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CENTRIFUGAL SEPARATORS

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Fig. 1.

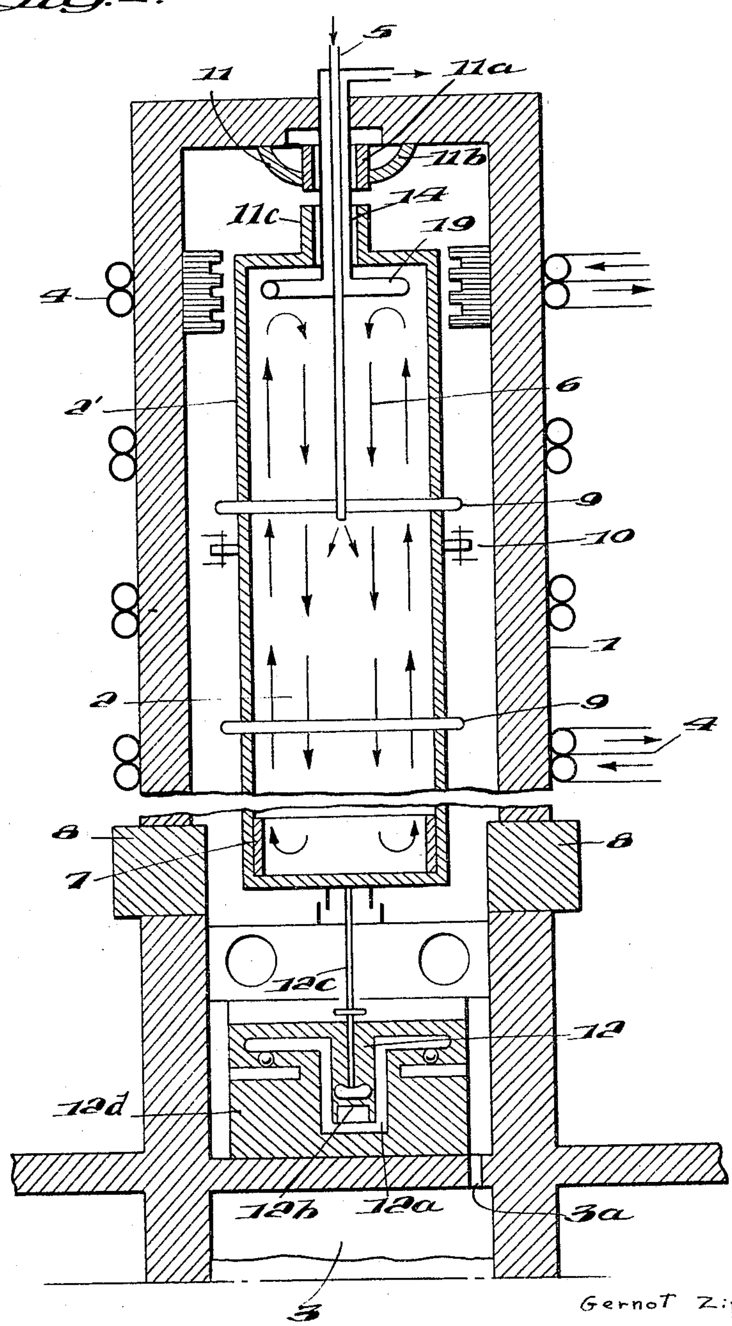

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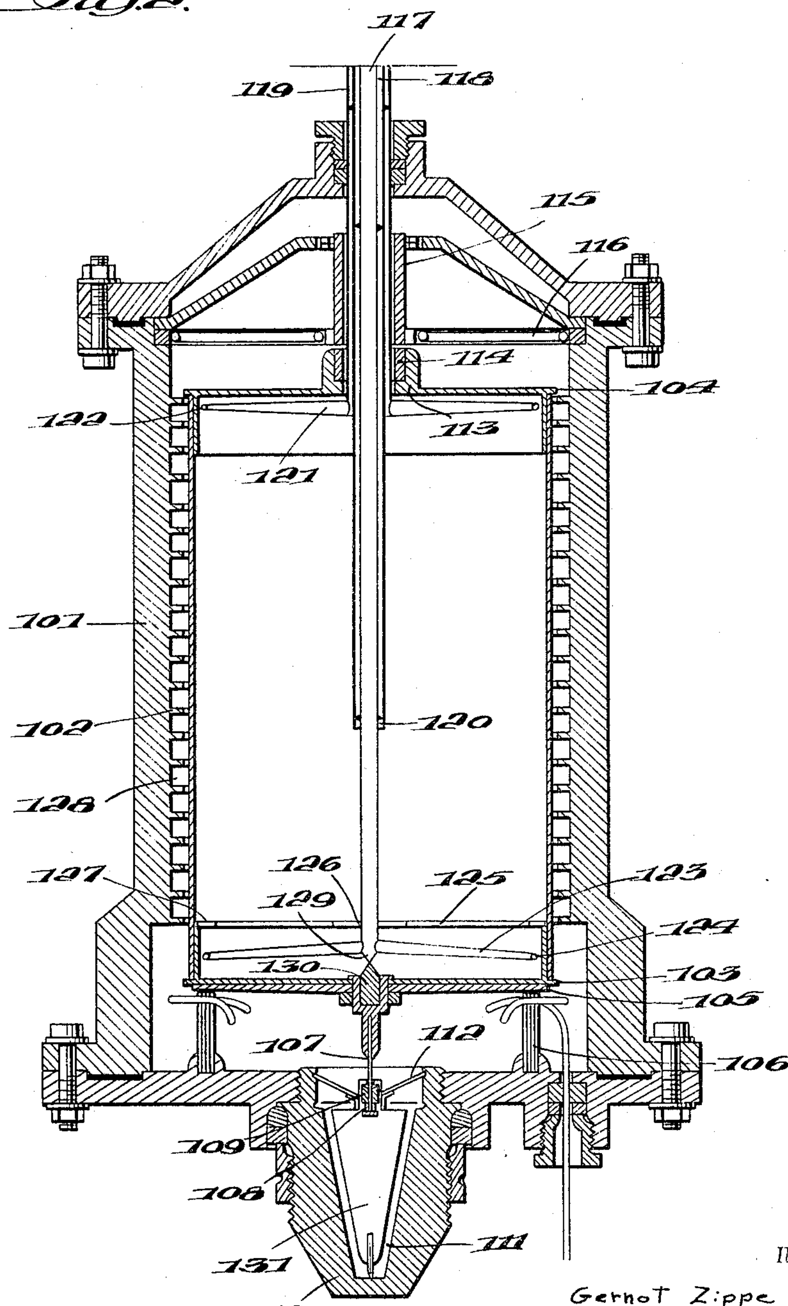
Fig. 2.



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The invention relates to an apparatus for the separation of mixtures of gases or gaseous isotopes by means of a centrifuge operating in a vacuum. More particularly, in contrast with the prior art, the purpose is to provide a centrifuge which has a self-stabilizing rotating system.

The primary object of the invention is to provide a centrifugal system which requires less power than those normally used and likewise is of substantially lighter construction, while at the same time this lightened construction does not require special precautions against the explosion of the rotor.

According to the invention the rotor can be rigid or can be made flexible, and at the same time a favorable ratio between the length and diameter in relation to the separating efficiency can be obtained.

In order to pass through the critical speed of rotation up to the operating speed while maintaining a high ratio of length to diameter of the rotor, means are provided in connection with the rotor for damping the rapid oscillations of the system. It has also been found that a long rotor can be caused to run especially quietly by providing adjustable supports arranged perpendicularly to the axis of rotation, so that the passage through the critical speed can be carried out in the shortest possible time. The supports can for instance be arranged in contact with the outside of the rotor.

The arrangement of the rotor to turn about a perpendicular axis also makes it possible to dampen certain vibrations, for example the slower ones, at the upper end and the rapid vibrations in the lower end.

