NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON, D.C. 20546

REPLY TO
ATTN OF: GP

October 15, 1970

TO: USI/Scientific & Technical Information Division
Attention: Miss Winnie M. Morgan

FROM: GP/Office of Assistant General
Counsel for Patent Matters

SUBJECT: Announcement of NASA-Owned
U.S. Patents in STAR

In accordance with the procedures contained in the Code GP to Code USI memorandum on this subject, dated June 8, 1970, the attached NASA-owned U.S. patent is being forwarded for abstracting and announcement in NASA STAR.

The following information is provided:

U.S. Patent No. : 3,276,679

Corporate Source : Langley Research Center

Supplementary
Corporate Source :

NASA Patent Case No.: XLA-00415

Gayle Parker

Enclosure:
Copy of Patent

NASA-HQ

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N71-16079

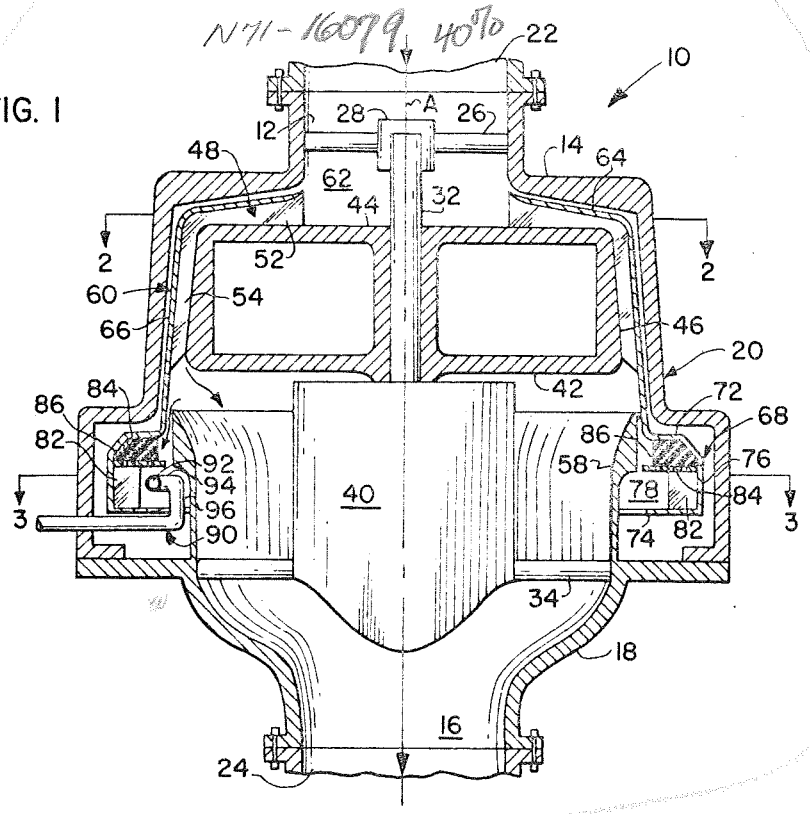
Oct. 4, 1966 F. W. BOOTH 3,276,679

SEPARATOR

Filed Oct. 4, 1963 2 Sheets-Sheet 1

N71-16079 40%

FIG. 1



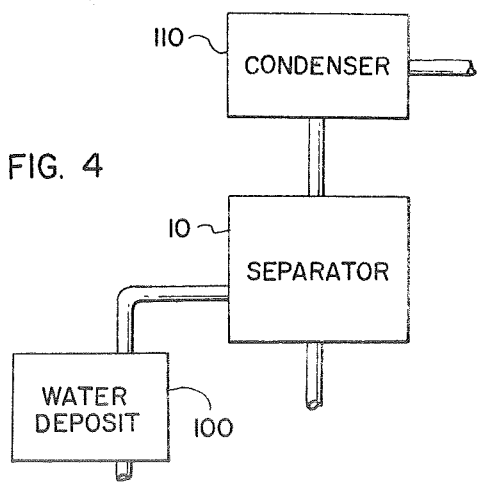


FIG. 4

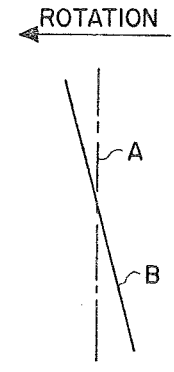


FIG. 5

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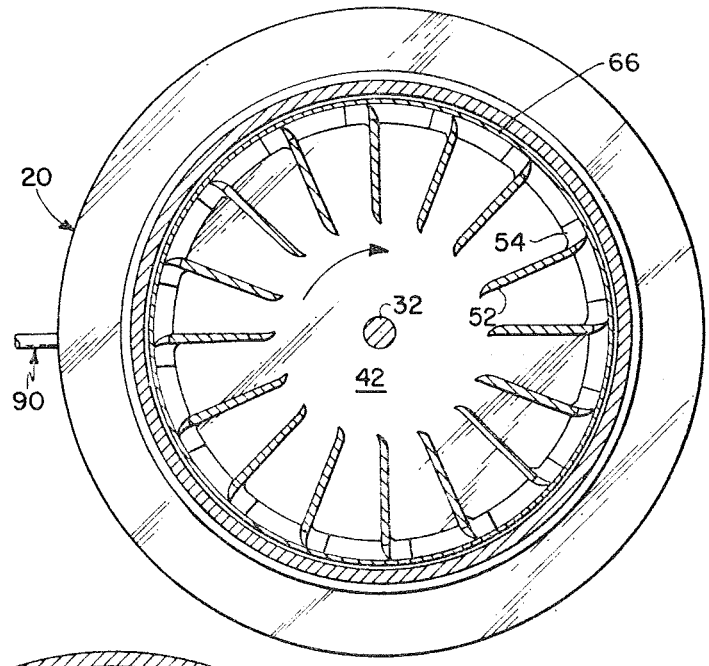
FIG. 2



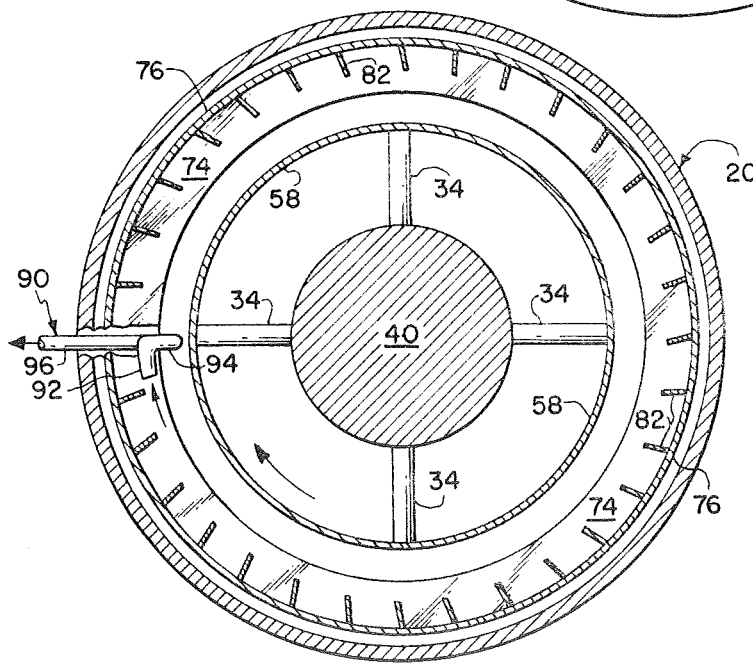


FIG. 3

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United States Patent Office 3,276,679 Patented Oct. 4, 1966

3,276,679

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Filed Oct. 4, 1963, Ser. No. 314,074
9 Claims. (Cl. 233—11)

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

This invention relates generally to separators and more particularly to liquid-gaseous separators operating in zero gravity environments.

During sustained flights into outer space it becomes necessary to purify materials, especially water, in order to reuse them and to maintain low humidity within the space vehicle without unduly increasing weight or size requirements. Use of separators utilizing a centrifugal force to aid purification is well known. Although such separators have means for forcing material or ingredients outwardly, they rely upon gravity for removal of at least one of the separated ingredients and in a zero gravity environment could not accomplish their intended function. Failure to remove a separated ingredient would result in an overabundance thereof with the consequence that, after a short period of operation, the collected ingredient would prevent further collection. The prior art separators are of a size that would require a considerable volume within the vehicle for efficient operation. Additionally, the weight of known separators is such that their use in space vehicles is impractical.

Accordingly, it is an object of the present invention to provide a simple and efficient separating apparatus that is capable of operating in a zero gravity environment and is of a size and weight to be practicable in a space vehicle.

Another object of the invention is a separating apparatus for operation under zero gravity conditions which utilizes a centrifugal force for separating materials and positive displacement means for removing the collected material.

Still another object of the instant invention is a centrifuge separating apparatus operating in cooperation with a condenser for dehumidification in a zero gravity environment.

