Dec. 17, 1963 AKE L. NYBERG 3,114,413

ROTARY REGENERATIVE HEAT EXCHANGER

Filed July 8, 1960 4 Sheets-Sheet 1

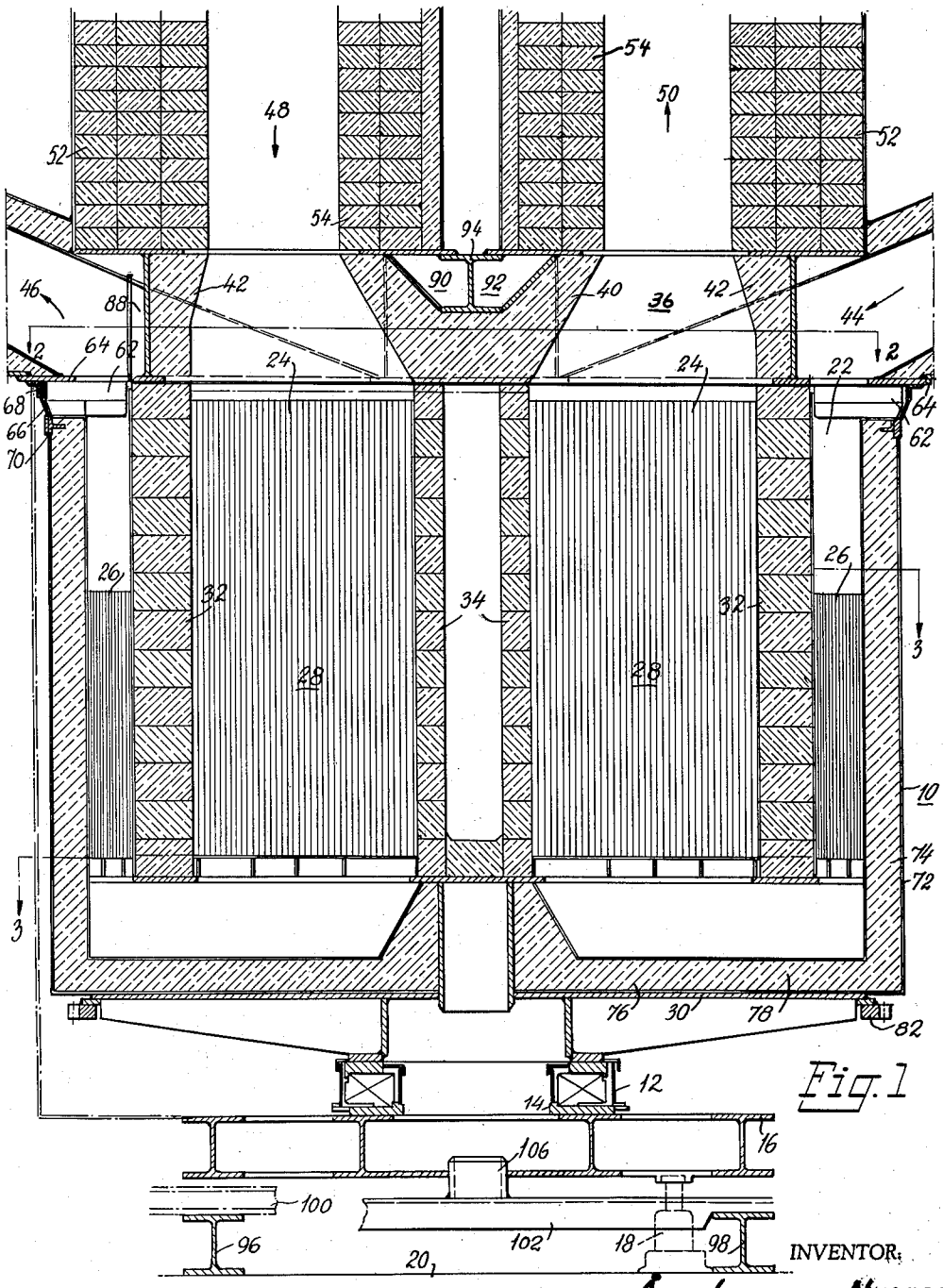



Fig. 1

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ROTARY REGENERATIVE HEAT EXCHANGER

