United States Patent [19]

Madsen

[11] **3,902,658**

[45] **Sept. 2, 1975**

[54] **ULTRA CENTRIFUGAL CASCADE**

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[73] Assignee: **Allmanna Svenska Elektriska Aktiebolaget,** Vasteras, Sweden

[22] Filed: **June 1, 1972**

[21] Appl. No.: **258,823**

[30] **Foreign Application Priority Data**

June 7, 1971 Sweden 7308/71

[52] **U.S. Cl.** **233/11;** 233/18; 233/27

[51] **Int. Cl.** **B04b 15/02**

[58] **Field of Search** .... 233/11, 1 R, 1 C, 17, 18, 233/23 R, 23 A, 24, 27, 28

[56] **References Cited**

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Primary Examiner—George H. Krizmanich
Attorney, Agent, or Firm—Kenyon & Kenyon Reilly Carr & Chapin

[57] **ABSTRACT**

An ultra centrifuge cascade has centrifuge cascade groups mounted between horizontal upper and lower plates and enclosed by a common containment vessel for all of the centrifuges, the latter being positioned vertically and parallel to each other between the plates, all piping being also enclosed by the common or single containment vessel.

9 Claims, 6 Drawing Figures

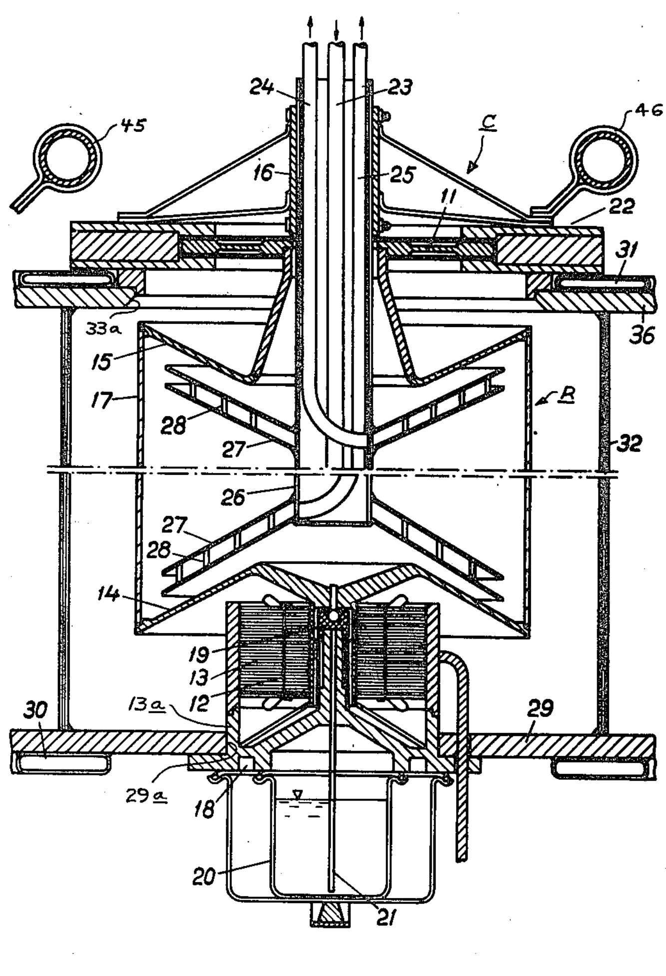


Fig.1

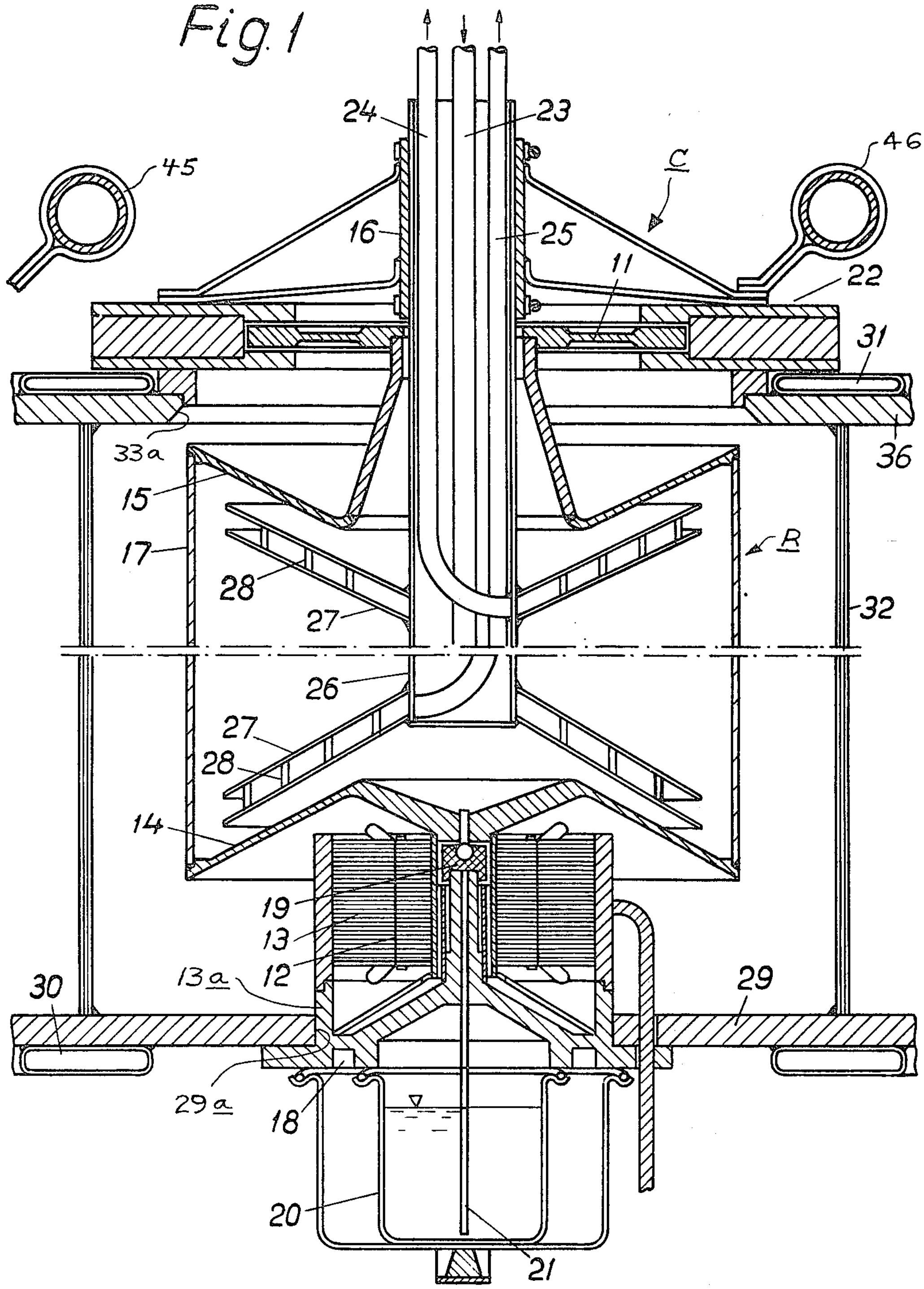

24
23
45
46
C
16
25
11
22
31
33a
36
15
17
R
28
32
27
26
27
28
14
19
13
12
13a
30
29
29a
18
20
21

