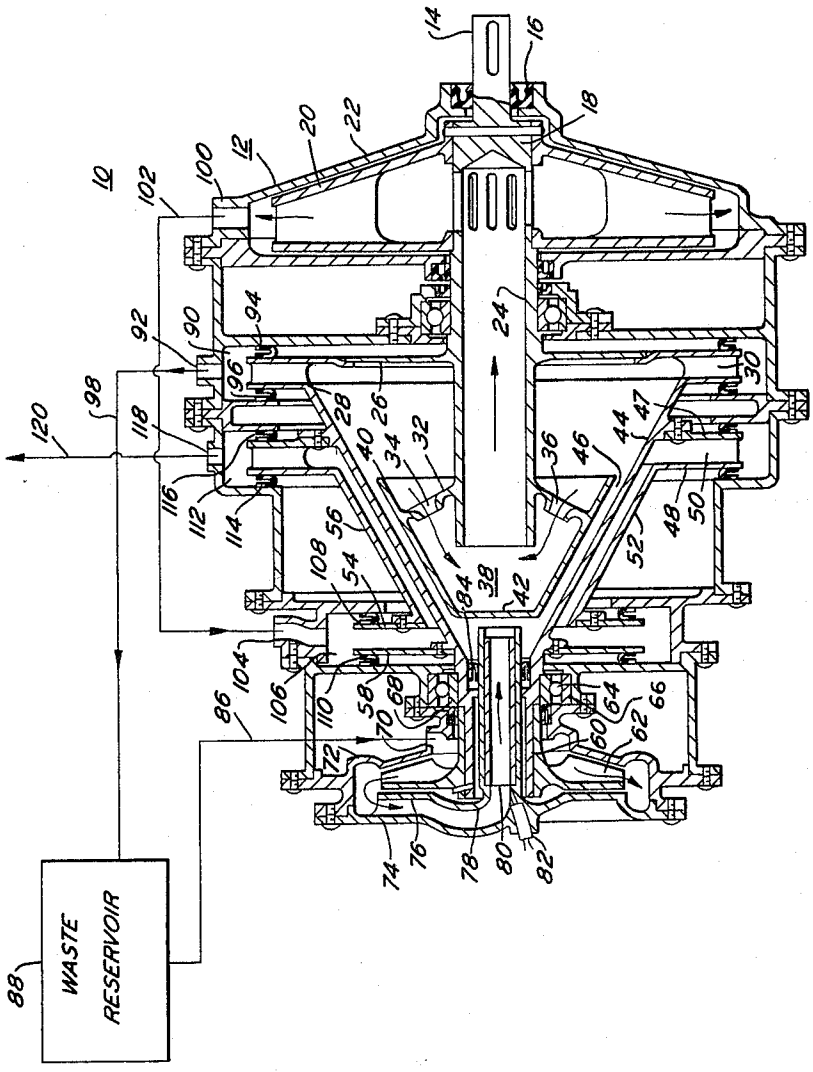
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APPARATUS FOR COMPRESSING VAPORS IN THE DISTILLATION OF A ROTARY CONICAL FILM

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INVENTOR.
ROBERT A. TIDBALL

BY Arthur H. Seidel

ATTORNEY

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APPARATUS FOR COMPRESSING VAPORS IN THE DISTILLATION OF A ROTARY CONICAL FILM

Robert A. Tidball, Swarthmore, Pa., assignor to Baldwin-Lima-Hamilton Corporation, Philadelphia, Pa., a corporation of Pennsylvania

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In general, this invention relates to a new and improved distillation apparatus, and more particularly, to a compression distillation apparatus adapted to convert human wastes to potable water under zero gravity conditions.

In this space age it is to be expected that problems will arise in the furbishing of space craft and space stations with regard to the supply of water for possible passengers therein. Therefore, it would be extremely desirable to utilize the human wastes of the passengers so that they can be converted into potable water. However, this conversion process and apparatus must meet severe criteria. That is, the apparatus cannot consume a great deal of power in the conversion process. In fact, a present standard would be the conversion of four gallons of water for evary 500 watts of power supplied to the apparatus.

Additionally, the zero gravity conditions under which the apparatus must operate raise certain problems with regard to distillation apparatus. Normally, distillation apparatus on the earth utilizes the buoyancy principle to separate vapor from droplets of water. Additionally, the lighter vapor will normally rise so that it can be transferred to a different part of the apparatus for condensation purposes. Under zero gravity conditions, this is not possible. The apparatus of the present invention is adapted to obviate the need for gravity at any point in its operation with minimal expenditure of power to complete the distilling process.

Therefore, it is the general object of this invention to avoid and overcome the foregoing and other difficulties of the prior art practices by the provision of a new and better distillation apparatus.