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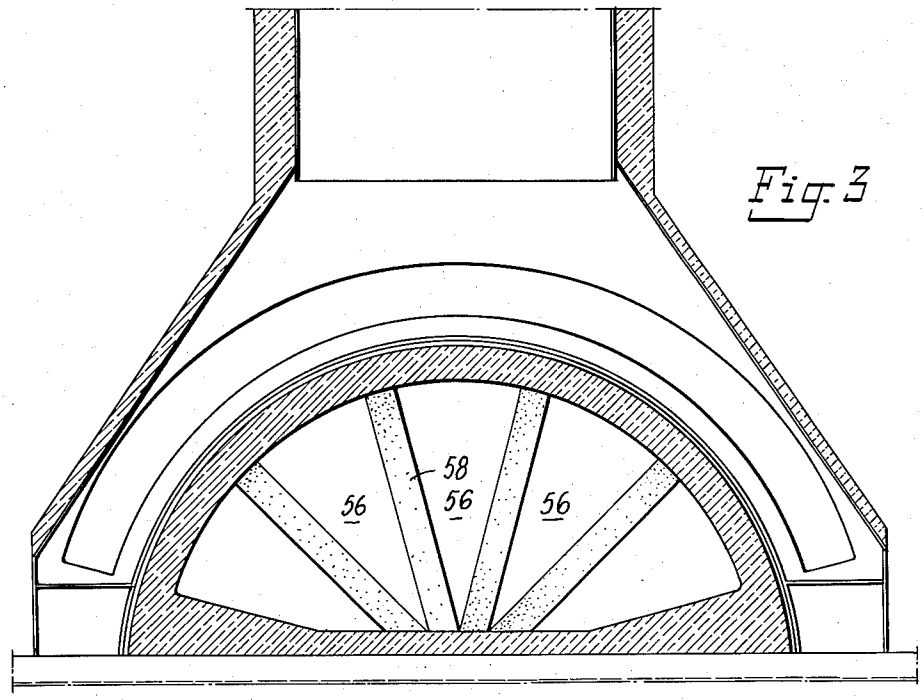



Fig. 3

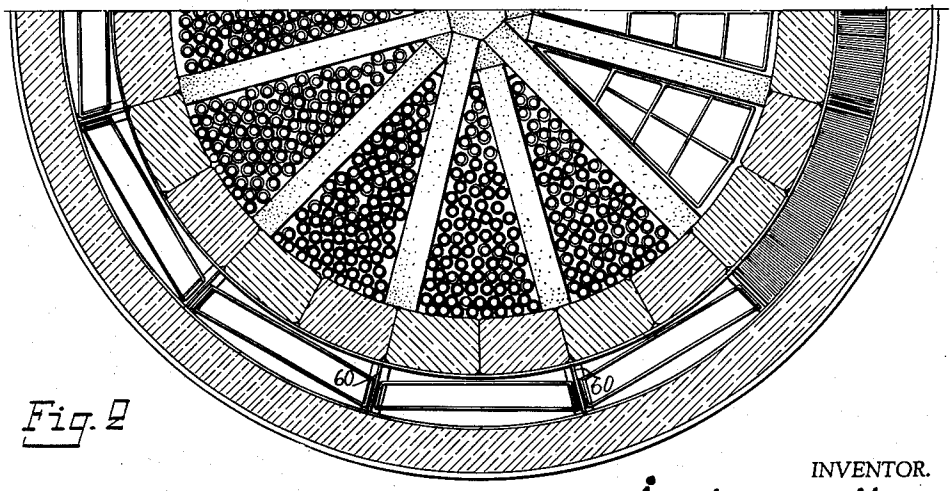



Fig. 2

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ROTARY REGENERATIVE HEAT EXCHANGER

