CENTRIFUGAL ABSORPTION AIR CONDITIONER

Original Filed March 6, 1968 6 Sheets-Sheet 1

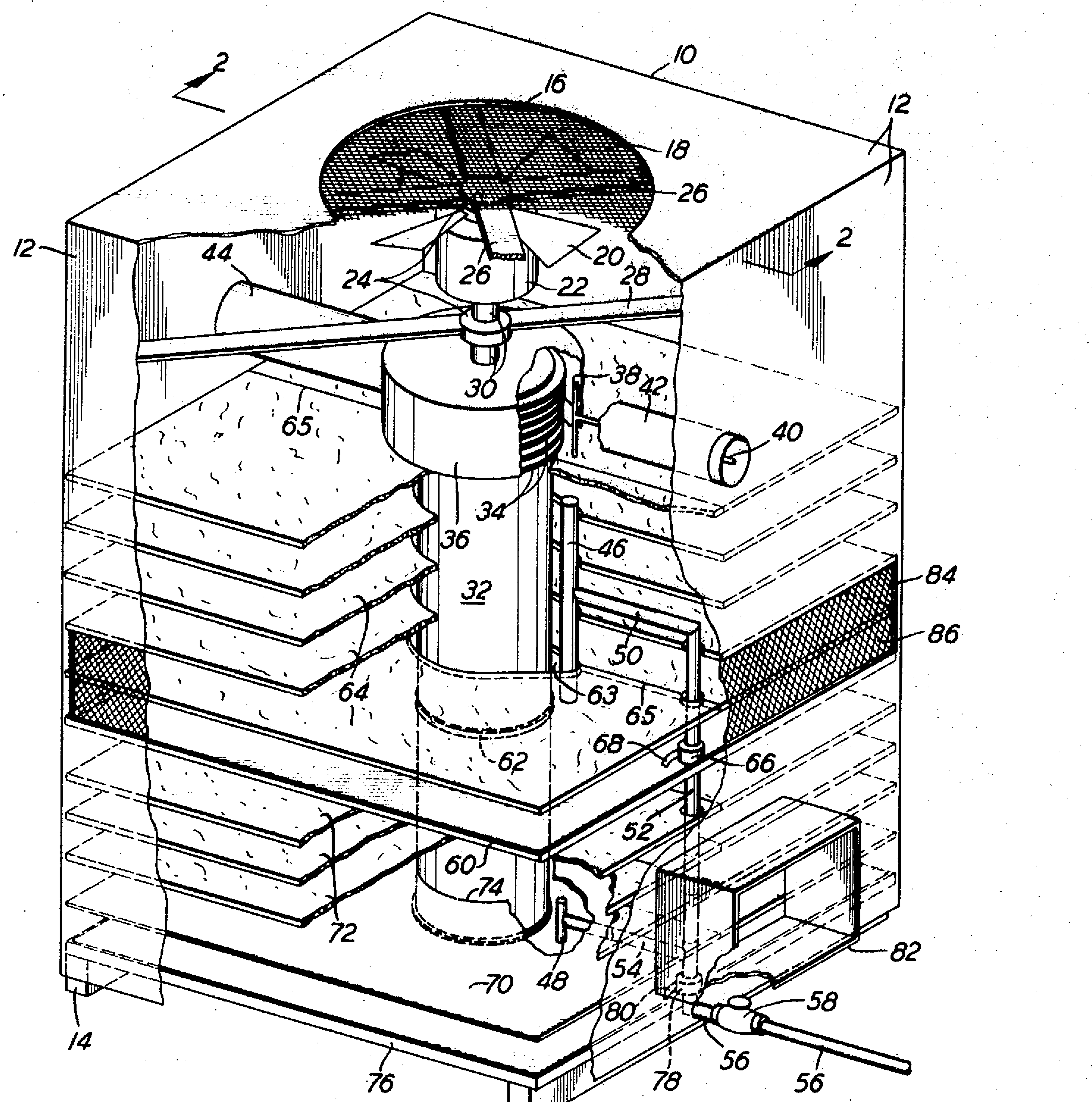


FIG.1

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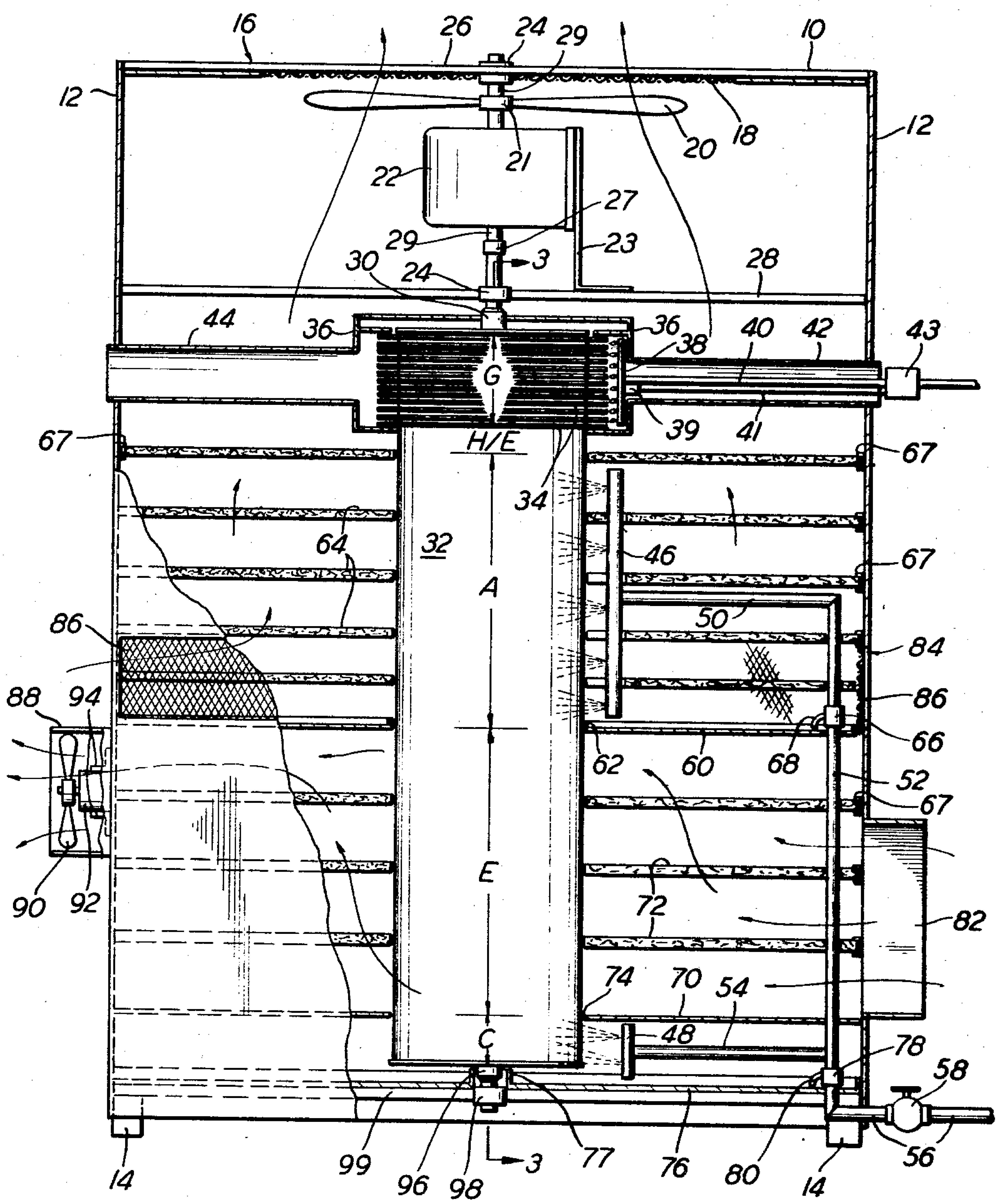


