

Nov. 4, 1969

R. W. GUERNSEY ET AL

3,476,174

REGENERATOR MATRIX

Filed Dec. 29, 1967

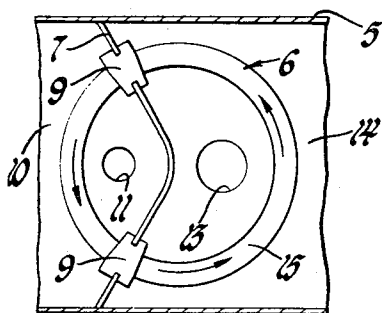


Fig. 1

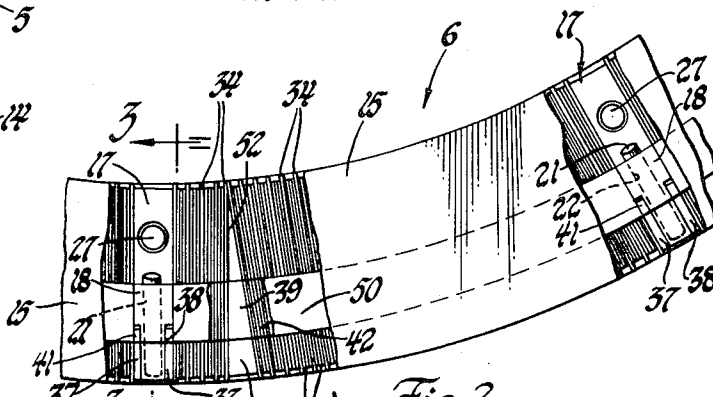


Fig. 2

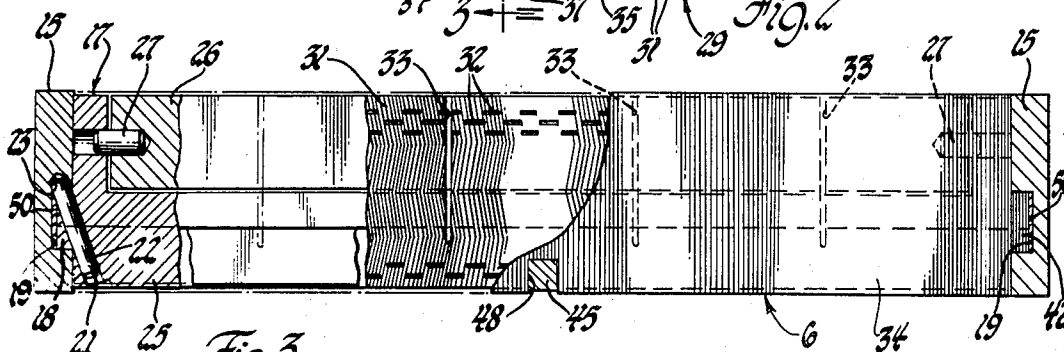


Fig. 3

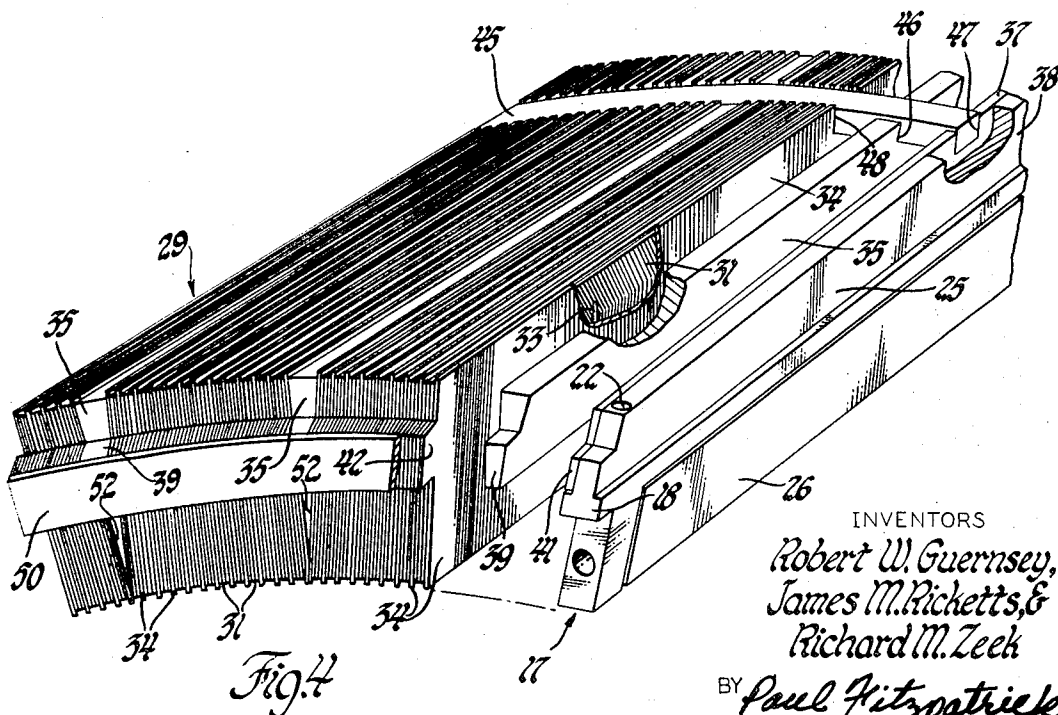


Fig. 4

INVENTORS

Robert W. Guernsey,
James M. Ricketts, &
Richard M. Zeek

BY *Paul Fitzpatrick*
ATTORNEY

1

3,476,174

REGENERATOR MATRIX

Robert W. Guernsey, Rochester, James M. Ricketts, Oxford, and Richard M. Zeek, Farmington, Mich., assignors to General Motors Corporation, Detroit, Mich., a corporation of Delaware

Filed Dec. 29, 1967, Ser. No. 694,690

Int. Cl. F28d 19/00, 17/00

U.S. Cl. 165—9

5 Claims

ABSTRACT OF THE DISCLOSURE

An annular matrix for a radial-flow regenerator has rims at each end of the matrix with stiffeners connecting the rims. A heat transfer segment mounted between each pair of stiffeners embodies permeable heat transfer material (shim packs) and labyrinth seal plates extending from the surface of the shim packs. Thermal deflection of the segment is minimized by beams extending across the matrix from rim to rim and a bridge intermediate the rims connecting the beams. The bridge is brazed to the seal elements and shim packs. The beams have low thermal deflection and thus, through the bridge, control the thermal deflection of the heat transfer material and seal elements.

Our invention relates to rotary regenerators and particularly to an improved structure of the matrix of such regenerators effective to reduce thermal distortion of the matrix. It is well known that such matrices tend to distort in operation because of the considerable temperature difference between the hot and cold faces of the matrix. Particularly in applications of regenerators in which there is a substantial pressure difference between the two fluids, it is important to seal as closely as feasible to the matrix so as to minimize escape of the high pressure fluid into the low pressure area.

Our invention is directed to providing a matrix which, by virtue of simple and feasible structure, substantially reduces the deflection of the matrix due to temperature differences so that the parts which cooperate with fixed seals in the regenerator better accomplish the sealing function, provides for much closer spacing of the sealing elements, and also provides a matrix convenient to assemble.

