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Tahara et al.

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[54] **CENTRIFUGAL GAS SEPARATOR WITH ELECTRIC MOTOR DRIVE**

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[52] **U.S. Cl.** ..... **233/24**, 233/1 C

[51] **Int. Cl.** **B04b 9/02**

[58] **Field of Search** ..... 233/8, 1 C, 1 A, 233/1 R, 11, 13, 23 R, 23 A, 24; 74/573, 574; 308/10

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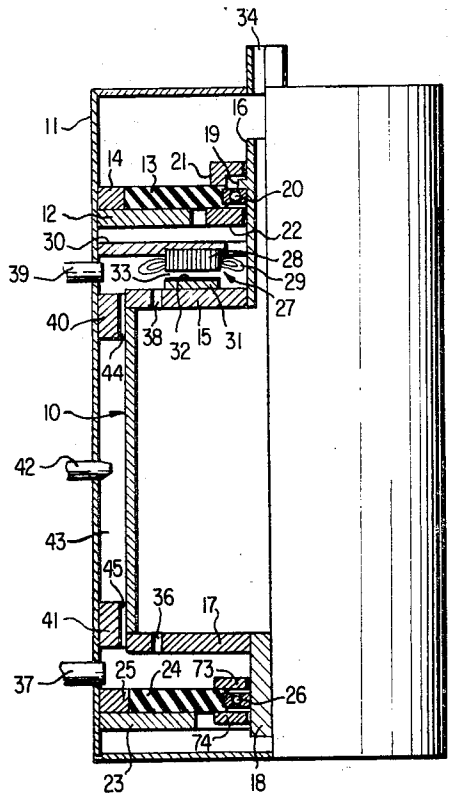
[57] **ABSTRACT**

A centrifugal gas separator is disclosed which employs a vertically oriented centrifuge drum mounted on suitable bearings within a stationary housing and driven by an electric motor. The electric motor is constructed in annular form with its stator portion fixed to the stationary housing and its rotor portion fixed to the centrifuge drum and positioned generally below its stator portion. When the electric motor is energized, the magnetic attraction between its stator and rotor portions tends to lift the centrifuge drum, thereby reducing the weight supported by the bearings and reducing bearing wear. In addition, elastic or magnetic devices are alternatively provided to dampen the vibration of the rotating centrifuge drum.

