

Sept. 22, 1936.

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2,055,071

SEALING MEANS FOR HEAT EXCHANGERS

Filed Nov. 5, 1931

2 Sheets-Sheet 1

Fig. 1

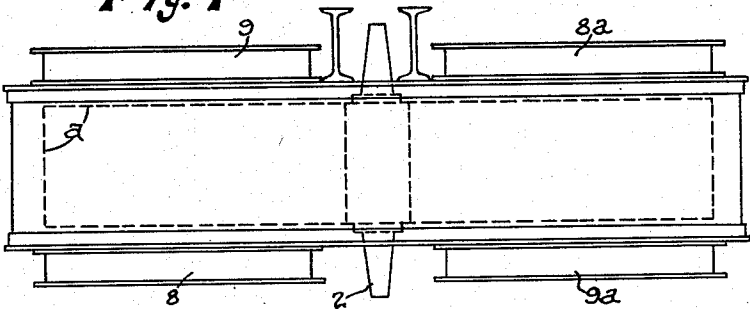


Fig. 2

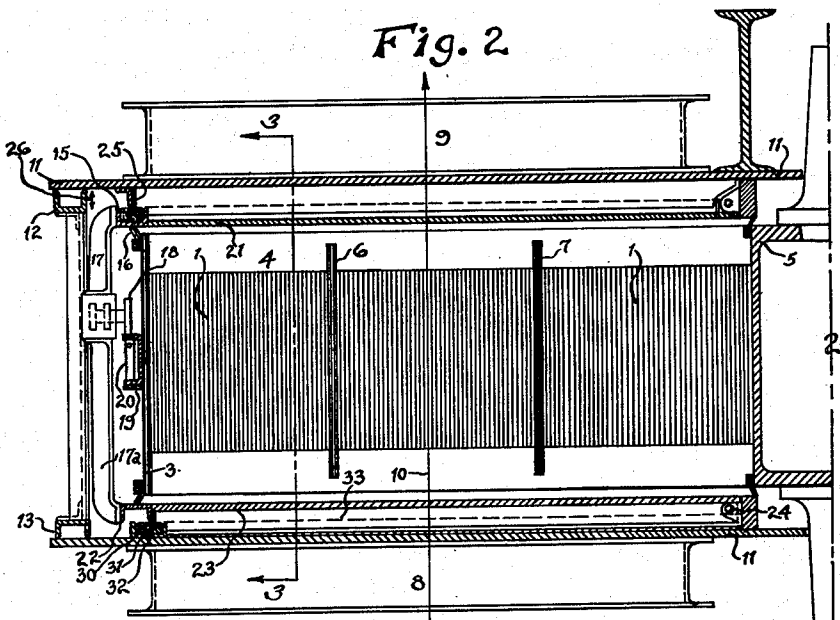
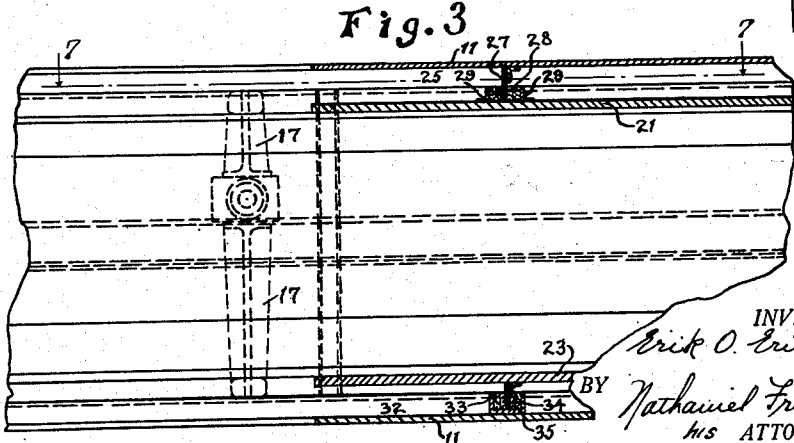


