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 [31] **20,297/68**

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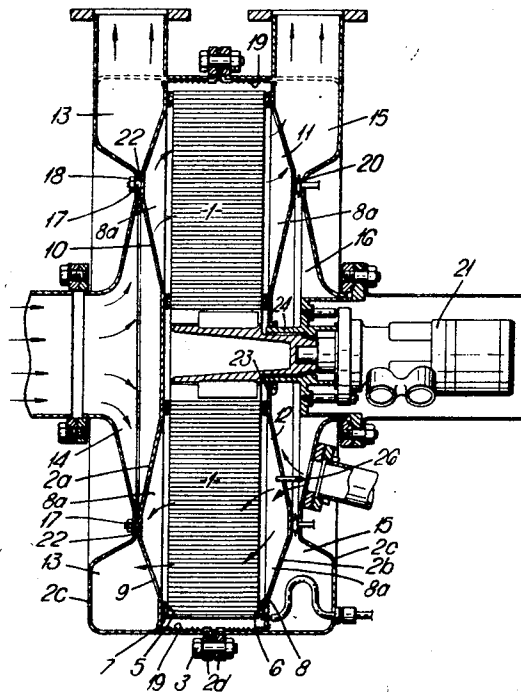
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[54] **ROTARY REGENERATIVE HEAT EXCHANGERS**  
 14 Claims, 3 Drawing Figs.

