US 20090000762A1

(19) **United States**

(12) **Patent Application Publication**

Wilson et al.

(10) **Pub. No.: US 2009/0000762 A1**

(43) **Pub. Date: Jan. 1, 2009**

(54) **BRUSH-SEAL AND MATRIX FOR REGENERATIVE HEAT EXCHANGER, AND METHOD OF ADJUSTING SAME**

(75) Inventors: **David Gordon Wilson**, Winchester, MA (US); **Jon M. Ballou**, Beverly, MA (US); **Kelly Ward**, Peabody, MA (US)

Correspondence Address:
CANTOR COLBURN, LLP
20 Church Street, 22nd Floor
Hartford, CT 06103 (US)

(73) Assignee: **WILSON TURBOPOWER, INC.**, Woburn, MA (US)

(21) Appl. No.: **11/770,904**

(22) Filed: **Jun. 29, 2007**

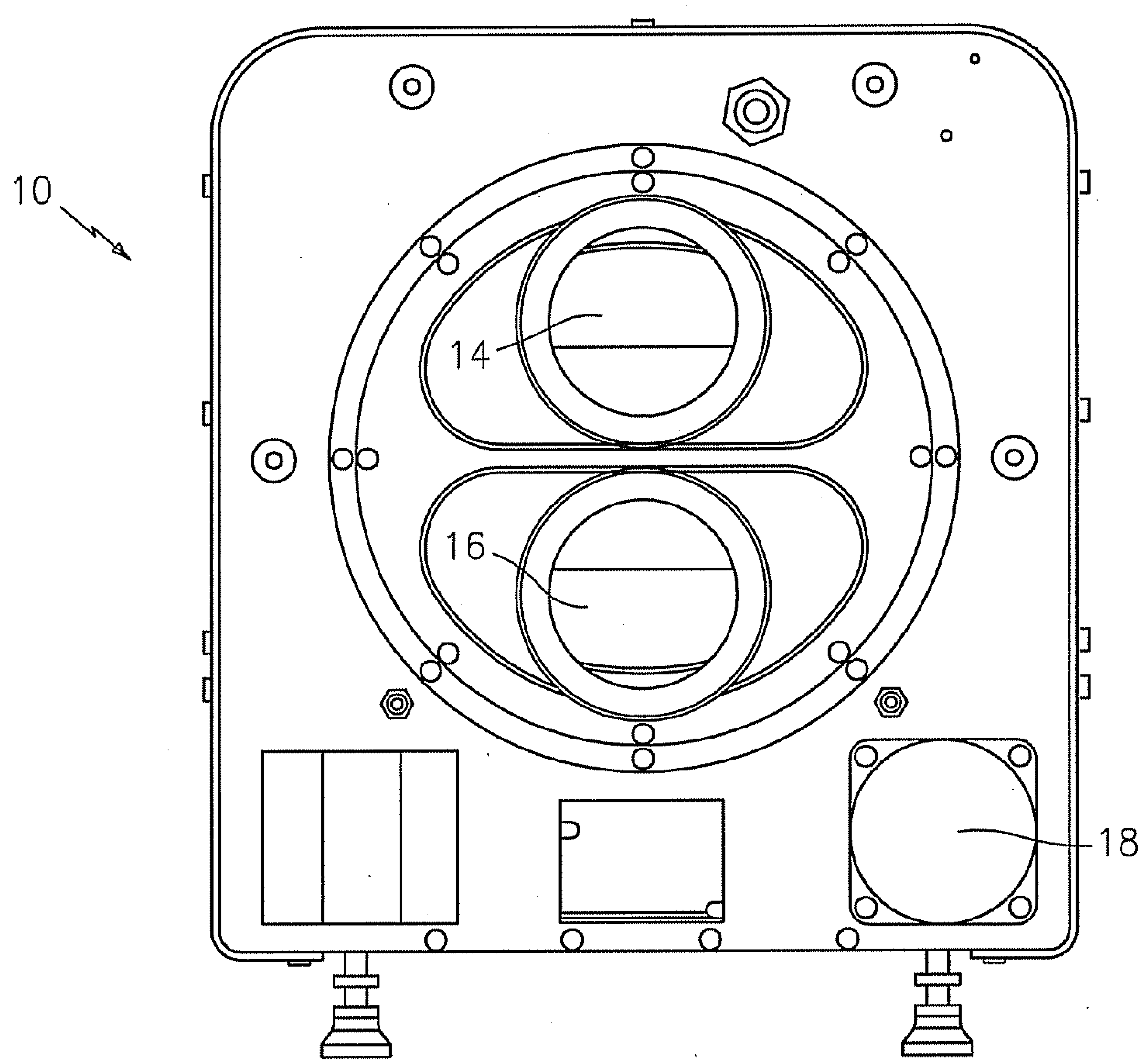
Publication Classification

(51) **Int. Cl.**
F23L 15/02 (2006.01)

(52) **U.S. Cl.** **165/9**

(57) **ABSTRACT**

Disclosed is a regenerative heat exchanger including a brush-seal configuration to prevent mixing of fluid flows. The regenerative heat exchanger includes a regenerator, and at least two conduits, each conduit having a matrix end abutting a face of the regenerator matrix. The at least two conduits carrying at least two fluid flows, the fluid flows which pass through the regenerator matrix. The regenerative heat exchanger includes a plurality of brush-seals, each brush-seal located at a matrix end of each conduit without contacting the matrix, thereby sealing around a periphery of each conduit to prevent mixing of fluid flows. Also disclosed is a method for establishing a minimal gap between a regenerator matrix of a regenerative heat exchanger and a plurality of brush-seals.