FIG. 2

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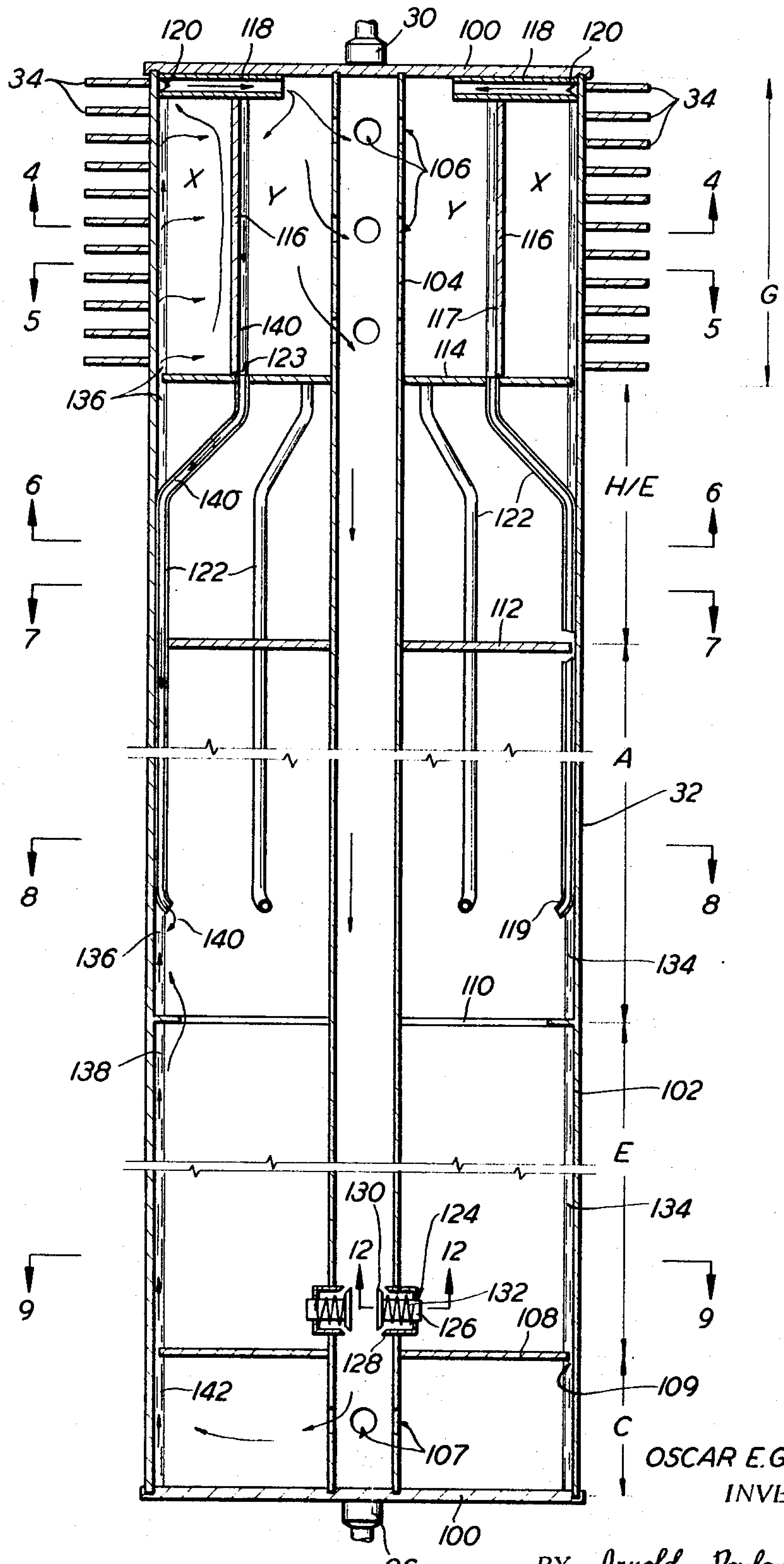


FIG. 3

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**Sept. 20, 1971** O. E. GAMMILL, JR **3,605,436**