8 Claims, 4 Drawing Figures



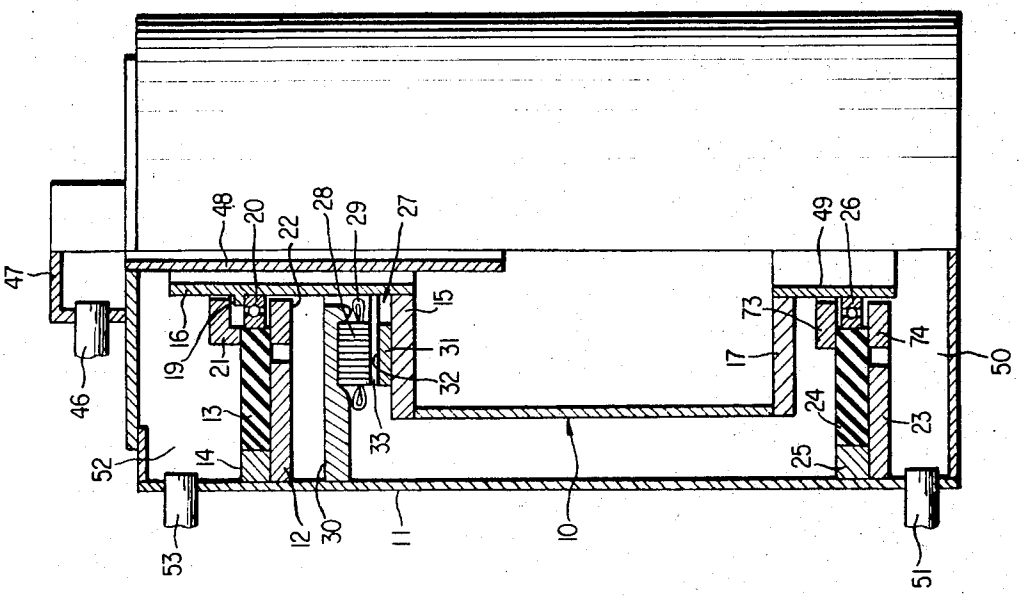


FIG.2

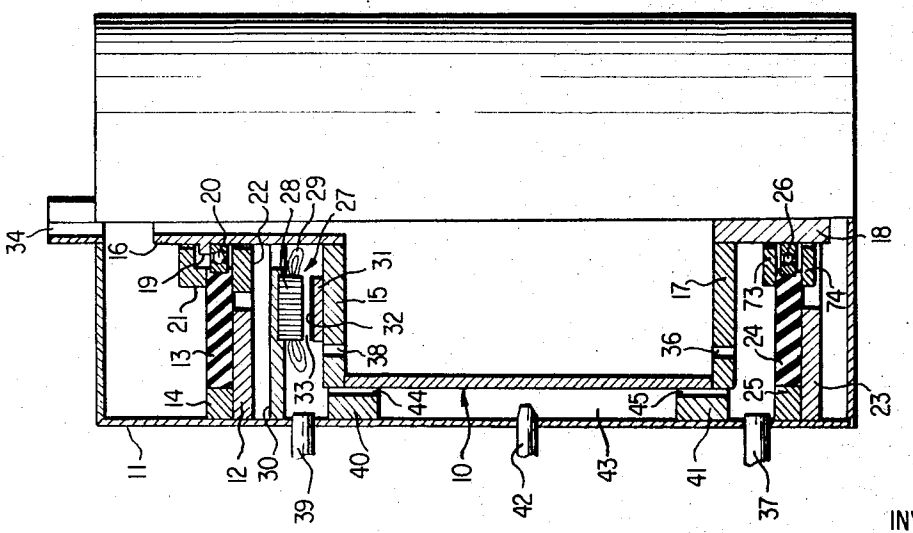


FIG.1

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ATTORNEYS

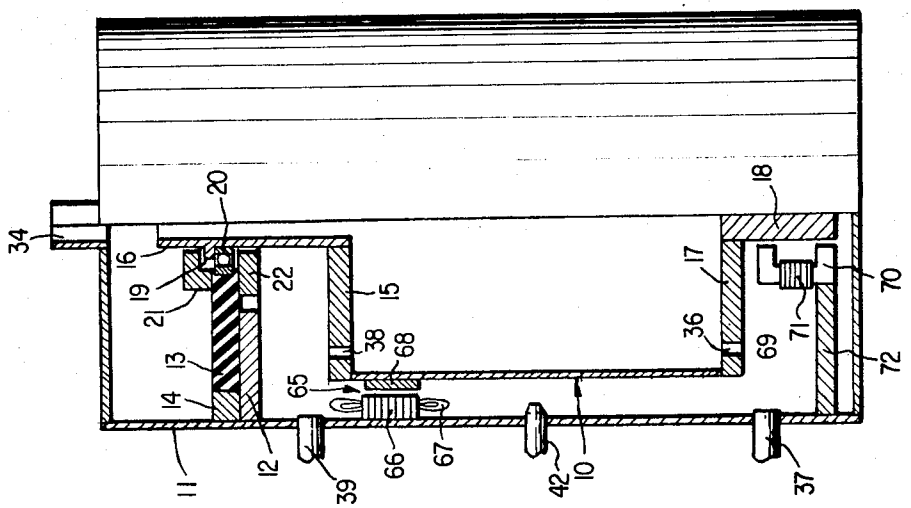
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FIG. 4

