

July 16, 1968

A. TOPOUZIAN
SPIRALLY WOUND ROTARY HEAT EXCHANGER
HAVING BARREL CENTER MOUNT
Filed Nov. 3, 1966

3,392,776

FIG. 1

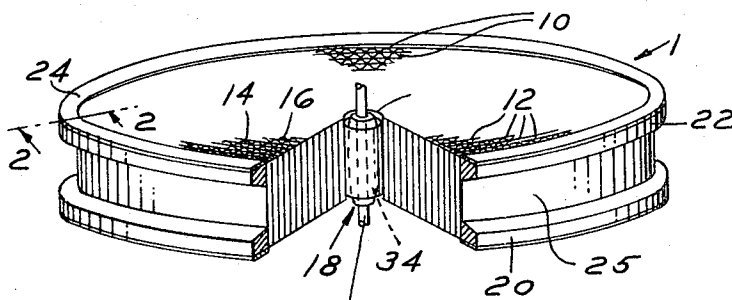


FIG. 2

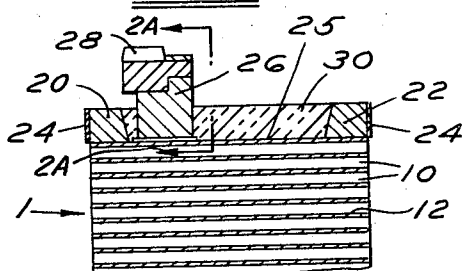


FIG. 3

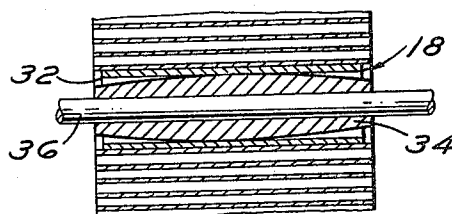


FIG. 2A

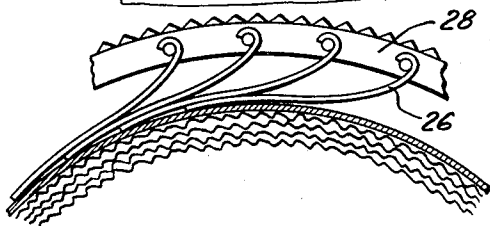


FIG. 5

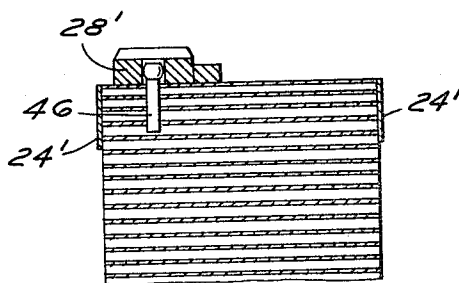
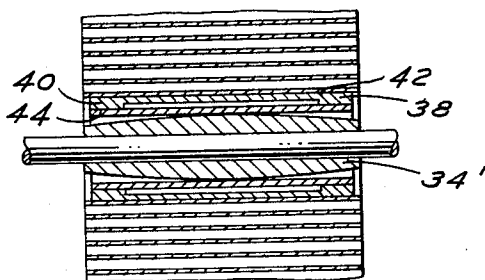


FIG. 4



INVENTOR

ARMENAG TOPOUZIAN

BY

John R. Faulkner
Robert E. Mc Callum

ATTORNEYS

1

2

3,392,776

SPIRALLY WOUND ROTARY HEAT EXCHANGER HAVING BARREL CENTER MOUNT

Armenag Topouzian, Detroit, Mich., assignor to Ford Motor Company, Dearborn, Mich., a corporation of Delaware

Filed Nov. 3, 1966, Ser. No. 591,783

3 Claims. (Cl. 165-8)

ABSTRACT OF THE DISCLOSURE

A disc type rotary heat exchanger for use in automotive type gas turbine engines, the heat exchanger having a spirally wound matrix with axially spaced peripheral flanges each spirally wound, the space between the flanges providing an anchorage for flexible clips drivingly securing the matrix to a rotatable ring gear, the matrix being tiltably and rotatably mounted by cooperating sleeve means on a barrel center support.

This invention, in general, relates to a heat exchanger. More particularly, it relates to the construction of a heat exchanger of the rotary disc type commonly used in motor vehicle type gas turbine engines.

One of the objects of the invention is to provide a rotary heat exchanger of the disc type that is relatively simple in construction and easy to assemble, provides good heat exchange properties, and relieves the matrix of deformation stresses resulting from the large pressure and temperature gradients that occur during normal operation.