Fig. 3



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Fig. 4

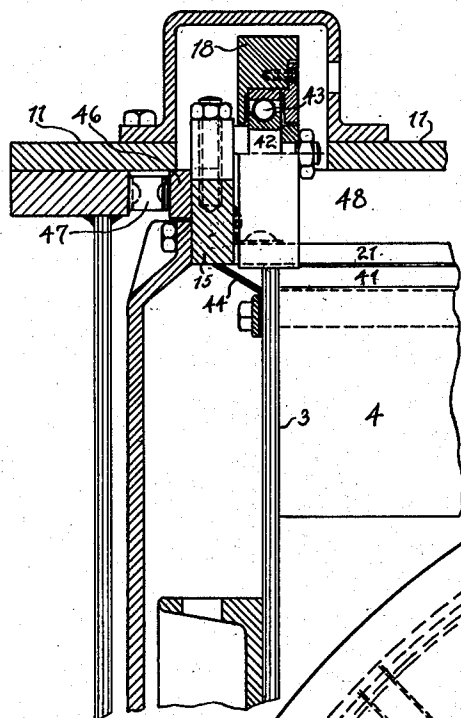


Fig. 6

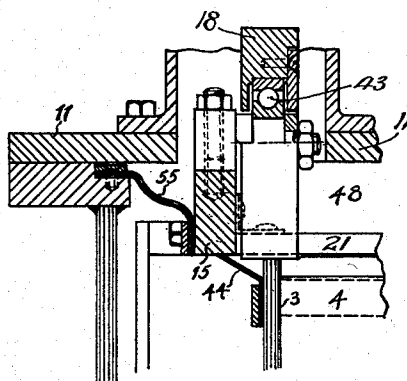


Fig. 5

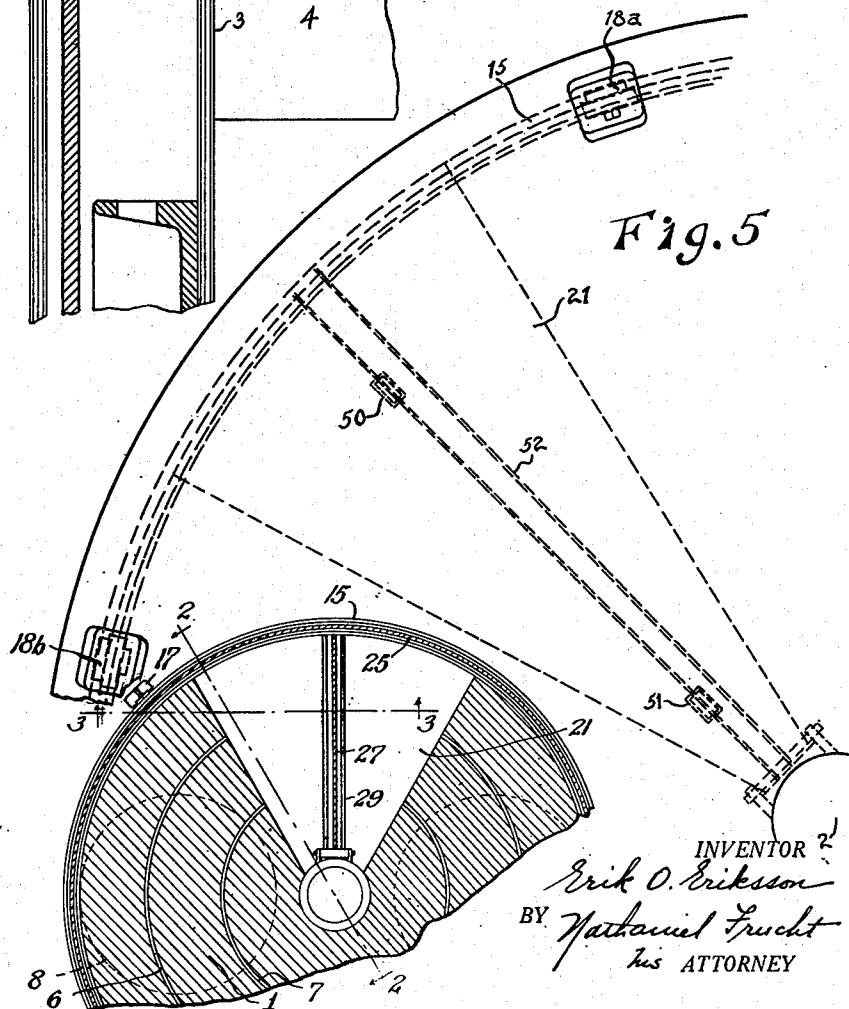


Fig. 7

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SEALING MEANS FOR HEAT EXCHANGERS

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13 Claims. (Cl. 257—6)

My present invention relates to regenerative heat exchange apparatus, and has particular reference to improved sealing means therefor.

Regenerative heat exchange apparatus has been utilized in which a relative rotation occurs between a cylindrical frame containing a regenerative mass, and inlet and outlet arrangements for the fluids between which the exchange of heat is to occur. Other forms of heat exchange constructions include a frame containing regenerative material and either mounted as a body of revolution for rotation in the fluid to be cooled and the fluid to be heated, or else mounted to be stationary and to be adjacent fluid channels which move relatively to the frame, so that similar heat exchange conditions are obtained.

Sealing means between the moving and the stationary parts have been utilized to reduce the fluid leakage from one fluid passage to another. Such sealing means, for example, have utilized projecting parts adapted to frictionally contact the parts that have relative motion, their sealing being comparatively satisfactory for the channels in small heat exchanging apparatus. This type of sealing is not, however, sufficiently effective for larger sizes, because the frame containing the regenerative material is subjected to temperature variations tending to produce varying distances between the relatively moving parts, with the result that the sealing means satisfactory at one temperature is not satisfactory at other temperatures.