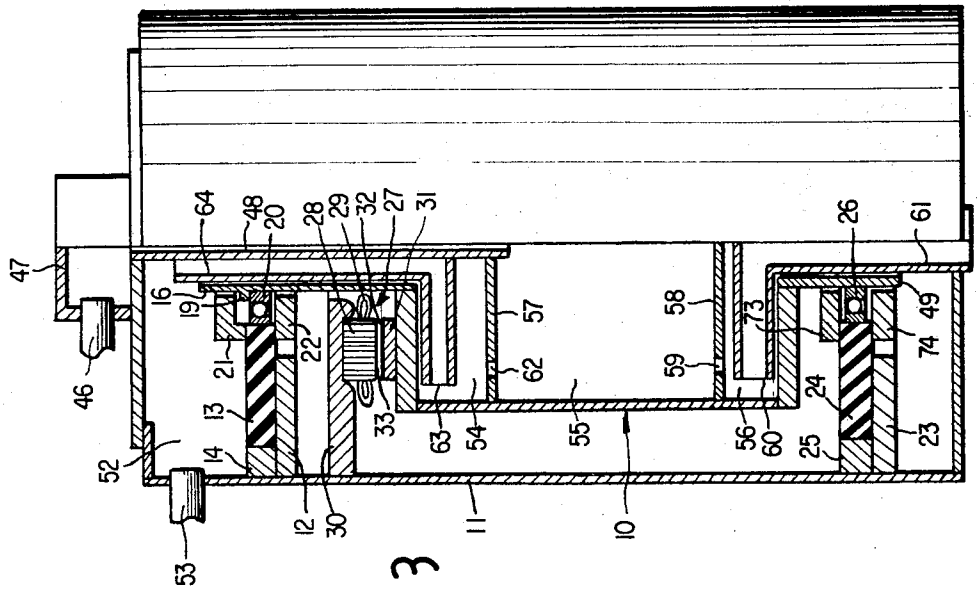
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FIG. 3

CENTRIFUGAL GAS SEPARATOR WITH ELECTRIC MOTOR DRIVE

BACKGROUND OF THE INVENTION

1. Field Of The Invention

The present invention relates to gas separators, and more particularly to centrifugal gas separators which may be used, for example, for separating enriched uranium (U^{235}) from gaseous uranium hexafluoride (UF_6).

2. Description Of The Prior Art

Gas centrifuges customarily include an elongated cylindrical drum which is filled with the gas to be processed, then rotated at an extremely high angular speed. Because of the extremely high angular speeds and because of the weight of the centrifuge drum, it has been observed that gas centrifuges tend to wear out their drum supporting bearings in a relatively short time. Naturally, the useful life of a gas centrifuge is no longer than the life of the centrifuge bearings, since excellent bearings are crucial in order to maintain suitably high rotational speeds. Accordingly, in order to prolong the life of the centrifuge, it is necessary to minimize wear on the bearing surfaces. It has been found that one way of greatly reducing bearing wear is to minimize the weight load borne by the centrifuge bearings when the centrifuge drum is in operation.

SUMMARY OF THE INVENTION

Accordingly, one object of the invention is to provide an electric motor driven centrifuge in which the rotor and stator portions of the driving electric motor are arranged so that the magnetic attraction between them lifts the centrifuge drum, and removes a portion of its weight from the drum bearings.

Another object of the invention is to provide a centrifuge having a rotating cylindrical drum of a relatively short axial length to reduce the vibration thereof.

Yet another object of the invention is to provide a gas centrifuge that includes either an elastic or a magnetic vibration damping device.

Briefly, these and other objects of the invention are achieved by constructing a vertically oriented centrifuge apparatus equipped with an annular electric motor. The rotor portion of the motor is mounted on the centrifuge drum, while the stator portion thereof is mounted to the centrifuge housing above the rotor portion. When the motor is energized, the magnetic attraction between the rotor and stator portions thereof tends to lift a portion of the weight of the centrifuge drum, thereby reducing bearing wear. Either a magnetic or an elastic device is secured to the drum bearing to dampen the vibration thereof.

BRIEF DESCRIPTION OF THE DRAWINGS

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

FIG. 1 is a partially cut-away illustration of a first embodiment of the centrifuge apparatus of the instant invention;

FIG. 2 is a partially cut-away illustration of a second embodiment of the centrifuge apparatus of the instant invention;

FIG. 3 is a partially cut-away illustration of a third embodiment of the centrifuge apparatus of the instant invention; and,

FIG. 4 is a partially cut-away illustration of a fourth embodiment of the centrifuge apparatus of the instant invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the Drawings, wherein like reference numerals designate identical or corresponding parts throughout the several views, and more particularly to FIG. 1 thereof, a cylindrical drum **10** is shown positioned in an evacuated cylindrical housing **11.**

An annular shelf **12** is provided within housing **11** at an upper portion thereof. An annular disk-shaped damper **13** of elastic material is mounted on the shelf **12** and is held at the outer periphery thereof by a ring member **14.**

The drum **10** includes an upper end plate **15,** a hollow shaft **16** axially extended therefrom, a lower end plate **17** and a shaft **18** axially extended downward therefrom.