A further object of the present invention is to provide a method of separating materials in a zero gravity environment by deflecting an influent against the interior of a centrifuge bowl where one of the influent ingredients is collected and removed to a storage container.

Generally speaking, the foregoing and other objects are accomplished in accordance with this invention by providing a deflector within a centrifuge which directs the materials toward the wall of the centrifuge where the heavier or more dense material is collected and from which it is withdrawn by an impact pump and conveyed through a conduit to a storage container.

A more complete appreciation of the invention and many of the attendant advantages thereof will be readily apparent as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawing wherein:

FIG. 1 is a longitudinal section view of one embodiment of the centrifuge separating apparatus for operation in a zero gravity environment;

FIG. 2 is a sectional view taken on line 2—2 of FIG. 1;

FIG. 3 is a sectional view taken on line 3—3 of FIG. 1 with portions omitted for clarity;

FIG. 4 is a schematic of a system incorporating the invention; and

FIG. 5 is a line diagram showing the blade angle.

Referring now to the drawing wherein like reference numerals designate identical or corresponding parts throughout the several views, and more particularly to FIG. 1 wherein the separator, generally designated by reference numeral **10**, is shown as having a casing **20** with a central longitudinal axis A. Although casing **20** may be of any shape, it is shown as being substantially bell-shaped having an inlet **12** located centrally of the shoulder end **14** thereof and an outlet **16** centrally located in mouth closure member **18**. Conduit **22** is attached to inlet **12** for conveying the material to be separated into separator **10** and conduit **24** is connected to outlet **16** to provide means for conveying a separated material or ingredient from separator **10**. Attached to the interior of casing **20** at inlet end **14** is shaft mount **26** that supports shaft bearing **28** in order to permit efficient rotation of a shaft **32**. Motor mount **34** is located adjacent mouth closure member **18** of casing **20** for rigidly securing motor **40** in place within casing **20**. In order to assist in the separation of the materials, the interior of closure member **18** may be provided with a circumferential cover flange **58** that extends toward inlet **12** of casing **20**. As more fully described hereinafter, the edge of cover flange **58** nearest inlet **12** need only be spaced a slight distance inwardly from the interior side of casing **20**.

Motor **40** is provided with a shaft **32** that has one end thereof supported by bearing **28**. Shaft **32** has disk-shaped deflector **42** attached thereto. The face of deflector **42** nearest the inlet of casing **20** is substantially perpendicular to axis A and acts as a deflecting surface **44** to direct the influent outwardly toward the interior of the wall of casing **20**. The circumferential edge **46** of deflector **42** has fan blades **48** mounted thereon. These fan blades **48** are substantially inverted L-shaped and have first portion **52** secured to deflecting surface **44** and second portion **54** secured to circumferential edge **46**. It has been found that omission of first portion **52** of blades **48** does not detract from the overall efficiency of the separator and, accordingly, first portion **52** of fan blades **48** may be omitted without departing from the concept of the invention.

Within casing **20** and extending beyond face **44** of disk-shaped deflector **42** and attached to fan blades **48** is a substantially bell-shaped centrifuge bowl **60** having inlet **62** centrally located in closed portion **64** which is positioned adjacent inlet **12** of casing **20**. The side wall **66** of centrifuge bowl **60** terminates in a substantially U-shaped collecting ring or channel **68** having side flanges **72** and **74** and a bottom **76**. As shown in FIG. 1, side wall **66** of centrifuge bowl **60** is tapered such that the diameter of centrifuge bowl **60** is greater near mouth **78** thereof than at the shoulder or closed portion **64** thereof. The collecting ring **68** extends circumferentially around mouth **78** of centrifuge bowl **60** and has blades or projections **82** mounted on bottom **76** thereof for maintaining the rotary motion of the collected ingredient. The collecting ring or channel **68** may also be provided with a cellular or porous material **86**, such as sponge rubber or plastics, adjacent flange **72** and a perforated member **84** extending inwardly from bottom **76** toward central longitudinal axis A. The cellular material **86** and perforated member **84** provide additional means to aid by capillary action in the collection of a separated ingredient, but may be omitted without detracting from the operation of the invention.