The present invention pertains to a novel sealing construction that functions independently of temperature variations in the heat exchanger, and includes an annular element which may have sealing means, and which cooperates with the cylindrical frame, the annular element having a relative rotary movement with respect to the frame and being mounted to follow such movements or changes in form of the frame as are produced by expansion due to heat.

Other advantageous features of the invention will be readily apparent from the detailed description following, in conjunction with the accompanying drawings.

In the drawings,

Fig. 1 is a diagrammatic elevation of a rotary type regenerative heat exchange apparatus embodying the novel sealing means;

Fig. 2 is an enlarged sectional detail of half an axial section of Fig. 1;

Fig. 3 is a section on the line 3—3 of Fig. 2;

Fig. 4 is an enlarged fragmentary sectional

detail showing a modified form of sealing means;

Fig. 5 is a fragmentary plan view of a heat exchanger embodying the modified form shown in Fig. 4, on a reduced scale;

Fig. 6 shows a further modified form; and

Fig. 7 is a fragmentary sectional view on the line 7—7 of Fig. 3.

In the heat exchanger diagrammatically shown in Fig. 1, a relative rotary movement occurs between the inlets and outlets for the two fluids between which heat exchange occurs and the regenerative mass 1, the latter being mounted in a cylindrical frame *a* rotatable about the axis 2. The fluid to be cooled, which may for example be flue gases from a furnace, enters through the inlet 8 and exits through the outlet 9 after having transferred heat to the regenerative mass. The fluid to be heated, such as combustion air, enters through the inlet 8*a* and exits through the outlet 9*a* after absorption of the transferred heat in the regenerative mass.