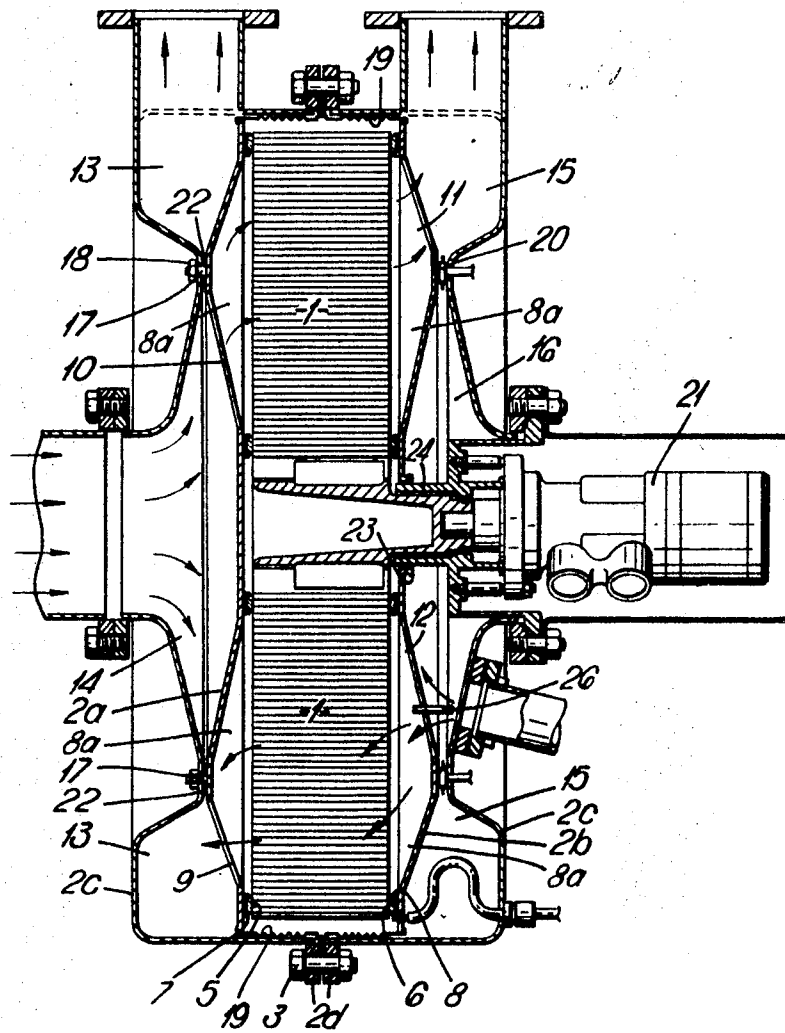
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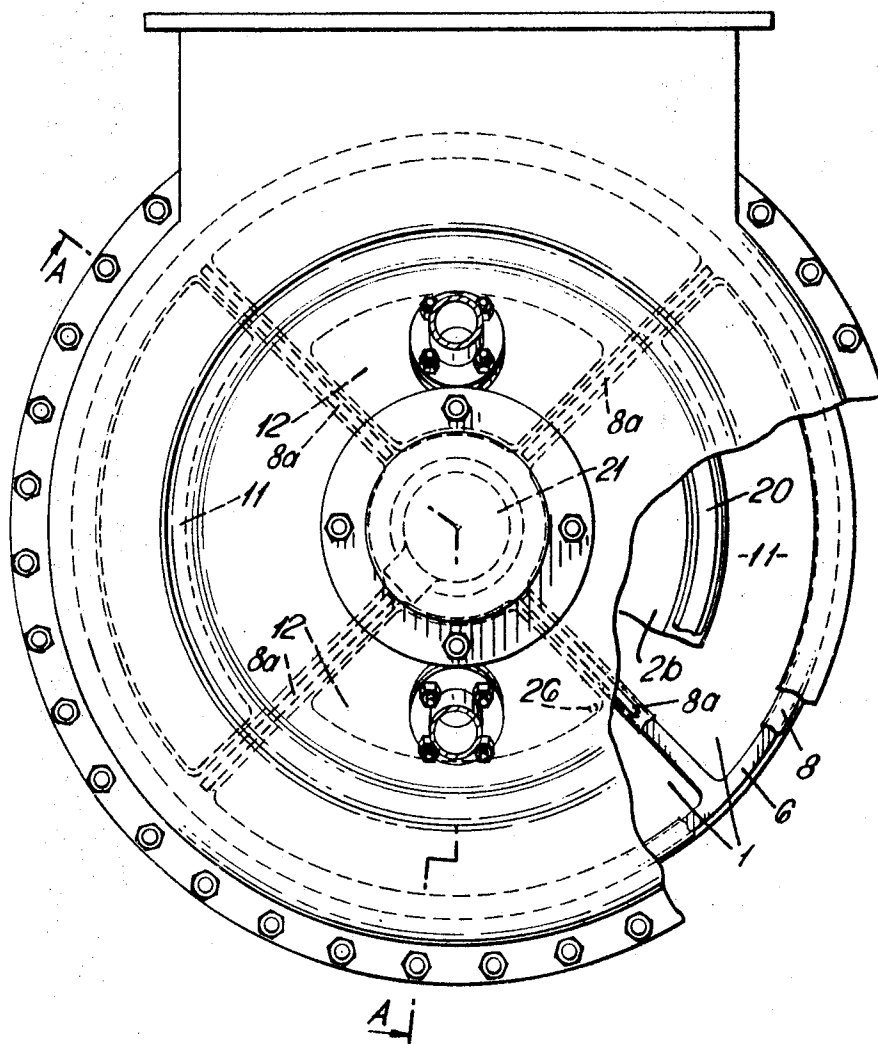
**ABSTRACT:** A rotary regenerative heat exchanger has a disc-form rotor mounted in a casing which, on each side of the rotor, defines a pair of concentric spaces or ducts for the fluids that flow through the rotor, the respective fluids each passing through one of the spaces on each side of the rotor. Apertures from said spaces to mutually sealed segmental portions of the rotor keep the fluid flows separate from each other. The casing structure includes an outer envelope which with inner members defines the concentric spaces, the inner members themselves cooperating with the sealing means of the rotor and being arranged to be able to accommodate thermal expansion without imposing asymmetrical stresses on the outer envelope.