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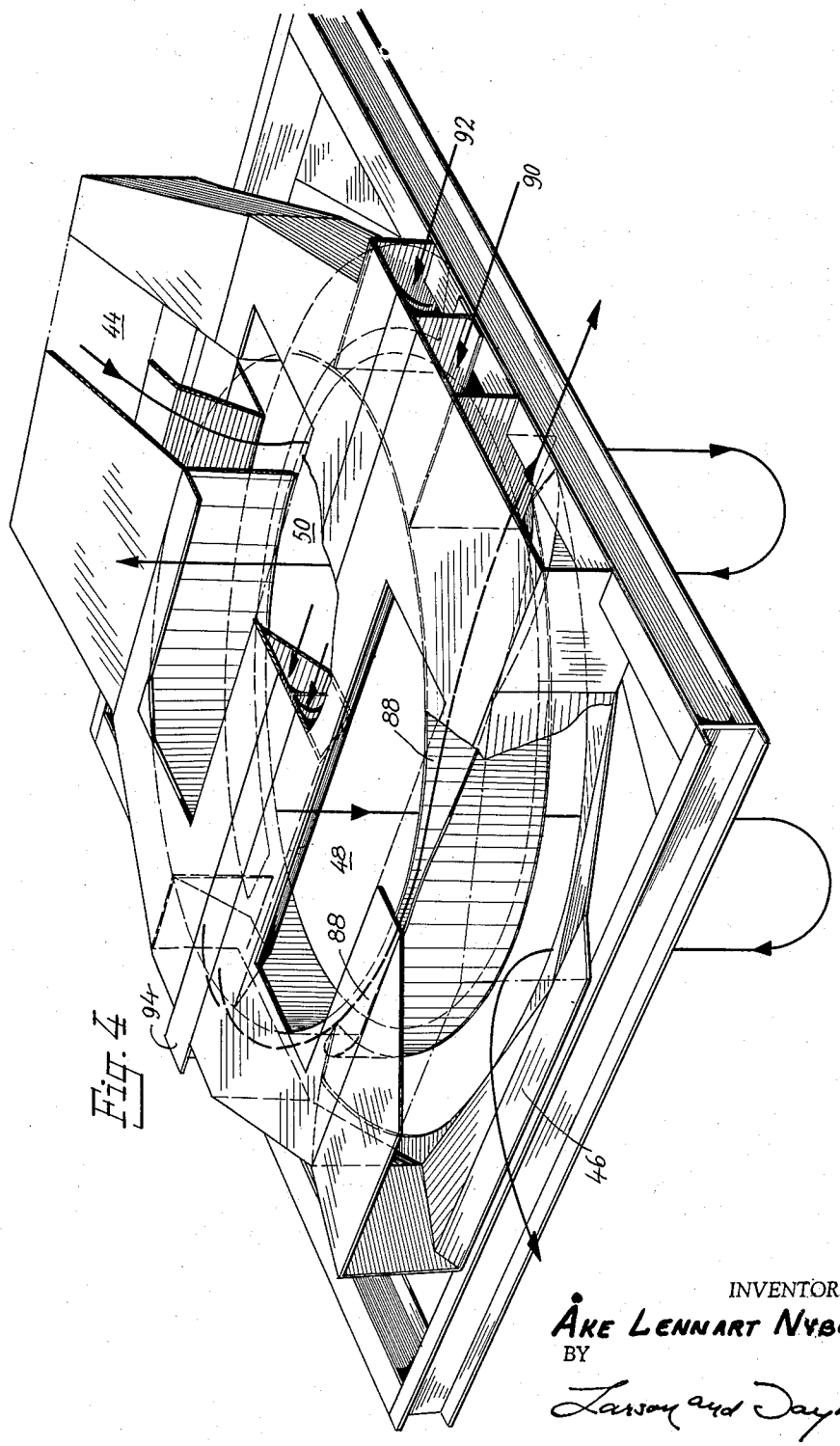