Fig. 2 discloses the left portion of the apparatus of Fig. 1 in section, and illustrates how the frame *a* is enclosed by a cylindrical jacket 3 within which the regenerative material is mounted, the latter preferably consisting of plane and corrugated metal plates. The jacket is connected to a central hub portion 5 of the frame by radially positioned partitions 4; the partitions 4 thus divide the frame into a number of segments which may be further subdivided by cylindrical plates 6 and 7, particularly when the frame is of large diameter.

The specific heat exchanging apparatus described is an air preheater utilizing flue gases as the heat yielding medium, the flue gases passing through the air preheater in the direction indicated by the arrow 10. Preferably, fans are mounted in the conduit connecting the outlet 9 with the stack, for expelling the flue gases; the air is also preferably expelled by means of a fan or the like, thus compensating for the air preheater resistance and simultaneously providing forced draft for the furnace.

The rotor is enclosed by a casing 11 which may, if desired, be formed of plates which are joined together by welding and are of sufficient thickness to obtain the necessary strength and rigidity. The casing may also be formed of special shaped members, such as U shaped members such as indicated at 12, 13, which compose the frame carrying the parts, with the remainder of the casing formed of thinner plates.

Heretofore, sealing devices have been positioned between the rotating frame and the sta-

tionary casing 11, in order to prevent peripheral leakage as well as leakage from one fluid flow channel to the other between the rotating frame and the partitions. However, since the rotor during use has a higher temperature at its lower edge than at its upper edge, it will tend to assume a saucer shape when heated, with the jacket 3 elevated; this effect results from the differential expansion and the tensions of the rotor parts due to the differences in temperature at the hot and cold ends. Although this elevation is counteracted by the weight of the rotor, it has been found that the elevation in an air preheater rotor having a diameter of five meters will amount to from 10 to 15 millimeters.

The tendency towards becoming saucer shaped is greater if the gases are introduced to make the rotor hottest at its upper portion, or if the preheater is formed with a horizontal axis of revolution, as the alteration of shape is not then compensated for by the weight of the rotor. The sealing means and engaging edges that have been found most suitable for air preheaters of the type described must be adjusted to fit between the rotor and the walls of the casing when the preheater is cold; when the air preheater is subjected to the heating effect of the gases and the rotor becomes saucer shaped, for example by 12 millimeters, the contacting edges will either be ground off or become permanently offset away from the rotor edge for the distance the rotor edge is distorted. A play of 12 millimeters would therefore be produced between the rotating and the stationary parts between the preheater channels, the play being smaller if the temperature difference is smaller, but being sufficient to cause a large detrimental leakage.

In order to ensure an approximately uniform distance between the rotating and the stationary parts, a ring or a ring segment 15 is utilized, having a mounting which is changed in correspondence with changes in the shape of the frame produced by expansion due to heat. In this embodiment, the ring 15 is positioned about the rotor in proximity to the upper edge of the jacket 3, and a sealing edge 16 is mounted on the jacket 3 and extends towards the ring when the jacket is elevated; the ring 15 also moves so as to maintain the same distance from the jacket and therefore from the sealing edge 16, this movement being produced through the medium of an arm 17 connected to the ring 15 and having a wheel or roller 18 on the free end resting on a projecting part 19 of the rotor jacket, which is preferably formed with an integral toothed rack cooperating with a pinion (not shown) for rotating the rotor. The roller 18 is journaled on the arm 17 by means of one or more bearings, such as ball bearings, and rests on a plane portion of the part 19 that is perpendicular to the axis of rotation 2 of the rotor.

The ring 15 is rigidly connected to an arm or spoke 21 which in turn is pivotally connected with the casing 11 at a point adjacent the axis of rotation 2. In the construction illustrated the arm 21 is connected to the casing 11 by a hinged joint, such as a bolt mounted in eyes. In previous constructions of air preheaters of the type described, disks formed of sheet metal and of the size of a rotor segment have been arranged to cooperate with the partitions dividing the rotor casing into channels for the different fluids, so that the sections will successively move from one channel to the other only after the segment has been covered by a disk, thus preventing leakage

from one channel to the other through a rotor segment.