A further object of the invention is to provide a center bearing support for a disc type heat exchanger that permits cocking or angular tilting of the matrix during engine operation.

A still further object of the invention is to provide a heat exchanger of the disc type having a matrix constructed by spirally winding a stack of two thin sheet metal strips, one being circumferentially corrugated, to provide back-to-back axial fluid passages, the other being flat sheet stock to separate the passages; the matrix being rotatably supported upon a center barrel-like support permitting angular tilting of the matrix by the differential pressure forces between the fluids entering opposite sides of the matrix.

Other objects, features and advantages of the invention will become apparent upon reference to the succeeding detailed description thereof, and to the drawings illustrating the preferred embodiments thereof, wherein:

FIGURE 1 illustrates, isometrically, a rotary heat exchanger embodying the invention, with parts broken away and in section;

FIGURE 2 illustrates a cross-sectional view of a portion of the heat exchanger of FIGURE 1; FIGURE 2a is a cross-sectional view taken on a plane indicated by and viewed in the direction of the arrows 2A-2A of FIGURE 2;

FIGURES 3 and 4 are enlarged cross-sectional views of a detail of FIGURE 2; and

FIGURE 5 illustrates a modification of the FIGURE 2 showing.

The so-called solid center core, metallic, rotary disc-type heat exchangers generally have thermal stress problems because of differential cooling characteristics of the matrix and the center support. Also, heat exchangers of this type experience large pressure stress buildups in the matrix and at the bearing area due to the inability of

the center support to cock under the differential pressure forces acting on opposite sides of the matrix.

The invention eliminates the above disadvantages by providing a uniform matrix structure tiltably about a center bearing support. The uniform structure not only minimizes thermal gradients, but provides a smooth continuous line from the outer periphery of the matrix to the hub during matrix deflections.

FIGURE 1 shows an over-all view of a disc type rotary heat exchanger embodying the invention, while FIGURE 2 shows more of the details. The matrix 1 of the heat exchanger is constructed by spirally winding as a unit two continuous thin sheet metal strips 10 and 12, strip 10 being circumferentially corrugated and strip 12 flat. The corrugated strip is super-imposed upon the flat strip, and during winding, tension is applied only to the flat sheet strip. This presses the corrugated stock between the flat separator sheets and forms a multitude of axially extending separated air or gas passages 14 and 16. The strips initially are tacked to a tubular hub 18 and when wound to the desired diameter, flat sheet 12 is welded to itself.

At its outer periphery, the matrix is formed with two axially spaced annular gas seal rubbing flanges 20 and 22. Each of these are constructed by again spiral winding flat and corrugated narrow strip stock that is tacked to the matrix and welded to itself after the desired diameter is reached. The whole matrix is then brazed and trimmed to size. The outer lateral sides of the flanges are coated with a metallic spray to form a gas seal ring flange 24 of essentially zero thickness.

The recess 25 between flanges 20 and 22 provides an annular space for the mounting of a number of circumferentially spaced flexible clips 26 that are attached at their opposite ends to a driving ring gear member 28. The ring gear thus has a floating mount. The excess space not filled by clips 26, if desired, can be filled with insulation 30.

As seen in FIGURE 3, the hub 18 of the matrix consists of a tube or sleeve 32. Pressed into the tube is a barrel-like center bearing support 34 of a material that would be self-lubricating and would grow radially approximately the same amount as tube 32. The center support is rotatably mounted on a stationary shaft 36 to which the conventional stationary gas turbine engine regenerator seal members (not shown) are secured.

The details of construction and operation of the sealing members are not shown since they are known and believed to be unnecessary for an understanding of the invention. Suffice it to say that the seal members would include semi-circular or circular flexible sealing strips on opposite sides of the disc. The sealing strips would be biased against the sprayed metal flanges 24 at the disc outer periphery and against the inner peripheral portions of the matrix at the hub. This would prevent communication between the high pressure, low temperature compressor discharge air and the high temperature, low pressure turbine exhaust gases flowing through alternating matrix passages in opposite directions.

With the construction as described, it will be seen that the entire matrix and sleeve hub have essentially a point or a short line contact with the surface of the barrel shaped center support 34. This not only permits free rotation of the matrix and barrel about the fixed shaft, but at the same time permits a cocking, swiveling or angular tilting of the matrix on the outer radius of the barrel, and with respect to shaft 36, under the influence of the gas pressure gradient across the matrix.

