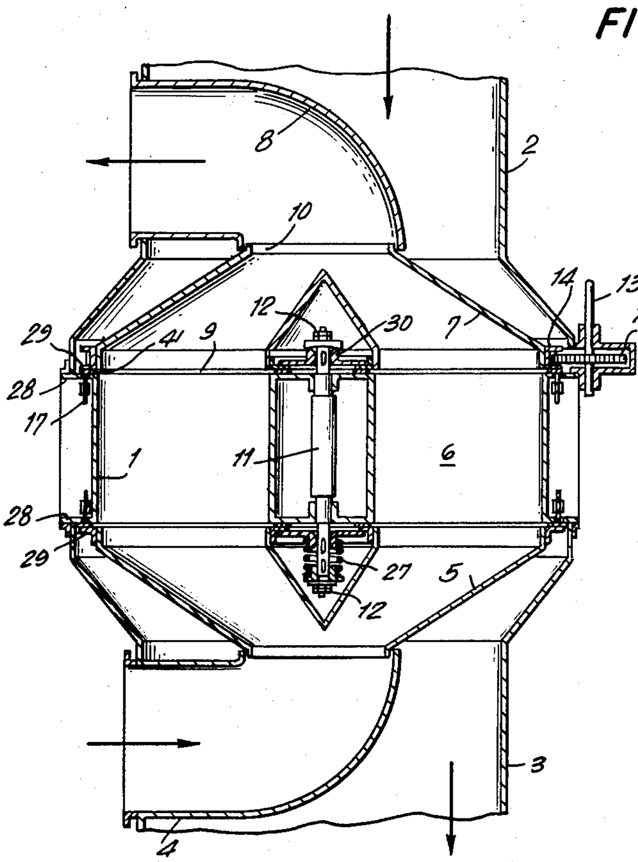
REGENERATIVE FLUID HEATER

Original Filed Aug. 1, 1958 3 Sheets-Sheet 1

FIG. 1



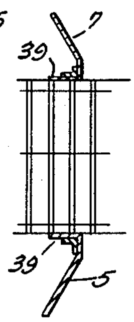


FIG. 3

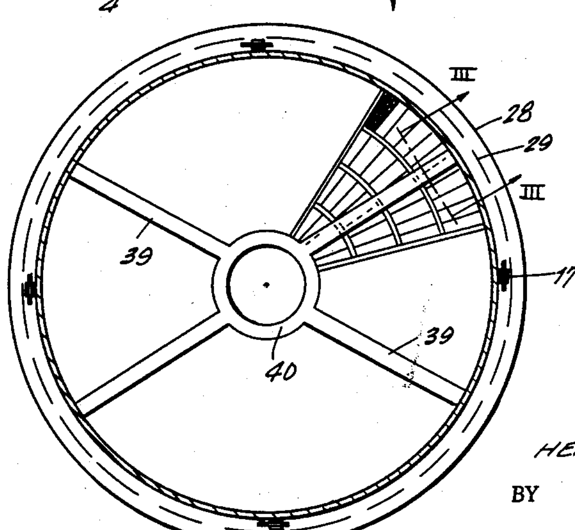


FIG. 2

