the depth of the strong solution 140, as it continues to build up in separator compartment Y, will cover and completely immerse the drain tube opening. Initially in the cycle, when the depth of the strong solution 140 is relatively shallow, and does not completely cover drain tube opening 123, strong solution 140 and a very small quantity of steam will flow downwardly through drain tubes 122 to be laterally distributed by centrifugal force directly into the absorber section A where the strong lithium bromide solution 140 is redeposited into solution 134 along the interior surfaces of wall 102 above ring 110. The small quantity of steam that may initially move through the drain tubes 122 will condense and the water will be redeposited into the absorptive solution 134. When the depth of strong solution 140 in compartment Y becomes deep enough to completely immerse the drain tube opening 123 only a flow of strong solution 140 will move through drainage tube 122 to be redistributed into the absorber section A.

While the above described heating action has been taking place in the generator section G and solution 134 in the form of steam and a fine mist or spray of strong lithium bromide solution is being removed from solution 134 in the vicinity of the velocity tubes 118, the centrifugal and velocity forces acting on solution 134 in the heat exchanger, absorber, evaporator, and the condenser sections are such as to cause solution 134 to flow generally upwardly along the inner surfaces of wall 102 to replace the evaporated water and the strong lithium bromide solution that has been evacuated from solution 134 within generator compartment X. As the strong lithium bromide solution 140 is transferred through drainage tubes 122 into the absorber section A, the absorptive solution above separating ring 110 becomes a strong absorptive solution 136 having a higher concentration of the absorbing medium and lower vapor pressure than the weak absorptive solution 138 below separating ring 110 which has not received strong lithium bromide solution 140. Because of the low vapor pressure of the more concentrated absorptive solution 136 above ring 110 in the absorber section A, higher pressure water vapor from the weaker solution 138 below retaining ring 110 in evaporator section E moves to the absorber section where the water vapor is absorbed causing dilution of the absorptive medium solution 136. However, as more strong lithium bromide solution is continually being returned from separator compartment Y through drainage tubes 122 and is being redeposited in the absorber section A, a constant cycle occurs in which the solution 136 in the absorber section absorbs water vapor from the solution 138 in the evaporator section thereby diluting the solution in the absorber section that flows upwardly toward the generator section G. Solution 136 is a weak lithium bromide solution in contrast to the strong lithium bromide solution 140 being returned from the separator compartment Y.

The steam admitted into cylinder 104 from separator compartment Y through upper apertures 106 travels downwardly through the interior cylinder 104 and past closed centrifugal action valves 124 and through lower apertures 107 into a third compartment or condenser section C where the steam is condensed and distributed against the inner surfaces of cylinder wall 102 between base plate 100 and condenser plate 108. As the evaporation cycle, as hereinbefore described, is accomplished for transferring water vapor from the solution 138 in the evaporator section E into the solution 136 in the absorber section A, condensed water 142 flows upwardly through the annular

space 109 to replenish the supply of solution 138 available in a fourth compartment or evaporator section and further dilutes solution 138, causing a greater vapor pressure differential between solutions 136 and 138. Due to the forces acting upwardly on solution 136 in the fifth compartment or absorber section above separating ring 110, moving upwardly toward the generator section to replace the evaporated water and strong lithium bromide solution withdrawn within generator compartment X, a pressure differential is again established across separating ring 110, causing a flow of liquid from the high pressure evaporator section below ring 110 to move through the pin-sized apertures 144 (see FIG. 11) into the absorber section.

This cycle of evaporation of the water vapor from solution 138 in the evaporator section and the continual drainage or leakage of the solution from the evaporator section into the absorber section through apertures 144 in ring 110, causes a continual flow and cycling of the solutions within cylindrical vessel 32. It can readily be seen, that as absorptive solution 138 leaks through apertures 144 in separating ring 110, as shown in FIG. 11, and distilled condensed water 142 is being deposited along the inner surfaces of walls 102 in the condenser section, the solution 138 in the evaporator section will continue to be diluted until the solution is essentially composed of condensed water with a very small residue of the absorptive medium present.

As the water vapor from solution 138 evaporates from the evaporator section E and is absorbed by the weak solution 136 in the absorber section A, solution 138 will be cooled by the evaporation, and the weak absorptive solution 136 will be heated by the absorption or concentration of the water vapor. The heat gained by weak solution 136 in the absorber section is offset by heat loss through the walls of cylinder 102 to the cooling medium, i.e., movement of the heat rejection fluid about the outer surfaces of cylinder 102 adjacent the absorber section A and the action of the water spray 46 directed on the outer surface of vessel 32 adjacent the absorber section A, as shown in FIGS. 1 and 2. As hereinbefore mentioned, the condensing of the water vapor in the condenser section C is accomplished by cooling the outer surface of cylinder 102 and the outer surface of base plate 100 by the use of a water spray from head 48 as shown in FIGS. 1 and 2. To conserve heat in the absorption cycle, a heat exchanger section H/E is provided in which the hot strong lithium bromide solution, passing through drainage tubes 122, is immersed in the cooler weak solution 136, and preheats the solution 136 as it moves upwardly along the interior surfaces of wall 102 toward the generator section G.

As shown in FIG. 2, the outside air to be cooled is drawn in through intake duct 82 and passed through the filter elements 72 and around the outer surface of cylindrical vessel 32 adjacent the evaporator section E and then discharged through the conditioned air discharge duct 88 for redistribution. The air drawn in through air intake duct 82 will lose heat as it passes over the outer surfaces of cylindrical vessel 32 to the cooled condensed water solution 138 through the walls of cylinder 102. The cooled air passing upwardly through the filter pads 72 will become saturated with moisture, a portion of which is absorbed by the filter pads as the air passes upwardly and is withdrawn and discharged for redistribution through the conditioned air discharge duct 88.

The hereinbefore described absorption refrigerating cycle will be maintained continuously while cylindrical vessel 32 is being rotated at a predetermined rotational velocity and heat is being applied to fins 34 for boiling off the water vapor from weak solution 136 in generator compartment X. The preferred rotational speed for rotating the cylindrical vessel 32 during the cooling cycle has preferably been found to be 1200 to 1800 revolutions per minute obtaining a rotational velocity of 40 f.p.s. or

greater. Other speeds could obviously be utilized with a modified cylindrical vessel structure as long as an appropriate rotational velocity is obtained to completely distribute the absorptive solution 134 over the inner surface of cylinder 32.

Referring now to FIGS. 1, 2 and 3, to accomplish the heating cycle of the air conditioning unit 10, the speed of two-speed motor 22 is reduced to a predetermined lower speed. Upon the reduction of speed by motor 22, the centrifugal clutch 21, of conventional design, disengages from motor shaft 29 and disables heat rejection fan 20. At the same time, as the rotational velocity of cylindrical vessel 32 is reduced, centrifugal action valves 124 within vessel 32 open and allow a substantial portion of the steam within cylinder 104 to be admitted directly into the evaporator section E. In the heating cycle, valve 58 in the outside water line 56 is manipulated to shut off the water spray from heads 46 and 48. As shown, the shutoff valve 58 is manually operated, however, it may be automatically operated when the unit goes into the heating cycle.