Further objects and advantages of the invention will appear more fully from the following description, especially when taken in conjunction with the accompanying drawings, which form a part thereof.

In the drawing

FIG. 1 shows in vertical cross-section an apparatus embodying the invention.

FIG. 2 shows in vertical cross-section a modified form of the invention.

In the arrangement according to FIG. 1, the centrifuge housing **1** contains a rotor **2** mounted to rotate about a vertical axis. In the bottom of the housing is a suction device **3** connected by passage **3***a* to the interior of the housing, in order to maintain a reduced pressure therein. The rotor contains a steel ring **7**, which lies in the range of a rotating electric field which is produced in the winding **8**. The arrangement is such that the rotor runs out of synchronism with the electric field until it reaches the desired operating speed when it is automatically synchronized with the field. On the outside of the housing are pipe systems **4** through which warm and cold fluids such as water can flow in opposite directions, in order to produce temperature changes which are transmitted by radiation to the rotor.

The mixture to be separated is introduced by pipe **5** into the interior of the rotation rotor where the temperature differences set the mixture into a path of travel in the direction of the arrows **6** and also rotation about the axis. This circulation is induced by the temperature differential produced by pipes **4** which induce thermal currents in the fluid. Circulation is also improved by the provision in the rotor of a receiving tube **19** which has openings at the ends of its arm facing towards the direction of rotation of the rotor and which decreases the rotational velocity of the gas within the rotor in the vicinity of the openings and thereby decreases the pressure at the periphery of the rotor in this area.