CENTRIFUGAL ABSORPTION AIR CONDITIONER

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FIG. 4

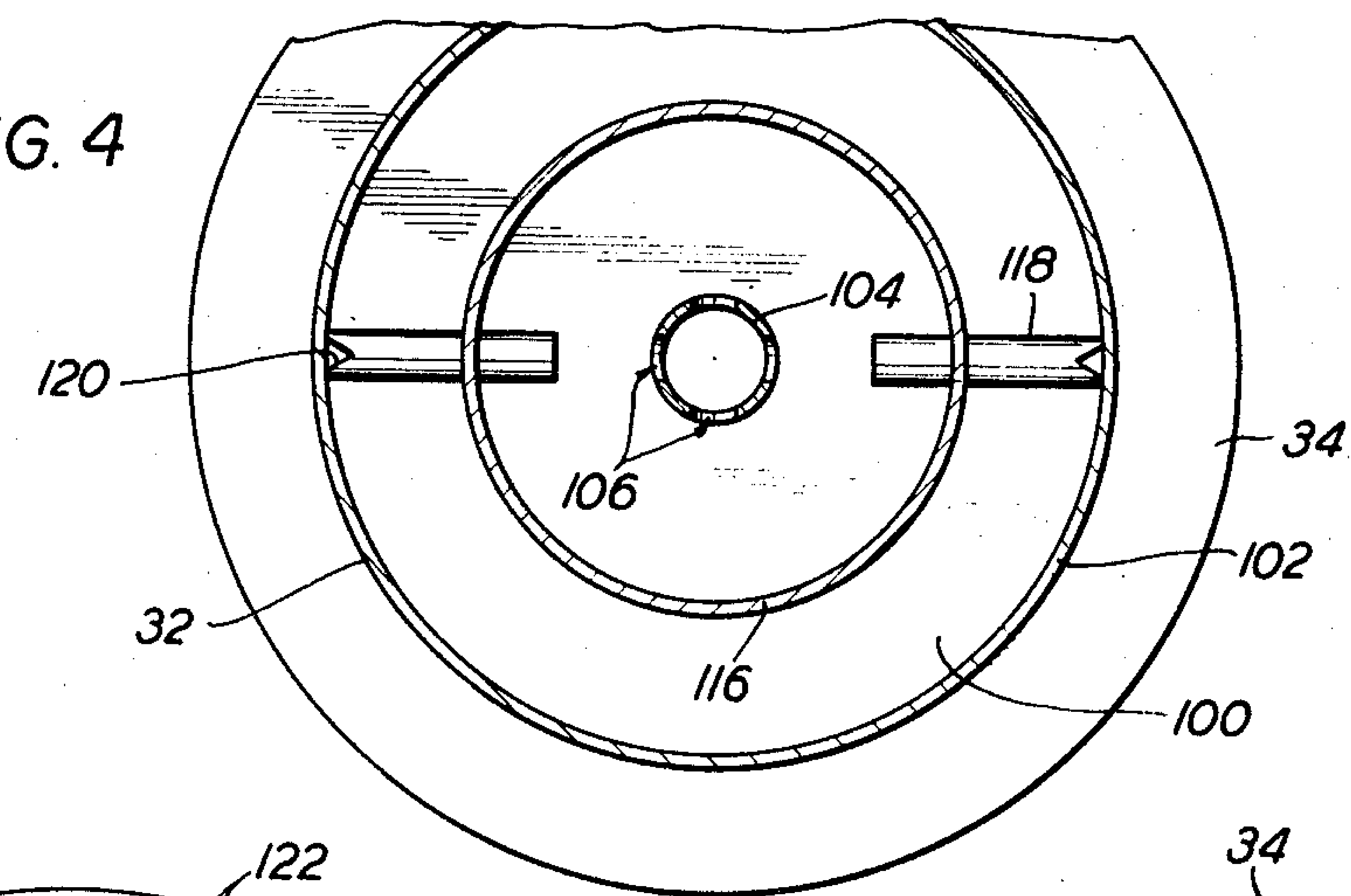