With the heat rejection fan 20 disabled and water spray 46 shut off, there is no cooling medium acting on the outer surfaces of the cylindrical vessel 32 adjacent the absorber section A, and the heat gain by the weak solution 136 is not offset by any heat loss through the walls of cylinder 102 as was accomplished in the cooling cycle. Weak solution 136 will continue to absorb heat due to the absorption of water solution 138 and the return of the hot strong solution 140 from the separator compartment Y until the vapor pressure of the heated weak lithium bromide solution 136 is equal to or exceeds the vapor pressure of the condensed water solution 138 and the evaporation cycle ceases. However, the upward fluid flow cycle within cylindrical vessel 32 continues due to the continued boiling away of steam and the removal of solution through velocity tube 118 from the weak solution 136 from the walls of the generator compartment X. When the evaporator cycle ceases the condensed water solution within the evaporator section E is no longer cooled, and there is some heat transfer from the higher temperature, weak lithium bromide solution 136 above separating ring 110 to the condensed water solution 138 through cylinder wall 102 and ring 110. Further, with the opening of centrifugal action valve 124, hot steam is directed from the interior of pipe 104 into the evaporator section E where the steam condenses into hot water and further heats solution 138.

With the cylindrical vessel 32 in its heating cycle, as hereinbefore described, cold air is drawn into air conditioner housing 12 through air intake duct 82 and is passed over the outside surfaces of cylinder wall 102 to gain heat from water solution 138 through cylinder wall 102. The heated air is then discharged through conditioned air discharge duct 88 to be distributed for heating purposes.

It has been found advantageous to use rotational speeds of 900 to 1200 revolutions per minute or rotational velocities of approximately 30 f.p.s. As hereinbefore discussed for the cooling cycle, it may be seen that other combinations of structure and rotational speeds may be employed to achieve the heating cycle hereinbefore described. It may further be seen from the hereinbefore described operation of the cooling and heating cycles that heating and cooling may be automatically obtained by the use of one air conditioning unit utilizing gas to heat the generator of the cylindrical vessel 32 and by the utilization of the same refrigerant and absorptive medium for both cycles. Further, it may be readily seen that an increase in exposed surfaces available for heat exchange with a heating or cooling fluid medium may be effected by the use of radial fins or grooved or fluted surfaces on the exterior or interior of vessel 32.

Referring now to FIGS. 4-9, a series of horizontal cross-sectional views of the cylindrical vessel 32 as seen

in FIGS. 1, 2 and 3, and taken along lines 4—4 through 9—9 of FIG. 3 are shown. In FIG. 4, the horizontal cross-sectional view is looking upwardly into the generator compartment G showing the outer cylinder 102 of cylindrical vessel 32 with attached radial fins 34. Generator cylinder wall 116 is shown concentrically disposed between inner cylinder 104 and the outer cylinder 102. Top plate 100 closes the sealed cylindrical vessel 32 and is fixed to cylinders 102, 104 and 116. Velocity tubes 118 are shown extending through generator compartment X, defined by cylinders 102 and 116, and through cylinder wall 116 to extend into the separator compartment Y, defined by inner cylinder 104 and generator cylinder 116.

FIG. 5 is a horizontal cross-sectional view looking downwardly in the generator compartment G showing the outer cylinder 102 of cylindrical vessel 32 having radial fins 34 attached thereto. Generator cylinder 116 and inner cylinder 104 are concentrically disposed within cylinder 102 to define a generator compartment X and a separator compartment Y. The circular plate 114 dividing the generator and heat exchanger sections is shown providing the bottom floor of generator compartment X and separator compartment Y. Drainage tubes 122 are seen symmetrically disposed in generator plate 114 and immediately adjacent surface 117 of wall 116 for receiving the strong lithium bromide solution 140 (see FIG. 3) for redistribution to the inner surface of cylinder wall 102 in the absorber compartment A (see FIG. 3).

FIG. 6 is a horizontal cross-sectional view looking upwardly in the heat exchanger compartment H/E. Cylinder 102 of cylindrical vessel 32 is shown with fins 34 projecting from its outer surface. Circular plate 114 dividing the generator compartment G and the heat exchanger compartment H/E is shown with a narrow annular space 109 separating it from wall 102. Inner cylinder 104 is shown concentrically disposed within outer cylinder 102 to provide passage for the steam from the separator compartment Y (see FIGS. 3, 4 and 5) as hereinbefore described. Drain tubes 122 are shown as they project downwardly to be redistributed to the absorber compartment A of vessel 32.

FIG. 7 is a horizontal cross-sectional view looking downwardly into the heat exchanger compartment H/E. Outer wall 102 of the cylindrical vessel 32 is shown disposed concentrically around inner cylinder 104. The circular plate 112 which divides the heat exchanger and absorber sections is shown encircling inner cylinder 104 and leaving a narrow annular space 109 between the edge of plate 112 and the inner surface of cylinder 102. Drainage tubes 122 are shown symmetrically disposed about the inner surface of cylinder 102 in the space 109. Plate 112 is suitably notched to accept the outer periphery of each of the drainage tubes 122 for providing longitudinal stability for the tubes and preventing their vibration and movement while cylindrical vessel 32 is rotated.

Referring now to FIG. 8, a horizontal cross-sectional view looking downwardly from the absorber compartment into the evaporator compartment is shown. The outer cylindrical wall 102 of cylindrical vessel 32 is shown concentrically surrounding the inner cylinder 104. Separating ring 110 is shown attached to the inner surface of the outer wall 102 to provide the means of fluid separation between the solutions contained in the absorber and evaporator compartments as hereinbefore described. Circular condenser plate 108 is attached to inner cylinder 104 for separating the condenser compartment from the evaporator and absorber compartments. Pin-size apertures 144, as hereinbefore described in reference to FIGS. 3 and 11, are shown symmetrically distributed about separating ring 110. The lower portion of drainage tubes 122 are shown as are the inwardly flared tips of each drainage tube.

FIG. 9 is a horizontal cross-sectional view looking downwardly from the evaporator compartment towards the condenser compartment showing the outer cylinder wall 102 of vessel 32 concentrically encircling inner cylinder wall 104

to which is attached condenser plate 108. Plate 108 is not coextensive with the interval between cylinders 102 and 104 but its radius is slightly smaller to allow a narrow annular opening 109 between the edge of plate 108 and the inner surfaces of cylinder 102 to permit fluid passage as hereinbefore described in FIG. 3. Disposed in cylinder 104 are two centrifugal action valves 124 which functions have been hereinbefore generally described in FIG. 3.

