

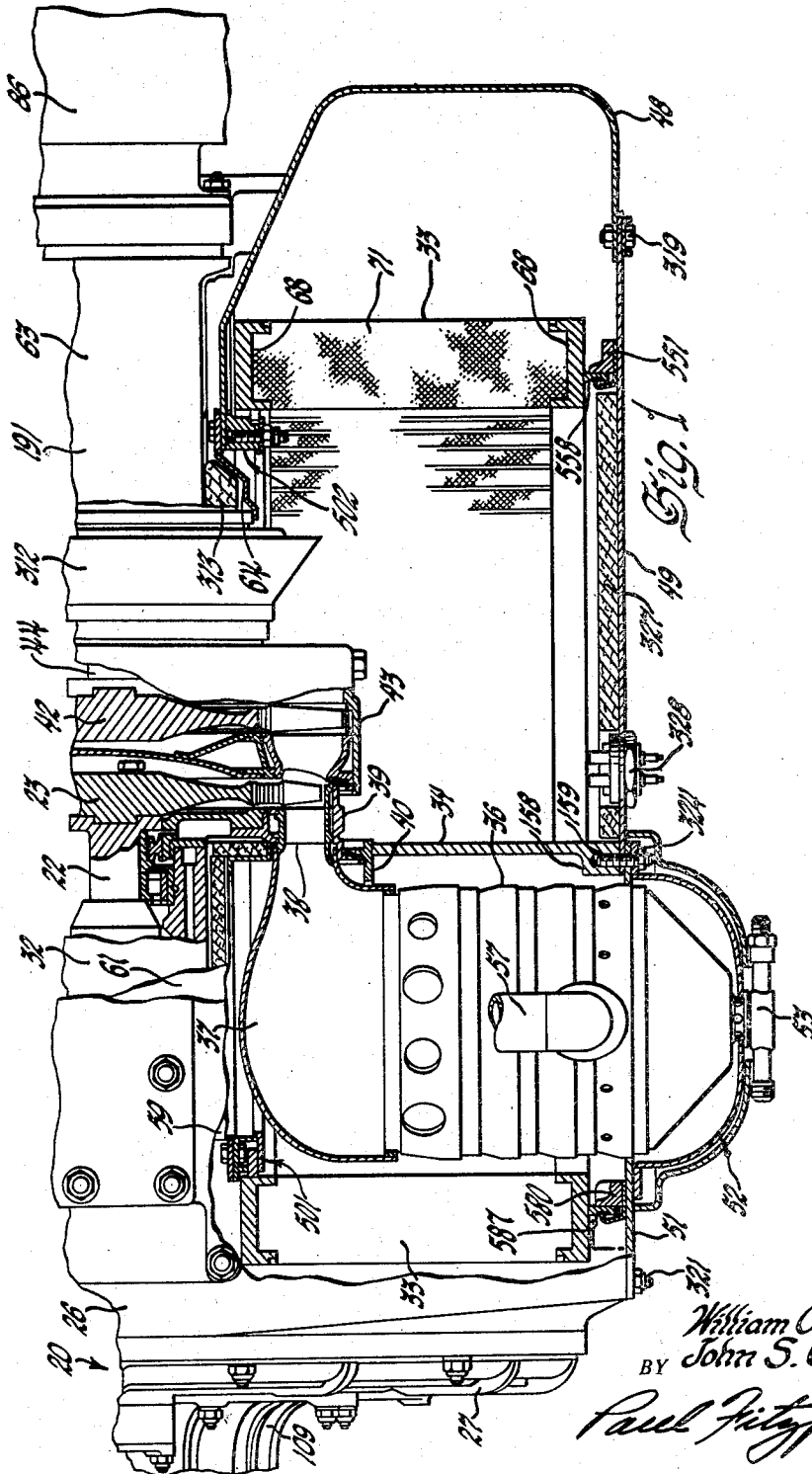
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W. C. BUBNIAK ET AL
ROTARY REGENERATOR SEALS