Fig. 4

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ROTARY REGENERATIVE HEAT EXCHANGER

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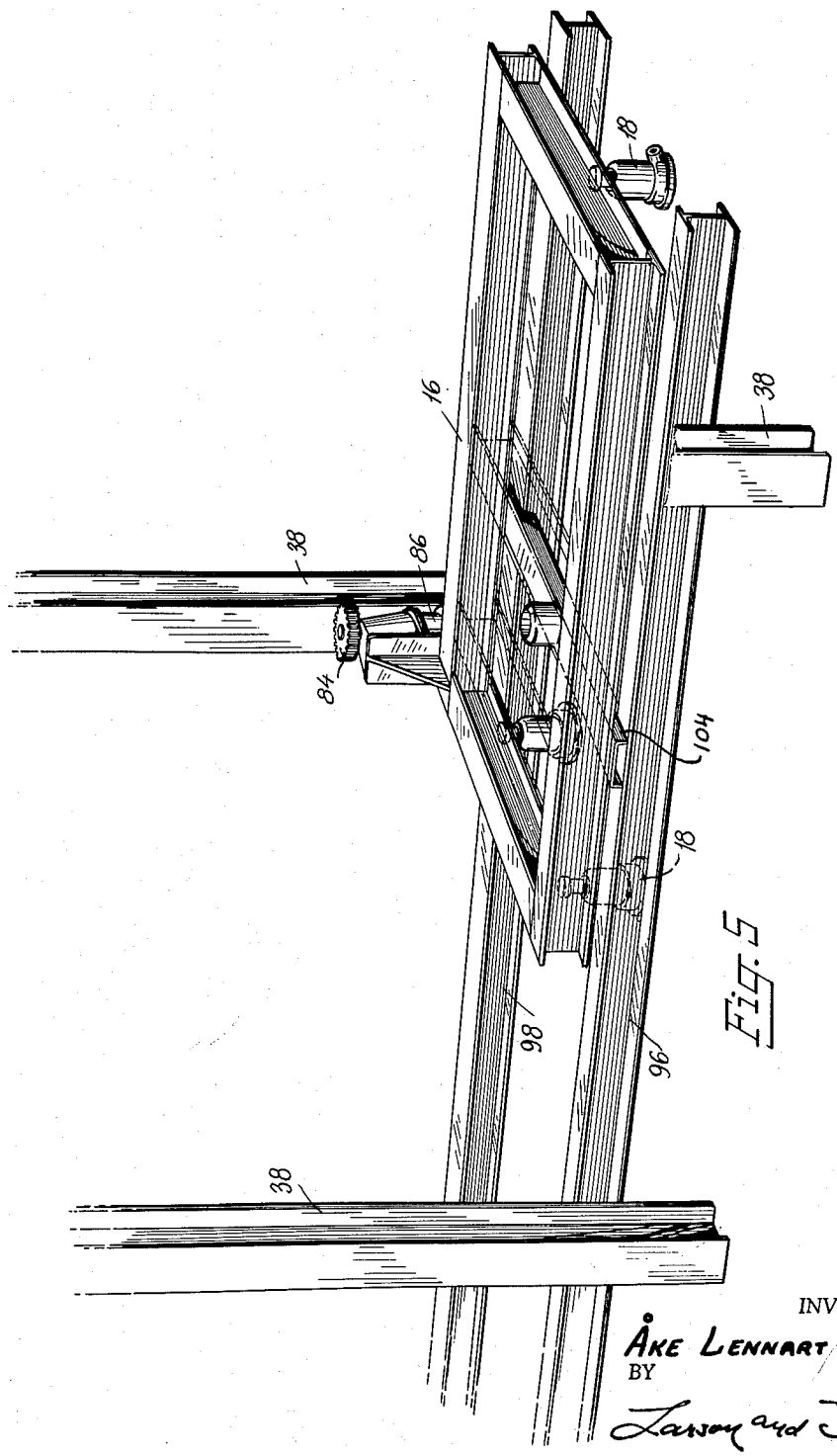