FIG. 10 is a detailed cross-sectional view of a portion of the generator section of the cylindrical vessel 32 shown in FIGS. 2 and 3. Top circular plate 100 is shown attached to outer cylinder wall 102 to form the closed upper portion of vessel 32. A portion of drive shaft 30 is shown fixed to upper plate 100 for rotating vessel 32. Fins 34 are shown radially projecting from the outer surface of cylinder wall 102 throughout length of the generator section G (see FIGS. 2 and 3). Cylinder walls 104 and 116 are shown disposed within outer cylinder wall 102 for defining generator compartment X and separator compartment Y. A recessed groove 103 is shown that circumferentially extends around the inner surface of wall 102 adjacent its intersection with top circular plate 100. Velocity tube 118 has its notched end 120 inserted into the recess 103 and extends through generator compartment X, pierces cylindrical wall 116 and terminates centrally within separator compartment Y. Velocity tube 118 is disposed longitudinally adjacent top plate 100 and is attached thereto. A ring of apertures 106 are shown symmetrically disposed about inner cylinder or pipe 104. Weak lithium bromide solution 136 is shown distributed over the inner surface of cylinder wall 102 and a strong lithium bromide solution 140 is shown distributed over the inner surface 117 of cylinder 116.

Referring now to FIGS. 1, 2, 3 and 10, as the heat from the gas burner 38 is distributed over the rotating radial fins 34, heat is conducted through the fins and outer cylinder 102 to the weak lithium bromide solution 136. As the weak lithium bromide solution 136 absorbs the conducted heat, the water within the solution begins to vaporize and steam will begin to collect within the confines of generator compartment X. As the weak lithium bromide solution 136 reaches the desired generator temperature, advantageously found to be approximately 220° F., the water from the solution will boil off into steam having a temperature of approximately 120° F. This high temperature steam will continue to collect within the confines of generator compartment X thereby raising the pressure within the compartment. Notched end 120 of velocity tube 118 is designed to provide an extremely small apex triangular aperture 121 that will project above the weak lithium bromide solution 136 distributed over the inner surfaces of cylinder wall 102. Aperture 121 provides a relief valve for the pressurized steam within generator compartment X, and a small quantity of the steam will begin to leak through aperture 121 and the interior of the velocity tube 118 into the separator compartment Y. As hereinbefore described, as the steam pressure within generator compartment X increases, the velocity of the steam moving through aperture 121 and velocity tube 118 increases until the steam reaches a velocity that will cause the aperture 121 to act as a venturi tube lowering the pressure above the surface of the weak lithium bromide solution 136 trapped within velocity tube 118 and sucking the solution within the notched end 120 into the flow of steam to be carried into separator compartment Y.

In separator compartment Y, the fine mist or spray of solution particles will be thrown outwardly against the surface 117 of generator wall 116 by centrifugal force and be distributed uniformly as hereinbefore described in FIG. 3. The steam entering separator compartment Y passes through apertures 106 and inner cylinder 104 and moves downwardly through inner cylinder 104 to the condenser section C as hereinbefore described in FIG. 3.

The recessed groove 103 is provided to allow a more even distribution of the weak lithium bromide solution over the upper portion of the inner surfaces of cylinder 102 within the generator compartment X. Without recessed groove 103, and with the steam removing a steady flow of the lithium bromide solution 136 through velocity tube 118, there would be an unequal upward flow of solution 136 resulting in an unequal distribution of the solution in the generator compartment X in the vicinity of tube 118. Such an uneven flow would cause the distributed solution to become thinner in areas adjacent top plate 100 and directly lateral the velocity tube 118, allowing "hot spots" to occur in which the temperature of the solution 136 and the walls 102 would greatly exceed the desired optimum operating temperature and allow overheating of the extreme upper portion of cylinder 102 which can cause a weakening of the weld or braze that secures wall 102 to circular top plate 100.

Referring now to FIG. 12, a detailed cross-sectional view of the centrifugal valve 124 is shown. Valve 124, as may be seen in FIGS. 3 and 9, provides a means of communication between inner cylinder or pipe 104 and the evaporator section E within cylindrical vessel 32. Valve 124 is comprised of a cylindrical valve seat member 128 disposed in the wall of inner cylinder 104 and projecting into the evaporator section E and is shown suitably welded or brazed at 125. Valve seat member 128 has a flanged end 131 extending into the evaporator section and into which a cylindrical sleeve 129 is attached. The open end of valve seat member 128, projecting into the interior of inner cylinder 104, has a seating surface 133. Valve plunger 126 has a circular head with seating surfaces 130 and is slidably disposed within sleeve 129. Valve plunger 126 has apertures 127 in its side walls that are exposed above sleeve 129 and interconnect the interior of cylinder 104 with the evaporator when the valve is open and plunger 126 is fully extended into cylinder 104. Valve plunger 126 has a flanged rim 105 about the end extending into the evaporator section for stopping the inward movement of plunger 126 against the outer edge of sleeve 129. Plunger spring 132 encircles valve plunger 126 and valve sleeve 129 with its opposite ends contacting the inside flat surface of valve plunger seat 130 and the interior surface of valve seat member flange 131 to provide a spring resistance urging plunger 126 with attached seat 130 inwardly toward the center of steam cylinder 104. Spring 132 has a spring rate that exerts a preselected force for thereby urging the valve plunger 126 in its inward extended position urging centrifugal valve 124 open when cylindrical vessel 132 is rotating at a velocity equal to or below the desired rotational velocity during the heating cycle. However, when the desired rotational velocity of cylindrical vessel 32 is achieved during the cooling cycle, the centrifugal forces acting on the mass of the valve plunger 126 and the valve seat 130 will overcome the spring bias of spring 132, thereby forcing spring plunger 126 to slide outwardly through sleeve 129 toward outer wall 102 (see FIGS. 3 and 9) and causing valve seating surfaces 130 to mate with seating member surfaces 133 to close valve 124.

Referring now to FIGS. 3, 9 and 12, centrifugal valve 124 will, in its open position during the heating cycle, allow the steam traveling downwardly through inner cylinder 104 to enter between seating surfaces 130 and 133 and pass through apertures 127 and through the interior of the cylindrical plunger 126 directly into the evaporator section E of the cylindrical vessel 32. In the cooling cycle, when the increased rotational velocity of cylindrical vessel 32 has caused valve 124 to close, the steam traveling downwardly through the inner cylinder 104 will be prevented from entering through valve 124 into the evaporator section E and will enter the condenser section C in the bottom of vessel 32 through

ports 107 of cylinder 104 as hereinbefore described.

Referring now to FIGS. 13 and 14, a partial vertical cross-sectional view of another embodiment of the cylindrical vessel is shown utilizing two-stage generator, absorber and evaporator compartments or sections. In FIG. 13, cylindrical vessel 232 is shown having projecting fins 234 radially extending about a portion of its upper cylindrical wall 302, which portion is adjacently opposite first stage generator compartment G'. Vessel 232 is closed at the top of outer cylinder wall 302 by means of a top circular plate 300 and is fitted with rotatable and support drive shafts 230 and 296, respectively. Concentrically within outer cylinder 302 is disposed an inner cylinder or pipe 304 that acts as a steam passage cylinder in the same manner as cylinder 104 in the first embodiment. A top plate 317 is disposed between inner cylinder 304 and outer cylinder 302 and is coextensive therebetween for closing off a narrow cylindrical space 343 from the remainder of vessel 232. Radially disposed adjacent cylinder wall 304 are a series of apertures 319 symmetrically distributed in plate 317 for reasons to be hereinafter described. Another circular plate 312 is spaced from plate 317 and attached to inner cylinder 304 leaving a small annular space between the outer edge of flange 345 and the inner surface of cylinder wall 302 to permit fluid flow of the absorptive solution as hereinbefore described for the first embodiment. The interval between plates 317 and 312 defines the generator compartment of this embodiment.