3,116,785

Original Filed Sept. 10, 1958

2 Sheets-Sheet 1



INVENTORS
William C. Bubniak &
John S. Collman
BY Paul Fitzpatrick
ATTORNEY

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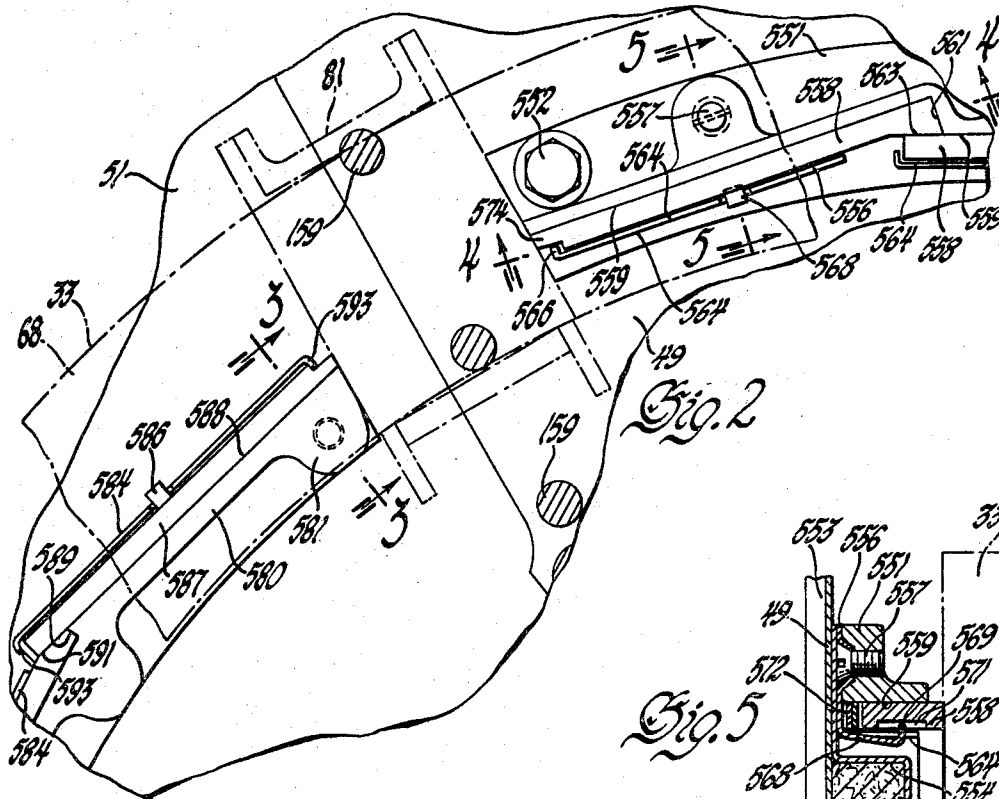


Fig. 2

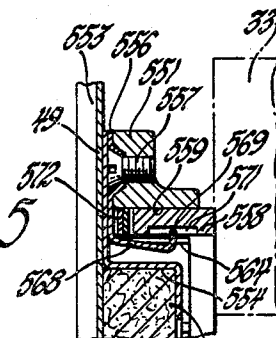


Fig. 5

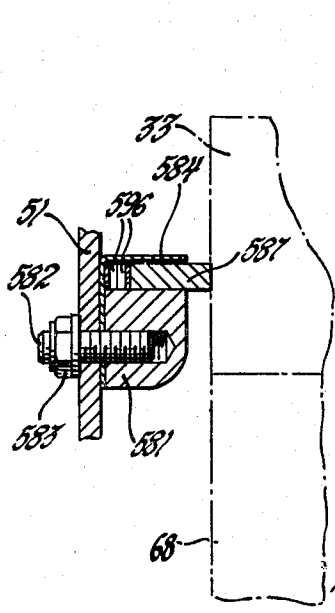


Fig. 3

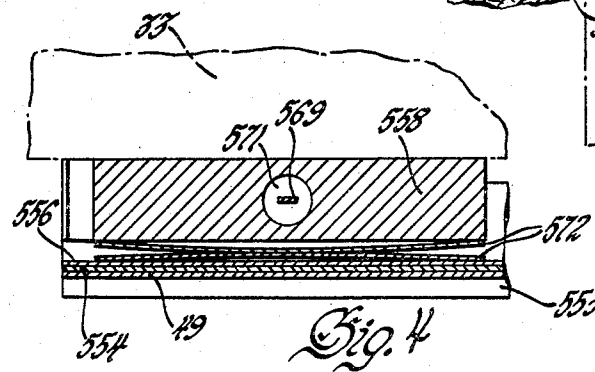


Fig. 4

INVENTORS
William C. Bubniak &
John S. Collman
BY Paul Fitzpatrick
ATTORNEY

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ROTARY REGENERATOR SEALS

William C. Bubniak and John S. Collman, Detroit, Mich., assignors to General Motors Corporation, Detroit, Mich., a corporation of Delaware