*Fig. 1.*



*Fig. 2*





## ROTARY REGENERATIVE HEAT EXCHANGERS

This invention relates to regenerative heat exchangers, hereinafter referred to as rotary regenerative heat exchangers, which comprise a stator housing a rotor in the form of a disc containing heat-storing material with passages therein permitting the flow of fluid through the rotor disc in a direction from end face to end face of the disc in a direction substantially parallel to the axis of rotation of the disc. The stator has two types of compartment within it, one type of compartment having hot fluid circulated therethrough and the other type having cold fluid circulated therethrough. As the rotor rotates it passes alternately from a hot fluid compartment, where the hot fluid flows through its passages to heat it, to a cold fluid compartment, where its heat-storing material is cooled by giving up its heat to the cold fluid flowing through its passages.

Recent developments in glass-ceramic and similar low thermal expansion materials have provided the possibility of using such materials for the heat storing material of rotary regenerative heat exchangers. Such an arrangement has the advantage that difficulties due to differential thermal expansion of the rotor are considerably reduced or obviated.

The virtual elimination of thermal distortion in the rotor can ease the problem of sealing on the rotor to prevent leakage across its end faces between hot and cold fluid compartments of the stator. Nevertheless the seals acting on the end faces of the rotor are mounted on the stator, which being of metal such as steel, is itself subject to differential thermal expansion.

According to the invention, there is provided a rotary regenerative heat exchanger comprising a disc-form rotor mounted within a stator casing that is provided with sealing means engaging opposed end faces of the rotor to divide the area of each face into mutually sealed sectors, the casing having a pair of concentric ducts on each side of the rotor and internal openings to the opposed faces of the rotor as said sectors communicating with respective ducts for the passage of the heat-exchange fluids through the rotor between inlet and outlet apertures in the concentric ducts.

Such an arrangement is able to reduce the problem of thermal distortion of the stator and can offer further advantages with regard to the ease with which the regenerator can be connected to other compartments of a plant in which it is used. Thus, in many instances annular inlet and outlets for the hot and cold fluid would facilitate connection to other parts of the plant.

Preferably, the casing comprises respective inner members on opposite sides of the rotor that carry said sealing means and provide said openings, an outer member on each side of the rotor being engaged with the inner members to form therebetween said pairs of concentric ducts. This is able to assist further in avoiding the problems arising from differential thermal expansion in that the rotor and the casing inner members may each be made a low thermal expansion material. Also, at each side of the rotor the inner and outer casing members may be attached to each other through a circular line of contact concentric with the rotor, or by a form of nonpositive engagement that allows some limited radial movement of the members relative to each other.

To transfer the fluids between the concentric ducts and the mutually separated sectors defined by the sealing means, there may be provided two mutually sealed pairs of diametrically opposed openings on each side of the rotor, one pair extending from apertures in an inner concentric duct and the other pair from apertures in an outer concentric duct and the two pairs being mutually offset by 90°, the openings on both sides of the rotor each giving access to substantially the same radial extent of the rotor.

In the preferred arrangement hot gas enters an inner concentric duct on one side of the rotor and cold fluid after it has been heated in the rotor leaves via an outer concentric duct on the same side. On the other side of the rotor cold fluid enters an inner concentric duct and hot fluid which has been cooled on the rotor leaves via an outer concentric duct. The regenerator thus has a hot side and a cold side and a drive is connected to the disc rotor on the cold side.

One embodiment of a rotary regenerative heat exchanger according to the invention will now be more particularly described with reference to the accompanying drawings in which:

5 FIG. 1 is a section through the rotary regenerative heat exchanger on line AA of FIG. 2, while

FIG. 2 is an end view of FIG. 1 partially cut away to show seals acting on the rotor, and in which the fluid apertures on one side of the rotor are only indicated, and

10 FIG. 3 is a sectional view of a modified form of heat exchanger according to the invention.

Referring to the drawings, the rotary regenerative heat exchanger comprises a disc-form rotor 1 of a material such as a glass-ceramic or other low thermal expansion material. The rotor 1 is mounted for rotation in a stator comprising two inner casing members 2a and 2b and an outer casing 2c. In the embodiment shown outer casing 2c is in two parts bolted together along flanges 2d by bolts 3.