As shown in FIGS. 1 and 3, an impact pump **90** is utilized as a positive displacement means for removing the collected ingredient and conveying it to some desired location. The impact pump **90** is formed from a tubular member and is provided with a first portion **92** that acts

as an inlet or scoop the open face of which is directed into the rotary direction of the material collected in collecting ring or channel **68**. The first portion **92** of impact pump **90** is located substantially parallel to the bottom of collecting ring **68**, outwardly of side wall **66** and inwardly of the outer portion of blades or projections **82**. Attached to and forming an extension of first portion **92** of impact pump **90** is a second portion **94** that is directed inwardly toward central longitudinal axis A and is substantially perpendicular to bottom **76** of collecting ring **68**. Impact pump **90** is also provided with a third portion or outlet **96** that extends, and acts as a conduit for conveying the collected material, to a storage container **100** that may be located as desired.

In order to adapt the system for operation as a dehumidifier, any known type of condenser **110**, as shown diagrammatically in FIG. 4, may be provided for converting gas to aerosol containing vapor prior to the gas flowing into separator **10**. Conventional mechanism, such as a pressure pump, not shown, may be provided if necessary for forcing the air through the condenser and the vapor through the separator rather than utilizing a built-in fan.

Operation

The apparatus of the instant invention will have means such as conduit **22** for conveying the material to be separated into separator **10**. A gas vapor containing aerosols is forced into inlet **12** in casing **20** and encounters deflecting surface **44** which changes the direction of flow of the vapor toward the interior of side wall **66** of centrifuge bowl **60**. Rotation of shaft **32** and associated fan blades **48** aids in directing the vapor toward centrifuge side wall **66**. When the vapor impinges upon side wall **66**, the water, being the heavier or denser of the ingredients of the vapor, is forced outwardly by centrifugal force and forms a thin layer or film on the interior of side wall **66**. As shown in FIG. 1, side wall **66** of centrifuge bowl **60** has an increasing diameter from closed portion **64** toward collecting ring **68**; thus, the water is caused, by centrifugal force, to flow from closed portion **64** toward collecting ring **68**. Because centrifugal forces tend to force the heavier or more dense material outwardly, the thin film of water is maintained and flows toward collecting ring **68** where it is collected.

The collected water, because of centrifugal forces, tends to collect on bottom **76** of collecting ring **68**. The blades or projections **82** on bottom **76** of collecting ring or channel **68** act to maintain the rotary or circular motion of the collected water which is necessary for the proper functioning of impact pump **90**. When a sufficient amount of water has been collected in channel **68** to cover first portion or inlet **92** of impact pump **90**, the water is forced into first portion **92** and the pressure of the water behind that entering forces the water in inlet **92** through second portion **94** and third portion **96** and subsequently into a liquid storage container **100**, such as is shown in the schematic of FIG. 5.

As indicated hereinbefore, the heavier or denser water forms a thin film on side wall **66** of centrifuge bowl **60** and, since the gas is less dense than the water forming the film, the centrifugal force created within the centrifuge has less effect thereon. Accordingly, because the gas is being forced through separator **10** and a smooth flow thereof is aided by cover flange **58**, the gas will not tend to flow outwardly and will thus flow through the separator and be exhausted through outlet **16**. In the event that the gas needs to be retained, a conduit **24** is attached to casing **20** at outlet **16** thereof.

It has been found that by placing center line B of fan blades **48** at an angle to central longitudinal axis A, as shown in FIG. 5, of casing **20** and centrifuge bowl **60**, it is possible to accomplish greater efficiency in operation of separator **10**. It is to be understood that in some particular operations it is desirable to omit first portion **52** of fan blades **48** in order to avoid heat, produced by friction of the influent engaging the blades and interior of closed portions **64**, that would tend to evaporate the moisture contained in the vapor and thus enhance the overall efficiency of separator **10**. It is also to be understood that deflector **42** on shaft **32** and fan blades **48** may have some other type of fan, such as a squirrel cage type, substituted therefor. In fact, the fan structure may be completely omitted if the influent has sufficient force and a deflector is provided for directing the influent outwardly toward side wall **66** and a conventional mechanism is provided for rotation of centrifuge bowl **60**.

Obviously many modifications and variations of the subject invention are possible in the light of the above teachings. It is, therefore, to be understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically described.

What is claimed as new and desired to be secured by Letters Patent of the United States is:

1. A separator comprising: a casing having an inlet and an outlet; the cross-sectional area of said casing being equal to or greater than the area of said inlet; a motor having a shaft extending substantially parallel to the line of flow of said casing inlet; deflector means; centrifuge bowl means mounted on said shaft; said centrifuge bowl means increasing in diameter from one end to the other in the direction of flow; channel means on said centrifuge bowl for collecting a separated ingredient; and pump means for removing the collected ingredient whereby separation of fluids can be effected in a zero gravity environment.