A circular plate 315 having a flanged outer rim 313 and an axial opening to accommodate cylinder 304 is fixed intermediate plates 312 and 317 with the outer flanged rim turned downwardly. Circular plate 314 is welded to the outer rim 313 of plate 315 and centrally to cylinder 304 to form a narrow cylindrical compartment 347. The closely spaced parallel plates 314 and 315 also mark the division between the first and second stages G' and G'', respectively, of the generator section. As mentioned above in describing plate 312, there is a narrow annular space or gap between the outer face of rim 313 and the inner surface of cylinder wall 302.

A cylinder 316 is concentrically spaced intermediate cylinders 302 and 304 and between top plate 317 and plate 315 to divide the cavity between plates 315 and 317 into two concentric compartments X and Y, the first-stage generator compartment and the separator compartment, respectively. The velocity tube 318, the function of which is identical to velocity tube 118 hereinbefore described for the previous embodiment, extends through cylindrical wall 316 and provides communication between generator compartment X and separator compartment Y. Velocity tube 318 has a slanted end 320, the pointed tip of which is spaced from the inner surface of wall 302. The other end of velocity tube 318 terminates centrally within separator compartment Y.

A cylindrical wall 346 is disposed intermediate outer cylinder 302 and inner cylinder 304 between circular plates 312 and 314 to divide the cylindrical area between plates 312 and 314 into two compartments similar to compartments X and Y just described. Another cylinder 348 is disposed intermediate outer cylinder 302 and cylindrical wall 346 between plates 312 and 314 to define two concentric cylindrical compartments X' and X''. The three compartments defined by cylindrical walls 302, 348, 346 and 304, and plates 312 and 314 are shown as Y', X' and X'' reading from the innermost compartment outwardly to the outermost compartment. Compartment Y' is the second-stage generator compartment as hereinafter described. Compartment X' is a steam heating compartment for providing heat for the second-stage generator compartment Y'.

A J-shaped tube 335 is shown disposed through circular plates 314 and 315 to provide communication between the first-stage separator compartment Y and the steam heating compartment X'. Tube 335 extends upwardly into separator compartment Y and has an outwardly bent end 337 projecting toward wall 316 for reasons to be here-

inafter described. The other end of tube 335 terminates in wall 346 of compartment X'. Tubing sections 322, spaced at regular intervals radially about compartment X', interconnect the outermost portion of narrow compartment 347 between discs 314 and 315 with tubing sections 323 interconnected to the bottom of wall 346 to provide communication between narrow cylindrical space 347 and the interior of the second stage generator compartment Y'. Apertures 349 radially disposed in plate 315 and immediately adjacent the generator compartment Y' surface of cylinder wall 316 provide a series of openings connecting the separator compartment Y with the narrow space 347 between plates 315 and 314. Apertures 349, narrow space 347 between discs 314 and 315, tubing sections 322 and 323 provide direct communication between the separator compartment Y and the bottom of the second-stage generator compartment Y'.

An S-shaped tubing 352 has one end extending upwardly into the second-stage generator compartment Y', immediately adjacent wall 346, and passes downwardly through plate 312 and bends outwardly and then downwardly to parallel closely to the inner surface of outer wall 302. Drainage tube 350 has one end immediately adjacent to the steam heating compartment X' side of wall 348 and extends downwardly through plate 312 directly through the absorber compartment A of cylindrical vessel 232. A spacer member 354 is attached to the inner surface of outer cylinder wall 302 and is attached to drainage tubes 350 and 352 to provide rigid support for the tubes and prevent vibration and movement while vessel 232 is being rotated.

Referring now to FIG. 14, the lower half of the second embodiment of the cylindrical vessel 232 is shown. Inner cylinder or pipe 304 is shown concentrically and axially disposed within outer cylinder wall 302. A circular base plate 300 is suitably attached to the lower end of cylinders 304 and 302 to apply a base closure means for vessel 232 as previously described in the first embodiment for base plate 100. A support shaft 296 is fixed to the outer surface of plate 300 to provide a means of supporting the cylindrical vessel 232 during rotation. Disposed adjacent base plate 300, but spaced above and parallel thereto is a circular plate 308 attached to cylinder 304. The outer rim of plate 308 is spaced from the inner surface of outer cylinder 302 to provide a narrow annular space 309 around the outer periphery of plate 308 and provides a means for passage of condensed water as hereinbefore described in the previous embodiment. A ring of apertures 307 are disposed symmetrically about inner cylinder 302 between base plate 300 and the condenser plate 308 to provide communication between the interior of inner cylinder 304 and the condenser compartment C.

Referring now to FIGS. 13 and 14, two circular plates 358 and 360 are disposed within cylindrical vessel 232 intermediate circular plates 308 and 312 and are spaced apart as shown in FIG. 14 defining compartments V and V'. Circular plates 358 and 360 are secured to inner cylinder 304 by means of integral structural webs 364 that have alternate openings 362, as shown in FIG. 15, a partial horizontal cross-sectional view of the cylinder taken along lines 15-15 of FIG. 14. A cylinder 356 is spaced intermediate inner cylinder 304 and outer cylinder 302 and attached to plates 358 and 360 around the outer periphery of openings 362, shown in FIGS. 14 and 15, to define two concentric cylindrical compartments, W and Z-Z'. The openings 362 between adjacent ribs 364 that are integral to rings 358 and 360 provide a means of communication between compartments V and V'.

A separating ring 310 is disposed circumferentially about the inner surface of outer wall 302 to provide a means of separating the distilled water and lithium bromide solution as previously described in the prior embodiment. It may be seen that ring 310 divides compartment Z-Z' into two compartments Z and Z'. It will be noted that plates 358 and 360 are not attached to the inner sur-

face of wall 302 but are spaced closely thereto for providing a narrow annular space for the passage of the absorptive solution during the operation of the cylindrical vessel 232 as previously described for the first embodiment.

Drainage tube 352 extends downwardly through plate 358 into the absorber section A and terminates in an inwardly flared tip 359 adjacent the top of separating ring 310. Drainage tube 350 extends downwardly through plate 358 past separating ring 310 and terminates in an inwardly flared tip 359 below plate 360 in the evaporator compartment E between plates 360 and 308.

As described for the previous embodiment, cylindrical vessel 232 contains a predetermined quantity of an absorptive solution composed of a suitable refrigerant, namely, distilled water, and an absorbing medium, namely, lithium bromide. As hereinbefore described, when cylinder 232 is rotated at a desired rotational velocity the absorptive solution will be distributed evenly over the inner surfaces of outer cylinder wall 302 by passing through the narrow annular aperture around the rim of plates 308 and 360 until the upward flow of the solution is stopped by the separating ring 310. However, as hereinbefore described in connection with separating ring 110 in the first embodiment, and referring again to FIG. 11, separating ring 310 has a series of pin-sized apertures 144 disposed radially about the ring and intermediate the inner and outer edges of the ring. These pin-sized apertures 144 provide a means of fluid communication through ring 310 to allow the absorptive solution, being forced upwardly by the centrifugal forces created by the rotational velocity of vessel 232, to be distributed evenly and completely over the entire inner surface of cylinder 302 between circular base plate 300 and the top generator plate 317.