Fig. 5

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# 3,114,413
# ROTARY REGENERATIVE HEAT EXCHANGER

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11 Claims. (Cl. 165—7)

The present invention relates to rotary regenerative heat exchangers with a rotor divided by means of annular intermediate walls into an outer and an inner zone and a stationary upper portion located above the rotor and provided with inlet and outlet ducts for a heat imparting medium and with inlet and outlet ducts for a heat absorbing medium.

By this known design of heat exchanger it was intended to eliminate important defects in heat exchangers of the rotary regenerative type, viz. to provide for very much improved seals between the rotor and the casing on both sides of the heat exchanging media. However, the conventional sealing problems between both ends of the rotor and the end plates of the casing still remain and it has not hitherto been taken into consideration that the stationary casing is not required.

It is true that in order to obtain the greatest efficiency in heat exchangers the sealings must be well adapted so that they follow the changes of form which arise between the rotor and the casing during operation.

Particularly in heat exchange at high temperatures such adapting, however, will be difficult to achieve so that for such reason more or less complicated means have been proposed in order to closely follow the change of form between the rotating and the stationary parts of the heat exchanger above and below the same.

In order to simplify the construction flow in counterdirection between the heat exchanging media has been utilized so that by provision of a cold and a hot end in the heat exchanger the sealing difficulties are reduced.

According to the present invention we provide a rotary regenerative heat exchanger having a rotor divided by means of an annular intermediate wall into an outer and an inner zone and a stationary upper portion located above the rotor and provided with inlet and outlet ducts for a heat imparting medium and with inlet and outlet ducts for a heat absorbing medium which is characterized in that the inlet duct for the heat imparting medium is adapted to supply the heat imparting medium to the inner zone of the rotor and the outlet duct is adapted to discharge the heat imparting medium from the outer zone of the rotor and further characterized in that the inlet duct for the heat absorbing medium is provided to supply the heat absorbing medium to the outer zone of the rotor and the outlet duct is adapted to discharge the heat absorbing medium from the inner zone of the rotor, whereby the flow direction between the media in respective zones is performed in counterdirection.

A further important characteristic feature of the invention is that all the necessary sealing means between the rotary and stationary parts of the heat exchanger are located at one and the same end of the heat exchanger. By this means the sealing problems are greatly simplified and further the difficulties are eliminated as regards effecting all desired adjustments under varying conditions of operation in order to maintain best possible sealing action. In such a design according to the invention the sealing means may be assembled into one single common plane by means of which simple cooperating adjustment means are made possible for adapting the sealing clearances.

Particularly the invention is suitable for heat exchangers operating at high temperatures and incorporating high



temperature resistant refractory regenerative material disposed in the inner zone and metallic regenerative material disposed in the outer zone of the heat exchanger, preferably so adapted that substantially one and the same mass flow is obtained in the respective zones.

The invention is particularly applicable to heat exchangers operating at high temperatures in which according to a suitable design in accordance with the present invention the stationary casing may be completely dispensed with as compared with conventional preheaters of the rotary regenerative type in which a stationary casing comprises one of the principal components. In such a construction according to the invention the rotor may be supported from its lower end. A preferred construction of this kind according to the invention consists in mounting on the floor a stand carrying a bearing for the rotor, said bearing for instance being constructed according to the wire ball bearing principle. In this construction rotation of the rotor may be effected in a simple manner by a peripheral drive, for instance so arranged that the rotor at its circumference is provided with a tooth or pin rack driven by a motor through appropriate gearing.