In the present embodiment, the arm or spoke 21 may be formed as a segment shaped plate of the same type, the radially disposed partitions 4 being provided with the usual sealing edges adjacent the segment plate and bearing on or being directed against the segment plate 21. As the ring 15 is always mounted at approximately the same distance from the jacket 3, the segment plate 21 will also be positioned at approximately the same distance from the radially disposed plates 4, thus ensuring the same sealing effect for the contacting edge and preventing leakage from one channel to the other.

In certain constructions, the radial sealing device 16 may be arranged so that a complete movable ring 15 is not required. In such constructions, it is sufficient to use the segment plate 21 as the sealing means and to keep it at a uniform distance from the radially disposed partitions 4 in the above described manner, the plate 21 thus acting as the ring portion which follows the movement or altered shape of the frame produced by temperature variations.

Since changes in the sealing effect are not only produced in the hottest portion of the rotor, but also at the other end of the rotor, it is preferable to mount a ring 22 at the other end, which ring is connected through an arm 17a with the roller 18. The ring 22 is also movably connected to the rotor casing 11 as at 24 by means of spokes or the like or by an element 23 formed as a disk. Thus the sealing between the rotor and the parts 15, 21 and 22 and 23, which are relatively movable to a limited extent, is maintained constant or substantially constant.

This construction necessitates further sealing between the last named parts 22 and 23, which are mounted on rollers, and the stationary rotor casing. The ring 15 is preferably provided with a U shaped cross-section to engage a sealing edge 25 provided on the casing 11; there is no rotary movement between the parts, but instead a movement upward or downward in the direction of the arrow 26, between the sealing edge 25 and the ring 15. The sealing edge may therefore be mounted so as to enter the U shaped portion of the ring and have its end surrounded with sand or some other heat resistant mass, this construction thus providing complete sealing while permitting relative vertical movement between the ring and the casing 11 without appreciable wear. The wall 27 which separates the flow channels in the casing is also formed as a sealing edge and is adapted to enter a sand seal 28 (see Fig. 3) in a groove formed by angle irons 29 in the disk 21.

Fig. 3 illustrates the preferred construction for the last described sealing device, and shows the sealing edge 27 extending radially through an opening, not shown, in the U shaped ring 15 as far as the sealing edge 25. A sealing edge 30 is arranged in the same manner, in the lower part of the rotor, see Fig. 2, within the ring 22, the edge entering into a sand seal 31 provided in a groove 32. Similarly, a sealing edge 33 is positioned on the disk 23, and extends into a sand pocket 34 provided in a groove 35 in the casing 11, see Fig. 3; in this case, also, the sealing edge 33 extends radially outward to the sealing edge 30.

The above described constructions admittedly provide double seals, but are preferred because there is no rotary movement between the seals that must correspond to the altered plane resulting from the rotor becoming saucer shaped,

namely, the seals between the movable plates, 21, 23, and the frame 11. On the other hand, the seals which prevent leakage between the rotating and non-rotating parts namely, the seals between the rotor and plates 21, 23, extend over a play or an intermediate space that is substantially constant. Consequently, the first type of seals may be formed with no consideration for wear between the parts that touch each other, whereas the second type must be formed with engaging edges so that a minimum amount of leakage results. As these conditions are fulfilled by the embodiment described with reference to Figs. 2 and 3, a far better and more efficient seal can be obtained than has been possible heretofore.

Fig. 4 illustrates a modified arrangement, the upper part of the rotor and such parts as are positioned adjacent the upper edge of the rotor jacket 3 being shown. In this modification, the rotor contains regenerative material having radially disposed partitions 4. The radial partitions are provided with sealing edges 41 directed against the segment-shaped disk 21 which either has an integral annular portion or else is carried by the ring 15, as preferred. Either the ring 15 or the plate 21 may extend beyond the upper edge of the jacket 3, or the ring 15 may be positioned in the vicinity of the upper edge of the jacket 3.