Original application Sept. 10, 1958, Ser. No. 760,211, now Patent No. 3,077,074, dated Feb. 12, 1963. Divided and this application Sept. 29, 1960, Ser. No. 59,223 11 Claims. (Cl. 165-9)

This application is a division of application Serial No. 760,211, filed September 10, 1958, now Patent No. 3,077,074, granted February 12, 1963. It is directed to a new and improved rim or bypass seal for a rotary regenerator. The preferred structure of the invention is particularly suited to an automotive engine such as that described in detail in Patent No. 3,077,074 and briefly herein.

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

FIGURE 1 is a partial longitudinal sectional view, taken on a horizontal plane, of a gas turbine engine with a regenerator incorporating our bypass seals.

FIGURE 2 is a partial elevation view of the seals.

FIGURE 3 is a fragmentary sectional view taken on the plane indicated by the line 3-3 in FIGURE 2.

FIGURE 4 is a fragmentary sectional view taken on the plane indicated by the line 4-4 in FIGURE 2.

FIGURE 5 is a fragmentary sectional view taken on the plane indicated by the line 5-5 in FIGURE 2.

By way of introduction to the more detailed description of the invention, its general environment will be outlined briefly with reference to FIGURE 1. The engine comprises a centrifugal compressor 20 including a rotor mounted on a horizontal shaft 22 on which also is mounted the rotor wheel 23 of a first or compressor turbine. The stator of the compressor comprises the rear case 26 and a front cover assembly 27. A generally annular outlet for the compressor is defined between outer and inner portions of the rear case 26. The compressor diffuser lies between the front cover and rear case. A suitable air inlet 109 may be provided. The compressor rear case is part of a unitary structure which may be termed the forward frame or compressor turbine housing, and which includes a shaft housing 32 within which shaft 22 is supported.

Two regenerator matrix drums 33 (only one being illustrated) are mounted for rotation about a horizontal axis intersecting the axis of shaft 22. Each matrix passes at two points through a bulkhead 34 which comprises an arcuate plate of generally rectangular outline bolted at its upper and lower edges to the compressor rear case portion 26 of the forward frame. Two flame tubes or combustion liners 36 (one being illustrated) are mounted in the space between the matrix and the bulkhead at the forward side of the bulkhead, one at each side of the engine. These discharge through transition sections 37 into a first or power turbine nozzle 38 mounted in a first turbine case 39. This case 39 is connected to a bulkhead cylinder 40 which defines a circular opening through the bulkhead 34. The second or power turbine, including a rotor wheel 42, is mounted in a second or power turbine case 43 connected to the first turbine case 39. Power turbine wheel 42 is mounted on a shaft 44 which drives the power output shaft of the engine (not illustrated). Shafts 22 and 44 extend between the two matrices 33. The portion of each matrix to the rear of the bulkhead is housed in its individual exhaust collector 48.

Each side of the engine is closed by cover plates which provide for access to the matrix and flame tube on that

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side. A rear cover plate 49 is bolted to the margin of a large opening in the exhaust collector and to the side of the bulkhead. A front cover plate 51 bolted to the sides of the bulkhead and compressor turbine housing and a double walled combustion chamber cover 52 fixed to the cover plate 51 close the forward side portion of the engine. A fuel nozzle 53 and an igniter (not illustrated) mounted on the combustion chamber cover project into the flame tube 36. Openings in the upper surface of the exhaust collectors provide for connection of exhaust pipes (not illustrated). The two flame tubes are connected by a cross-over tube 57.

An inner inlet case mounted on the forward frame comprises a front wall 59 which bridges the space between the two matrices ahead of the bulkhead and mounts rim seals 501 for the inner rims of the matrices. The inner inlet case also includes a shaft housing shroud 61 which encloses the shaft housing 32.

The power turbine shaft 44 is supported by a rear frame or power turbine housing 63 which extends from top to bottom of the engine at the rear end thereof. The rear frame includes a power turbine shaft housing 191 around which is disposed an inner exhaust case or power turbine shaft housing shroud 64. This shroud is integral with a rear wall (not shown) which closes the rear part of the engine case between the exhaust collectors 48.