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FIG. 4

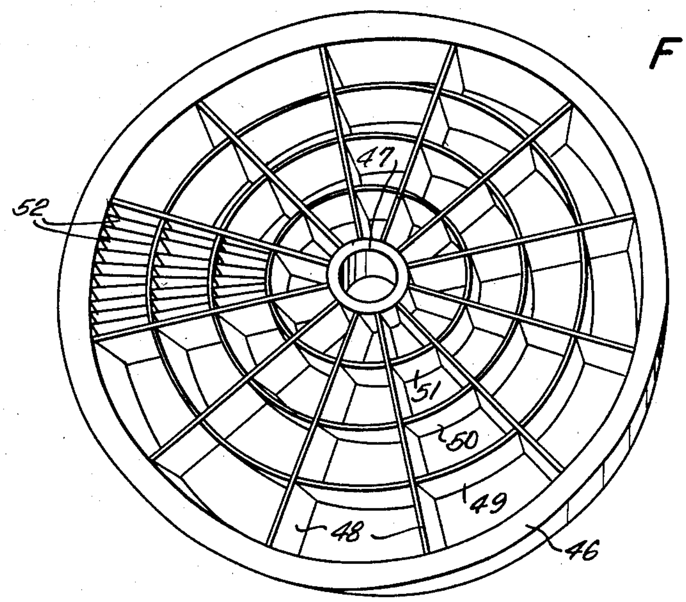
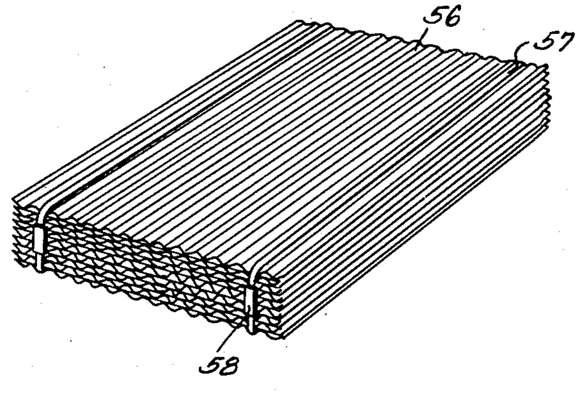


FIG. 6



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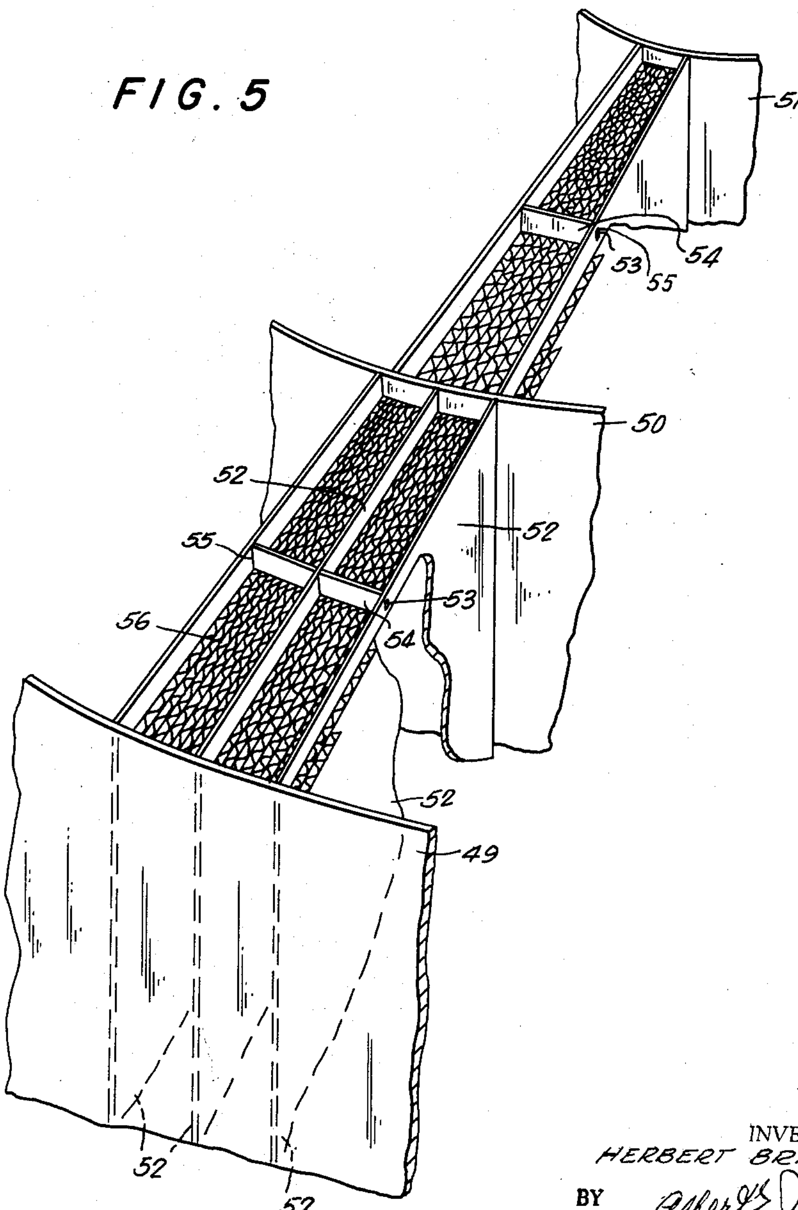
June 29, 1965 H. BRANDT 3,191,666