A further object of this invention is to provide a new and better compression distillation device for converting human wastes to potable water under zero gravity conditions.

Another object of this invention is to provide a better compression distillation device which will operate with a minimum power input.

A still further object of this invention is to provide a better and more inexpensive compression distillation device which utilizes centrifugal forces to separate droplets from water vapor.

An additional object of this invention is to provide a new and improved compression distillation device in which the evaporator, compressor, brine pump and product pump are combined within one housing and with one drive.

Other objects will appear hereinafter.

For the purpose of illustrating the invention, there is shown in the drawings a form which is presently preferred; it being understood, however, that this invention is not limited to the precise arrangements and instrumentalities shown.

In the drawing, there is shown the compression distillation device of the present invention generally designated by the numeral **10**.

The compression distillation device **10** consists of an outer stationary housing **12** through which passes a main drive shaft **14**. The shaft **14** is suitably sealed by rotary seals **16** so that liquid within the housing cannot pass through the shaft opening.

The shaft **14** has an enlarged extension **18** on which are mounted integral compressor blades **20**. The compressor blades **20** are equally spaced about the enlarged portion **18** and are located within a compressor housing portion **22** of the main housing **12**.

The enlarged portion **18** of the shaft **14** has an integral tubular extension **24** which extends into the center of the housing **12**. The tubular extension **24** is mounted on suitable bearings secured to the housing **12** for rotation with respect thereto.

Additionally, there is provided a circular plate **26** integral with and perpendicular to the axis of the tubular extension **24**. Plate **26** has a diameter slightly less than the diameter of the housing **12**. There is provided, spaced from and parallel to the plate **26**, an annular flange **28** having an outer diameter equal to the outer diameter of the plate **26**. Extending between the plate **26** and the annular flange **28** are spaced pumping blades **30** which are utilized for purposes to be discussed below. The plate **26** is positioned midway along the length of the extension **24**.

Near the end of the extension **24** opposite from the shaft **14**, suitable webs **32** are provided integral with the extension **24**. A plurality of holes **34** and **36** pass through the webs **32**. The webs **32** are part of an eliminator or separator **38** which is formed of a conical section **40** secured to the webs **32** having a closed flat end **42** at the small end of the conical section. The conical section **40** being integral with the shaft **14** through webs **32**, extension **24**, and enlarged portion **18** will rotate therewith. This is also true of plate **26** and annular flange **28**, the flange **28** being rotated due to its integral connection to the plate **26** through pumping blades **30**.

The annular flange **28** is an integral extension of a second conical section **44** parallel to and spaced from the conical section **40** so as to form a passageway **46** between the inner surface of the second conical section **44** and the outer surface of the first conical section **40**.

A second annular flange **47** is provided integral with the second conical section **44** and parallel to the first annular flange **28** centrally of the conical section **44**. A third annular flange **48** is additionally provided spaced from the second annular flange **47** and connected thereto by means of pumping blades **50**. The annular flanges **48**, **47** and **28** and the annular plate **26** have approximately the same diameter.

The third annular flange **48** is integral with a third conical section **52** which rotates about the same axis as conical sections **44** and **40**. The third conical section **52** is slightly larger than the second conical section **44** so as to provide a passageway **56** between the inner surface of the third conical section **52** and the outer surface of the second conical section **44**. For purposes of clarity, the second conical section **44** will hereinafter be termed a phase barrier. The reason for this terminology will be clearer when the operation of the compression distillation apparatus is discussed below.

A fourth annular flange **54** is provided adjacent to the small diameter end of the third conical section **52**. This annular flange **54** is spaced from and parallel to a fifth annular flange **58** integral with the small diameter end of the second conical section **44**. The fourth and fifth annular flanges **54** and **58** have the same outer diameter. Since the second and third conical sections **44** and **52** are rotating, their associated annular flanges **54** and **58** will also rotate.

The second conical section **44** has a cylindrical extension **60** at the small diameter end thereof. The extension **60** has pumping blades **62** integral therewith at the end thereof. This tubular extension **60** is rotatably mounted in suitable bearings **64** which are placed between a race **68** integral with the tubular extension **60** and an outer race **66** mounted on the housing **12**.

Spaced from the bearing race **66** is a suitable inlet conduit **70** leading to the pumping blades **62** mounted within a suitable pump housing portion **72** of the housing **12**.

The pump housing portion **72** includes the face plate **74** of the housing **12**, the face plate **74** being removable for cleaning of the distillation apparatus. Additionally, the face plate **74** has secured thereto a suitable conduit **76** leading from the pump housing portion **72** to an inlet conduit **78** having an axis in line with the tubular extension **60**. The outer diameter of the inlet conduit **78** is smaller than the inner diameter of the tubular extension **60** so that the tubular extension **60** can rotate with respect to the stationary inlet conduit **78**. Along the inner surface of inlet conduit **78** is placed a suitable electric heating unit **80** which is connected through suitable conductors **82** to a source of electrical current so as to heat the inner surface of the inlet conduit **78**. Rotary seals **84** are also provided between the outer surface of the inlet conduit **78** and the inner surface of the extension **60**.