In such an embodiment according to the invention the rotor can be axially moved upwards into a very effective sealing position in relation to a stationary portion above the rotor and comprising a horizontal disposed disc shaped structure supported by pillars or the like. The stationary upper portion comprises a frame work which in the outer zone of the heat exchanger consists of metallic material and in its inner zone consists mainly of high temperature-resistant refractory material. Both zones are preferably divided into radially spaced pairs of through flow openings serving as inlets and outlets for respective media.

In order to accurately adjust the location of the rotor in proper sealing position in relation to the stationary disc shaped sealing arrangement, the rotor is preferably supported by vertically adjustable lifting means, for example, by hydraulic jacks. Particularly in heat exchangers for operation at high temperatures it is convenient to construct the rotor so that it is exchangeable, or at least removable for inspection. An effective design for meeting this objective may according to the invention consist of a frame work structure supported by the adjustable jacks, which frame work serves as a foundation for the bearing means upon which the rotor is mounted. Below said supporting frame-work for the rotor, rail means may be disposed, the said rail-means being provided with rollers or the like on to which the said frame work carrying the rotor may be lowered and upon which it may be displaced.

For a more close understanding of the invention and the improvements and advantages obtained in connection therewith, reference may be had to the accompanying drawings which show by way of example a suitable embodiment of the invention.

In the drawings:

FIG. 1 shows in an axial section of a heat exchanger constructed according to the principle of the invention

FIG. 2 shows a partial section along the plane 2—2 of FIG. 1.

FIG. 3 shows in same manner a partial section of a section viewed from above according to the lines 3—3 of FIG. 1.

FIG. 4 shows in perspective view a stationary upper portion covering the rotor according to the illustrated example of a heat exchanger according to the invention.

FIG. 5 shows also in perspective view suitable means for supporting the rotor.

Referring to the drawings the rotor **10** is supported at its lower end by a bearing **12**, the bottom bearing portion **14** of which rests on a horizontal support **16** which,

as illustrated, consists of a frame work. This support, in its turn, is carried by vertically displaceable means which in the example illustrated consists of jacks **18**. These jacks due to the temperature conditions, may be designed as mechanical means, viz. as jack screws, resting upon a floor **20**.

The rotor **10** carried by the bearing **12** has an outer zone **22** and an inner zone **24**, the outer zone embodying mainly metallic material such as plates or the like **26**, and the inner zone embodying mainly refractory material, preferably ceramic material **28**.

The outer portion of the rotor, which forms the carrying portion for the regenerative masses performing the heat exchange, is mainly cup-shaped and its bottom portion is denoted **30**.

Between the inner and the outer section of the rotor a partition wall **32** is disposed, which in the example shown consists of refractory, preferably ceramic, material. The central portion **34** of the rotor is constructed in the same manner as the partition wall **32**.

Above the rotor there is a stationary structure **36** provided with inlet and outlet ducts for the heat exchanging media. This stationary structure comprises in the illustrated embodiment a frame work carried by means of supporting pillars **38** projecting upwardly from the floor **20**. The upper portion **36** may be provided, as shown, with appropriate covers **40**, **42**, respectively, made of high temperature-resistant material and of similar construction to the central portion **34**. The partition wall **32** of the rotor is built up of similar material. The inlet duct **44** for the air, which is to be heated, and the outlet duct **46** for the cooled gas may consist of plates while the inlet duct **48** for the hot gas and the outlet duct **50** for the heated air may consist of ceramic or other suitable material **52** and **54**, respectively.