REGENERATIVE FLUID HEATER

Original Filed Aug. 1, 1958 3 Sheets-Sheet 3

FIG. 5



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United States Patent Office 3,191,666
Patented June 29, 1965

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REGENERATIVE FLUID HEATER

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Continuation of abandoned application Ser. No. 752,616, Aug. 1, 1958. This application Nov. 22, 1963, Ser. No. 325,566
5 Claims. (Cl. 165—4)

This application is a continuation of my copending application Serial No. 752,616, filed August 1, 1958, and now abandoned.

The present invention relates to improved sealing means for regenerative gas or fluid heaters of the type having a cylindrical casing which carries plates by which heat is stored and delivered, said casing being divided by radial partitions into sectors through which flow alternately the medium from which heat is absorbed and the medium to which heat is delivered.

In such heat exchangers the surfaces through which heat is transmitted are usually those of stacks or packets of plates which comprise flat plates alternating with non-planar plates which space the flat plates one from another and form with them narrow channels through which flow the media between which heat is to be exchanged. Alternate connection with inlet and outlet pipes provided for the respective media is effected by relative movement of the casing and the inlet and outlet pipes. It is therefore necessary to minimize leakage between the adjacent surfaces of the casing on the one hand and of the inlet and outlet pipes on the other hand. It is naturally of the greatest importance that the sealing means should cause as little idling loss as possible.

While a variety of seals have heretofore been employed, the elimination of the idling loss has hitherto not been possible. Thus, for example, in known constructions annular labyrinth seals have been provided upon the inner and outer periphery of the heat storing body, while radial seals for connections of sector form are made by sealing plates also of sector form arranged upon the junction surfaces of each sector wall of an inlet or outlet connection, the sealing plates corresponding in form and size to the sectors of the exchanger body and sliding on resilient laminations fastened to the junction edges of the sector wall of the exchanger body. When such a heat exchanger is divided, as is usual, into, say, twelve sectors, these radial sealing plates cover, and shut off flow through, two complete sectors, so that some 17 percent of the entire heat exchange surface, namely the surface of the "dead sectors," is idle.

In an effort to eliminate these dead sectors heat storing plates have been arranged radially in the heat exchanger body so as to make the edges of the plates project from the casing and to use them as a sealing means. In this way it is possible to provide comparatively narrow radial sealing strips on the pipe connections and so to eliminate the dead sectors. A construction of this type, however, has the disadvantage that the edges of the heat storing plates, which are only about 0.6 millimeter thick, become corroded after a short time of operation so that there is no longer a satisfactory seal.

It is the object of the present invention to overcome the above-mentioned difficulties and to provide durable sealing means which will eliminate the dead sectors by making possible the use of narrow sealing plates without causing wear on the heat storing plates.

In accordance with the present invention, a durable radial seal for regenerative fluid heaters, which substantially completely eliminates the dead sectors hitherto obtained, is formed by division of the usual chambers of sector form into narrow cells in such a manner that the

edges of the cell walls lie in the same plane as the radial chamber dividing walls and serve as sealing edges against correspondingly narrow sealing strips on the pipe connections, while the heat storing plates contained within the cells end a little short of the plane of seal and do not contribute to the seal.

In a preferred embodiment of the invention a regenerative fluid heater, having a regenerative chamber of cylindrical form which is divided into sectors through which may pass the fluid to be heated and the heat-providing fluid, inflow and outflow members for the respective media, means for causing relative rotation of said regenerator chamber and said inflow and outflow members, is provided with sealing means between adjoining cross-sections of the regenerator chamber and adjacent inflow and outflow members, said sealing means being formed by providing the cylindrical casing of the regenerator chamber with coaxially evenly-spaced cylindrical walls so as to form separate annular chambers, radially dividing the annular chambers into segments by sector walls, which are arranged in such a manner that the angles between adjacent sector walls are equal, subdividing each of said segments of the annular chambers into narrow cells by evenly spaced radial partitions the edges of which lie in the same plane as that formed by the radial chamber dividing walls and serving as sealing edges against comparatively narrow radial sealing strips between the inflow and outflow members for the fluid to be heated and the fluid providing the heat and the surfaces of the regenerator chamber, thereby eliminating the dead sectors which hitherto shut off flow through some 17 percent of the entire heat exchange surfaces, the mean circumferential width of the narrow cells formed by the radial partitions being approximately the same in all segments of the inner and outer annular chambers, and filling said cells with packets of heat storing elements having fluid passages between them, the edges of said heat storing elements terminating a little short of the plane of seal and thus not contributing to the seal.