The pump inlet conduit **70** is connected through a suitable waste line **86** to a waste reservoir **88**. It is through this waste line **86** that human wastes are introduced into the compression distillation apparatus.

Between the plate **26**, the first annular flange **28**, the pump blades **30** and the housing **12**, there is formed a liquor collecting chamber **90**. The liquor collecting chamber **90** has an outlet conduit **92** through which the liquor is returned to the waste reservoir **88**. The liquor collecting chamber **90** is sealed by rotary seals **94** and **96** between the outer surfaces of plate **26** and flange **28** and the housing **12**. The liquor collector conduit **92** is connected through a liquor return line **98** to the waste reservoir **88**. Through this line passes the liquid droplets which have been separated from the water vapor and which will be returned to be redistilled within the apparatus **10**.

The compressor chamber **22** has a water vapor outlet conduit **100** which connects through a water vapor line **102** to an inlet conduit **104** adjacent a water vapor chamber **106**. The chamber **106** is formed between the housing **12** and the fourth and fifth annular flanges **54** and **58**. The fourth and fifth annular flanges **54** and **58** being rotatable are suitably sealed by rotary seals **108** and **110** respectively to the housing **12**.

A distillate collector chamber **112** is formed between the second and third annular flanges **47** and **48** and the housing **12**. The second and third annular flanges **47** and **48** are suitably sealed from the housing **12** by rotatable seals **116** and **114** respectively. The distillate collector chamber **112** has an outlet conduit **118** connected to a product recovery line **120** leading to a storage tank (not shown) for the water.

The operation of the apparatus **10** is as follows:

In the beginning, human wastes are stored within the waste reservoir **88** on the space vehicle. In order to convert these wastes into potable water, the shaft **14** is driven from a suitable source of motive power and the heater **80** is energized through the wires **82** so as to heat the inlet conduit **78** to a temperature of approximately 80° F. By rotating the shaft **14**, the pumping blades **62** are rotated to draw waste products from the reservoir **88** through the waste line **86** and conduit **70** into the pump chamber **72**. The pumping blades **62** force the waste products into the stationary conduit **76**. Waste products will not enter the space between pumping blades **62** and inlet conduit **76** as the centrifugal force of the blades will keep them out of this area. Additionally, any waste products which should enter and fall adjacent the outer surface of the inlet conduit **78** will be prevented from further movement by the rotating seals **84**.

As the waste products pass through the conduit **76**, they enter the inlet conduit **78** and are heated by the heater **80**. The heater **80** partially vaporizes the waste products by raising them to a temperature of at least 80° F.

The resultant mixture of vapor and liquor is forced against the baffle plate **42** of the eliminator **38**. This prevents any laminar flow of liquids and vapors and allows them to be acted upon by the centrifugal force of the eliminator **38** and second conical section **44**. The mixture of liquid and vapor passes through the passageway **46** between the outer surface of the first conical section **40** and the inner surface of the second conical section **44**.

As the liquor and vapor are being forced outwardly by centrifugal force, they will move up the conical surface. However, the liquor having a greater mass than the mass of the water vapor will be thrown closer to the inner surface of the second conical section **44** than the water vapor. Thus, two layers of fluid will pass through the passageway **46**. The outer layer will be liquor and the inner layer will be water vapor.

As these two layers reach the outer diameter of the first conical section **40**, the water vapor layer loses the surface on which it was moving, i.e. the outer surface of conical section **40**. Therefore, its laminar flow is disrupted. At this point, the water vapor is drawn through the holes **34** in the webs **32**. This occurs due to the vacuum created by the compressor blades **20** drawing the vapor through the tubular extension **24** of the shaft **14**.

The liquor, however, flows along the inner surface of the second conical section **44** by centrifugal force, and is forced through the pumping blades **30** into the liquor collector chamber **90**. Thus, the pumping blades **30** raise the pressure of the liquor to an amount greater than atmospheric pressure. Thus, the liquor can be forced through the liquor outlet conduit **92** and liquor line **98** back into the waste reservoir **88**. It will then be retransmitted through the inlet waste line **86** to the apparatus **10**.