Referring now to FIGS. 1, 2, 13, 14 and 15, as projecting fins 234 are heated by the action of the burning gas from burner 38, the heat is conducted through fins 234 and wall 302 and is transmitted to the absorptive solution distributed along the inner surface of wall 302 in the generator section. As hereinbefore described for the previous embodiment, as the absorptive solution is heated, the water from the solution is boiled off as steam within the first stage generator compartment X. It will be noted, by referring to FIG. 13, that the slanted end 320 of velocity tube 318 has its projecting tip immersed below the surface level of the absorptive fluid but the opposite side of the slanted end extends slightly above the surface of the absorptive solution to provide an extremely small aperture 321 communicating through the interior of tube 318 to compartment Y.

As previously described for the embodiment of the velocity tube 118 described in FIGS. 3 and 10, as the steam pressure within the first-stage generator compartment X increases the steam will begin to move through the very small exposed aperture 321 into the interior of velocity tube 318 to be directed into the separator compartment Y. As the pressure within compartment X continues to rise, the flow of steam through the narrow aperture 321 will continue to increase in velocity creating a venturi tube effect identical to that previously described for velocity tube 118 shown in FIG. 10. The high velocity steam will carry with it a fine spray or mist of absorptive solution droplets from which a high proportion of the distilled water content has been vaporized in the form of steam. The steam and the fine spray of absorptive solution is injected into the separator compartment Y where the particles of the solution, acted upon by the centrifugal forces created by the rotating vessel 323, are distributed evenly over the surface of cylindrical wall 316. The injected steam travels downwardly through compartment Y and begins to flow through steam tube 335 where it is transferred into the interior of the steam heating compartment X'. A small volume of steam injected into compartment Y through velocity tube 318 moves through aperture 319 in plate 317 into the narrow cylindrical space

343. The steam heats circular top plate 300 and the corner joint between plate 300 and outer cylinder wall 302 and provides a "washing" action by the condensed steam that helps to prevent corrosion by the highly corrosive lithium bromide and provides sufficient cooling to protect the weld at the joint of wall 302 and top plate 300.

The strong lithium bromide solution 340 is distributed over cylinder wall 316 within the separator compartment Y and flows downwardly over wall 316 and through aperture 349 into the narrow compartment 347 where it is forced outwardly by centrifugal force to be distributed over the inner surface of flange 313 of plate 315. The strong lithium bromide solution then flows downwardly through tube 322 into tubing member 323 and into the bottom of the second-stage generator compartment Y'. The strong lithium bromide solution then flows upwardly along the surface of cylindrical wall 346 until it is uniformly distributed over the entire wall surface. As previously mentioned, steam from the separator compartment Y is directed into the steam heating compartment X' where its heat is conducted through cylinder wall 346 and transferred to the strong lithium bromide solution distributed over the inner surface of wall 346. This heating of the solution causes more of the water present in the strong lithium bromide solution to be boiled off as steam in compartment Y' leaving a very strong lithium bromide solution 341 distributed over the inner surfaces of wall 346 in second-stage generator compartment Y'. The outwardly bent end 337 of tube 335 prevents the entry of liquid particles since the entry end of tube 335 is facing radially outwardly and the particles will be forced past the opening in the end of tube 335 against the wall 316.

The steam vaporized from solution 341 within compartment Y' moves through apertures 306 into inner cylinder 304 and flows downwardly to be distributed into the condenser section C as will be hereinafter described. The remaining hot, very strong lithium bromide solution 341 flows into the open end of tube 352 and drains downwardly into the heat exchanger and absorber sections where some of its heat is exchanged to the "cooler" upward flowing weak lithium bromide solution 336. The steam that is released into the interior of the steam heating compartment X' condenses as its heat is transferred through cylinder wall 346 to the strong lithium bromide solution as hereinbefore described. The condensed steam is distributed as a layer of water 338 over the inner surface of cylinder wall 348. Condensed water 338 flows downwardly along wall 348 and into drainage tubes 350 to be distributed into the evaporator section E.

Referring now to FIGS. 13 and 14, the downwardly flowing very strong lithium bromide solution 341 from the second-stage generator compartment Y' is redistributed against the inner surface of cylindrical wall 302 in compartment Z' above separating rings 310 to recirculate the absorptive medium. The condensed water 338 from the steam heating compartment X' flows downwardly through drainage tube 350 and is distributed below separating ring 310 in the compartment V where it is redistributed over the inner surface of wall 302.

The steam generated in the second-stage generator compartment Y' that is traveling downwardly through the interior of cylinder 304 will flow through apertures 307 of cylinder 304 into condenser section C to be condensed and distributed over the inner surface of wall 302. The addition of condensed water in the condenser compartment causes an upward flow of the condensed water 342 through the annular opening 309 between plate 308 and the interior of wall 302 upwardly into the evaporator section E. As previously described in the first embodiment, steam may also pass directly into evaporator compartment E through centrifugal valve 324 when the cylindrical vessel 232 is being rotated at a slower predetermined rotational velocity during the heating cycle, but will not flow through valve 324 when vessel 232 is being rotated during the cooling cycle.

In FIG. 14, a two stage absorption cycle is shown in which water vapor from the first-stage evaporator compartment V between plates 360 and 308, passes through the "open" cylindrical compartment W, between plates 360 and 358, to be absorbed in the first-stage absorber compartment V' between plates 358 and 312 (see FIG. 13). Absorption also takes place in the closed compartment Z' as the water vapor from the second-stage evaporator compartment Z between separating ring 310 and plate 360 communicates with and is absorbed by the absorbing medium present in the solution in the second-stage absorber compartment Z' above ring 310 and below plate 358. It may be seen that a two-stage absorption has hereby been accomplished.

Referring now to FIGS. 1, 2, 13 and 14, as hereinbefore described burner 38 will be located adjacent the generator portion of vessel 232 having projecting fins 234 for transferring heat through the fins 234 to solution 336 within the first-stage generator compartment X. Water from spray head 46 and the air flow provided by the heat rejection fan 20 would be directed around the outer surface of cylinder 302 of vessel 232 adjacent the absorber sections between plate 312 and separating ring 310 and water from condenser spray head 48 would be directed over the outer surface of cylinder wall 302 directly adjacent the condenser section C at the base of the cylinder 232.