Fig.2

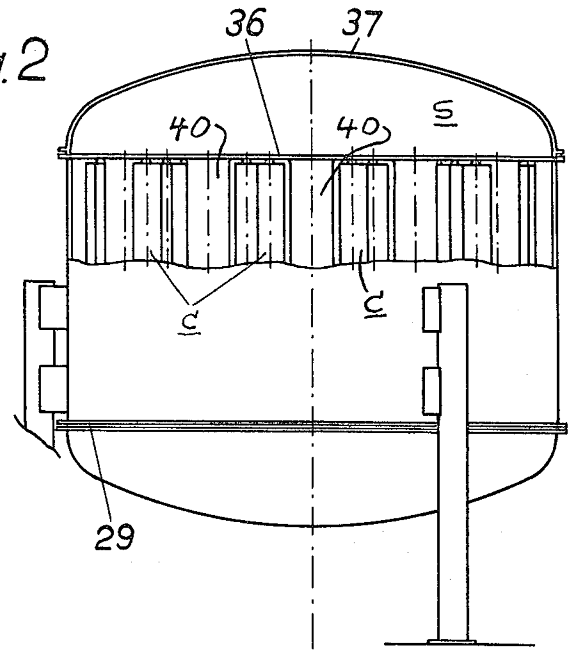


Fig.3

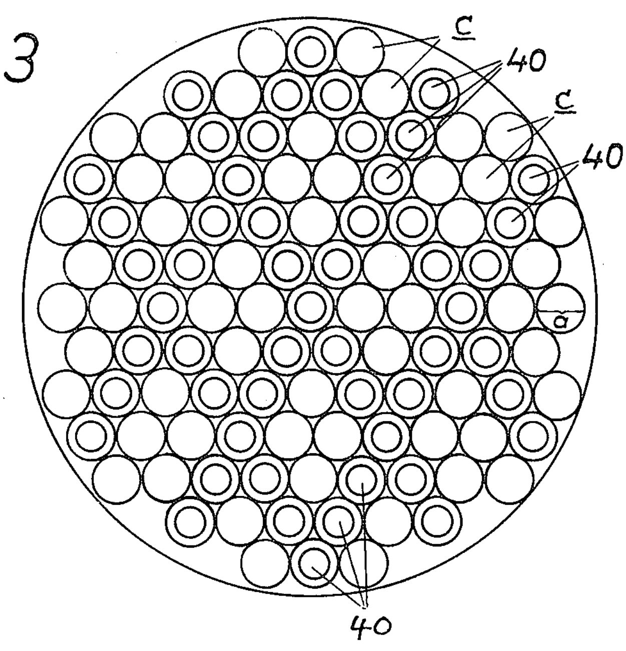


Fig. 4

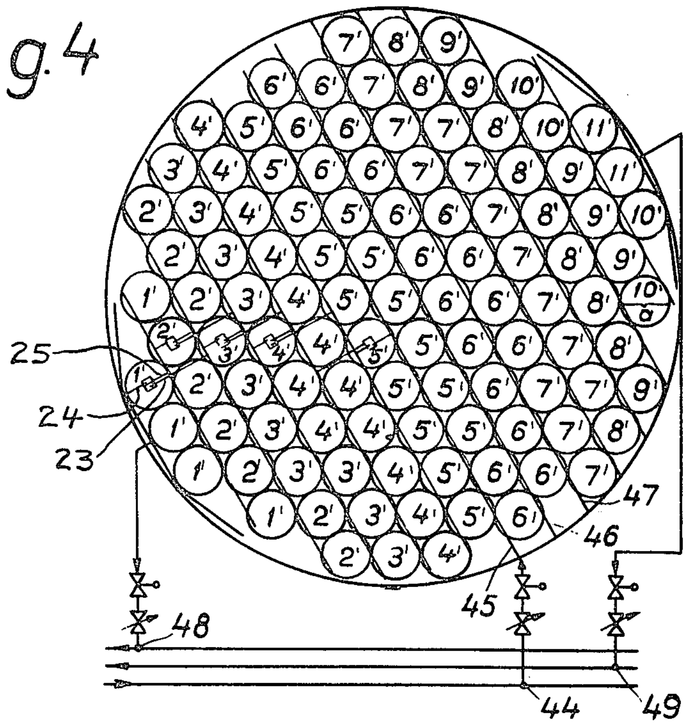


Fig. 5

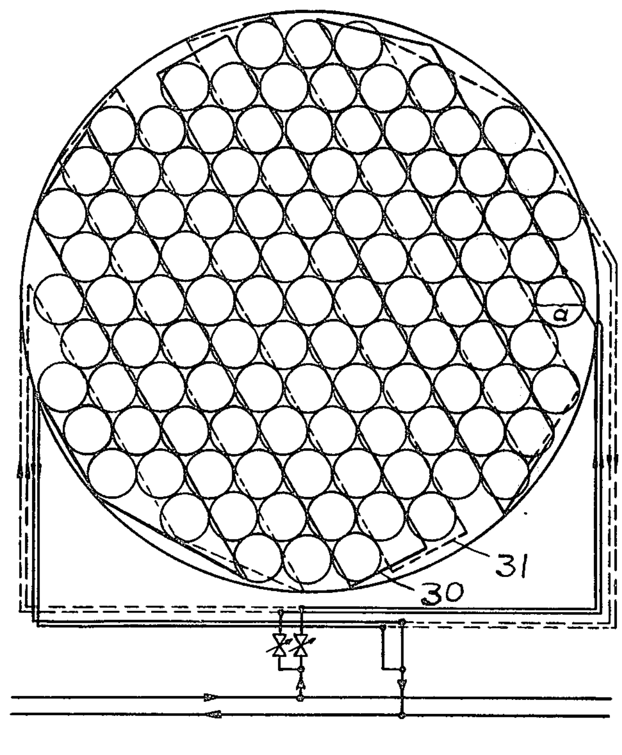
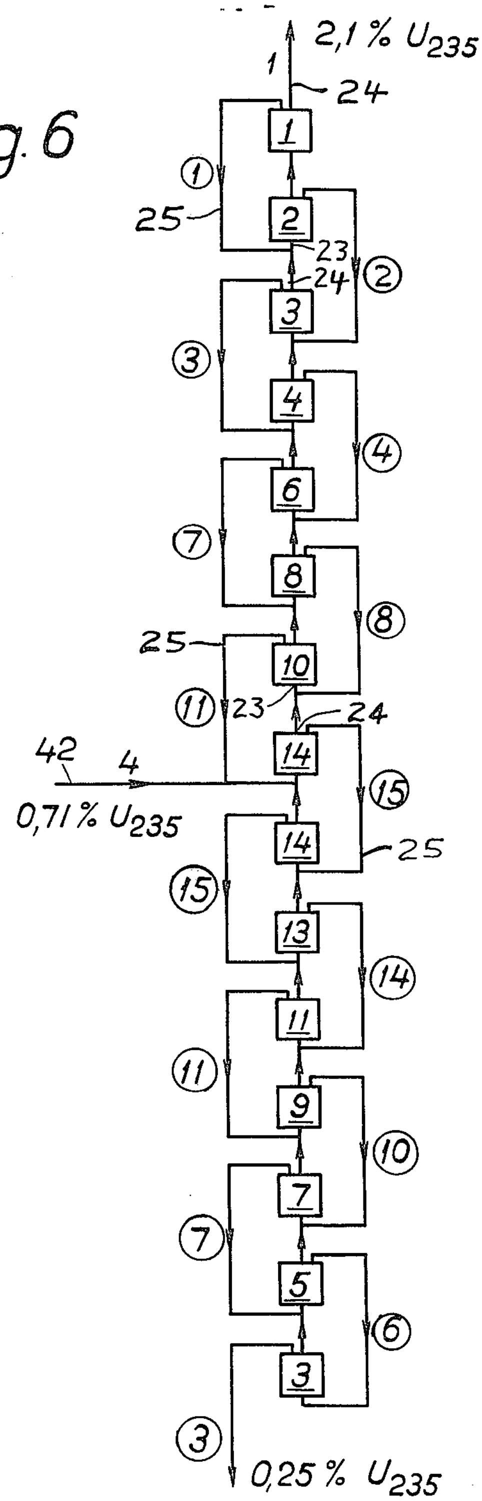


Fig. 6


2,1 % U235
1
24
1
1
25
2
23
24
2
3
3
4
4
6
7
8
8
25
10
11
23
24
42
4
0,71 % U235
14
15
14
25
15
13
14
11
11
9
10
7
7
5
6
3
3
0,25 % U235

ULTRA CENTRIFUGAL CASCADE

The present invention relates to an ultra centrifugal cascade, complete or partial, in a common outer vessel.