To rotatably suspend the drum **10** from damper **13,** an annular tab **19** is provided around hollow shaft **16.** The annular tab **19** is mounted on an inner race of a bearing **20** which is also supported in a central opening of the damper **13.**

The damper **13** also supports a pair of conventional gas sealing devices **21** and **22** at the innermost portion thereof to prevent gas from leaking along the surface of hollow shaft **16.**

An annular shelf **23** is provided within housing **11** at the lower portion thereof for supporting an annular-shaped damper **24** of elastic material which may be substantially the same as damper **13.** Similarly, the outer periphery of the damper **24** is held by a ring **25.** A bearing **26** is positioned in a central opening of the damper **24** for rotatably supporting shaft **18** of drum **10.** A pair of conventional gas sealing devices **73** and **74** are mounted on the innermost portion of damper **24** to prevent gas from leaking along the surface of the shaft **18.**

In order to rotate the drum member **10,** an electric motor **27** of the axial air gap type is mounted within housing **11.** The electric motor **27** includes an annular or disk-shaped stator core **28** supported by the inner wall of housing **11** through stays **30** and an annular or disk-shaped rotor **31** mounted on end plate **15** of drum **10.** The rotor **31** is preferably made of a plate of soft iron, permendur or the like, and has plated on the surface thereof a material having a relatively higher conductivity such, for example, as copper or aluminum, which is denoted by the numeral **32.** An air gap **33** separates stator core **28** from rotor **31.**

The motor **27** also includes a stator winding **29,** which is energized from a high frequency A.C. voltage source (not shown) such, for example, as a motor-generator set or a static inverter, which generates a revolving electromagnetic field in the air gap **33** to cause the rotor **31** to rotate.

In operation, as is well known in the art, a mixed gas to be isotopically separated is introduced into drum **10** through an inlet **34** in housing **11** and through a hollow shaft **16.** The lower portion of the drum **10** is heated by a heater (not shown), and the upper portion of the drum **10** is cooled by a refrigerating apparatus (not

shown), thereby producing a temperature gradient across the drum **10** which causes the mixed input gas to positively circulate in the drum.

The centrifuging operation and the temperature gradient causes a gas separation, which results in a gas of a relatively light molecular weight being exhausted through orifices **36** positioned in the peripheral area of end plate **17**. The lighter gas is then expelled through an outlet **27**. The separated gas of heavier molecular weight is exhausted through orifices **38** positioned peripherally in upper end plate **15**. The heavier gas is then expelled through an outlet **39**.

To prevent the separated gases from recombining within housing **11**, a pair of ring members or gas seals **40** and **41** are mounted on the inner wall of housing **11**. Narrow clearances **44** and **45** are defined between rings **40** and **41** and the side wall of drum **10** to impede the flow of gas therethrough into a common area **43**. This separating effect may be enhanced by the provision of a nozzle **42** which extends through the side wall of housing **11** into space **43** between the inner wall of housing **11** and the side wall of drum **10**. A carrier gas such, for example, as helium may be emitted from the nozzle **42** into the space **43**, then directed partially to outlet **39** through the clearance **44** and partially to outlet **37** through the clearance **45**.

Referring again to the electric motor **27**, it will be readily understood that the rotor **31** of the motor **27** is lifted slightly upwards along with the drum **10** to which it is attached by the electromagnetic attractive force which occurs in the air gap **33** of the motor **27** during energization of the motor. Consequently, the thrust or lead on bearing **20** due to the weight of drum **10** is effectively reduced, thereby prolonging the life of bearing **20**. The same is, of course, true of bearing **26**.

It can further be seen that with the use of the type of motor disclosed herein, the drum **10** does not require a conventional driving motor positioned on an extension of the axis of the drum. Accordingly, it is possible to shorten the entire axial length of the drum and motor combination. Thus, undesirable vibrations which result from a rotational body having a greater axial length can be effectively reduced.

It will also be apparent that the additional bearings necessary when conventional electric motors are used can be eliminated, whereby the total number of bearings can be reduced to prolong the life of the centrifuge apparatus.

In another embodiment of the invention illustrated in FIG. **2**, a mixed gas is introduced into drum **10** through an inlet **46**, an enclosure **47** mounted on the housing **11**, and a stationary pipe **48** extending through the hollow shaft **16** of the drum **10**. In this embodiment of the invention, the separated light gas is exhausted from drum **10** into a lower chamber **50** through a hollow shaft **49** extending through a lower end plate **17** and is then expelled out of the chamber **50** through an outlet **51**. The separated heavier gas is exhausted from the interior of drum **10** through hollow shaft **16** into an upper chamber **52**, and is then expelled out of the chamber **52** through an outlet **53**.