The warm air to be conditioned during the cooling cycle would flow over the outer surfaces of cylinder 302 adjacent the first-stage evaporator compartment V to heat the condensed water 338 and causing vaporization. The water vapor then passes through cylindrical compartment W to be absorbed by the lithium bromide solution in the first-stage absorber compartment V'. The warm air flowing over the outer surfaces of the cylinder wall 302 will lose heat due to the transfer of heat through cylinder wall 302 to the cool condensed water solution 338 in evaporator compartment V. The cooled air is then recirculated and reapplied (not shown in FIGS. 1 and 2) over the outer surface of wall 302 in the area adjacent the second-stage evaporator compartment Z between separating ring 310 and plate 360. Although cooled, the air applied adjacent the second-stage evaporator compartment Z will provide sufficient heat by conduction through cylinder wall 320 to cause vaporization of a portion of the condensed water 338 in compartment Z because of the low pressure within the sealed cylindrical vessel 232. The water vapor in compartment Z will then be absorbed within the second-stage absorber compartment Z' above ring 310 and below plate 358 by the absorbing medium in solution 336. The lithium bromide solution 336 is diluted within the first and second-stage absorber compartments V' and Z', respectively. This diluted or weak lithium bromide solution will flow upwardly through the absorber sections and the second-stage generator section into the first-stage generator compartment G' where it will again be heated, the water boiled off as steam, and the strong lithium bromide solution carried along with the high-velocity steam through velocity tube 318 into the separator compartment Y, as hereinbefore described, to continue the absorption cycle.

By utilizing the dual staging of the generator, evaporator and absorber sections, as herein described in FIGS. 13, 14 and 15, an approximate 40 percent savings in operating costs can be effected. Such savings are possible since the dual staging of the generator section will require no additional consumption of fuel, and the reapplication of the air to be conditioned against the outer surface of cylindrical vessel 232 to accomplish dual-staged evaporation and absorption will accomplish greater cooling of a given volume of air, thereby increasing the efficiency of the evaporation and absorption cycles.

Referring to FIGS. 1, 2, 13 and 14, during the heating cycle fan 20 will be disconnected and water sprays 46 and 48 will be shut off as hereinbefore described for



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the first embodiment. As previously described, the fluid solution flow will continue within cylindrical vessel 232 although the evaporation-absorption cycle ceases. The condensed water solution 338 in the evaporator section E will gain heat to be transferred through wall 302 to outside cold air drawn in through intake duct 82. Centrifugal action valve 324 will open at the slower rotational velocity of vessel 232 during the heating cycle and admit hot steam directly into first-stage evaporator compartment V to further increase the heating of water 338. In the heating cycle, the cold air drawn in through duct 82 would flow over the outer surface of cylinder 302 adjacent the first stage evaporator compartment V and be discharged through duct 88 for distribution. Appropriate conventional damping means could be utilized to prohibit the recirculation of the conditioned air over the second stage evaporator compartment Z as was hereinbefore described for the cooling cycle since dual-staging is not necessary in the heating cycle.

It may additionally be seen that the invention disclosed herein particularly lends itself to "thin-film" fluid techniques. The efficiency of the absorptive air conditioning apparatus may be significantly increased by the use of thin-film distribution of the absorptive solution within the rotating vessel. A savings in operating costs may be effected since the generator efficiency will be increased due to the reduced fuel and heating requirement for boiling the solution. Similar increases in efficiency will be obtained in utilizing thin-film absorption and evaporation techniques.

Numerous variations and modifications may obviously be made in the structure herein described without departing from the scope of the present invention. Accordingly, it should be clearly understood that the forms of the invention described herein and shown in the figures in the accompanying drawings are illustrative only and are not intended to limit the scope of the invention.

What is claimed is:

1. In an air conditioning system employing absorption refrigerating and steam heating cycles, the combination comprising:

a vessel symmetrically disposed about an axis of rotation and having a plurality of axially disposed compartments, said vessel containing a fluid refrigerant and an absorbing medium in solution,

means for continuously rotating said vessel and establishing sufficient centrifugal and velocity forces for distributing said solution over the inner walls of said vessel and providing motive power for moving said solution between said axially disposed compartments,

means for continuously heating said solution within a first axial compartment of said rotating vessel for boiling said solution and expelling said refrigerant in a vapor state from said solution during the refrigerating and steam heating cycles,

means for transferring said expelled refrigerant vapor and a portion of said remaining solution from said first compartment,

a second compartment radially disposed within and immediately adjacent said first compartment and having vapor and fluid communication therewith for receiving said expelled refrigerant vapor and said portion of said solution,

a third compartment in vapor communication with said second compartment for receiving said expelled refrigerant vapor from said second compartment and condensing said vapor to a liquid state,

a fourth compartment in fluid communication with said third compartment for receiving said condensed refrigerant during the refrigerating cycle, said fourth compartment adapted for direct vapor communication with said second compartment during the heating cycle for receiving a substantial portion of said refrigerant vapor,

a fifth compartment in fluid communication with said second compartment for receiving said portion of

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said solution admitted to said second compartment, said fifth compartment further being in vapor communication with said fourth compartment for allowing absorption of said evaporated refrigerant into said solution, and

means interconnecting said first and fifth compartments for returning said solution from said fifth compartment to said first compartment.

2. The system as described in claim 1, wherein said system further includes:

means for directing a cooling medium against the outer surface of said vessel adjacent said fifth compartment for effecting heat transfer from said solution during the refrigerating cycle,

means for directing a cooling medium onto the outer surface of said vessel adjacent said third compartment for effecting heat transfer from said refrigerant vapor to cause the condensation of said vapor during the refrigerating cycle, and

means for causing heat transfer between the air to be conditioned and the fourth compartment of said rotating vessel during the refrigeration and heating cycles.

3. The system as described in claim 2, wherein said means for transferring heat from the air to be conditioned to said solution in said rotating vessel includes:

a plurality of filter elements encircling said vessel immediately adjacent the fourth compartment of said vessel and disposed the length of said fourth compartment in parallel spaced-apart relationship, and

means for directing the air to be conditioned through said filter elements and around the outer surface of said fourth compartment of said vessel to cause a transfer of heat from the air to said solution in said fourth compartment during the refrigerating cycle and to cause a transfer of heat from said solution in said fourth compartment to the air during the heating cycle.

4. The system as described in claim 3, wherein said means for transferring heat from the air to be conditioned to said solution in said rotating vessel further includes:

a first spray head spaced adjacent said vessel for directing a continuous spray of water onto the surface of said vessel immediately adjacent said fifth compartment,

a plurality of filter elements encircling said vessel and spray head and disposed the length of said fifth compartment in a parallel spaced-apart relationship, said filter elements receiving and absorbing a substantial portion of said water thrown from the surface of said rotating cylindrical vessel,

means for drawing air through said filter elements for cooling said air and directing said cooled air around the outer surface of said vessel adjacent said fifth compartment for aiding said water spray in effecting heat transfer from the solution within said fifth compartment,

a second spray head spaced adjacent said vessel for directing a continuous spray of water onto said vessel immediately adjacent said third compartment for cooling and condensing refrigerant vapor introduced into said third compartment.

5. The system as described in claim 1, wherein said third and fourth compartments and said first and fifth compartments are separated by spaced parallel plates disposed axially within said vessel and said fluid communication between said sections is accomplished by the circulation of said solution along the inner wall of said vessel through a narrow annular space between the outer rim of said plates and the inner surface of said vessel.

6. The system as described in claim 5, wherein said portion of said solution admitted to said second compartment is distributed evenly over the radially disposed walls of said second compartment by said centrifugal and velocity forces, and said fluid communication between said second and fifth compartments is accomplished by

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a plurality of drainage tubes each having one end adjacent one edge of said wall of said second compartment and extending downwardly closely adjacent the cylindrical wall of said vessel and terminating within said fifth compartment.