20 The inner casing members carry seals which in operation bear against the end faces of the disc rotor 1. Seal 5 is carried by inner casing member 2a and seal 6 by inner casing member 2b. Each seal comprises inner and outer concentric rings joined by four radial arms to define sector-shaped openings for the fluid flows. Each seal nests in a correspondingly shaped channel-section carrier mounted on the associated inner casing member, seal 5 being located in seal carrier 7 and seal 6 in seal carrier 8. The seals may have a facing of the same material as the disc rotor, or cermet or ceramic material, for example metal oxide.

25 The inner casing members each have two pairs of diametrically opposed arcuate openings, one pair in an inner ring area and the other pair in an outer ring area. Thus inner casing member 2a has a pair of diametrically opposed arcuate openings 9 in an outer ring and a pair of diametrically opposed arcuate openings 10 in an inner ring, the openings 10 being displaced through 90° relative to the openings 9. Only one opening of each pair can be seen in FIG. 1 because the upper half of the section is a section transverse to that shown in the lower half of the FIG. Likewise inner casing member 2b has a pair of diametrically opposed arcuate openings 11 in an outer ring area and a pair of diametrically opposed arcuate openings 12 in an inner ring area, the openings 11 being displaced by 90° relative to the openings 12. Here again only one opening of each pair can be seen because of the fact that the upper and lower halves of the FIG. lie on mutually transverse planes.

30 The seals 5 and 6 are arranged so that the sector-shaped openings they define are angularly aligned with the openings in their associated inner casing members and flange partitions 8a and coincident with each arm of the seal carriers extend axially to fill the space between the seal carriers and the inner members 2a, 2b respectively so that the adjacent openings in each inner member are isolated from each other.

35 The inner casing members 2a and 2b are disposed so that the openings in one member are displaced through 90° relative to the openings in the other member. Thus an opening in the inner ring of one casing member is angularly aligned with an opening in the outer ring of the other casing member and vice versa.

40 The wall of the outer casing member 2c is shaped so that it forms with each of the inner casing members two concentric ducts on each side of the rotor. Thus on one side of the rotor is an outer concentric duct 13 and an inner concentric duct 14 whilst on the other side of the rotor is an outer concentric duct 15 and an inner concentric duct 16. The outer ducts in each case and inner duct 16 are annular whilst inner duct 14 is circular but in some arrangements duct 14 may also be annular if desired.

45 The inner casing member 2a is attached to outer casing member 2c by studs 17 which pass through holes in the outer casing member and are secured by nuts 18. The studs are disposed in a ring. The inner casing member 2b has its inner and outer annular regions sealed from each other by a flexible tube 20 and has no positive radial attachment to the outer cas-

ing member but is instead radially located by an inner flange 23 supported by casing sleeve 24 of hydraulic drive unit 21. Rotation of the member 2b is prevented by a pin 26 projecting from the outer casing member to a corner of the aperture 12. Both inner casing members are flexibly mounted at their outer peripheries to metallic bellows members 19.

In operation, the seals 5 and 6 can be held firmly engaged with their associated faces of the rotor by virtue of the net gas pressure acting upon the inner casing member 2b. This net pressure can be controlled to some extent by choice of the diameter of the sealing member.

In a typical application hot fluid would be admitted to duct 14 and would flow through diametrically opposed openings 10 in inner casing member 2a. From openings 10 it would enter axial passages in the rotor 1 and then pass to annular duct 15 via diametrically opposed openings 11 in the inner casing member 2b. In passing through the rotor the fluid would be cooled.