The water vapor passing through the interior of tubular extension **24** is compressed by the compressor blades **20** in the housing **22** so that its pressure is increased and is thus forced through compressor outlet conduit **100** and water vapor line **102** into chamber **106** through its associated inlet conduit **104**. The water vapor as it enters inlet conduit **104** is still under pressure. Thus, it is forced into the space between fourth and fifth flanges **54** and **58** into cooling passageway **56**. The vapor as it passes through the passageway **56** is cooled by the phase barrier **44**. Phase barrier **44** is at the temperature of the liquor passing over its inner surface. As the water vapor passes over the outer surface of the phase barrier **44**, its temperature is lowered to the temperature of the liquor, thus condensing it. The condensed water is then forced up the phase barrier **44** by centrifugal force. The passageway **56** is small enough so that all of the water vapor is so condensed. This resultant distillate is pressurized by the pumping blades **50** and forced into the chamber **112**. From the chamber **112**, the water is fed through the outlet conduit **118** and distillate line **120** into a suitable tank. Since the pumping blades force the water to a pressure above atmospheric pressure, the water will continuously flow into a storage tank.

It will thus be noted that in no part of the apparatus **10** is the force of gravity utilized. Rather, it is expected that this system will operate under conditions of zero gravity. The water vapor and liquor are separated by centrifugal force. The liquor is forced into the waste reservoir by pumping blades **30**. The water vapor is drawn by compressor blades **20** and forced into the chamber **106**. The condensed water is moved along phase barrier **44** by the centrifugal force of the phase barrier. Additionally, this water is forced by the pumping blades **50** into its storage tank. Even the inlet waste is drawn into the device **10** by a suitable pumping blade assembly **62**. All of the power to the system is derived from the shaft **14**.

The heating of the inlet conduit **78** by heater **80** is only necessary until the waste approaches the desired temperature of 80° F. Once this occurs, the system may be continuously run while the power to the heater **80**

is cut off. Once some distilling takes place, the system will be self-regenerative as the heat lost from one portion of the system will be transferred to another part of the system.

The present invention may be embodied in other specific forms without departing from the spirit or essential attributes thereof and, accordingly, reference should be made to the appended claims, rather than to the foregoing specification as indicating the scope of the invention.

I claim:

1. Distillation apparatus operative under zero gravity conditions comprising a hollow stationary housing, first pumping means for pumping liquid into said housing, a rotary baffle, said pumping means adapted to force the liquid against said baffle, first and second conical surfaces rotatably mounted about the same axis, said second conical surface being larger than said first conical surface to form a conical passageway between said first and second conical surfaces, said rotary baffle being adapted to direct liquid impinging thereon to the small diameter end of said conical passageway, a liquid collector adjacent the large diameter end of said second conical surface to collect liquids centrifuged to the second conical surface, and a second pumping means located within said first conical surface for pumping water vapor adjacent said first conical surface to separate said water vapor from said liquid.

2. The distillation apparatus of claim 1 including means for heating the liquid before it reaches the rotary baffle, said heating means being adapted to partially vaporize the liquid.

3. The distillation apparatus of claim 1 wherein said first pumping means, said second pumping means, said rotary baffle and said first and second conical surfaces are mounted for rotation about the same shaft.

4. The distillation apparatus of claim 3 wherein said liquid collector includes compressor blades, said compressor blades being adapted to rotate at the same speed as said second conical surface, said first pumping means being adapted to pump liquid from a reservoir into said housing, said liquid collector being in communication with the reservoir whereby undistilled liquid can be pumped back into said housing.

5. The distillation apparatus of claim 1 including a third conical surface, said third conical surface being

parallel to, slightly larger than and along the same axis as said second conical surface, a second passageway being formed between said third and said second conical surfaces, the temperature in said second passageway being substantially the temperature of said second conical surface, said second pumping means being adapted to pump water vapor into said second passageway to condense the water vapor into water, said third conical surface being rotated at the same speed as said second conical surface.

6. The distillation apparatus of claim 5 including a water collector adjacent the large diameter end of said second conical passageway, said second pumping means being adapted to feed liquid into the small diameter end of said second conical passageway, said water collector including water pumping means for pumping water from said second conical passageway.

7. The distillation apparatus of claim 6 wherein said water pumping means includes pumping blades, said pumping blades being connected between said second and third conical surfaces and integral therewith.

8. The distillation apparatus of claim 6 including a drive shaft, said drive shaft being adapted to rotate said first and second pumping means, said first, second and third conical surfaces, and said rotating baffle.

9. The distillation apparatus of claim 8 including a conduit having a heated element adapted to be energized from a source of electrical energy, said heated conduit being adjacent said rotary baffle so as to partially vaporize liquid passing therethrough prior to the impingement of the liquid on said rotary baffle, said heated conduit being additionally operative to be de-energized after a few cycles of operation of said distillation apparatus.

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NORMAL YUDKOFF, *Primary Examiner.*

J. B. DONIHEE, *Assistant Examiner.*