The matrix 33 includes two rims 68, which are continuous rigid rings, and foraminous heat-transfer material extending between the rings. The means for supporting and rotating the matrix need not be described.

Air discharged by the compressor of the engine flows through the forward portion of the continuously rotating matrix 33 and into the combustion chambers 36, then through the turbine and outwardly through the rear portion of the matrix into the exhaust collector 48. The forward and rear portions of the matrix are separated by the bulkhead 34 through which each matrix passes at two points. Main seals 81, one of which is indicated in outline in FIGURE 2, are provided at each point where a matrix passes through the bulkhead to prevent, as far as possible, any leakage of gas through the bulkhead, which would bypass the turbine.

It is also important for efficient operation of the engine that all of the air flowing from the compressor to the combustion chamber and also the gas flowing from the turbine to the engine exhaust be forced to flow through the matrices so the most efficient heat recovery is promoted. This result is accomplished by walls which close off the space between the two matrices and by rim or bypass seals which extend around the rims of the matrices to substantially prevent any flow of gas around the edges of the matrix. In the engine in which the present invention is embodied, there are two sets of rim seals for each matrix. There are inner rim seals 501 and 502 which seal the inner rim of the matrix, that is, the rim nearest the turbine axis. The seals 501 are ahead of the bulkhead and seals 502 are behind the bulkhead. Since the structure of these seals has nothing to do with the present invention, they will not be described.

The outer rim seals are of a type which are projected axially of the matrix against the radial end face of the outer matrix ring 68. These seals also are divided into two sections, one forward of the bulkhead and the other behind, which differ in structure because of the difference in the direction of pressure drop at the two locations. Passing over for the present the details of structure of these seals, it may be pointed out that the rear outer rim seals are mounted on an arcuate support 551 fixed to the rear cover plate 49. The front rim seals are mounted on an arcuate support 580 fixed to the front cover plate 51. Thus, these seals are moved into engagement with the

matrix when the cover plates are installed on the engine after the matrix has been installed.

Before proceeding to the description of these seals, it may be desirable to mention briefly some elements of engine structure shown in FIGURE 1. Engine accessories are mounted in an accessory drive case 86 fixed to the rear end of the engine.

The side edges of the bulkhead 34 have flanges 158 receiving studs 159 for mounting the engine cover plates. These cover plates are mounted by bolts 319, nuts 321, and nuts 324 so that they are readily removable for access to the matrix or to the rim seals mounted on them. A thermocouple 328 is shown on the rear cover 49. The turbine exhausts through the annular space between the shroud 64, which is lined with heat insulating material 313, and an outer exhaust cone 312.

It is believed that the foregoing sufficiently explains the engine structure which embodies the inventions to provide for an understanding of our rim seals. Reference may be made, if required, to the parent application Patent No. 3,077,074 for further details.

The Outer Rim Seals

The outer rim seals illustrated in FIGURES 2 to 5 serve the function of preventing bypassing of the regenerator matrix. They engage the lateral radial face of the matrix rim rather than its inner perimeter. One reason for this lies in the fact that the outer rim seals are mounted on the outer covers of the engine and are not accessible when the covers are put in place. They may more readily, therefore, be made to engage the radial face of the matrix rim. As in the case of the inner rim seals, there are forward outer rim seals ahead of the bulkhead 34 and primary seal 81 and rear outer rim seals behind the primary seal.

The front and rear outer rim seals are alike in structure, except for one significant difference. Gas flow through the forward part of the matrix is from the outer surface to the inner surface and through the rear part of the matrix is from the inner surface to the outer surface. The pressure drop across the matrix is in the same direction in each case as the gas flow. The front seal, therefore, is made up of a number of seal blocks lying on the radially outer surface of a support so as to be biased toward it by the gas pressure differential. The rear seal is composed of a number of seal blocks lying on the inside of a support so as to be biased outwardly toward it by the gas pressure differential.