In a further embodiment of the invention the sector walls which separate the annular chambers into segments form an angle of approximately 30° with each other and the segments of the annular chambers are subdivided into narrow cells by evenly spaced radial partitions in such a manner that the mean width of the said narrow cells is approximately the same so that the angle included between the one partition and the following partition differs in the inner and outer annular chambers, this difference being less than 3° so that elastically deformable packets of heat storing elements of equal size can compensate for the small differences in the angles formed by the consecutive partitions forming the cells in the inner and outer annular chambers into which said packets are to be placed.

The construction in accordance with the invention has the advantage that the great number of cell separating radial partitions spaced only a little from each other so much stiffen the whole exchanger that the casing wall can be quite thin. The radial cell walls are thin and flexible. Their elastic flexibility makes it possible to incorporate retaining cross bars for the packs of heat storing plates, these bars occupying the space between the edge surfaces of the heat storing packs of plates and the junction edges of the cell walls and being anchored to the cell and chamber walls. If, for example, one such cross bar is provided in the middle of the radial length of a cell both on the upper and the lower edges of the pack of heat storing plates, the pack is reliably secured against axial shift. The cross bar may be simply interlocked with the cell or chamber walls which form the radial boundaries of the cell or tongues may be provided at the ends of the bars which enter slots in the cell or chamber walls. The bar can be stiff because the cell walls are flexible though it is preferable to make the bars thin also for they are short since the cell partitions are not far apart, and to have them so flexible that there is no difficulty in bending them sufficiently to engage their ends in the slots in the radial walls.

The assembly of the heat storing plates, never very simple, is now more laborious because of the largely increased number of cells, especially as it is not possible to make all the cells of any one casing identical, and consequently a great number of packets of heat storing plates must be prepared of several different shapes.

This difficulty is overcome by making each packet of plates in such a manner that in the radial direction, that is to say in the midplane of the heat storing plates, the packet is made of the exact length of the cell, while in a direction at right angles, in which, as a rule, flat plates alternate with resilient corrugated plates, or plates otherwise deformed from the plane, the packet is made too big. Before the packets are assembled in the casing, each is compressed sufficiently to enter the chamber for which it is intended.

Several modifications of this method of assembly are possible. Adjustable presses can be provided and uniform packets of suitably chosen deformable plastic materials may be so deformed as to bring them to their final dimensions within narrow limits. But it is also possible to make the packets of elastically deformable materials, as is now usual, and to compress them below their final dimensions, put them loose into the cells and then remove the pressure so that they expand and fill and fit the cells. The size of packet and its compression may be such that the packet remains under some compression when in the cell, and so is friction tight against the cell walls, which will tend to prevent displacement of the plates. As a result of the packet resiliently filling the cell the plates may be formed with interengaging parts, and the walls of the cells may be correspondingly formed so that all the arrangements of the heat exchanger are reliably locked together.

The packets when compressed may conveniently be temporarily held compressed by binding them, while under pressure, with tapes, wires or the like which should be easily releasable. The point at which the binding is to be released should be on the edge surface of the packet of plates, and the binding should run parallel to the corrugations of the non-planar plates. Care must be taken, if necessary by adding further binding at the ends or placing binds at the ends instead of in the middle, that the plates do not splay apart at their ends. This may alternatively be taken care of by providing stiff plates next to the walls of the cells. By making the individual cells very small in accordance with the invention, normal grade metal sheets having only a comparatively small elastic deformability (i.e. not high grade spring steel) may be used for the heating element packs as an expansion of approximately 5 percent of the packet thickness will suffice in this case.