In a third embodiment of the invention, illustrated in FIG. **3**, the interior of drum **10** is divided into three chambers **54**, **55** and **56** by means of a pair of horizontal partition walls **57** and **58**.

A mixed input gas is conducted into the intermediate chamber **55** of the drum **10** through inlet **46**, housing **47** and stationary pipe **48**. A separated light gas or product is introduced into a lower chamber **56** of drum **10** through orifices **59** provided at a peripheral portion of partition wall **58**. Stationary scoops **60** are provided in the chamber **56** for taking the stored gas out of chamber **56**, and the gas is exhausted through a tube **61** which is connected to scoops **60** and extends through a hollow shaft **49** of the drum **10**. Similarly, the separated heavier gas is conducted into the upper chamber **54** through orifices **62** provided in a peripheral portion of partition wall **57**. Stationary scoops **63** are provided in chamber **54** for taking the gas out of chamber **54**, and are connected to a stationary hollow tube **64** which is located between pipe **48** and hollow shaft **16**. Thus, the separated heavier gas is carried out of chamber **54** through scoops **63** and tube **64**; the same then enters into chamber **52** and is exhausted through outlet **53**.

In accordance with a still further embodiment of the invention illustrated in FIG. **4**, an electric motor **65** is provided, which includes a stator core **66** of a cylindrical ring configuration mounted on an inner wall of housing **11** and having a stator winding **67** wound thereon. A cylindrical ring-like rotor **68**, made of a material such, for example, as a plate of soft iron or permendur, is mounted on the side wall of drum **10**.

When the electric motor **65** is not energized, the magnetic center of stator core **66** is located at a slightly higher position than that of rotor **68**. Accordingly, when the motor **65** is energized, the rotor **68** will be lifted upwards from its unenergized level by the electromagnetic pull occurring in the air gap between the rotor and stator elements. Thus, the thrust loaded on bearings **20** and **26** due to the weight of drum **10** is reduced.

In the embodiment of FIG. **4**, a plurality of electromagnets **69** are provided around shaft **18**, each of which includes a core member **70**. Core member **70** includes a pair of magnetic pole pieces facing the surface of shaft **18** through a small air gap. An exciting coil **71** is wound on each of the cores **70**, and the cores **70** are mounted on an annular stay **72** around the periphery of shaft **18**. The electromagnetic pull of magnets **69** is adjustable and functions to hold the axis of shaft **18** at a regular centered position without contacting with magnetic pole piece members. By properly adjusting the magnetic pull of the magnets **69**, the vibration of the shaft **18** can be damped effectively.

Obviously, numerous additional modifications and variations of the present invention are possible in 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 herein.

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

1. A centrifugal gas separator comprising:

an enclosed housing,

elongated cylindrical drum means vertically oriented within said housing, and adapted to receive a mixed gas to be separated,

bearing means mounted within said housing for rotatably supporting said drum means,

electric motor means for driving said drum means mounted within said housing, said electric motor means comprising stator means and rotor means;

said rotor means rigidly mounted on said drum means,

and, said stator means rigidly mounted to said housing and positioned above at least a portion of said rotor means, such that upon energization of said electric motor means an electromagnetic attractive force is created between said stator means and said rotor means which tends to lift said drum means.

2. A centrifugal gas separator as in claim **1,** wherein: said rotor means and said stator means are both in the form of annular disks.

3. A centrifugal gas separator as in claim **2,** wherein: said rotor means is mounted to a top surface of said drum means.

4. A centrifugal gas separator as in claim **1,** wherein: said rotor means and said stator means are both cylindrical in form.

5. A centrifugal gas separator as in claim **4,** wherein: said rotor means is mounted on a peripheral surface of said drum means.

6. A centrifugal gas separator as in claim **1,** further comprising:

vibration dampening means mounted within said housing.

7. A centrifugal gas separator as in claim **6,** wherein: said vibration dampening means includes an element constructed of an elastic material.

8. A centrifugal gas separator as in claim **6,** wherein: said vibration dampening means includes a magnetic element.

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