The ring is attached to a shaft 42, on which a roller 18 is mounted by means of a ball bearing 43. The roller 18 contacts with and runs on the upper edge of the jacket 3. Consequently, the ring 15 and the segment-shaped plate 21 will always have the same position relatively to the upper edge of the jacket and the sealing edges of the plate 41, whereby a very small play of uniform magnitude can always be maintained between said parts. A sealing edge 44 is positioned between the jacket 3 and the ring 15, and prevents the gas from flowing to the space radially outside the jacket.

The ring 15 is thus stationary relative to the rotor, but follows the rotor movements produced by variations in temperature, and is therefore movable with respect to the casing 11 in the manner described with reference to Fig. 1. For this reason, sealing means must also be provided between the casing 11 and the ring 15, said sealing means preferably consisting of annular elements 46 pressed by springs 47 partly against the ring 15 and partly against the casing, these elements 46 thus preventing leakage from the upper part of the casing to parts thereof which are positioned radially outside the jacket.

The partition 48 which divides the casing into two channels is sealed against the segment disk 21 in the manner more fully disclosed in Fig. 5, in which reference numerals from Fig. 4 are used to designate corresponding parts. The sealing means consist of strips 52 suspended in hinge-like attachments 50 and 51, said strips bearing on the disk 21. The strips 52 may be suspended directly in the upper part of the casing 11, if the available space does not allow room for a special partition 48; in certain cases, the hinged member 52 per se may constitute the partition in the casing on that side of the rotor. Upon movement of the disk 21, which is of segment shape as indicated in Fig. 5, the movably suspended member 52 will assume different angular positions relatively to said casing. Fig. 5 also discloses that the ring 15 is mounted on a plurality of rollers 18a, 18b, etc., the rollers being distributed along the periphery

of the entire ring. When the rotor becomes dished, the ring 15 will not remain in one plane but will by reason of its resiliency take a form corresponding to the upper edge of the jacket 3. On the other side of the rotor, corresponding arrangements are resorted to for the necessary sealing.

In Fig. 6 the roller 18 is shown engaged with the upper edge of the jacket 3, and the ring 15 is suspended on the same shaft on which the roller 18 is mounted by means of a ball bearing which does not permit spherical rolling. The sealing means between the walls 4 of the roller and the partition 48 are similar to those described with reference to Figs. 4 and 5, this also being the case with the sealing edges 44 for preventing leakage between the ring 15 and the jacket 3. In contradistinction to the embodiment shown in Fig. 4, however, the sealing means between the ring 15 and the casing 11 is shown as comprising a flexible or resilient part 55, which is rigidly connected with the casing 11 and with the ring 15. This part 55 may be made from flexible or slitted sheet metal, or may consist of other heat resistive insulating material, such as for example asbestos fabric.

In all constructions, the bearings of the roller 18 are shown as accessible from the outside to facilitate lubrication. In Fig. 2, that portion of the arm which contains the bearing of the roller may also be mounted to partly extend outside the casing, in which case effective cooling of the bearings can be obtained.

With constructions according to the principle of the invention, sealing means may thus be provided between rotating and non-rotating parts, so that approximately the same or a comparatively small play can always be secured between the various sealing parts. The seals between parts that will be positioned at different distances from each other may be provided between such parts as do not rotate in relation to each other and which, therefore, are better adapted for the least possible leakage.

In accordance with the principles of the invention, it is feasible to construct air preheaters or other heat exchanging apparatus in which great alterations in shape are produced on account of tensions due to the influence of heat, without increased leakage. Heat exchanging apparatus may thus be constructed in a single large unit even for very large volumes of gas, where heretofore two or more units have been necessary to reduce the losses through leakage.

Obviously, the invention is not limited to the embodiments shown, as changes in the constructive details may be made to suit the requirements for particular installations, within the spirit and scope of the invention as defined in the appended claims.