The invention and the manner in which it may be put into practice will now be described with reference to the accompanying drawings without thereby limiting the scope of the invention.

In the drawings:

FIGURE 1 is a vertical section through a rotary regenerator;

FIGURE 2 is a diagrammatic plan view of a portion of the structure shown in FIGURE 1;

FIGURE 3 is a fragmentary sectional view taken along line III—III of FIGURE 2;

FIGURE 4 is a diagrammatic perspective view illustrating a casing with parts removed for purposes of clarity;

FIGURE 5 is a fragmentary perspective view illustrating a portion of the casing structure on an enlarged scale; and

FIGURE 6 is a perspective view of a pack of heat storing material.

The rotary regenerator of the invention is of the type shown in United States Patent No. 2,951,686, dated September 6, 1960, in the names of Herbert Sandmann and Herbert Brandt and entitled "Heat Exchangers."

In FIGURE 1, which is a vertical section through a regenerator having a vertical chamber axis, there is shown a casing including a fixed regenerator chamber **6**, within which are contained packets of heat storing material as disclosed hereinafter. The heating gases are introduced from above through a firmly attached stationary gas inlet duct **2**, and they leave the chamber from below through a stationary outlet duct **3**. The air is admitted through a pipe elbow **4** that has an axially disposed opening located in the center of the casing or chamber to flow into a lower rotary air connection **5**, the upper end of which slides over the lower end surface of the regenerator chamber, two joining sections being of sector form, while the lower end of the rotary air connection is concentric with the axis of rotation and makes a joint with the axially disposed opening of the pipe elbow **4**. The air passes through the regenerator casing and then into a similarly shaped upper rotary connection **7** which communicates with an upper air outlet elbow **8** mounted inside the stationary gas inlet duct **2**. In other words, there is an opposite flow relationship between the hot gases and the air to be heated.

The two rotary air connections **5** and **7** are mounted coaxially within the overall casing structure and respectively connect in two spaced planes of rotation **9** and **10**, the opposite end surfaces of the regenerator chamber **6** with the air inlets and outlets **4** and **8**, respectively. The rotary connection **7** can be supported on upper support rollers **17**, which project through openings in a flange **28** of the stationary regenerator chamber **6**. This connection **7** also carries the weight of the lower rotary connection **5** which is centrally suspended by means of the shaft **11**. Both the rotating connections are provided with spherical hub members **30** each of which has a bore, which widens out towards the ends thereof, so that the rotary pipe connection may have rocking flexibility while rotating on the rollers **17**, so that their angular position can be altered in relation to the shaft **11**, whereby the sealing flanges **29** on the upper and lower air connections remain parallel with the flanges **28** on the chamber **6** in the event of any heat expansion. Both of the rotary air connections are pressed against the upper and lower supported rollers **17** by a spring means **27**. This spring is mounted on the hub of the rotary connection **5** and the spring pressure is adjusted by means of adjusting nuts **12**. The drive for the rotary connections or nipples **5** and **7** is effected by a gear wheel **15** engaging rods **14** carried by flanges of the air connection **7**. The drive shaft **13** is mounted exteriorly of the housing or main chamber. The drive and supporting relationship form no part of the present invention, since the same is set forth in my copending application Serial No. 831,207, filed August 3, 1959, and entitled "Supporting Roller Assembly for Heat Exchangers."

FIGURE 2 shows the stationary regenerator chamber **6** with its outer cylindrical wall **1** and the flange **28**, as well as a set of rollers **17**. Only a portion of the inside of the casing is illustrated as containing the packets of heat storing material, since FIGURES 4 and 5 better illustrate this feature. Further, FIGURE 2 discloses the annular flange **29** as well as the inner annular sealing surface **40** and the four radial sealing strips **39** that are provided on the rotatable air inlet connection **5**. The radial strips **39** are slightly wider than the greatest width of the cell chambers described hereinafter. FIGURE 3 shows in section the covering of the narrow cell chambers in the regenerator casing by the oppositely located sealing strips **39**.

The present invention is directed to the construction and arrangement of the regenerative casing which in this instance is stationary. The casing as shown in FIGURES 3 and 4 comprises the outer cylindrical wall **46**, an inner cylindrical wall **47** and stiff radial walls **48**, respectively, dividing the space between the cylindrical walls into twelve sectors. There are also intermediate cylindrical walls **49**, **50** and **51**, coaxial with the walls **46** and **47** and evenly spaced radially from each other and these walls.