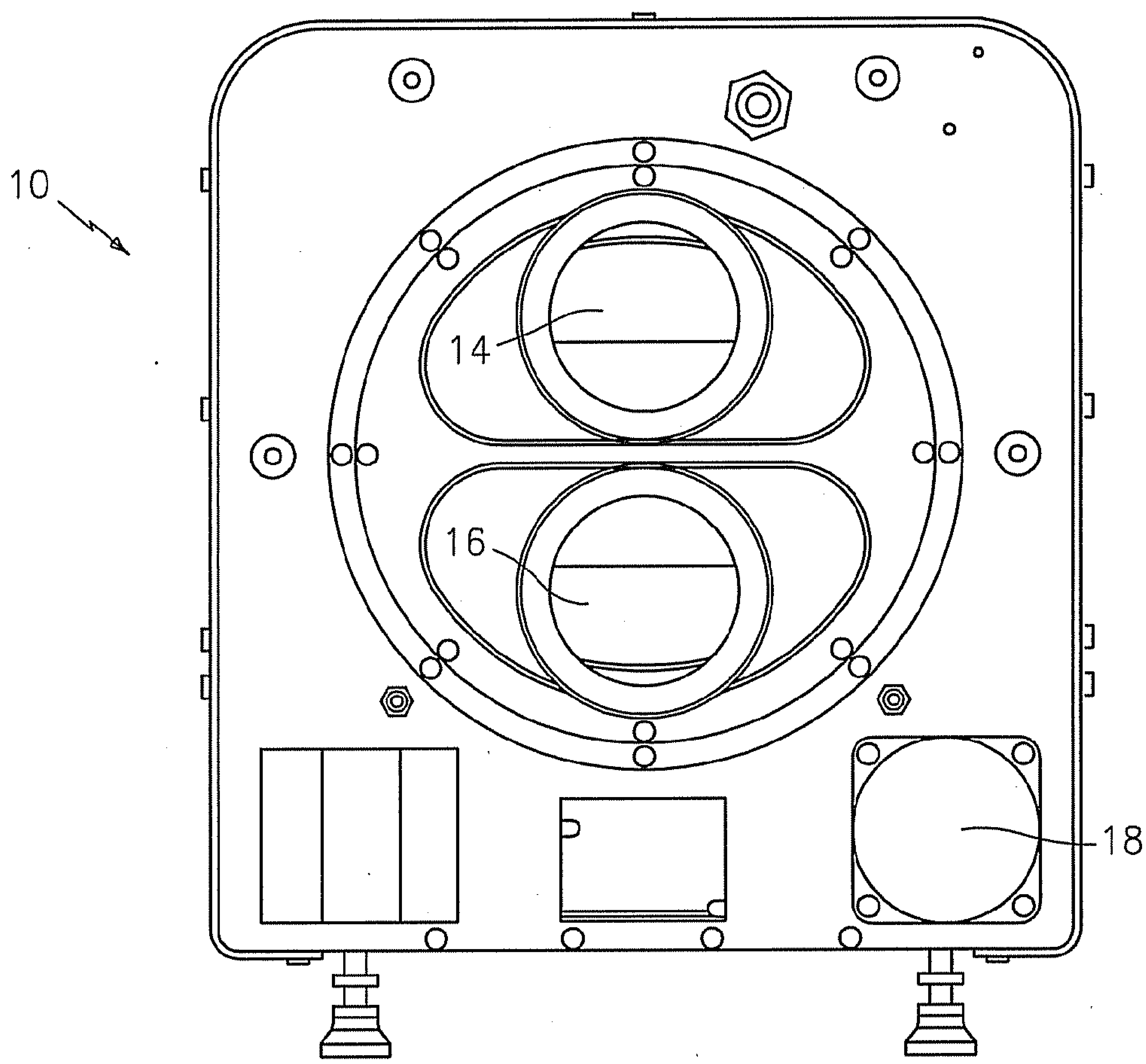


FIG. 1

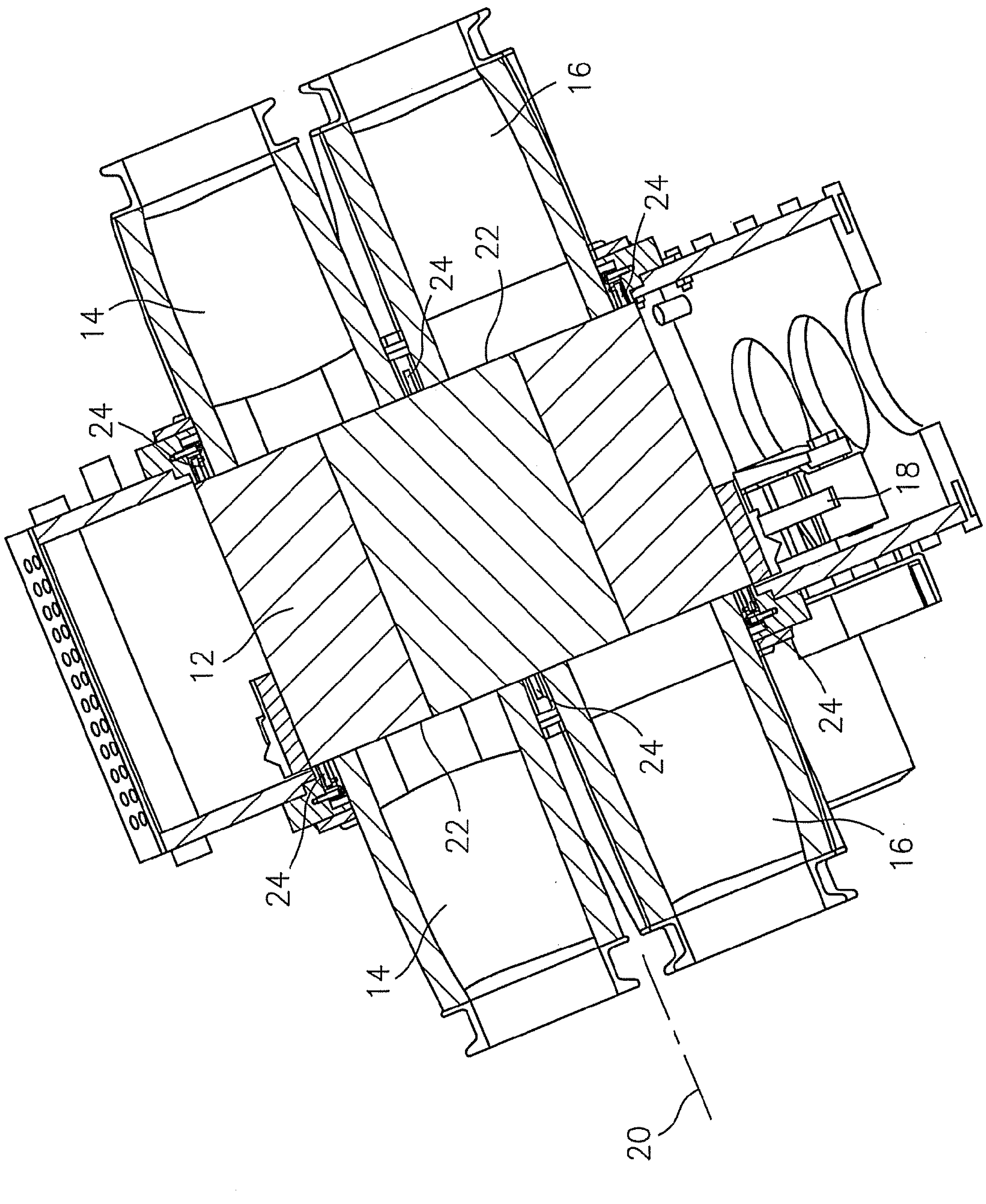


FIG. 2

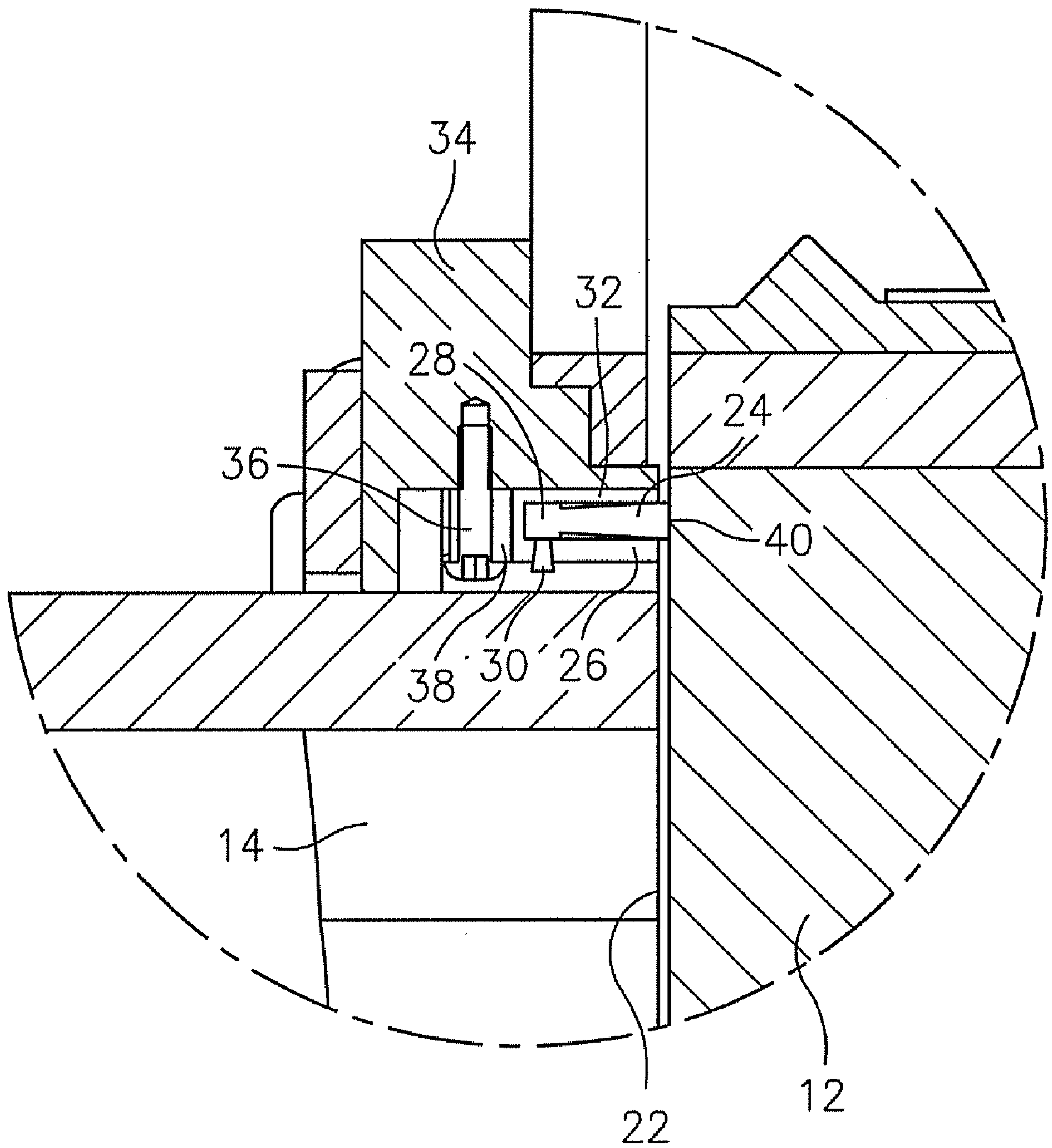


FIG. 3

BRUSH-SEAL AND MATRIX FOR REGENERATIVE HEAT EXCHANGER, AND METHOD OF ADJUSTING SAME

BACKGROUND OF THE INVENTION

[0001] This invention generally relates to heat exchangers. In particular, the present invention relates to seals for rotary regenerative heat exchangers.

[0002] A regenerative heat exchanger (regenerator) uses a heat transfer matrix which is rotated through a hot and a cold stream consecutively to transfer heat from the former to the latter. The device call also be used to transfer mass between two fluids differing in concentration in a targeted constituent and the exchange (be it mass and/or heat) can involve any number of flows greater than one.

[0003] Each of the hot and cold flows is typically carried to and from the matrix by a conduit. The flows enter and exit the matrix through a face of the matrix, and a configuration of seals is located between the conduits and the