The application of regenerators to gas turbines is generally understood. One example is described in U.S. Patent No. 3,077,074 of Collman et al. A discussion of the thermal distortion of such a regenerator matrix is to be found in U.S. Patent No. 2,888,248 of Bubniak et al. Structures to minimize thermal distortion of the matrix are described in U.S. Patents No. 3,181,603 of Bubniak et al. and 3,186,479 of Mondt, and a preferred structure of a permeable heat transfer shim pack of such a matrix is described in U.S. Patent No. 3,183,963 of Mondt.

U.S. Patents 3,181,603 and 3,186,479 are directed to structures in which each of the labyrinth seal elements of the matrix is associated with an individual beam or beams to reduce or minimize the warping or curvature of the matrix including the labyrinth element. Our invention is directed to the same general objects as those prior patents but, according to our invention, a common stiffening or restraining structure is applied to a considerable group of sealing elements. Instead of a distortion resisting beam or pair of beams for each labyrinth element, a relatively small number of such beams are coupled to a considerably greater number of labyrinth elements to provide the resistance to thermal distortion. The result is that space is available for a considerably greater number of labyrinth seal elements, thus providing for a greater number

2

of labyrinth seal elements cooperating with the fixed seal as the matrix passes through the bulkhead between the two fluids.

The structure according to our invention also facilitates compensation for the greater circumference of a radial-flow matrix at the outside than at the inside, and leads to a structure which is relatively easy to fabricate and assemble.

The nature of our invention and the advantages thereof will be clear to those skilled in the art from the succeeding detailed description of the preferred embodiment of the invention and the accompanying drawings thereof.

FIGURE 1 is a schematic diagram of a conventional radial-flow rotary regenerator.

FIGURE 2 is a partial elevation view of the matrix with parts cut away and in section.

FIGURE 3 is a sectional view of the matrix taken on a broken plane containing the axis thereof as indicated by the line 3—3 in FIGURE 2.

FIGURE 4 is a partial axonometric view of the matrix with parts cut away and in section.