Because the rotor has to pass through its critical speed, it is desirable to provide damping arrangements, which must be so constructed that the whole rotating system is self-stabilizing. This can be accomplished according to the invention by combination bearing and damping arrangements at the ends of the rotor.

The self-stabilizing can be accomplished by a flexible construction of the rotor, in that as shown the rigid parts **2′** of the rotor are connected through resilient parts **9**. These parts may be in the shape of rings of an elastic material, such as rubber, elastic synthetic material, metallic springs or the like. Furthermore, the rotor can be braced by the engagement of braces adjustable perpendicular to its axis of rotation, especially when the rotor is passing through its critical speed. Such braces may be wheels **10** located close to the outside of the rotor and mounted to turn about adjustable perpendicular axes, which brace the rotor while it is passing through the critical speed.

For the stabilization of a system rotating about a vertical axis, it is desirable to have a damping arrangement **11** which operates against slow vibrations in the top of the rotor and an arrangement **12** which operates against rapid vibrations and longitudinal vibrations and combinations of these at the lower end of the rotor.

The damping arrangement **11** consists of a metal ring **11***a*, which is connected through a stationary cup-shaped body **11***b* with the housing. The body **11***b* is formed of material with inherent resilience and damping power, such as rubber. The damping device **11** is not connected directly with the rotor **2**, but the circular body **11***a* is formed of a magnetized magnetic material, within the field of which is arranged the upward extension **11***c* of the rotor body which is formed of magnetic material.

The damping arrangement **12** consists of a carrier **12***a* for the lower cup bearing **12***b*, in which an elastic axis **12***c* is embedded, which is connected with the rotor. The carrier **12***a* is movable and rests in a cup **12***d* filled with oil, so that vibrations of the carrier **12***a* will be damped by the oil.

The tube **5** passes through opening **14** in the projection **11***c*. The arrangement **19** is built like a Pitot tube, which utilizes the pressure of the material inside the rotor and in this manner takes off the heavy fraction to the outside of the rotor. The light fractions can pass through opening **14** into the space between the housing **1** and the rotor **2** and then to suction device **3** through passage **3***a*.

A further modification of the invention is shown in FIG. 2. The construction includes a vacuum-tight housing **101** for the thin-walled rotor **102**, which is closed at the top and the bottom by lids or covers **104** and **103** respectively. The lid **103** carries on its outer side a steel core plate **105** which is arranged opposite a stator winding **106** on the inside of the housing. On the lower side of the lid **103** is an elastic flexible axle **107**, which rests on a hard metal plate **108** and is guided in the bushing **109**. The bushing is connected with the conical damping member **131**, which is located in an oil bath **111** in the bearing bracket 110. The spring 112 provides through its elastic resistance for maintaining the desired position of the rotor in the housing. The guiding bushing 109 transmits the vibrations of the rotor, which are dependent on the rigidity of the axle and moment of inertia of the rotor, to the damping arrangement 131, which for these vibrations gives a maximum absorption of energy.

The upper lid 104 is provided with a cylindrical projection 113, in which a hollow iron cylinder 114 is embedded. Above this cylinder is a magnet 115 which is connected to the housing by a damping arrangement 116. The stationary pipe systems 117, 118, 119 pass through the projection 113 and ring 114 with an air space therebetween. The tube 118 serves for the introduction of gas and ends somewhere about the middle of the rotor at 120. Tube 119 ends below the upper cover in transverse pipes 121 with openings 122 in their ends. The inner tube 117, which like the tube 119 serves for the removal of gas, extends to the bottom of the rotor and has laterally extending pipes 123 provided with inlet openings 124 at their ends in the neighborhood of the outer rotor wall.

In the bottom of the rotor above pipes 123 is arranged a rigid separating wall 125 with central and peripheral openings 126, 127 respectively. The inside of the housing 101 is provided with spiral grooves 128.

The operation of this centrifuge is as follows:

The driving of the rotor is produced through the operation in the vacuum space of the three phase winding stator, the plate 105 secured to the bottom cover forming the armature of this winding. The stator is fed with current of a frequency which causes the desired speed of rotation of the rotor and produces the corresponding rotating field. After beginning operation asynchronously, the armature is automatically brought into synchronism and the speed of rotation of the rotor corresponds with the frequency of the current. Nothing more is required but this direct and synchronous driving of the rotor, and no connecting elements are necessary which might interfere with the operation of the centrifuge.