Cold fluid would enter annular duct 16 and reach the axial passages in the disc rotor 1 via diametrically opposed openings 12 in the inner casing member 2b. After leaving the rotor in a heated state, the fluid passes to annular duct 13 via diametrically opposed openings 9.

With such an arrangement the left-hand side of the regenerator shown in FIG. 1 is the hot side and the right-hand side the cold side. A hydraulic drive unit 21 is mounted on the cold side and drives the rotor 1.

The ducts conveying fluid to and from the heat exchanger can be located in many different positions to suit circumstances because the ducts 13, 14, 15 and 16 are all annular or circular and concentric.

The flow of fluid through the heat exchanger need not be that described above. For example the flows could be interchanged. Generally speaking, however, the cold fluid will be arranged to flow through the rotor in a direction opposite to that of the hot fluid.

When the hot and cold fluid are at different pressures such as, for example, in the use of the heat exchanger with gas turbine plant, the members 17 and 18 and the member 20 must effect a seal between the inner casing members and the outer casing members. In the case of the members 2a and 2c an annular sealing strip 22 may be interposed between contacting faces. In the case of member 20 this is of itself a flexible continuous ring and can therefore perform a sealing function.

Bellows members 19 serve to prevent leakage along the peripheral face of the rotor 1 between the inner casing members 2a, 2b and the outer casing member 2c. They also allow for any differential expansion between the outer casing member 2c and the inner casing members 2a, 2b.

With the stator construction described it is possible to form inner casing members of the same material as the disc rotor or to use material having similar thermal expansion properties to that of the rotor so that problems of thermal distortion between rotor and the seal-carrying members are substantially reduced. The outer casing member can be of steel whilst there might be thermal distortion of it, this is minimized by the fact that only one inner casing member is directly secured to it and that attachment being along a circular line of contact so that they are each free to expand or contract on either side of this line.

The construction shown in FIG. 3 is similar in many respects to that already described. For ease of manufacture, casing members 32a, 32b, 32c have modified profiles, the outer members now being flat-sided. The gas flow passages are differently distributed in that one flow enters and leaves the rotor through axially opposed inner spaces 33, 34 of the two concentric pairs of spaces and the other gas flow utilizes the outer pair of concentric spaces 35, 36. A further point of difference lies in the support of the rotor being offered by a cantilever shaft 38 projecting from one side of the outer casing into the hollow output shaft 39 of the hydraulic driving unit.

I claim:

1. A rotary regenerative heat exchanger comprising in combination a disc-form rotor having passages for the through-flow of heat exchange fluids, a stator casing within which the rotor is mounted, sealing means between the stator and the opposite end faces of the rotor to thereby divide the area of each said end face of the rotor into first and second sets of mutually sealed sectors for the through-flow of first and second heat exchange fluid respectively, each set comprising at least two sectors, the said sectors of said first and second sets being disposed alternately around each end face of said rotor, two ducts being provided in the casing to the side of each end face of the rotor and at each said side of the rotor the respective ducts communicating with the respective first and second sets of sectors at the associated end face, said ducts at each end face being symmetrically disposed about the axis of rotation of the rotor but differently spaced from said axis, and inlet and outlet apertures in said ducts to and from the heat exchanger.

2. A heat exchanger according to claim 1 wherein the casing comprises respective inner members to the sides of opposite end faces of the rotor, said inner members carrying said sealing means and having openings therein which provide communication between the duct and the sectors, an outer member to the side of each end face of the rotor being engaged with the inner members to form therebetween said ducts to the side of each end face of the rotor.

3. A heat exchanger according to claim 2 wherein the rotor and the casing inner members are each made of a low thermal expansion material.

4. A heat exchanger according to claim 2 wherein the two ducts are concentric and further comprising attachment means provided at least to the side of one end face of the rotor to connect together the inner and outer member there at a line concentric with the rotor.

5. A heat exchanger according to claim 4 wherein said line of contact forms a division between the inner and outer concentric ducts.