rotating matrix face to prevent leakage of the flows from the conduits into the environment or from one flow into another. Two types of seals are generally used, non-contact seals or contact seals. With non-contact seals (which do not contact the matrix face), it is a major challenge to properly adjust a gap between the matrix face and the non-contact seal minimizing leakage to maximize efficiency of the heat exchanger. Contact seals (which do contact the matrix face) ensure lower leakage which improves efficiency of the regenerator as compared to non-contact seals. Use of contact seals, however, causes increased seal wear and also reduces efficiency of the regenerator due to the increased function between the contact seal and the matrix that must be overcome in the rotation of the matrix. Additionally, rubbing of the contact seals on the regenerator matrix can over time produce solid material (either from the matrix or the seals) which will contaminate the flow and might lead to clogging in a porous matrix.

BRIEF DESCRIPTION OF THE INVENTION

[0004] The present invention solves the aforementioned problems by providing a regenerative heat exchanger including a brush-seal configuration to prevent mixing of fluid flows. The regenerative heat exchanger includes a regenerator matrix, and at least two conduits, each conduit having a matrix end abutting a face of the regenerator matrix. At least two conduits carry at least two fluid flows which pass through the regenerator matrix. The regenerative heat exchanger includes a plurality of brush-seals. Each brush-seal is located at a matrix end of each conduit without contacting the matrix, thereby sealing around a periphery of each conduit to prevent mixing of fluid flows.

[0005] A method for establishing a minimal gap between a regenerator matrix of a regenerative heat exchanger and a plurality of brush-seals is disclosed. The method includes installing the plurality of brush-seals such that a bristle end of each brush-seal contacts a face of the regenerator matrix. The regenerator matrix is rotated at a desired speed about an axis substantially perpendicular to the face of the regenerator matrix. During rotation, friction between the bristle end and the face causes material to be removed from the bristle end. The rotation is stopped when a power required to rotate the regenerator matrix at the desired speed reaches a predetermined level. This stops the removal of material from the bristle end and establishes a minimal gap between the bristle end and the face of the regenerator matrix.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006] The above, as well as other advantages of the present invention, will become readily apparent to those skilled in the art from the following detailed description of preferred embodiments when considered in light of the accompanying drawings in which:

[0007] FIG. **1** depicts an end view of an embodiment of a regenerative heat exchanger;

[0008] FIG. **2** depicts a cross-sectional view of the regenerative heat exchanger of FIG. **1**; and

[0009] FIG. **3** depicts an enlarged view of the circled portion of FIG. **2**.