7. The system as described in claim 1, wherein said means for transferring said expelled refrigerant vapor and said portion of said solution from said first compartment to said second compartment comprises:

a plurality of velocity tubes disposed radially within said vessel and communicating between said first and second compartments, one end of each of said tubes projecting into said first compartment and being spaced closely adjacent the outer wall of said vessel and immersed in said absorptive solution disposed thereon,

said one end of each of said tubes having a plurality of V-shaped notches disposed about its outer edge with the apex of each notch spaced slightly above the level of said immersing solution for providing an aperture to allow said refrigerant vapor within the generator to escape through the interior of said tube into said second compartment, the velocity of said vapor escaping through said tube causing a venturi effect and withdrawing droplets of said remaining solution immediately adjacent said aperture to be carried into said second compartment with said vapor.

8. The system as described in claim 7, including a pipe axially disposed through said vessel and communicating with said second, third and fourth compartments for transferring said refrigerant vapor expelled from said first compartment to said third and fourth compartments.

9. The system as described in claim 8, including valve means for admitting a substantial portion of said expelled refrigerant vapor into said fourth compartment during the heating cycle and blocking the flow of said expelled refrigerant vapor into said fourth compartment during the refrigerating cycle.

10. The system as described in claim 9, wherein said valve means comprises

a plurality of centrifugally actuated valves disposed in the wall of said pipe carrying said refrigerant vapor from said second compartment to said fourth compartment, said valves being actuated to a closed position during the refrigerating cycle when said vessel is driven at a first rotational velocity and actuated to an open position during the heating cycle when said vessel is driven at a second rotational velocity.

11. The system as described in claim 1, including: heat exchanging means for preheating said solution returned to said first compartment from said fifth compartment.

12. The system as described in claim 11, wherein said heat exchanging means includes a plurality of drainage tubes each interconnecting said second and fifth compartments and closely spaced adjacent the wall of said vessel between said first and fifth compartments, said drainage tubes carrying said solution from said second compartment to said fifth compartment and immersed in said solution flowing from said fifth compartment to said first compartment for effecting heat transfer from said solution flowing in said drainage tube to said solution flowing between said fifth and first compartments.

13. The system as described in claim 1 wherein said means for providing heat to said rotating vessel comprises a series of radially projecting fins encircling the outer walls of a portion of said vessel adjacent said first compartment for providing a maximum heat transfer surface, and

a heat source longitudinally disposed adjacent said finned portion and directing heat against said surfaces as said vessel rotates for maximum heat transfer through said fins and said vessel wall to said first compartment.

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14. In an air conditioning system employing absorption refrigerating and steam heating cycles, the combination comprising:

a vessel symmetrically disposed about an axis of rotation and containing a fluid refrigerant and an absorbing medium in solution, said vessel having a plurality of axially disposed compartments including:

a generator compartment for boiling said solution to expel said refrigerant in a vapor state during the refrigerating and heating cycles,

means for transferring said expelled refrigerant vapor and a portion of said strong solution from said generator compartment,

a separator compartment disposed concentrically within and immediately adjacent said generator compartment and having vapor and fluid communication therewith for receiving said expelled refrigerant vapor and portion of said strong solution for separation,

a condenser compartment in vapor communication with said separator compartment for receiving and condensing said expelled refrigerant vapor to a liquid state,

an evaporator compartment in fluid communication with said condenser compartment for receiving said condensed refrigerant and permitting evaporation of said refrigerant during the refrigerating cycle, said evaporator compartment adapted for vapor communication with said separator compartment during the heating cycle for admitting a substantial portion of said refrigerant vapor directly into said evaporator,

an absorber compartment in fluid communication with said separator compartment for receiving said strong solution, said absorber further being in vapor communication with said evaporator for absorbing said evaporated refrigerant into said solution and providing a weak solution to be returned to said generator compartment during the refrigerating cycle,

a heat exchanger compartment in fluid communication with said absorber and generator compartments for preheating said weak solution as it passes from said absorber compartment to said generator compartment,

said condenser and evaporator compartments and said absorber and generator compartments being separated by spaced parallel plates disposed axial within said vessel, said plates having a narrow annular space between their outer rim and inner surface of said vessel,

means for continuously rotating said vessel and establishing sufficient centrifugal and velocity forces for distributing said solution over the inner walls of said vessel and communicating said solution between said compartment by flow through said narrow annular space between the outer rim of said plates and the inner surface of said vessel,

means for continuously heating said solution within said generator compartment of said rotating vessel for boiling said solution and expelling said refrigerant vapor during the refrigerating and steam heating cycles,

means for directing a cooling medium against the outer surface of said vessel adjacent said absorber compartment for effecting heat transfer from said solution within said absorber during the refrigerating cycle,

means for directing a cooling medium onto the outer surface of said vessel adjacent said condenser compartment for effecting heat transfer from said refrigerant vapor to cause the condensation of said vapor during the refrigerating cycle, and means for causing heat transfer between the air to

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be conditioned and the evaporator compartment of said rotating vessel during the refrigeration and heating cycles.

15. In an air conditioning system, employing absorption refrigerating and steam heating cycles, the combination comprising:

a vessel symmetrically disposed about an axis of rotation and having a plurality of axially disposed compartments, said vessel containing a fluid refrigerant and an absorbing medium in solution,

means for continuously rotating said vessel and establishing sufficient centrifugal and velocity forces for distributing said solution over the inner walls of said vessel and providing motive power for moving said solution between said axially disposed compartments,

external means for continuously heating said solution within a first generator compartment of said vessel for boiling said solution to expel a substantial portion of said refrigerant in a vapor state leaving a strong solution of absorbing medium and some absorbed refrigerant,

a separator compartment concentrically disposed within and immediately adjacent said first generator compartment and having vapor and fluid communication therewith,

means for transferring said expelled refrigerant vapor and a portion of said strong solution from said generator compartment to said separator compartment for separation,

a second generator compartment for receiving said strong solution from said separator compartment and further heating said solution to expel an additional quantity of said refrigerant in a vapor state,

a heating chamber disposed concentrically about said second generator compartment for receiving said expelled refrigerant vapor from said separator and heating said strong solution in said second generator compartment, said vapor condensing within said heating chamber as liquid refrigerant,

a condenser compartment in vapor communication with said second generator compartment for receiving and condensing said additional expelled refrigerant to a liquid state,

a first evaporator compartment in fluid communication with said heating chamber and said condenser compartment for receiving said condensed refrigerants therefrom,

a second evaporator compartment in fluid communication with said first evaporator compartment for receiving condensed refrigerant therefrom,

a first absorber compartment in fluid communication with said second generator for receiving said strong solution, said first absorber compartment further being in vapor communication with said second evaporator for allowing a first quantity of said expelled refrigerant vapor to be absorbed into said solution,

a second absorber compartment in fluid communication with said first absorber compartment and having vapor communication with said first evaporator compartment for allowing a second quantity of said refrigerant vapor to be absorbed into said solution for providing a weak solution to be returned to said first generator compartment,

means interconnecting said second absorber and first generator compartments for returning said weak solution from said second compartment to said first generator compartment.