In order to obtain a quiet running of the rotor in a gas ultra-centrifuge, it is necessary to operate the rotor in a highly evacuated housing. Such a vacuum is ordinarily maintained through continuous pumping which requires the use of substantial pumping devices, so that such an apparatus is fairly expensive. According to the invention, however, the rotor alone in connection with the corresponding formation of the housing and with the gas withdrawal system serves for sealing the rotor, that is, "active sealing" is produced by which the necessary vacuum is automatically maintained.

The spiral grooves 128 on the inner wall of the housing operate, at sufficiently high peripheral speeds of the rotor, to drive back gas tending to enter into the evacuated flow space from above. The gas conveyed up between the outer rotor wall and the housing wall passes through the air space between the cylinder 114 and the outer pipe 119 into the rotor, and is then driven by centrifugal force to the inner wall of the rotor and passes out through the outlet system 121 and 123. If the rotor is driven at a peripheral speed of more than 400 meters per second, the projections or grooves on the housing walls can be omitted without losing the desired suction effect on the gas.

The path of the gas in the rotor is from the pipe 118 to the pipes 117, 119. This pipe system is held in position at its lower end by an iron core 129 and a corresponding permanent magnet 130 (see FIG. 2). For producing the circulation of gas inside the rotor a temperature variation is not necessary as it is in known constructions, and instead the necessary circulation is produced mechanically. Since the gas finds no resistance in a tangential direction on the separating wall 125 which turns with the rotor, it can, without interference by the centrifugal force, move from the middle of the rotor to the separating wall and maintain the high pressure on this wall. In the other end are located the transverse pipes 121 with the take-off openings 122 directly in the gas stream and produce for the rotating gas a substantial resistance. In this manner the gas, retarded through the transverse arm, loses the speed of circulation, so that a part of the centrifugal force is overcome and the gas pressure at the periphery of the rotor will be smaller at this point. From this pressure difference at the end of the rotor the necessary circulation for the gas flow through the rotor results, so that the device has the further advantage that the energy required for producing the circulation, through mechanical means only, is small.

The lighter gases, those not enriched with heavy components, which undergoes a smaller centrifugal effect, pass through the central opening 126 of the separating wall 125 and are drawn off separately in the bottom part of the rotor through the openings 123 of the transverse arms 124. The backed-up pressure of the rotating gases produced by the escaping movement in the opening of the transverse tubes produces the movement of the separated fraction through the outlet arrangement. The resistance to flow in the transverse tube must be so selected that it allows to pass the same mixture with the optimum ratio. Outside this optimum the prevailing resistance will cause more or less material to flow so that with respect to the passage of gas a predetermined self-stabilizing results. By connecting in series a number of centrifuges in cascade, the transmission of any error in one unit to the next unit of the cascade will be limited, so that such an arrangement gives increased certainty of operation.

Such a centrifuge, having the characteristics described above, can be constructed very simply and of light materials and occupy little space. It has been found that with a peripheral speed of the rotor of more than 330 meters a second the requirement for the driving power is about 100 watts per meter of length, which is much lower than could heretofore be attained.

While we have described herein some embodiments of our invention, we wish it to be understood that we do not intend to limit ourselves thereby except within the scope of the claims hereto or hereinafter appended.

We claim:

1. In a centrifugal separator for gaseous mixtures comprising a vacuum chamber, and an elongated thin-walled hollow rotor, means for mounting the rotor in the chamber to turn about a substantially vertical axis, said mounting means in normal operation being located at the lower end only of the rotor and including means positively positioning the lower end of the rotor at all times during rotation thereof while permitting tilting of the upper part of the rotor about its vertical axis, said rotor and said chamber including at the upper end of the rotor adjacent but non-contiguous bodies one of which is magnetized while the other is magnetic, said bodies being symmetrical about the vertical axis of the rotor and maintaining the rotor axis substantially vertical, said bodies being annular rings, and means forming three separate passages for the introduction of the gaseous mixture and the removal of the separated components respectively extending from the outside of the rotor through said rings into the rotor.

2. A device as claimed in claim 1 in which said mounting means comprises an elastic axle.

3. A device as claimed in claim 2, comprising a bushing rotatably holding said axle, and an oil-damped carrier holding said bushing.

4. In a device as claimed in claim 1, said mounting means including a carrier, means mounting the carrier for movement, and means to damp such movement of the carrier.

5. In a device as claimed in claim 1, damping means mounting one of said bodies on the chamber.

6. In a device as claimed in claim 1, means to drive the rotor comprising means to produce a rotating electric field and a steel body carried by the rotor within said field.

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