DETAILED DESCRIPTION OF THE INVENTION

[0010] The detailed description explains embodiments of the invention, together with advantages and features, by way of example with reference to the drawings.

[0011] Shown in FIG. **1** is an embodiment of a regenerative heat exchanger (regenerator) **10**. Referring now to FIG. **2**, the regenerator **10** includes a regenerator matrix **12**. The matrix **12** generally comprises a body having a plurality of internal passageways (not shown) oriented in all axial direction, and may be formed of a low-thermal-conductivity and high-heat-capacity material, for example, a ceramic material. In some embodiments, the matrix **12** may include an abradable coating layer (not shown) to protect the matrix **12** material from wear. The matrix **12** in some embodiments is cylindrical in shape, but other shapes are contemplated within the scope of this invention. The matrix **12** is disposed across two or more fluid streams. Each fluid stream is carried in a conduit. In this embodiment, a cold fluid stream is carried in a first conduit **14** and a hot fluid stream is carried in a second conduit **16**.

[0012] The matrix **12** is connected to a drive motor **18**. The drive motor **18** causes the matrix **12** to rotate about a matrix axis **20** and transfer heat from the hot fluid stream carried through second conduit **16** to the cold fluid stream carried through first conduit **14**. Because the matrix **12** moves relative to the first conduit **14** and the second conduit **16**, a configuration of seals is required on a face **22** of the matrix **12** to prevent leakage, including leakage from the conduits **14** or **16**, and leakage between the first conduit **14** and the second conduit **16**.

[0013] Sealing between the face **22** and each of the conduits **14** and **16** is accomplished by a brush-seal configuration **24**. The brush-seal configuration **24** between first conduit **14** and the face **22** is substantially identical to the brush-seal configuration **24** between second conduit **16** and the face **22**, so only the brush-seal configuration **24** between first conduit **14** and the face **22** will be described herein. The brush-seal configuration **24** may be made from a variety of materials including metal, super alloys, ceramics, etc., and is chosen depending on thermal and chemical requirements of the application. As shown in FIG. **3**, the brush-seal **24** extends around a periphery of the first conduit **14** at the face **22**, and is fixed to a seal holder **26** at a base end **28** of the brush-seal **24** by a plurality of seal screws **30** or other means. In this example, the seal holder **26** has a U-shaped section **32** for receiving brush-seal **24**. A seal screw **30** is inserted though a screw hole (not shown) in the section **32** and threaded into a seal hole (not shown) securing the blush-seal **24** to the seal holder **26**.

[0014] The seal holder **26** is secured to a casing **34** by a plurality of casing screws **36**. The casing **34** extends circumferentially around the first conduit **14**, and is fixed relative to the first conduit **14**. The casing screws **36** are inserted in a radial direction through axially-slotted holes **38** in the seal holder **26** and into threaded casing holes (not shown) in the casing **34**, thereby securing the seal holder **26** to the casing **34**. The slotted holes **38** allow the position of the seal holder **26** to be adjusted relative to the casing **34**, and thus the position of the brush-seal **24** relative to the face **22** can be adjusted. Initially, the brush-seal **24** is positioned so the bristles **40** are in contact with the face **22**. It is to be appreciated that the attachment scheme of the blush-seals **24** described herein is only an example. Other attachment schemes including, for example, adhesive attachment, are contemplated within the scope of this invention.

[0015] When the blush-seals **24** are installed, a break-in process is employed to establish a minimal gap between the blush-seals **24** and the matrix **12** at the faces **22**. In one embodiment, a necessary power, P_{ref}, for rotation of the matrix **12** at a desired rotation speed is determined prior to installing the brush-seals **24**. The brush-seals **24** are installed so the bristles **40** contact the matrix **12** as described above. The matrix **12** is rotated to the desired rotation speed, and a power required to rotate the matrix **12**, P_{in}, is monitored. Initially, because of the contact between the bristles **40** and the matrix **12**, $P_{in}>P_{ref}$. During this break-in process, the regenerator **10** is run under normal wordings conditions, i.e. the flows passing through the regenerator will be at the temperatures of the flows during normal operation. The friction between the bristles **40** and the matrix **12** during the break-in process increases the temperature of the bristles **40** and the matrix **12**, and thus will cause slightly increased thermal expansion of the matrix **12** and the bristles **40** over that which would occur during normal operation.