Referring first to FIGURE 1, a radial-flow regenerator of usual type may be considered to embody a housing 5 and an annular matrix 6. The matrix is rotated about its axis by means, not illustrated, so as to pass through a bulkhead 7 at two places. Main seals 9 surround the matrix where it passes through the bulkhead to minimize leakage of fluid. These seals, as is well known, include shoes which lie in close proximity to or in light rubbing contact with the inner and outer surfaces of the matrix to cooperate with labyrinth seal elements of the matrix.

In operation, a first fluid to be heated may be considered to enter the housing at 10, flow inward through the matrix, and be exhausted through an outlet 11. The fluid which is to give up heat may enter the housing through an entrance 13 and leave through an outlet 14. Of course, the direction of flow could be reversed. The details of such structure may be generally as shown in U.S. Patent No. 3,057,604, No. 3,077,074, or No. 3,267,674. The matrix 6 includes two ring-shaped rims 15, one at each end of the matrix. The rims are structurally connected by a suitable number of parallel stiffeners 17 which are rigidly connected to the rims. In the particular structure illustrated, there are twelve such stiffeners equally spaced around the rim. The stiffeners are located with respect to the rims by tenons 18 which project into a circumferential groove 19 in the inner surface of the rim. The stiffeners are fixed to the rims by pins 21 driven into drilled and reamed generally radial bores 22 in the stiffener and 23 in the rim. The rims and stiffeners constitute a structural framework for the matrix.

To reduce thermal deflection of the stiffeners, each is made of two principal parts; a radially outer bar 25, which is the structural element connecting the two rims, and a radially inner bar 26 which serves as a space filler between the segments of the matrix on each side of the stiffener. The inner bar 26 is mounted on the outer bar by two dowels 27 fitted in aligned bores in the two bars. Clearance is provided at the end of bar 26 for relative expansion.

A heat transfer segment 29 is mounted in each of the twelve spaces defined between the rims and any two adjacent stiffeners 17. Each of these segments comprises a rather large number of packs of heat transfer material in the form of a number of laid-up thin corrugated sheet metal strips or shims 31 which are preferably of the type described in U.S. Patent No. 3,183,963. These have zig-zag corrugations, and have anticonduction slits or perforations 32 through the shim. Four radial slots 33 in the shims allow core thermal growth without undue loading of the deflection control means.

Labyrinth seal elements 34 disposed between adjacent shim packs are of such dimensions as to project slightly from the radially outer and inner faces of the shim pack. The labyrinth elements have straight radial corrugations as shown most clearly in FIGURES 3 and 4. These also are of thin sheet metal. In a particular example, sheets 31 are of 0.002 inch stock and sheets 34 of 0.003 inch stock.

Each 30° heat transfer segment also includes a number of deflection control beams. Specifically, each includes three main control beams 35 and two minor or end control beams 37. The end control beams lie against the stiffener, the radially outer portion of which is cut away on each face as indicated at 38 to provide a recess for the beams. The control beams include bosses 39 and 41, respectively, which project into the groove 19 in the inner surface of the rim. The heat transfer shim and labyrinth seal elements also are provided with tongues, indicated at 42, which project into the groove 19. Thus, all of the elements of the heat transfer segment are located radially by the tongues or projections extending from them into the groove 19 in the rim.

The labyrinth seal elements 34 and the control beams 35 and 37 are rigidly connected together by a bridge 45 extending from edge to edge of the heat transfer segment midway between the rims 15. This bridge, which lies substantially in the plane of the outer surface of the heat transfer shim packs, fits into notches 46 in the main control beams, 47 in the end control beams, and 48 in the heat transfer shims 31 and labyrinth elements 34. The arcuate bridge 45 is brazed to these elements 31, 34, 35, and 37. The ends of the bridge are slightly spaced from the stiffeners.

The remaining elements of structure of the heat transfer segment are two retainer ring segments 50 which extend across the ends of all of the projections or tongues 39, 41, and 42, and are brazed to the tongues of the labyrinth elements 34. These tongues extend slightly beyond the tongues of the heat transfer shims 31. These ring segments fit into the groove 19 in the rim when the assembly is made, and serve to hold the parts of the heat transfer segment assembled before they are placed into the framework of the matrix. They also prevent leakage past the ends of the tongues of the labyrinth elements.

It should be noted that the beams 35 and 37 extend only about forty percent of the thickness of the matrix, and are thus relatively shallow in the radial direction. Also, they are relatively thick in the circumferential dimension of the matrix as compared to the heat transfer shim elements and the seal elements, so that the temperature gradient in these beams is relatively slight and the thermal deflection therefore relatively slight. These beams serve to locate the bridge 45 radially of the matrix, and the bridge 45 being brazed to the labyrinth elements locates them radially at the mid-point of the matrix.