FIGURE 2 shows the upper rear end of a front outer rim seal and the upper front end of a rear outer rim seal. FIGURES 3, 4 and 5 are cross-sectional views of these seals. The rear outer rim seal comprises an arcuate support 551 extending alongside the outer rim of the matrix from the upper to the lower primary seal and fixed by a ring of bolts 552 to the rear cover plate 49, which has a peripheral stiffening flange 553. A sheet metal retainer 554 for the insulating blanket 327 on the rear cover plate is retained between ring 551 and the cover plate by the bolts 552. A sheet metal retainer 556 is fixed to the rear face of ring 551 by flat head screws 557 received in countersinks in the retainer and in the outer surface of the support ring 551. The seal against the outer radial surface of the matrix rim is provided by a ring of overlapping seal blocks 558 lying against flat faces 559 on the inner surface of the support. One end of each seal block abuts a generally radial abutment 561 joining adjacent faces of the support. The end of the seal block 558 which engages the abutment 561 is chamfered outwardly as indicated at 563 so as to lie in the plane of the next face 559 and against the outer surface of the next seal block 558. The seal blocks are urged against the abutments 561 by the rotation of the matrix, which is clockwise as viewed in FIGURE 2.

The retainer 556 serves to hold the seal blocks against falling out of place before the engine is assembled and

when it is out of operation. The retainer includes a number of portions 564 bent outwardly at 90° from the plane of the base of the support which overlie the face of the seal block opposite to the support. The portions 564 overlie the blocks somewhat loosely. The tip 566 of a portion 564 of the retainer is bent outwardly to lie adjacent the end of the seal block and restrain it against movement to the left as viewed in FIGURE 2. The portion 564 of the retainer overlying the seal block is in two sections, and between them there is a spring finger 568 extending from the base portion 566 of the retainer. The extreme end of the finger 568 is recurved as indicated at 569 to provide a tip which lies loosely with ample clearance in a pocket 571 in the adjacent face of the seal block. This spring finger holds the seal block against falling out of the support when the cover plate is removed from the engine. The seal block may be inserted by springing the finger out slightly and sliding the block into place.

Each seal block is biased toward the matrix rim by two opposed curved single leaf springs 572 which lie between the retainer and the seal block. Since gas pressure can get behind the seal, it also urges the seal block into engagement with the matrix. The pressure drop from the inside to the outside of the matrix biases each seal block against the support face 559. The seal block 558 immediately adjacent the primary seal 81 has an extension 574 beyond the retaining tab portion 566.

Since the front outer rim seal is much like the rear seal, it will be described only briefly. It comprises an arcuate support 580 having bosses 581 secured to the front cover 51 by studs 582 and nuts 583 or by cap screws. The retainer 584 is essentially the same as that previously described, including a spring finger 586 engaging in a cavity in the seal block 587 to keep it from falling out of place. Seal blocks 587 engage flat faces 588 on the outer surface of the support and, except for the end blocks engage generally radial abutments 589. The seal blocks overlap and are chamfered inwardly as indicated at 591 at one end to secure a close fit between the overlapping portions and minimize leakage. Retainer 584 for the end block has two bent down portions 593, since there is no abutment on the support for the end seal block 587 to engage. When the main seal is in place, the end of this seal block engages the primary seal 81. Springs 596 bias the seal blocks 587 against the matrix, and the radially inward pressure drop biases the seal blocks against the abutting faces of the support.

Efficiency of the engine is benefitted by the improved regenerator seals. It may be noted that the outer rim seals are so constituted that the pressure drop across the matrix biases the seal blocks against the matrix, assisting the biasing springs. It also biases the seal blocks laterally against a support. Both effects tend to minimize leakage. The outer rim seals provide overlapping seal blocks without the usual gaps which provide leakage paths in overlapping seal structures.

The invention is not to be considered to be limited by the detailed description of the preferred embodiment thereof for the purpose of explaining the principles of the invention. Many modifications may be made by the exercise of skill in the art within the scope of the invention.

We claim:

1. A regenerative heat exchanger comprising, in combination, a housing, an annular pervious matrix rotatable in the housing about an axis and including means defining a rim of the matrix, the rim having a surface radial to the said axis, and an arcuate rim seal cooperating with the said surface to prevent bypassing of the matrix, the rim seal comprising an arcuate support mounted on the housing, the support having one peripheral surface bounded by a succession of flat faces each at an acute angle to the faces next thereto, the faces being joined by generally radial abutments, a generally rectangular seal

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block extending across each face, resting upon the said face, engaging the said rim surface, engaging an abutment at the end of the face, and projecting beyond the other end of the face, the ends of mutually adjacent seal blocks overlapping and one end of each block being chamfered to conform to the overlapping block, and means cooperating with the block urging the block into engagement with the rim.