The division of the chambers thus formed into narrow cells in accordance with the invention is shown in FIGURE 4 in the outer annular spaces of one sector. It is effected by the addition or insertion of thin radial partitions **52** between the annular walls **49, 50, 51.** It will be clear that the stiffening afforded by these addiitonal partitions permits the walls **48, 49, 50** and **51** to be thinner than was formerly possible.

Lugs **53** at the ends of retaining cross bars **54** engage in slots **55** in the chamber walls **48** and radial partitions **52.**

The intermediate cylindrical walls **49, 50** and **51** are evenly spaced and are connected together by the closely spaced radial partitions **52** which possess a certain amount of elasticity. The mean distance apart of the partitions **52** is the same throughout, but the angles between neighboring partitions are different in the several rings of chambers. The packets of plates **56** are entered into the chambers under pressure and are further secured against axial movement by cross bars **54** set on edge.

FIGURE 6 shows one packet of plates **56** held in compressed condition by tapes **57** of such width as to lie within the corrugations of the outermost plates. The fastenings **58** of the tapes are on the end surface of the packet so that they are easily unfastened and the tapes withdrawn after assembly, leaving the packet to expand elastically.

The foregoing is intended as illustrative and not as limitative since, within the terms of the appended claims, various modifications of the invention are possible. The locking of the cross bars may be effected in several ways, and these bars may be of specifically different shape from that shown. Other methods of assembly of the plates may be employed and the packets of plates may be used in other casing constructions.

What is claimed is:

1. A regenerative fluid heater having a durable radial seal and substantially free from dead sectors, said heater comprising a cylindrical regenerator chamber divided into sectors through which may pass the fluid to be heated and the heat-providing fluid, inflow and outflow members for the respective fluids, means for causing relative rotation of said regenerator chamber with respect to said inflow and outflow members, and sealing means between adjoining cross-sections of the regenerator chamber and adjacent inflow and outflow members, said sealing means being formed by providing the cylindrical regenerator chamber with coaxially equi-spaced cylindrical walls to form separate annular chambers, radially dividing the annular chambers into segments by means of sector walls so arranged that the angles between adjacent sector walls are equal, subdividing each of said segments of the annular chambers into narrow cells by means of equi-spaced radial partitions the edges of which lie in the same plane as that formed by the radial chamber dividers and serving as sealing edges against comparatively narrow radial sealing strips provided between the inflow and outflow members for the fluid to be heated and the fluid providing the heat and the surfaces of the regenerator chamber, thereby eliminating the dead sectors which hitherto shut off flow through some 17 percent of the entire heat exchange surfaces, the mean circumferential width of the narrow cells formed by the radial partitions being approximately the same in all segments of the inner and outer annular chambers, and packets of heat storing elements filling said cells and having fluid passages between them, the edges of said heat storing elements terminating somewhat short of the plane of the seal and forming no part of said seal.

2. A regenerative fluid heater according to claim **1,** in which the sector walls which divide the annular chambers into segments form an angle of approximately 30° with each other and the segments of the annular chambers are subdivided into the narrow cells by evenly spaced radial partitions so that the mean width of the said narrow cells is approximately the same and the angle included between preceding and succeeding partitions differing in the inner and outer annular chambers by less than 3°, and the packets of heat storing elements being of equal size and elastically deformable to compensate for the small differences in the angles formed by the consecutive partitions forming the cells in the inner and outer annular chambers into which said packets are placed.

3. A radially sealed regenerative fluid heater according to claim **2,** in which the radial partitions are flexible and resilient.

4. A radially sealed regenerative fluid heater according to claim **3,** in which each of the narrow seals is provided with at least one crossbar lying across the edges of the heat storing elements and not projecting beyond the plane of the edges of the chamber walls and cell partitions.

5. A radially sealed regenerative fluid heater according to claim **4,** in which the crossbar is flexible and resilient.

References Cited by the Examiner

FOREIGN PATENTS

865,625 2/53 Germany.

CHARLES SUKALO, *Primary Examiner.*