Such cascades are already known (see German Pat. No. 1,191,750) but it is a problem to achieve a stable construction of the various centrifuges in a cascade adjacent each other and to protect the various centrifuges against damage if an adjacent centrifuge breaks down, at the same time avoiding complicated pipe-laying, etc. for transfer and cooling tubes.

The present invention provides a solution of these and other similar problems and is characterized in that several, possibly all the ultra centrifugal rotors and possibly also their drive members are attached in common upper and lower perforated plates arranged inside an outer vessel common for the centrifuges. Such a construction utilizes the space inside the vessel to the full while at the same time providing satisfactory stability in relation to the vessel and between the centrifuges. The arrangement of the centrifuges in groups, with intermediate protection in the form of protective plates or rows of protective tubes, is simple and the mutual configuration of the groups can be selected in many different ways without the need for reconstruction. The arrangement of the centrifuges in this way in a common vessel also means that the wall thickness of protective plates and casing plate will be as great as the plate thickness which would be required to protect a single centrifuge and, therefore, the arrangement according to the invention also involves a considerable saving in material.

The accompanying drawings show presently preferred modes for carrying out the invention.

FIG. 1 is a section through a centrifuge,

FIG. 2 a cascade vessel, partly exposed,

FIG. 3 a cross-section through a cascade vessel,

FIG. 4 a pipe-laying diagram for a cascade and

FIG. 5 a cooling system for a cascade.

Finally, FIG. 6 shows a cascade connection diagram.

FIG. 1 shows a single, vertical centrifuge C which is part of a cascade (see below). A hollow rotor consisting of a cylindrical part **17** and two end pieces **14** and **15**, is journalled in an upper perforated plate **33** via one of its perforations **33***a*. The rotor is driven by an asynchronous motor (rotor **12**, stator **13**) or other drive means and the lower part of the non-rotative motor box **13***a* is attached in a lower perforated plate **29** (or grid plate **29**) via one of its perforations **29***a*. Lubrication is arranged via a lubricant storage space in a depending chamber **20** containing a lubricant wick **21** extending to the lower rotor bearing **19**. The upper and lower perforated plates and **29**, respectively, are held together by support pipes **32**. The centrifuge rotor is journalled at its top in an upper electromagnetic bearing **22** supported on the upper plate **36** via its upper surface.

The gas or isotope mixture to be separated is introduced through the pipe **23**, possibly coming from a previous centrifuge or group or centrifuges in a cascade, and the concentrated gas is removed through the conduit **24**, the depleted gas being removed through the conduit **25**. The gas is withdrawn from the interior of the rotor R through exhausts **27** and **28**. The motor stator **13** is attached in the motor box **13***a*, the latter having a flange **18** attached to the lower perforated plate **29** via its lower surface. An upstanding tube **16** connected to the top of the bearing **22**, houses the conduits **23, 24** and **25** and mounts the exhausts **27** and **28** non-rotatively via the tube **26**.

FIG. 2 shows a vessel for a centrifugal cascade with the various centrifuges C attached in the upper and lower perforated plates **36** and **29**, respectively, and the whole cascade arranged inside the cylindrical containment casing **37**. The individual centrifuges are shown at C, vertically positioned and parallel to each other, the casing's axis being vertical.

FIG. 3 shows in cross-section a centrifugal cascade such as illustrated by FIG. **2**, having rows of protective vertical tubes **40** which separate groups of the centrifuges C from other groups of these centrifuges so that a break down of one centrifuge will not cause any damage except possibly to those centrifuges within the same limited group within the cascade, the others being protected by the row of protective tubes **40**. The rows of protective tubes may be replaced by protective plates. This means of protection gives the advantage that whereas a protection was previously required around each centrifuge, such protection is now sufficient only at the outer walls of the vessel and/or between groups of centrifuges, which is a considerable saving in material.