According to the invention seals are only necessary on the upper side of the heat exchanger located between the upper end of the rotor **10** and the lower end of the stationary upper portion **36**. Characteristic of the invention, therefore, is that these sealing means are assembled into a common plane. The rotor **10** is according to conventional design divided into sector shaped chambers **56** by means of radially disposed partition walls. These partition walls **58**, **60** consists, in the inner zone **24**, of high temperature-resistant material **58**, such as refractory ceramics, and in the outer zone **22** of radially disposed plate walls **60**. The radial seals **62** in the outer zone **22** preferably consist of strips or the like of metallic material, attached to the upper end of the plate walls **60**, and sweeping over adjacent annular circumference **64** of the lower end of the stationary portion **36**. The adjacent ends of the walls **32**, **34** and **40**, **42**, respectively, formed by high temperature-resistant material are surface ground in order to conform to each other in a very precise manner and to give improved sealing and reduction of leakage between the inner and outer zones of the heat exchanger.

By arranging the seals between the inlets and outlets for the media in a common plane the difficulties of sealing are mostly eliminated as compared with a heat exchanger having a rotor located in a casing provided with end walls and a shell encircling the rotor. The invention is further characterised in that the cold medium, which is to be preheated, enters an outer section of the rotor and after flowing down into this outer section is discharged by flowing upward through the inner section of the rotor. According to the same principle the hot medium flows down in the inner section of the rotor and is returned upwardly in the outer section of the rotor. It will be noted that exactly the same kind of flow is maintained in corresponding sections of the stationary portion of the heat exchanger.

It will also be noted that at the annular partition wall **32**, **42** the inner peripheral leakage clearances connect in this construction the hot gas stream with the cold gas



stream and the cold air stream with the hot air stream, so that thereby any leakage between the said clearances is a more internal occurrence.

The only peripheral sealing member, which according to the invention may be necessary, can be constructed in the form of sealing strips **66** disposed between the outer periphery of the rotor **10** and corresponding lower end of the stationary upper portion **36** of the heat exchanger. By way of example the said peripheral sealing member for elimination of any leakage clearance may consist of sealing strips fastened to an annular protrusion **68** on the lower end plate **64** of the stationary portion **36** and sweeping over the upper part of the side wall of the rotor **10**. Preferably the upper rotor end may be provided with a wear shoe **70**. Alternatively, the annular strip may be attached to the end of the rotor to sweep over the stationary end plate or a protrusion thereof.

As is evident from the foregoing, in the heat exchanger according to the invention the higher temperature is directed to the inner section of the exchanger and the cooler temperature to the outer section. In this way, it is ensured, as far as possible, that the heat exchanger, particularly the rotor thereof, is thermally separated from the ambient. This thermal separation can further, as is shown, be improved by making the outer jacket **72** of the rotor double walled. For the same reason of temperature protection a similar design can be applied to the bottom portion **30** of the rotor in order to further protect the means for supporting and driving the rotor. In the double walled interspace **74**, **76** an insulation **78** of temperature resistant material may be applied. According to the said preferred embodiments of the heat exchanger according to the invention it is not necessary to utilise a stationary casing jacket but in cases when such may be required such one is easily and inexpensively applied in the form of a plate shell **80** or the like as shown.

For driving the rotor a peripheral gear or pin rack drive can be utilized. In the latter case the lower portions **30** of the rotor is provided with an outer rack **82** by means of which the rotor is caused to revolve by an inner gear **84** of a prime mover **86** attached to a stand of the rotor. This is only to be taken as an example, since the invention in its varied forms thereof is not principally dependent on this particular kind of drive or the location thereof.

On the outer side of the refractory arcuate separation wall, which in the stationary upper portion **36** separates the inlet **48** and the outlet **46** of the heat emitting medium, a cooling jacket **88** is provided for a cooling medium passing through this cooling jacket along the whole arcuate length thereof.

The supporting beam **40**, which bridges the stationary portion **36**, can be provided with cooling channel means which in the example illustrated consists of a pair of channels **90**, **92** one on either side of the supporting beam **94**. The cooling medium, for instance air, is supplied for passing through the supporting beam **40** from one end thereof to the other, whereafter the cooling medium is caused to pass through the arcuate cooling jacket. If the cooling medium consists of air, preferably the said air is passed into the outlet **50**.