I claim:

1. In a regenerative heat exchanger, a cylindrical frame containing regenerative material, inlets and outlets for fluids to be cooled and to be heated, said frame and said inlets and outlets being relatively rotatable, and sealing devices between said relatively rotating parts having a relative movement with respect to the frame and including means compensating for distortion of the movable part produced by temperature variations, said means including a member in rolling contact with a frame surface in a plane at right angles to the cylinder axis.

2. In a regenerative heat exchanger, a channel for fluid to be cooled and a fluid to be heated, a

rotor having a plurality of segments and movable in said channels, a casing around said rotor, and sealing means between said channels including a member mounted adjacent the rotor and movably connected with said casing for movement axially with respect to said rotor.

3. In a regenerative heat exchanger, channels for fluid to be cooled and a fluid to be heated, a rotor having a plurality of segments and movable in said channels, a casing around said rotor, and sealing means between said channels including a member mounted adjacent the rotor and movably connected with said casing and secured to said casing adjacent the axis of rotation of said rotor.

4. In a regenerative heat exchanger, channels for fluid to be cooled and a fluid to be heated, a rotor having a plurality of segments and movable in said channels, a casing around said rotor, and sealing means between said channels including a member mounted adjacent the rotor and movably connected with said casing and pivotally secured to said casing adjacent the axis of rotation of said rotor.

5. In a regenerative heat exchanger, channels for fluid to be cooled and a fluid to be heated, a rotor having a plurality of segments and movable in said channels, a casing around said rotor, sealing means between said channels including an arcuate member mounted adjacent the rotor and movably connected with said casing, and segment shaped disk means pivotally securing said arcuate member to said casing adjacent the axis of rotation of said rotor.

6. In a regenerative heat exchanger, a casing having channels for fluid to be cooled and a fluid to be heated, a rotor having a plurality of segments and movable in said channels, said rotor having a frame, and sealing means between said channels including an arcuate member mounted adjacent the rotor and having cooperating sealing elements respectively in sealing engagement with said casing and said frame.

7. In a regenerative heat exchanger, a casing having channels for fluid to be cooled and a fluid to be heated, a rotor having a plurality of segments and movable in said channels, a frame around said rotor, and sealing means between said channels including an arcuate member mounted adjacent the rotor and in sealing en-

gagement with said casing, and having rolling engagement with the upper edge of said frame.

8. In a heat exchanger, a rotor containing regenerative material and rotatable about a vertical axis, an annular member on said rotor, and sealing means including a second annular member having rollers mounted thereon, said rollers engaging the upper surface of said first annular member.

9. In combination, a casing, a rotatable frame therein subject to distortion, a movable non-rotatable sealing element in sealing relation to said casing, and means for maintaining said sealing element at a predetermined distance from said rotatable frame.

10. In combination, a casing, a rotatable frame therein subject to distortion, a movable non-rotatable sealing element in sealing relation to said casing, and means secured to said sealing element and engaging said rotatable frame for maintaining said sealing element at a predetermined distance from said rotatable frame.

11. In combination, a casing, a rotatable frame therein subject to distortion, cooperating sealing elements comprising one element secured to the casing and a second element movable with respect to said first element, and sealing means between said rotatable frame and said second element.

12. In combination, a casing, a rotatable frame therein subject to distortion, cooperating sealing elements comprising one element secured to the casing and a second element movable with respect to said first element, sealing means between said rotatable frame and said second element, and means for shifting said second element in the direction of the axis of the rotatable frame.

13. In combination, a casing, a rotatable frame therein subject to distortion, cooperating sealing elements comprising one element secured to the casing and a second element movable with respect to said first element, sealing means between said rotatable frame and said second element, and means for shifting said second element in the direction of the axis of the rotatable frame to maintain a predetermined distance with respect to said frame, said means comprising mechanism secured to said second sealing element and engaging said rotatable frame.

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