2. A heat exchanger as recited in claim 1 including retaining means connecting the blocks to the support with lost motion.

3. A regenerative heat exchanger as recited in claim 1 in which the said peripheral surface of the support is a radially interior surface.

4. A regenerative heat exchanger as recited in claim 1 in which the said peripheral surface of the support is a radially exterior surface.

5. A heat exchanger as recited in claim 2 in which the direction from the block to the support is the direction of the pressure drop across the seal.

6. A heat exchanger as recited in claim 2 in which the direction from the block to the abutment it engages is the direction of rotation of the matrix.

7. A regenerative heat exchanger comprising, in combination, a housing, an annular pervious matrix rotatable in the housing about an axis and including means defining a rim of the matrix, the rim having a surface radial to the said axis, and an arcuate rim seal cooperating with the said surface to prevent bypassing of the matrix, the rim seal comprising an arcuate support mounted on the housing, the support having one peripheral surface bounded by a succession of flat faces each at an acute angle to the faces next thereto, the faces being joined by generally radial abutments, a generally rectangular seal block extending across each face, resting upon the said face, engaging the said rim surface, engaging an abutment at the end of the face, and projecting beyond the other end of the face, the ends of mutually adjacent seal blocks overlapping and one end of each block being chamfered to conform to the overlapping block, a retainer overlying the face of each block opposite from the support, each block having a recess in the face thereof opposite from the support, the retainer including a portion loosely engaging in the recess to hold the block against falling off the support when not in engagement with the rim, and means cooperating with the block urging the block into engagement with the rim, the rim seal being so constructed that the direction from the block to the supporting face of the support is the direction of the pressure drop across the seal and the direction from the block to the abutment is the direction of rotation of the matrix.

8. A regenerative heat exchanger comprising, in combination, a housing, an annular pervious matrix rotatable in the housing about an axis and including means defining a rim of the matrix, the rim having a surface radial to the said axis, and an arcuate rim seal cooperating with the said surface to prevent bypassing of the matrix, the rim seal comprising an arcuate support mounted on the housing, the support having one peripheral surface bounded by a succession of flat faces each at an acute angle to the faces next thereto, the faces being joined

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by generally radial abutments, a generally rectangular seal block extending across each face, resting upon the said face, engaging the said rim surface, engaging an abutment at the end of the face, and projecting beyond the other end of the face, the ends of mutually adjacent seal blocks overlapping and one end of each block being chamfered to conform to the overlapping block, a retainer overlying the face of each block opposite from the support, the retainer including a portion adjacent the end of the block restraining movement of the block circumferentially of the axis away from the abutment, and means cooperating with the block urging the block into engagement with the rim, the rim seal being so constructed that the direction from the block to the supporting face of the support is the direction of the pressure drop across the seal and the direction from the block to the abutment is the direction of rotation of the matrix.

9. A regenerative heat exchanger comprising, in combination, a housing, an annular pervious matrix rotatable in the housing about an axis and including means defining a rim of the matrix, the rim having a surface radial to the said axis, and an arcuate rim seal cooperating with the said surface to prevent bypassing of the matrix, the rim seal comprising an arcuate support mounted on the housing, the support having one peripheral surface bounded by a succession of flat faces each at an acute angle to the faces next thereto, the faces being joined by generally radial abutments, a generally rectangular seal block extending across each face, resting upon the said face, engaging the said rim surface, engaging an abutment at the end of the face, and projecting beyond the other end of the face, the ends of mutually adjacent seal blocks overlapping and one end of each block being chamfered to conform to the overlapping block, a retainer overlying the face of each block opposite from the support, the retainer including a portion adjacent the end of the block restraining movement of the block circumferentially of the axis away from the abutment, each block having a recess in the face thereof opposite from the support, the retainer including a portion loosely engaging in the recess to hold the block against falling off the support when not in engagement with the rim, and resilient means cooperating with the support and the block urging the block into engagement with the rim, the rim seal being so constructed that the direction from the block to the supporting face of the support is the direction of the pressure drop across the seal and the direction from the block to the abutment is the direction of rotation of the matrix.

10. A regenerative heat exchanger as recited in claim 9 in which the said peripheral surface of the support is a radially interior surface.

11. A regenerative heat exchanger as recited in claim 9 in which the said peripheral surface of the support is a radially exterior surface.

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