It will be evident that such a cooling arrangement is not required on the air side of the heat exchanger, or generally, on the side thereof for through flow of the medium intended to be heated.

As is shown further, the floor or foundation **20** is provided with rails **96**, **98** which may support rollers **100** or the like when it is desired to replace the rotor **10**. The rotor with its bed, when lowered by the jacks, may be rolled along the rails for repairs or replacement. The rails **96**, **98** are further provided with a centering device **102** for the support of the rotor on the site of use. The said means consists of an iron profile **104** connected by means of bolts to the rails **96**, **98** and provided with a guiding shaft engaging the rotor support **16**. Before the replace-

ment of the rotor this centering may be removed which is easily performed.

What is claimed is:

1. A rotary regenerative heat exchanger comprising a rotor, said rotor including a cup-like shell having a circumferentially continuous side wall portion and an end wall, the cup-like shell being open at the opposite end, a circumferentially continuous partition wall mounted within said shell in radially spaced relation to said side wall portion of said shell and in axially spaced relation to said end wall portion of said shell, whereby to separate the interior of said shell into an inner core chamber and an outer annular envelope chamber surrounding said core chamber and communicating therewith at the closed end, heat exchanging material in said chambers providing a multiplicity of channels for flow of gaseous fluids in U-shaped paths of flow through said chambers from openings at the ends thereof remote from said end wall portion, and a stationary portion cooperating with said rotor and having duct work providing separate passages for flow of two different gaseous fluids to and from the chambers of said rotor and said passages having openings located to cooperate with the open end of the rotor, said stationary portion having inlet and outlet ducts for a heat imparting medium and inlet and outlet ducts for a heat absorbing medium, the inlet duct for the heat imparting medium positioned adjacent the inner core chamber to provide a passageway for the heat imparting medium from the inlet duct through the inner core chamber, the outlet duct for the heat imparting medium positioned adjacent the outer envelope to provide a passageway for the heat imparting medium from the outer envelope through the outlet duct, the inlet duct for the heat absorbing medium positioned adjacent the outer envelope to provide a passageway for the heat absorbing medium from the inlet duct through the outer envelope, and the outlet duct for the heat absorbing medium positioned adjacent the inner core chamber to provide a passageway for the heat absorbing medium from the inner core chamber through the outlet duct.

2. A heat exchanger according to claim 1 wherein said rotor is rotatably mounted on a bed.

3. A heat exchanger according to claim 2 and further including jack means for raising said bed and rotor towards the stationary portion of said heat exchanger.



4. A heat exchanger according to claim 3 wherein said jack means is disposed between the bed and the floor.

5. A heat exchanger according to claim 4 and further including rails on the floor for rolling said rotor and the bed when lowered by the jacks whereby repair may be effected.

6. A heat exchanger according to claim 1 including a high temperature resistant refractory regenerative material in said inner core member and a metallic regenerative material in the outer envelope, said material being so adapted that the same mass flow is obtained in respective zones.

7. A heat exchanger according to claim 1 including radial partition walls dividing said rotor into sector shaped chambers, the walls in the inner core member being of a refractory material and in the outer envelope being of metallic material.

8. A heat exchanger according to claim 1 including sealing means between the rotor and the stationary portion.

9. A heat exchanger according to claim 8 wherein said sealing means comprises sheet strips attached to the ends of the wall of the rotor and a cover ring on the stationary portion.

10. A heat exchanger according to claim 1 wherein the rotor outer wall is double walled and the space between the double walls is filled with heat insulating material.

11. A heat exchanger according to claim 1 and further including a cooling jacket provided on the outer face of a refractory arcuate partition wall portion which separates inlet and outlet ducts of the heat imparting medium in the stationary portion, through which cooling jacket is circulated a cooling medium along the whole arcuate length thereof.

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