FIG. 5

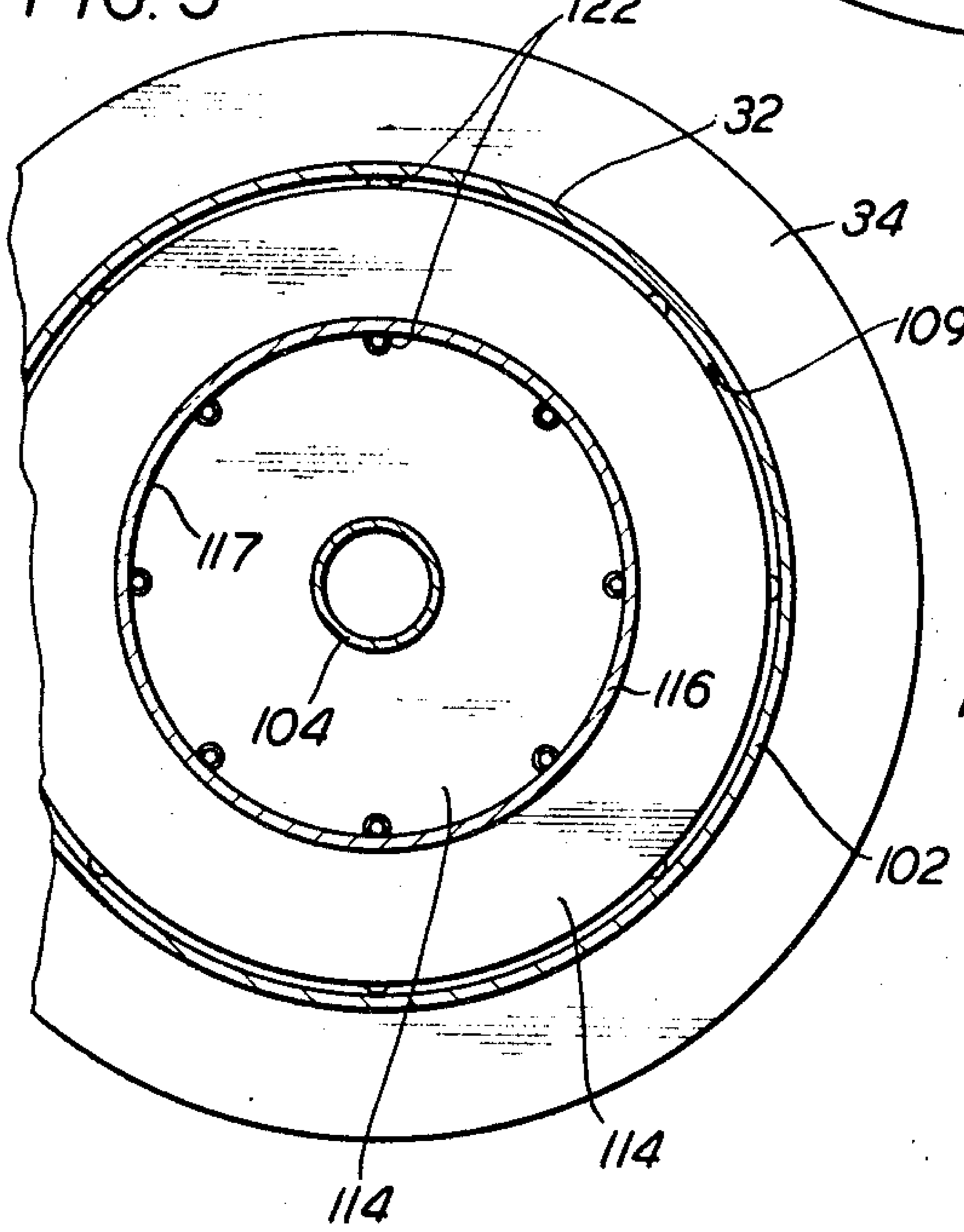



FIG. 6

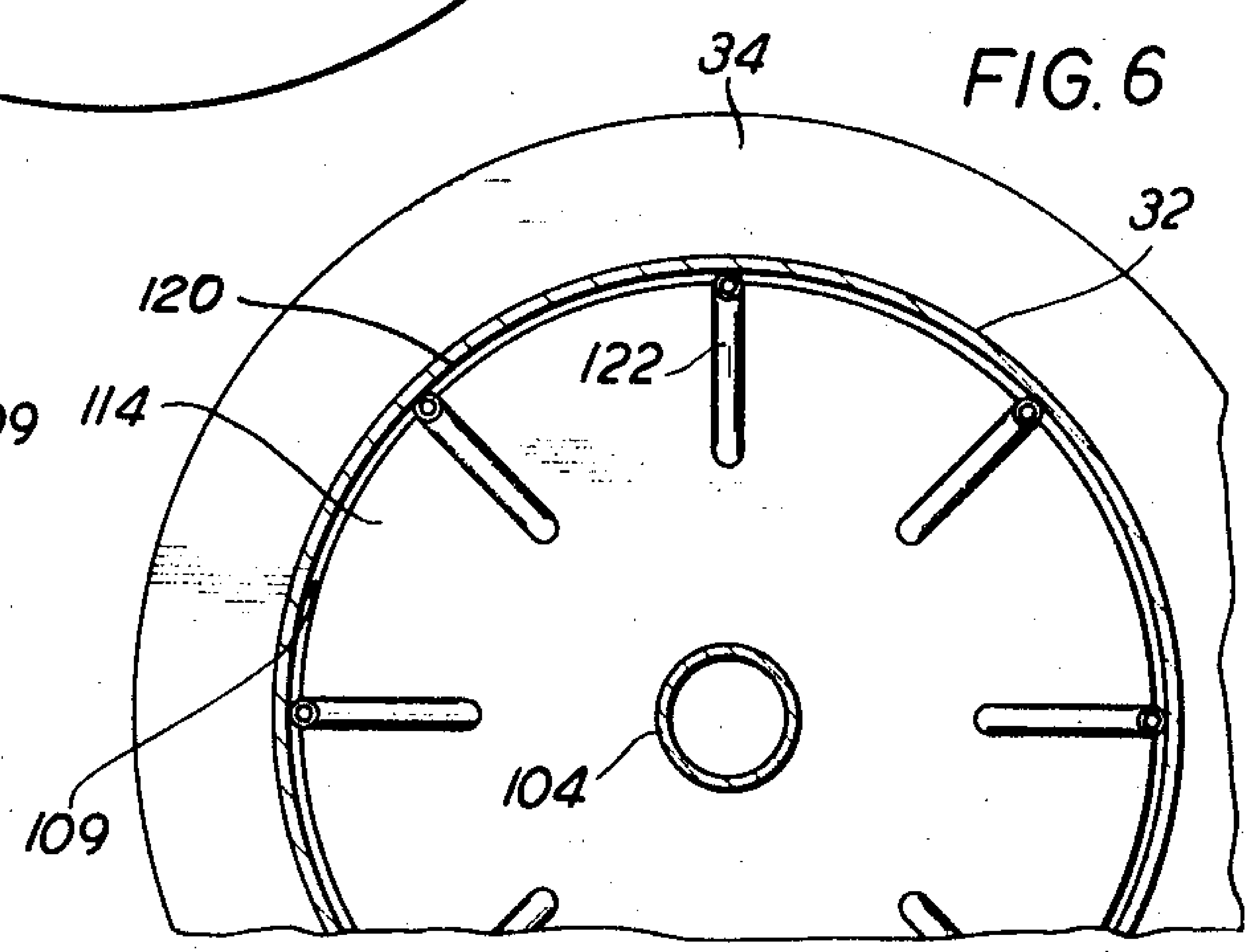
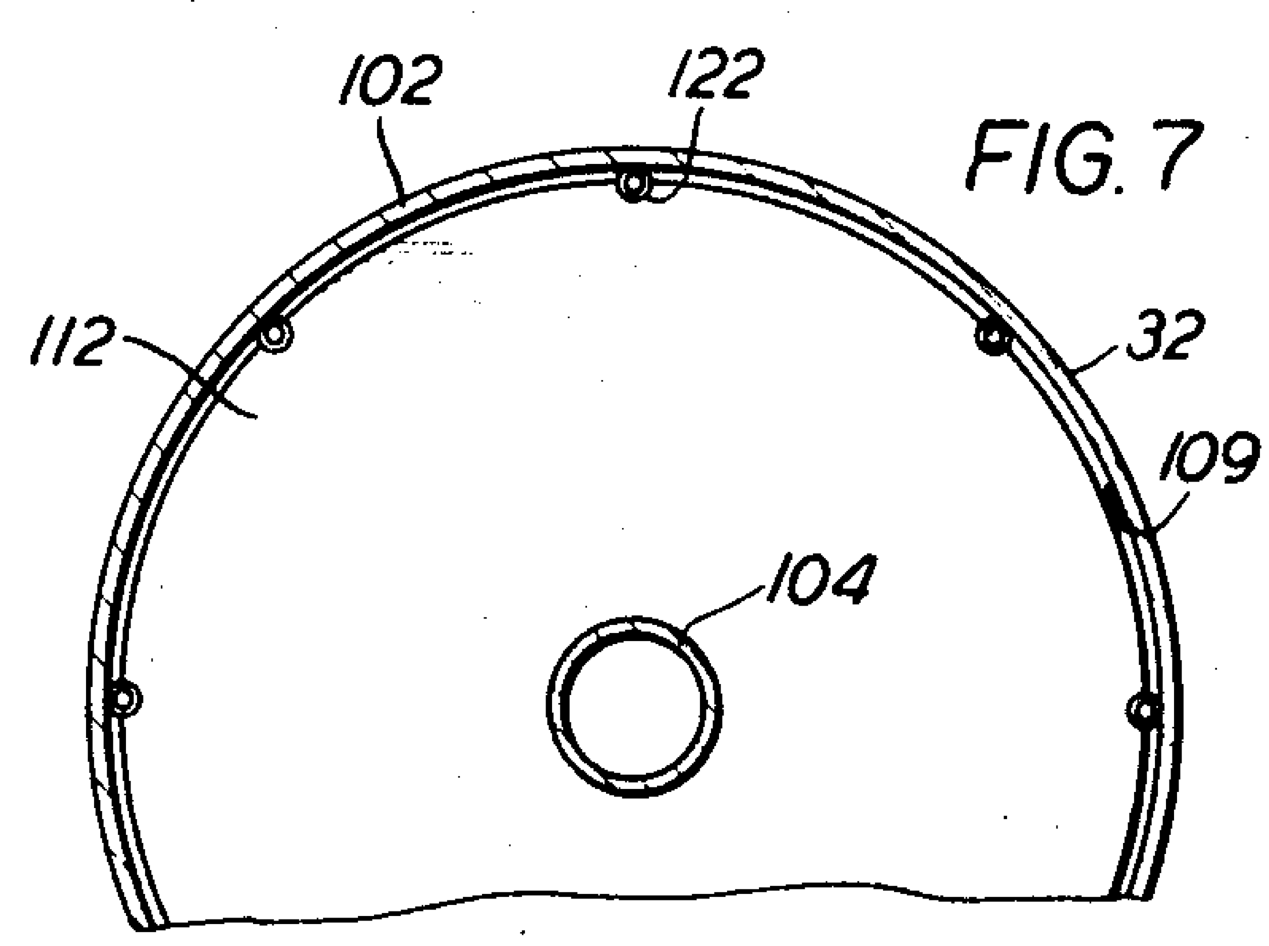