FIG. **6** shows diagrammatically the invention used as an ultra centrifugal cascade in which U_{235} - 0.71 percent is to be separated so that concentrated U_{235} is obtained. U_{235} is also contained in the depleting part. Unseparated gas (or isotope mixture) is introduced at **42** and initially separated in fourteen centrifuges operating in parallel as indicated by the upper box **14**, after which the partially enriched gas mixture is fed in the enriching direction (upwards in the figure) to the next "layer" or group in the cascade which has ten centrifuges operating in parallel as indicated by the upper box **10**. The number is fewer here because the quantity of gas is less as indicated by the encircled numerals representing flow quantity. Depleted gas is carried at **24** to the nearest preceding group where it is introduced at **23** and enriched again. At the end of the enriching process only one centrifuge is in operation, as can be seen from the upper box **1**, and the enriched gas contains 2.1 percent U_{235}. It is seen that depleted gas in all the groups is led to a preceding centrifuge in the cascade direction.

Depleted gas, 0.25 percent U_{235} is removed from the three centrifuges, represented by the lower box **14**, furthest away in the depletion direction, which operate in parallel.

The underlined number in each of the boxes represents the number of centrifuges of FIG. **1**, connected in parallel to form a cascade stage in all of the above.

FIG. **4** shows the pipe system for gas transfer between the various cascade groups, in principle in accordance with FIG. **6**. Natural UF_6 is supplied to a cascade at **44** and from this branching point the gas mixture is introduced to common pipe conduits (main conduits) for several centrifuges within the same group. The various groups (see FIG. 6) are designated **1'** to **11'** in FIG. **4**, one figure denoting centrifuges belonging to the same group but in this case not indicating groups of centrifuges as in FIG. **6**. **1** is the group (five centrifuges in the case shown) located furthest away in the depleting direction and **11** (two) is the group in the corresponding enriching direction.

From the inlet point **44** the gas is supplied to sixteen centrifuges operating in parallel and in the enriching direction the partically U_{235} enriched gas is taken out through conduits 46 and 47, connection details not shown but being the same as in the depleting direction and shown at 23, 24 and 25 in that instance. In this way all complicated pipe-laying is avoided using a large number of pipes, and all pipes are located within the casing 37. This means that any leakage at pipe joints will only have any effect inside the cascade vessel.

Depleted gas is removed at 48 from group 1, enriched gas at 49 from group 11.

The cooling system is shown in FIG. 5 and consists of a number of horizontal tubes 30 and 31 which run in contact with the upper and lower horizontal perforated plates 29, 36 (see FIG. 1), not vertically along the length of the centrifuges between the perforated plates. The number of cooling systems is thus reduced to one per cascade instead of requiring one per centrifuge.

Preferably only those centrifuges lying nearest the cascade inlet are provided with perforations for vertical passage of the tubes 30 and 31 through the perforated plates 29 and 36. A pressure gauge is suitably introduced in the outer vessel to indicate if one or more of the centrifuges stops functioning. The reason is that a centrifuge unit which has stopped functioning gives greater pressure leakage than one which is rotating. The upper perforated plate 36 has an aperture, or perforation, 33a for each centrifuge unit C, said aperture having a diameter slightly greater than that of the centrifuge cylinder, so that the cylinder can be passed through the aperture. The magnetic bearing stator of the centrifuge unit (at 22) has greater diameter than said aperture and is firmly bolted to the upper side of the upper plate (FIG. 1). The tube or holder 16 for the stationary inner parts of the centrifuge unit is formly bolted to the upper side of the perforated plate via the said magnet bearing stator. The driving motors (12, 13) of the centrifuge unit, bearing casing (18) and bearing box are attached to said lower perforated plate 29, and are removable via the aperture 29a (FIG. 1). The vertically positioned centrifuge units are suitably arranged in transverse, parallel rows (FIG. 3) in the cascade vessel and are connected so that the centrifuge units in one and the same row process uranium hexafluoride having almost the same concentration. Collection tubes (46,47) for uranium hexafluoride (FIG. 4) having approximately the same concentration are arranged in parallel with said rows. The shortest of said rows on one side of the cascade vessel (11, FIG. 4) comprises one or more centrifuge units which process uranium hexafluoride of the lowest concentration and a conduit from these units leads out through the wall of the cascade vessel to the outer main conduit for depleted uranium (49, FIG. 4). The short row (1) opposite said row (11) is connected in similar manner to the outer main conduit for enriched uranium (48 FIG. 4) and at least one of the longer rows (3 – 8) positioned substantially centrally between said two short rows, which are diametrically opposite to each other, comprises a number of centrifugal units which are connected by pipes 45 to the outer main conduit for the supply of uranium hexafluoride having the isotope content of the starting material.