6. A heat exchanger according to claim 2 wherein engagement means between the inner and outer members, to the side of at least one end face of the rotor, permit relative radial movement between the members at the engagement region.

7. A heat exchanger according to claim 6 wherein the two ducts are concentric and said engagement means comprises a flexible annular seal interposed between the inner and outer members to form a division between the concentric ducts.

8. A heat exchanger according to claim 1 having inner and outer concentric ducts and two mutually sealed pairs of diametrically opposed sectors on each side of the rotor, one pair extending from apertures in the inner concentric duct and the other pair from apertures in the outer concentric duct and the two pairs being mutually offset by 90°, the sectors at both end faces of the rotor giving access to substantially the same radial extend of the rotor.

9. A heat exchanger according to claim 1 wherein the fluids flow in opposite directions to each other through the rotor whereby the entry for the acceptor fluid and the outlet for the cooled donor fluid are to the side of the one end face of the rotor, drive means for rotation of the rotor being mounted to the heat exchanger on said one end face of the rotor.

10. A rotary regenerative heat exchanger comprising, in combination, a disc-form rotor having passages for the through-flow of heat exchange fluid, and a stator casing within which the rotor is mounted, said casing including respective inner members to opposite end faces of the rotor each carrying sealing means engaging opposite end faces of the rotor to divide the area of each end face of the rotor into mutually sealed sectors, and an outer member on each side of the rotor engaged with each inner member to form therebetween two concentric ducts to each end face of the rotor, attachment means being provided at least at one end face of the rotor to connect together the inner and outer members there at a line of contact concentric with the rotor, the heat exchanger further comprising inlet and outlet apertures to and from the heat exchanger in the concentric ducts, the inner members of

the casing providing internal openings to the opposite end faces of the rotor at said sectors, which openings provide communication with the respective concentric ducts for the passage of the heat exchange fluids on respective flow paths through the rotor between the inlet and outlet apertures of the concentric ducts.

11. A heat exchanger according to claim 11 wherein said line of contact forms a division between the inner and outer concentric ducts.

12. A rotary regenerative heat exchanger comprising, in combination, a disc-form rotor having passages for the through-flow of heat exchange fluids, a stator casing within which the rotor is mounted, said casing including respective inner members to opposite end faces of the rotor each carrying sealing means engaging opposite end faces of the rotor to divide the area of each end face of the rotor into mutually sealed sectors, and an outer member on each side of the rotor engaged with each inner member to form therebetween two concentric ducts to each end face of the rotor, engagement means between the inner and outer members, at least at one end face of the rotor, permitting relative radial movement between the members at the engagement region, the heat exchanger further comprising inlet and outlet apertures to and from the heat exchanger in the concentric ducts, the inner members of the casing providing internal openings to the opposite end faces of the rotor at said sectors, which openings provide communication with the respective concentric ducts

for the passage of the heat exchange fluids on respective flow paths through the rotor between the inlet and outlet apertures of the concentric ducts.

13. A heat exchanger according to claim 12 wherein said engagement means comprises a flexible annular seal interposed between the inner and outer members to form a division between the concentric ducts.

14. A rotary regenerative heat exchanger comprising in combination, a disc-form rotor having passages for the throughflow of heat exchange fluids, a stator casing within which the rotor is mounted, sealing means between the stator and the opposite end faces of the rotor to divide the area of each end face of the rotor into first and second pairs of mutually sealed sectors each giving access to substantially the same radial extent of the rotor for the throughflow of first and second heat exchange fluids respectively, the sectors of each pair being diametrically opposed to each other, inner and outer concentric ducts being provided in the casing to the side of each end face of the rotor, inlet and outlet apertures to and from the heat exchanger communicating with said concentric ducts, respective pairs of openings in the ducts leading to said sectors for the passage of the heat exchange fluids on respective flow paths between the inlet and outlet apertures by way of the rotor, the two pairs of openings to the side of each rotor end face being mutually offset by 90°.

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