FIG. 7



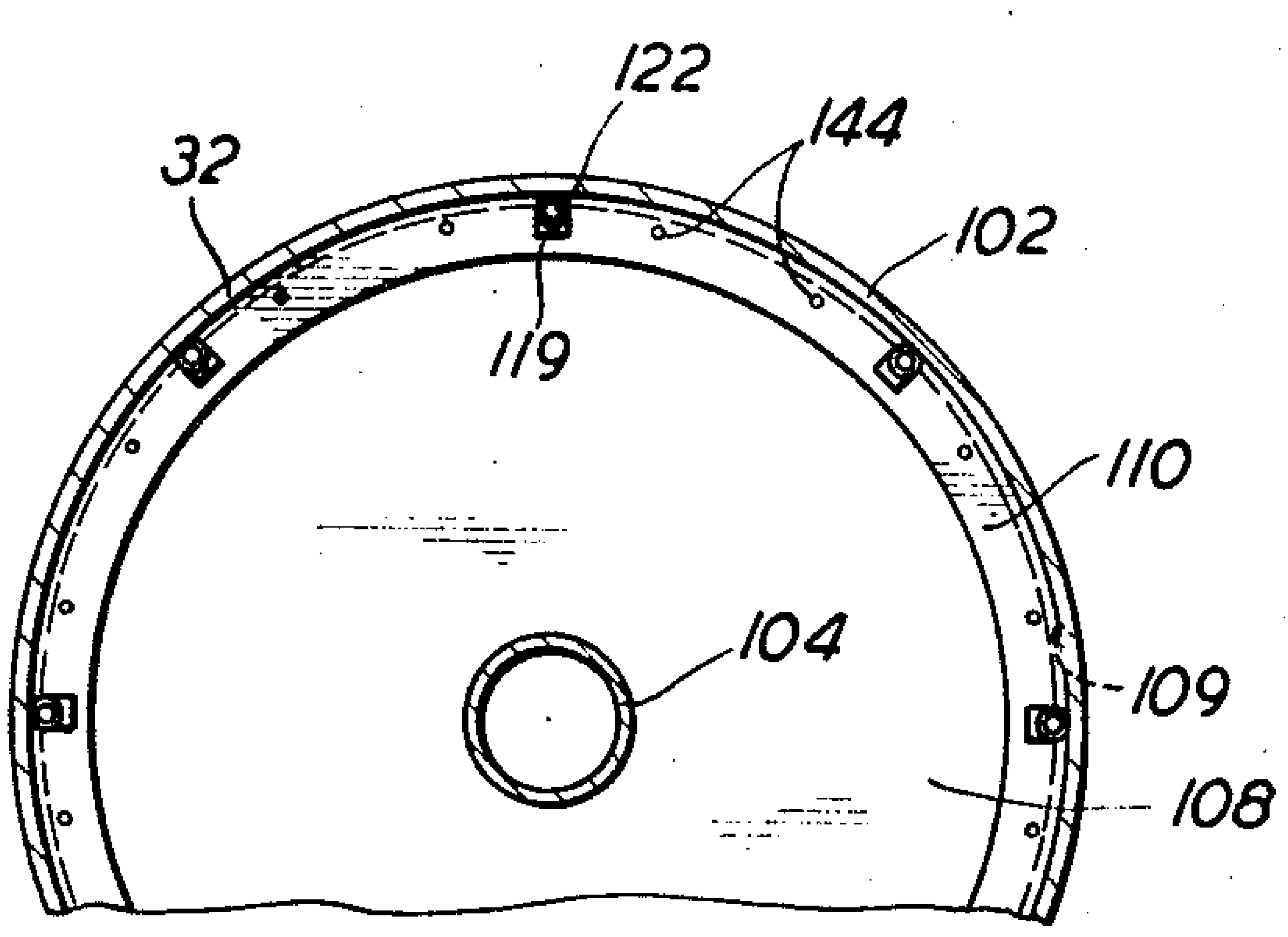




FIG. 8

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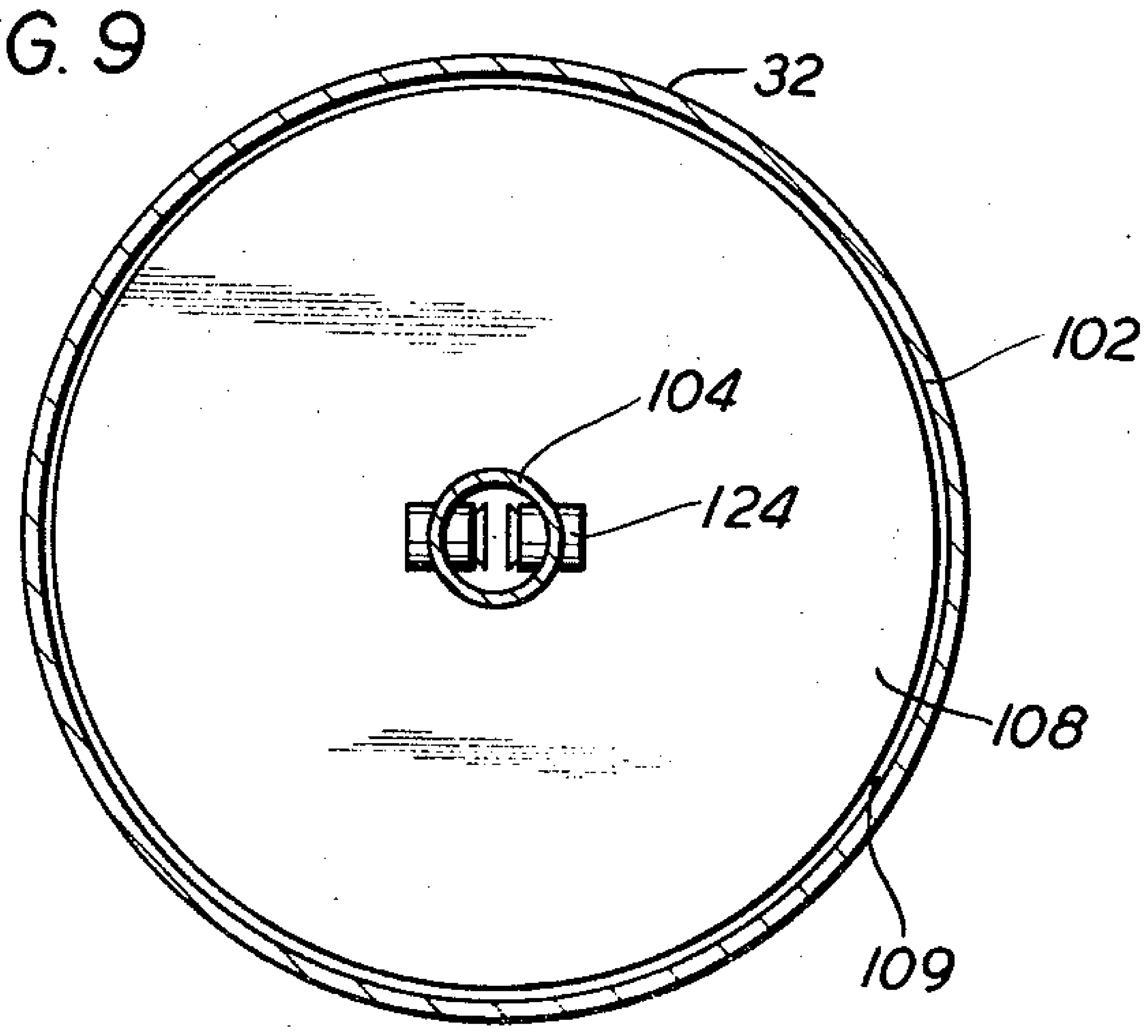
FIG. 9