16. The system as described in claim 15, wherein said system further includes:

means for directing a cooling medium against the outer surface of said vessel adjacent said absorber compartments for effecting heat transfer from said solution during the refrigerating cycle,

means for directing a cooling medium onto the outer surface of said vessel adjacent said condenser com-

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partment for effecting heat transfer from said refrigerant vapor to cause the condensation of said vapor during the refrigerating cycle, and

means for causing heat transfer between the air to be conditioned and said evaporator compartments of said rotating vessel during the refrigeration and heating cycles.

17. The system as described in claim 16, wherein said means for causing heat transfer includes:

a plurality of filter elements encircling said vessel and disposed the length of said first and second evaporator compartments in a parallel spaced-apart relationship, and

means for directing air to be conditioned through said filter elements and around the outer surfaces of said vessel adjacent said first evaporator compartment to cause a first transfer of heat from said air to said solution within said first evaporator compartment and redirecting the air around the outer surfaces of said vessel adjacent said second evaporator compartment to cause a second transfer of heat from said air to said solution within said second evaporator compartment during the refrigeration cycle.

18. The system as described in claim 17, wherein said heat transfer means directs the air to be conditioned through said filter elements and around the outer surfaces of said vessel adjacent said first and second evaporator compartments to cause a transfer of heat from said condensed refrigerant within said first and second evaporator compartments to the air during the heating cycle.

19. The system as described in claim 17, wherein said heat transfer means further includes:

a spray head spaced adjacent said vessel for directing a continuous spray of water onto the surface of said vessel immediately adjacent said first and second absorber compartments during the refrigeration cycle,

a plurality of filter elements encircling said cylindrical vessel and said spray head and disposed the length of said first and second absorber compartments in a parallel spaced-apart relationship for receiving and absorbing a substantial portion of said water thrown from the surface of said rotating vessel, and

means for drawing air through said filter elements for cooling said air and directing said cooled air around the outer surfaces of said vessel adjacent said first and second absorber compartments for aiding said water spray in effecting a heat transfer from the solution within said first and second absorber compartments during the refrigeration cycle.

20. The system as described in claim 19, wherein said heat transfer means further includes a spray head spaced immediately adjacent said condenser compartment of said vessel for directing a continuous spray of cooling water onto the outer surface of said condenser compartment for condensing said refrigerant vapor to a liquid state within said condenser compartment during the refrigeration cycle.

21. The system as described in claim 15, wherein said system further includes:

a heat exchanger in fluid communication with said second absorber and first generator compartments for preheating said weak solution prior to entry into said first generator by the transfer of heat from said strong solution.

22. The system as described in claim 21, including: a plurality of first drainage tubes each having one end communicating with the interior of said heating chamber and the other end communicating with said first evaporator compartment for transferring said condensed refrigerant from said heating chamber to said first evaporator compartment, and

a plurality of second drainage tubes each having one end communicating with the interior of said second generator compartment and the other end communi-

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cating with said second absorber compartment for transferring said remaining strong solution from said second generator compartment to said second absorber compartment.

23. The system as described in claim 22, wherein said means for transferring said expelled refrigerant vapor and said strong solution from said first generator compartment to said separator compartment comprises:

a plurality of velocity tubes disposed radially within said vessel and communicating between said first generator and separator compartments, one end of each of said tubes projecting into said generator and being spaced closely adjacent the outer wall of said vessel and immersed in said absorptive solution disposed thereon,

said one end of each of said tubes having a plurality of V-shaped notches disposed about its outer edge with the apex of each notch spaced slightly above the level of said immersing solution for providing an aperture to allow said refrigerant vapor within the generator to escape through the interior of said tube into said separator compartment, the velocity of said vapor causing a venturi effect and withdrawing droplets of said strong solution immediately adjacent said aperture to be carried into said separator compartment with said vapor.

24. The system as described in claim 22, wherein said heat exchanger compartment includes said drainage tubes carrying said strong solution and communicating between said second generator and second absorber compartments, said tubes axially passing through said heat exchanger compartment and spaced closely adjacent the wall of said vessel and immersed in said weak solution flowing to said first generator compartment for effecting heat transfer from said strong solution to said weak solution.

25. The system as described in claim 15, wherein said system further includes:

valve means communicating with said second generator and said first evaporator for admitting a substantial portion of said refrigerant vapor from said second generator directly into said first evaporator during the heating cycle.

26. The system as described in claim 25, including a pipe axially disposed through said vessel and communicating with said second generator, first evaporator and condenser compartments for transferring said refrigerant vapor expelled from said second generator compartment to said first evaporator and condenser compartments.

27. The system as described in claim 26, including said valve means cooperating with said axially disposed pipe for admitting a substantial portion of said expelled refrigerant vapor into said first evaporator compartment

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during the heating cycle and blocking the flow of said expelled refrigerant vapor into said first evaporator compartment during the refrigerating cycle.

28. The system as described in claim 27, wherein said valve means comprises:

a plurality of centrifugally actuated valves disposed in the wall of said pipe carrying said refrigerant vapor from said second generator compartment adjacent said first evaporator compartment, said valves being actuated to a closed position during the refrigerating cycle when said vessel is driven at a first rotational velocity and actuated to an open position during the heating cycle when said vessel is driven at a second rotational velocity.

29. The system as described in claim 15, wherein said condenser and evaporator sections and said absorber and generator sections are separated by a plurality of axially disposed spaced parallel plates within said vessel and said fluid communication between said sections is accomplished by the circulation of said solution along the inner walls of said vessel through a narrow annular space between the outer rim of said plates and the inner walls of said vessel.

30. The system as described in claim 15, wherein said external means for applying heat to said rotating vessel comprises:

a radially projecting ribbon of heat conducting material affixed to and encircling the outer walls of said vessel in a closely spaced relationship adjacent said first generator compartment, and

a heat source longitudinally disposed adjacent said radially projecting surfaces and directing heat against said surfaces as the vessel rotates for maximum heat transfer through said projecting surfaces and the walls of said vessel to said first generator compartment.

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UNITED STATES PATENT OFFICE  
CERTIFICATE OF CORRECTION

Patent No. 3,605,436

Dated September 20, 1971

Inventor(s) Oscar Elbridge Gammill, Jr.

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

- Column 5, line 27; after "end" insert -- of --.
- Column 9, line 47 should read -- ment X. The notches 120 of velocity tube 118 are so dis- --.
- Column 14, line 37; after "cylinder" insert -- wall --.
- Column 19, line 64; "distribtued" should be -- distributed --;
- line 68; "upuwardly" should be -- upwardly --.
- Column 22, line 40; "rotatig" should be -- rotating --.
- Column 23, line 52; "comparament" should be -- compartment --.
- Column 24, line 49; "axial" should be -- axially --.
- Column 26, line 41; "relationship" should be -- relationship --.
- Column 27, line 49; "evapoartor" should be -- evaporator --.

Signed and sealed this 21st day of March 1972.

(SEAL)

Attest: \_\_\_\_\_

EDWARD M. FLETCHER, Jr.  
Attesting Officer

ROBERT GOTTSCHALK  
Commissioner of Patents