The cascade containment vessel 37 forms internally enclosed spaces above and below the horizontal perforated plates 36 and 29, one being shown at S in FIG. 2. The necessary piping for the gas is enclosed in the upper one of these spaces, above the upper plate 36, as shown, the water-cooling pipes 30 and 31 being laid in contact with the plates. Thus the one containment vessel encloses everything presenting a hazard to the environment. Each centrifuge has its own individual bearing system and driving motor, each forming a unit that can be installed in any of the perforations of the perforated plates, in any grouping desired. These perforations are formed as pairs of perforations which are axially aligned vertically and to which the rotor bearing and motors of the centrifuges are applied removably.

The invention can be varied in many ways within the scope of the following claims.

I claim:

1. An ultra centrifugal separator comprising a plurality of ultra centrifugal vertical rotors clustered together, upper and lower plates positioned above and below said rotors and forming upper and lower perforations aligned with the rotors in each instance, said rotors each having a top end piece forming a hollow extension having an open top and porjecting upwardly at least partially into the one of said upper perforations with which the rotor is aligned in each instance, bearings mounted by said upper plate and journaling said rotors via their said extensions in each instance and with their said open tops unobstructed, said rotors each having a closed bottom piece, motors mounted by said lower plate in said lower perforations and journaling and driving said rotors in each instance via their said bottom pieces, and a single protective containment vessel for said separator and having a side wall peripherally surrounding all of said clustered rotors and a top wall covering said upper plate and forming an enclosed space above said upper plate and the open tops of said extensions.

2. The separator of claim 1 in which a pipe system positioned in said enclosed space above said upper plate interconnects said rotors via the open tops of their said extensions, for fluid transfer from one rotor to another.

3. The separator of claim 2 in which said system connects groups of said rotors for parallel operation, and connects said groups for casade operation with said groups formed by decreasing numbers of rotors in the cascading direction down to a last group having a minimum of at least one rotor, said vessel having a cylindrical side wall and said last group being formed by said system so it is next to said side wall.

4. The separator of claim 2 in which said system connects groups of said rotors for parallel operation, and the separator includes means for protectively separating said groups, each from adjacent groups.

5. The separator of claim 4 in which said means comprises rows of vertical tubular elements.

6. The separator of claim 1 in which said upper perforations have diameters greater than that of said rotors, and said bearings overlap said upper plates peripherally around said upper perforations and are removably fastened to said upper plate.

7. The separator of claim 1 in which said motors have flanges overlapping said lower plate peripherally around said lower perforations and are attached to said lower plate.

8. The separator of claim 1 in which said containment vessel has a bottom wall covering said lower plate and forming an enclosed space therebelow, and coolant pipes extend horizontally in contact with said horizontal upper and lower plates adjacently to said perforations for the extent of said rotors.

9. The separator of claim 8 in which said coolant pipes are positioned on the upper and lower sides of said upper and lower plates respectively, and a pipe system is positioned in said enclosed space above said upper plate and interconnects said rotors via the open tops of their said extensions, said coolant pipes and said pipe system being thereby separated from said rotors by said horizontal plates and said separator in its entirety being protectively enclosed by said single containment vessel.

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