As will be apparent, more than one bridge 45 could be provided between the rims. However, in the illustrative embodiment of the invention, one bridge only is preferred.

It should be further noted that the beams 35 taper radially so that the opposed faces of the beams are substantially parallel. These, therefore, provide for the radial convergence from outer diameter to inner diameter of the matrix without requiring any convergence of the other elements of the matrix. Note that the radially inner part of the heat transfer structure converges as indicated at 52 in FIGURE 2 from the inner edge of the beam 35 toward the inner diameter of the matrix where the seal elements 34 which abut the beam 35 engage each other.

To assemble the structure of the matrix, the individual elements of each heat transfer segments are stacked in a jig or fixture and put under pressure to obtain the desired total thickness or circumferential extent of the stack-up. The bridge 45 is then brazed to the heat transfer shims, the labyrinth elements, and the beams. The ring segments 50 are brazed to the tongues 42 of the labyrinth elements. The heat transfer segments may then be stacked on one

rim which is disposed with its axis vertical and then the stiffeners and the other rim may be put in place, after which the pins 21 are fitted to hold the entire assembly together.

Note that the beams and bridge resist and reduce deflection of the heat transfer body, the assembly of shim packs. This effect can be used in a matrix in which the projecting labyrinth elements are omitted.

In the illustrated structure, the three main and two end beams of each segment control the deflection of the segment, having about thirty labyrinth elements. Thus, each beam accounts for the restraint of about six labyrinth elements. By virtue of this structure, the number of labyrinths in a matrix of given size has been increased by a factor of four over previous designs, thus improving the efficiency of sealing and reducing pressure pulsations in the seals. Also, the control of distortion or deflection of the matrix is greatly improved, the deflection being reduced to one-half that of previous metal matrices of the same dimensions. This reduction in deflection also contributes to improvement in sealing between the fluids on the opposite sides of the regenerator bulkhead.

The detailed description of the preferred embodiment of the invention for the purpose of explaining the principles thereof is not to be considered as limiting or restricting the invention, since many modifications may be made by the exercise of skill in the art without departing from the scope of the invention.

What is claimed is:

1. An annular matrix for a rotary regenerator comprising, in combination, two coaxial rims, stiffeners distributed around the circumference of the matrix extending from rim to rim, and structurally connecting the rims, the rims and stiffeners defining spaces for heat transfer material, and a heat transfer segment mounted in each said space, each heat transfer segment comprising a plural number of deflection control beams extending from rim to rim, coupled to the rims and distributed circumferentially of the segment, a bridge extending circumferentially of the matrix spaced from the rims and fixed to the beams, the bridge extending substantially from stiffener to stiffener and terminating at the stiffeners, a number of labyrinth seal elements substantially greater than the number of said beams extending from rim to rim, the seal element being fixed to the bridge between adjacent beams, and heat transfer material mounted between the seal elements, the heat transfer material being of a structure pervious to fluid flow.

2. A matrix as recited in claim 1 in which the matrix is of cylindrical form adapted for radial flow of fluid, the seal elements and the beams extend substantially parallel to the axis of the matrix, and the bridge extends circumferentially of the matrix intermediate the ends thereof.

3. A matrix as recited in claim 1 in which at least some of the beams taper radially so that the opposed faces of adjacent beams are substantially parallel.

4. An annular radial-flow matrix for a rotary regenerator comprising, in combination, two rims disposed at the ends of the matrix, stiffeners distributed around the circumference of the matrix extending from rim to rim and structurally connecting the rims, the rims and stiffeners defining spaces for heat transfer material, and a heat transfer segment mounted in each said space, each heat transfer segment comprising a plural number of deflection control beams extending from rim to rim coupled to the rim, and distributed circumferentially of the segment, a bridge extending circumferentially of the matrix spaced from the rims and fixed to the beams, the bridge extending substantially from stiffener to stiffener and terminating at the stiffeners, and a heat transfer pack mounted between the beams, the heat transfer pack being of a structure pervious to fluid flow comprising sheet metal strips extending from rim to rim, the bridge being fixed to the heat transfer pack so as to resist radial deflection of the pack.

5. A matrix as recited in claim 4 in which the matrix defines a circumferential recess for the bridge and the bridge is mounted in the said recess.

3,301,316	1/1967	Mason	-----	165—10 X
3,367,405	2/1968	Addie et al.	-----	165—9

References Cited

ROBERT A. O'LEARY, Primary Examiner
5 ALBERT W. DAVIS, Assistant Examiner

UNITED STATES PATENTS

U.S. Cl. X.R.

3,294,156	12/1966	Beaufriere et al.	-----	165—10 X	165—10
-----------	---------	-------------------	-------	----------	--------