[0016] As the break-in process progresses, material is worn off of the bristles **40** and/or the face **22**. As material is worn off, friction between the bristles **40** and the matrix **12** is reduced. Because of the reduced friction, the temperature of bristles **40** and the matrix **12** are reduced slightly, reducing thermal expansion of the bristles **40** and the matrix **12**, thus creating a slight gap between the bristles **40** and the matrix **12**. The reduced friction also reduces P_{in} required for the matrix **12** to rotate at the desired speed. P_{in} is monitored until $P_{in}=P_{ref}$, at which point the break-in process is completed, leaving the desired gap between the bristles **40** and the matrix **12**.

[0017] While embodiments of the invention have been described above, it will be understood that those skilled in the art, both now and in the future, may make various improvements and enhancements which fall within the scope of the claims which follow. These claims should be construed to maintain the proper protection for the invention first described.

What is claimed is:

1. A regenerative heat exchanger comprising:

a regenerator matrix;

at least two conduits, each conduit having a matrix end abutting a face of the regenerator matrix, the at least two conduits carrying at least two fluid flows, the fluid flows passing through the regenerator matrix; and

a plurality of brush-seals, each brush-seal disposed at a matrix end of each conduit without contacting the matrix, thereby sealing around a periphery of each conduit to prevent mixing of fluid flows.

2. The regenerative heat exchanger of claim **1** wherein each brush-seal is affixed to a casing.

3. The regenerative heat exchanger of claim **2** wherein the plurality of brush-seals is affixed to the casing by a plurality of screws.

4. The regenerative heat exchanger of claim **3** wherein each screw is installed through a slotted hole in the casing, allowing the position of the brush-seal to be adjusted.

5. The regenerative heat exchanger of claim **2** wherein the plurality of brush-seals is affixed to the casing by adhesive.

6. The regenerative heat exchanger of claim **1** wherein the regenerator matrix includes a plurality of axially-oriented internal passageways.

7. The regenerative heat exchanger of claim **1** wherein the regenerator matrix is formed of a low-thermal-conductivity and high--heat-capacity material.

8. The regenerative heat exchanger of claim **7** wherein the regenerator matrix is formed from a ceramic material.

9. The regenerative heat exchanger of claim **1** wherein the regenerator matrix includes an abradable coating layer.

10. The regenerative heat exchanger of claim **1** wherein each brush-seal is formed from a superalloy material.

11. The regenerative heat exchanger of claim **1** wherein each brush-seal is formed from a ceramic material.

12. A method for establishing a minimal gap between a regenerator matrix of a regenerative heat exchanger and a plurality of brush-seals, the brush-seals sealing around a periphery of each conduit of a plurality of conduits carrying fluid flows which pass thorough the regenerator matrix, the method comprising:

installing the plurality of brush-seals such that a bristle end of each brush-seal contacts a face of the regenerator matrix;

rotating the regenerator matrix at a desired speed about an axis substantially perpendicular to the face of the regenerator matrix, friction between the bristle end and the face causing material to be removed from the bristle end and/or the face of the regenerator matrix;

stopping rotation of the regenerator matrix when a power required to rotate the regenerator matrix at the desired speed reaches a predetermined level, stopping the removal of material from the bristle end and/or the face of the regenerator matrix and establishing a minimal gap between the bristle end and the face of the regenerator matrix.

13. The method of claim **9** wherein the face of the regenerator matrix includes an abradable coating layer.

14. The method of claim **9** wherein the temperatures of the flows passing through the regenerator are substantially the same as at normal operation of the regenerative heat exchanger.

15. The method of claim **9** wherein the power is continuously monitored to determine when the power reaches the predetermined level.

16. The regenerative heat exchanger of claim **9** wherein the regenerator matrix is formed from a ceramic material.

17. The regenerative heat exchanger of claim **9** wherein each brush-seal is formed from a superalloy material.

18. The regenerative heat exchanger of claim **9** wherein each brush-seal is formed from a ceramic material.

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