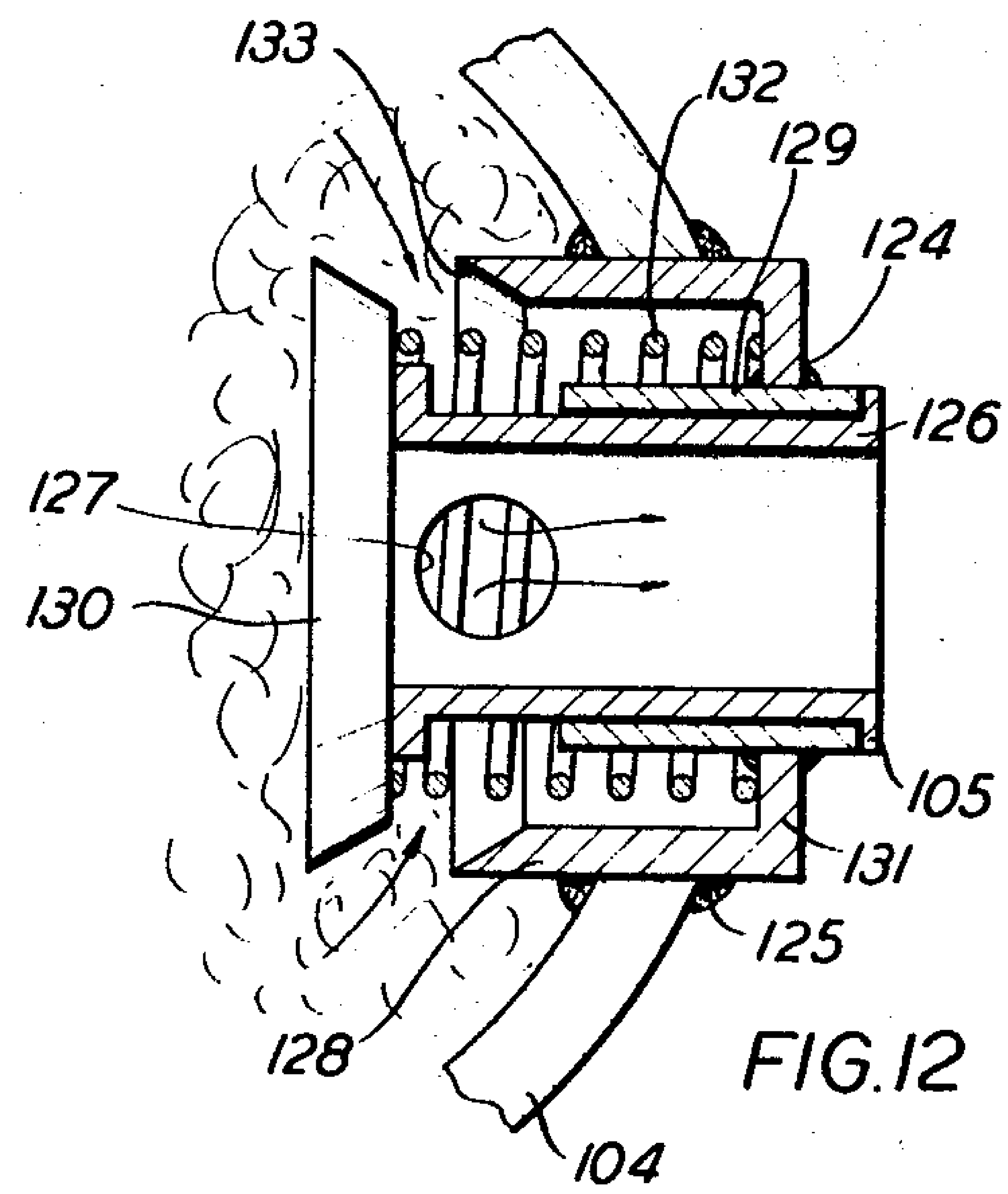




FIG. 12

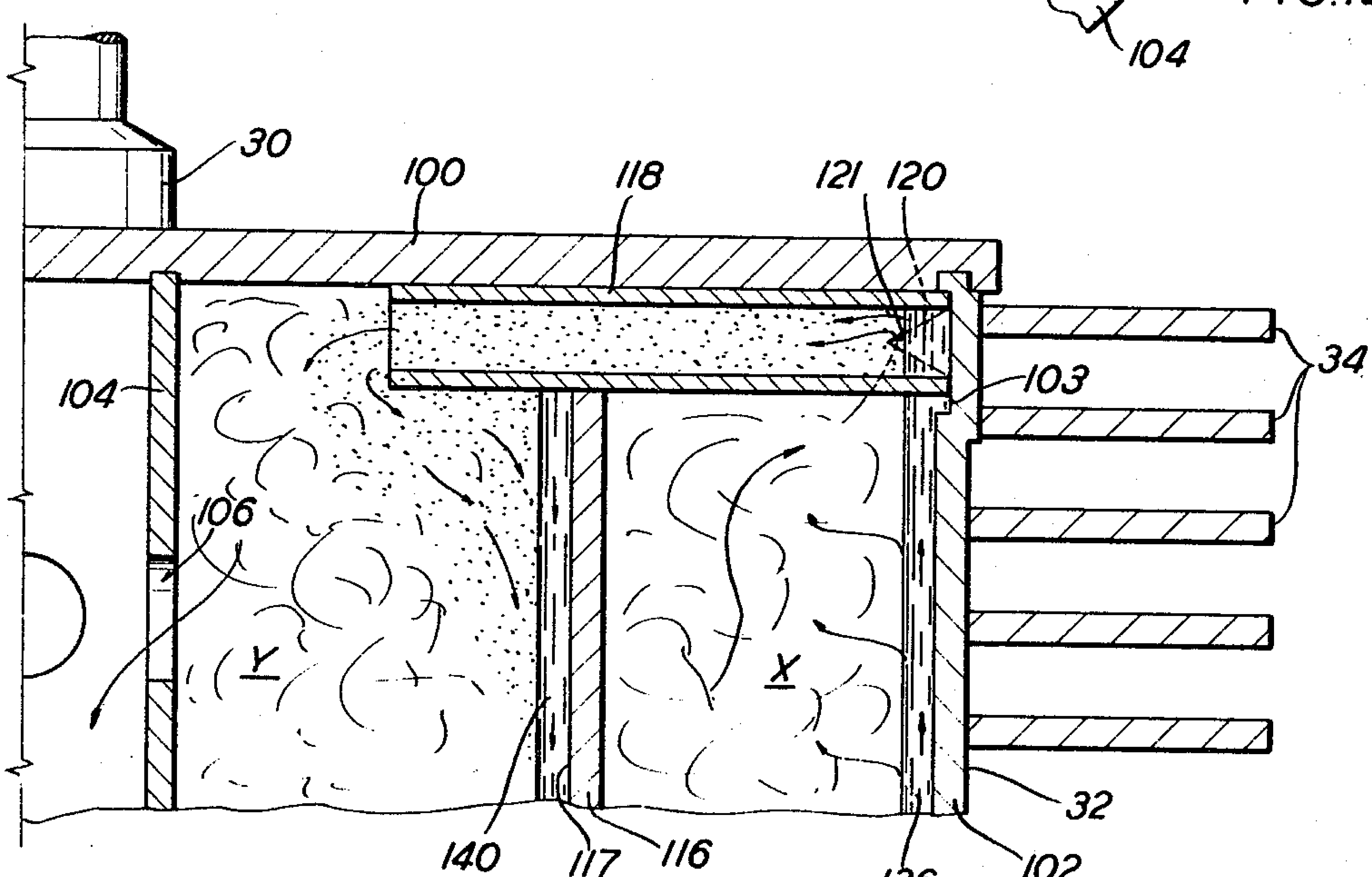
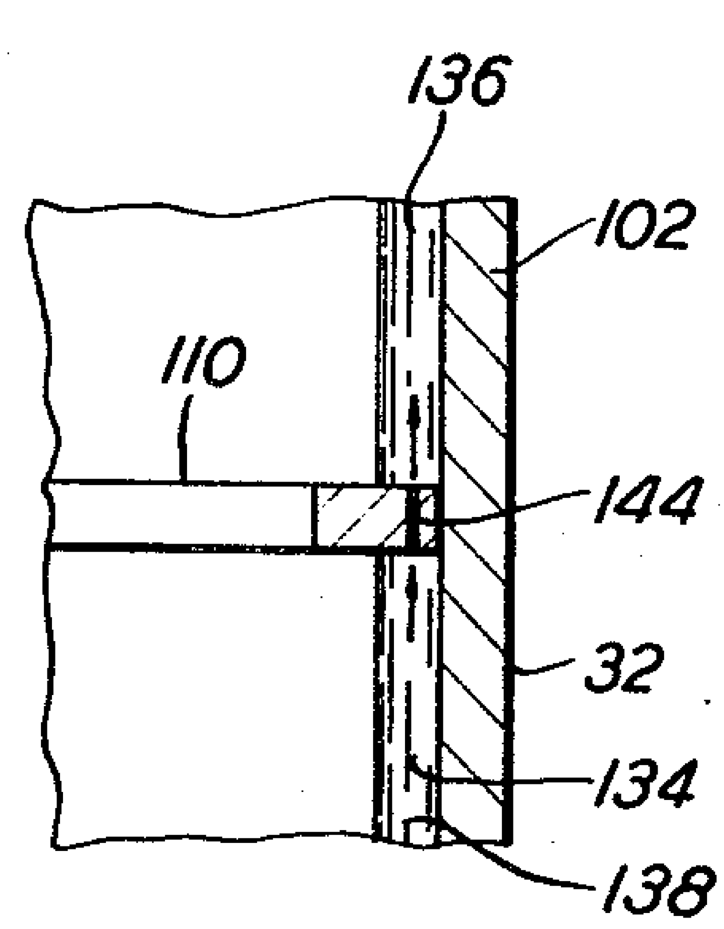