2. A separator for operation under zero gravity conditions comprising: a casing having an inlet at one end and an outlet at the other end; the cross-sectional area of said casing being greater than the area of said inlet; a motor having a shaft; said shaft extending into said casing; deflector means mounted on said shaft; centrifuge bowl means having an inlet and outlet; said centrifuge bowl means increasing in diameter from the inlet toward the outlet thereof; collecting means adjacent the outlet of said centrifuge bowl means for collecting the separated ingredient; and means for removing the separated ingredient from said collecting means.

3. A dehumidifier for operation under zero gravity conditions comprising: a casing having an inlet at one end and an outlet at the other end; the cross-sectional area of said casing being greater than the area of said inlet; a motor having a shaft; said shaft extending into said casing; deflector means mounted on said shaft; centrifuge bowl means having an inlet and outlet; said centrifuge bowl means increasing in diameter from the inlet toward the outlet thereof; collecting means adjacent the outlet of said centrifuge bowl means for collecting the separated ingredient; means for removing the separated ingredient from said collecting means; and means adjacent said casing inlet for condensing air into vapor whereby the liquid is separated from the vapor and dehumidification of air occurs.

4. A separator for operation in a zero gravity environment comprised of: a casing having an inlet at one end and an outlet at the other end; a centrifuge bowl mounted within said casing and having an inlet at one end thereof; the opposite end of said centrifuge bowl terminating in a collecting ring; means for maintaining the circular motion of matter in the collecting ring; pump means including means for taking the matter from said collecting ring and conveying it; said centrifuge bowl being mounted on the shaft of a motor; said shaft having a deflector attached thereto; said deflector having a surface of greater area than the cross-sectional area of the inlet of either said casing or said centrifuge bowl to form a means for directing the stream of flow against the side wall of the centrifuge bowl.

5. A separator for operation in a zero gravity environment comprised of: a casing having inlet and outlet conduits attached to the opposite ends thereof; said conduits

being of less cross-sectional area than said casing; a motor mounted within said casing; said motor having a shaft positioned about the central axis of said casing; the end portion of said shaft being enlarged to a diameter greater than that of the inlet conduit and having blades attached thereto at an angle to the longitudinal axis of the casing; a centrifuge bowl mounted upon said shaft; said centrifuge bowl having an inlet in the closed portion thereof; said centrifuge bowl increasing in diameter from adjacent the inlet conduit toward the outlet conduit; the lip of said centrifuge bowl being formed as a substantially U-shaped collecting ring having flanges and a bottom portion; the open portion of said collecting ring being directed inwardly; inwardly extending projections on the bottom portion of said collecting ring; a tubular member having a first portion located outwardly of the ends of said collecting ring flanges and inwardly of the said projections; and said tubular member having a second portion extending inwardly of the said collecting ring and a third portion extending from the said casing; whereby vapor entering the casing and centrifuge bowl is directed against the inside surface of the centrifuge bowl with the liquid forming a film thereon which moves toward the collecting ring from which it is removed and the gas is separated from the liquid to be emitted from the casing through the outlet thereof.

6. A separator for operation in a zero gravity environment as in claim **5** including means within said collecting ring for aiding in the collecting of one of the separated ingredients.

7. A separator for operation in a zero gravity environment as in claim **6** wherein said aiding means includes a porous material within said collecting ring.

8. A separator for operaton in a zero gravity environment as in claim **7** wherein said aiding means includes a perforated member extending inwardly from the bottom portion of said collecting ring thereby providing a perforated barrier between said porous material and said projections.

9. A dehumidifier for operation in a zero gravity environment comprised of: a conduit attached to the inlet of a condenser; means for forcing gas through the conduit and condenser; a casing having an inlet at one end thereof attached to the outlet of said condenser; a substantially bell-shaped centrifuge bowl having an inlet in the closed portion thereof; said centrifuge bowl terminating in a channel shaped collecting ring; the open portion of said collecting ring being directed inwardly toward the central longitudinal axis of said casing; said centrifuge bowl being mounted upon a shaft extending substantially parallel to the central longitudinal axis of said casing; a deflector mounted on said shaft substantially perpendicular thereto and adjacent the inlets of said casing and centrifuge bowl; fan blades mounted on the circumferential edge of said deflector at a longitudinal angle to the central longitudinal axis of said casing; means for rotating said shaft; impact pump means having an inlet within said collecting ring and extending through said casing; said casing having an outlet at the end opposite that of the inlet; and a second conduit attached to the outlet of said casing.

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