FIG. 10

FIG. 11

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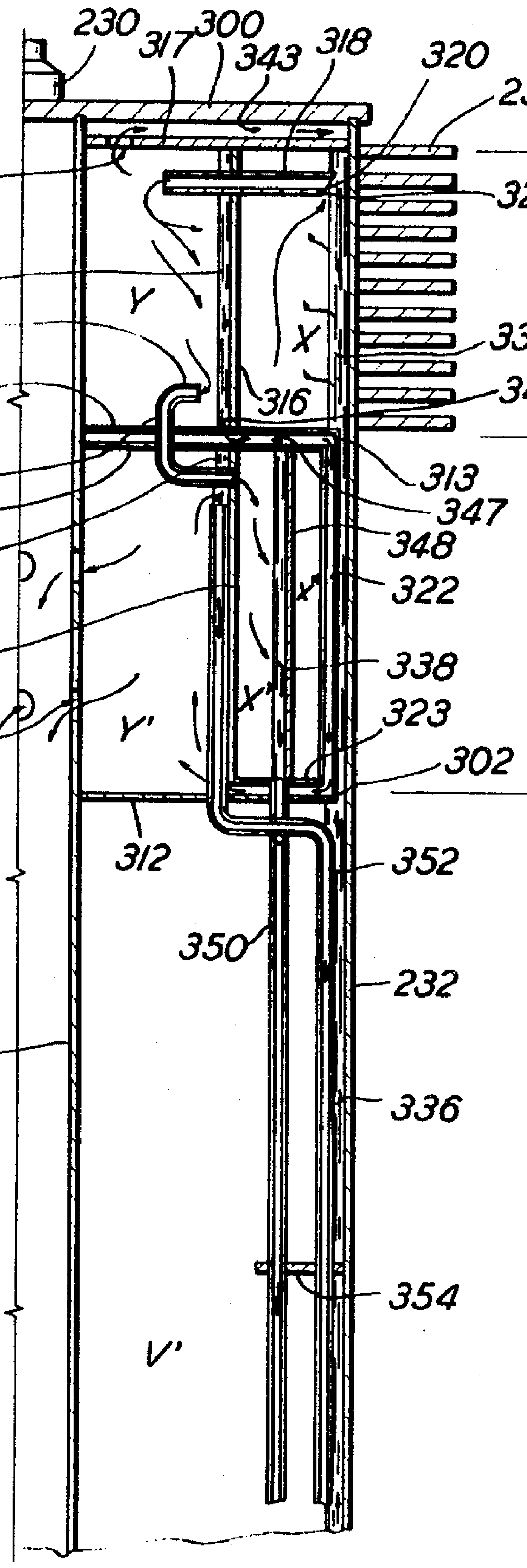


FIG. 13

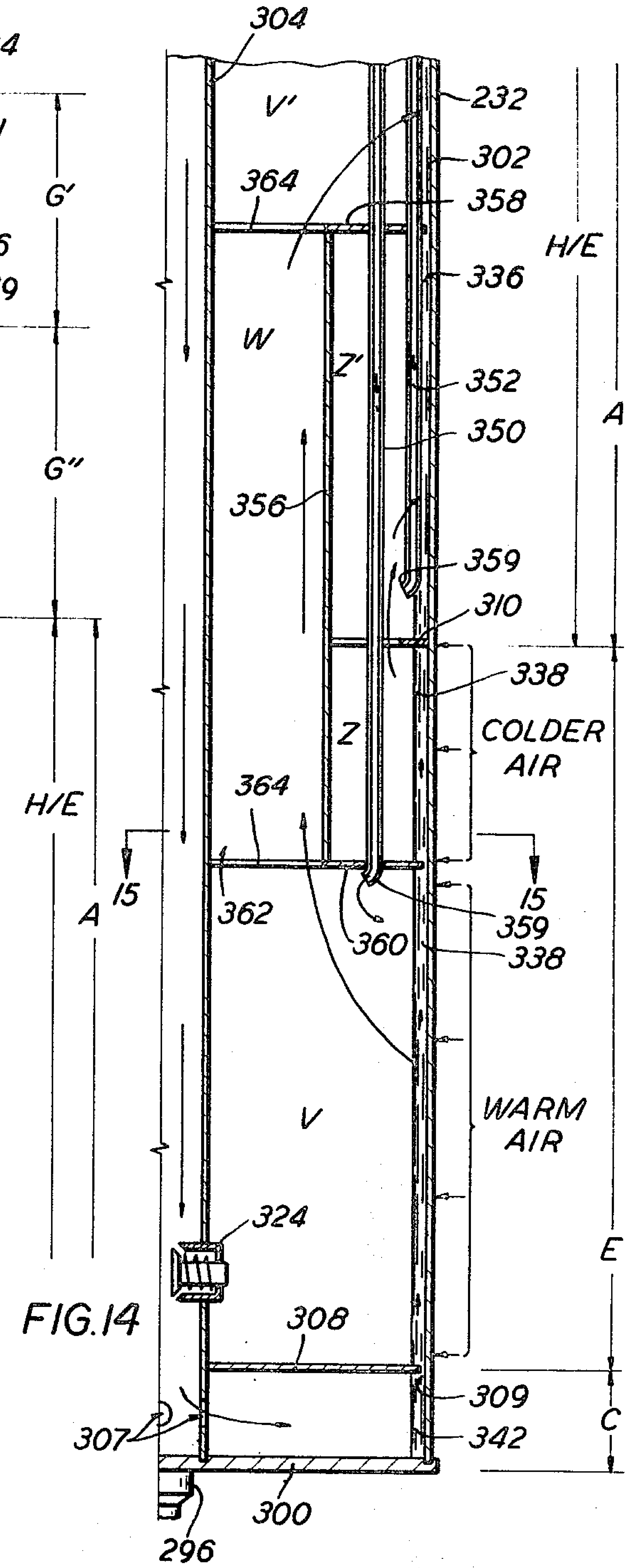


FIG. 14

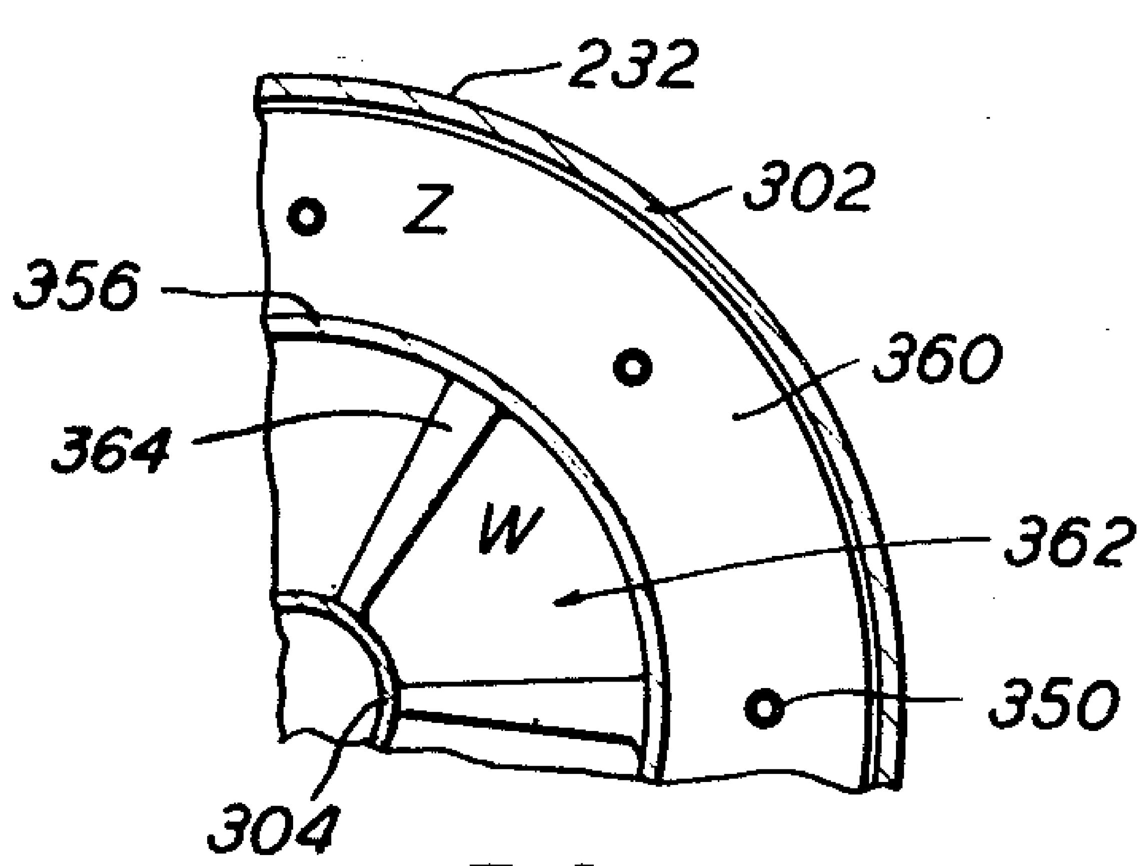


FIG. 15

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United States Patent Office

3,605,436

Patented Sept. 20, 1971



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



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 absorbing 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 map 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 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 redirected 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.



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 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 evaporator 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 aforemenposed 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 distributed 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 immdiately 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 asborber 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 aperatures **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 hereinafter 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 surface 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 distribtued 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 upuwardly 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 comparment 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 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 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 rotatig 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 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 comparament 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.

**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 expell 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 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 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 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 relationhip 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 communicaing with said first evaporator compartmet 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 communicating 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 evapoartor 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



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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U.S. Cl. X.R.

62—499

PO-1050
(5/69)

# 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; "relationhip" 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