FIGURE 4 shows an alternate center support construction that could be used when the bearing member 34 (FIGURE 3) is constructed of a material such as graph-

ite. When a material of this type is used, a differential expansion occurs when the matrix is hot. That is, the sleeve 32 (FIGURE 3) would expand away from barrel member 34, leaving a loose fit between the two. This would induce failure problems. To eliminate this, and provide good contact between the bearing surfaces at all times, the hub includes two sleeves. An outer sleeve 38 (FIGURE 4) has a central recess forming axially spaced flanges 40 and 42 on opposite lateral edges. A second sleeve 44 has a shrink fit within sleeve 38 and a press fit over the graphite-like barrel center support member 34'. When the matrix and sleeve 38 expand or grow radially during operation, the sleeve 44 will expand with it but will maintain good contact with center support 34'.

FIGURE 5 shows an alternate construction of the matrix. In this case, the axially spaced flanges 20 and 22 of FIGURE 2 are omitted, and the annular side sealing ring flanges 24' are merely sprayed on a portion of the matrix subsequent to its being spiral wound. Also, since there is no recess at the outer periphery, the ring gear 28' in this case is mounted on the matrix by a series of circumferentially spaced pins 46 fixedly secured in the matrix.

A typical installation of the above-described rotary heat exchange would be in the area adjacent the compressor discharge section of a gas turbine engine. The outer peripheral portion and the upper left-hand side (as seen in FIGURE 1) of the matrix, for example, would be subjected to the flow of high pressure compressor discharge air at, say, 400° F. The lower right-hand side of the matrix would be connected to a stationary ducting to receive the low pressure turbine exhaust gases at, say, 1400° F. Also, the upper right-hand and lower left-hand portions of the matrix would communicate with suitable sealed ducting that receives the discharged warmed compressor air at, say, 1300° F., and the cooled exhaust gases at, say 500° F., respectively.

It will be clear, therefore, that as the heat exchanger rotates, the heat transferred from the exhaust gases to the thin sheet metal walls of the passages formed by the corrugated and flat strips, as the matrix rotates through the lower half of its cycle, is then picked up by the low temperature, compressor discharge air as it passes through the warmed axial passages during the rotation of the matrix through the upper half of the cycle.

It will also be clear that with the high pressure compressor discharge air entering the heat exchanger on the upper left-hand side, and the lower pressure turbine exhaust gases entering the heat exchanger on the lower right-hand side, that a cocking or angular tilting force will be imposed on the matrix attempting to tilt it clockwise about its center support 34. With the construction as described above, providing a barrel shaped center support, the cocking force or action is permitted essentially without inducing any stresses in the matrix or center support.

I will also be clear, that due to the uniform construction of the matrix (thickness of passages and sheet metal, for example), that thermal gradients will be minimized, and that any matrix deflections provide a smooth continuous line from the outer periphery of the matrix to its hub.

From the foregoing, therefore, it will be seen that the invention provides a disc-type rotary heat exchanger construction providing minimum weight because of the lack of massive flanges or hub sections; minimum thermal gradients because of the uniform matrix structure; minimum fabrication and tooling costs because the complete structure can be brazed in one operation with a simple compressive strap on the matrix periphery; and that any matrix deflections provide a smooth continuous line from the outer periphery to the matrix hub due to the uniform structure of the matrix.

While the invention has been shown in its preferred embodiments in the drawings, it will be clear to those

skilled in the art to which the invention pertains that many changes and modifications may be thereto without departing from the scope of the invention. For example, the embodiment shown in FIGURE 2 illustrates flanges 20 and 22, with sprayed metal flanges 24, and insulation 30 between the flanges. The coating and insulation prevent communication of the cooler and high pressure compressor discharge to the side seals. This is advantageous in those instances where the seal material functions more efficiently under high temperature conditions.

An alternate construction would be to provide no sprayed flanges at all on the right-hand, high temperature side of flange 24, and to close the flange passages by machining over the inner axial sides of the flanges so that the seal is in a higher temperature environment. Alternatively, instead of machining over the inner ends, the ends could be spray coated, or both. This, together with insulation 30 would block off the high pressure compressor discharge air from acting on the seal. It also would permit the flange passages to serve as storage wells for loose or worn seal material pieces.

Another alternative is to leave the flange side faces untouched, i.e., no coating with metal or machining over, and with no insulation between the flanges. This allows cooler compressor discharge air to circulate through the flange passages and cool the face of the stationary seal. Also, loose seal material or foreign matter on the seal face would pass through the flanges.

I claim:

1. A rotary heat exchanger for use in a gas turbine engine comprising, a shaft, a hollow hub member coaxially and rotatably mounted with respect to and surrounding said shaft and having an inner bearing surface, a center barrel-like support member rotatably mounted on said shaft and having an outer peripheral bearing surface engaging said hub inner surface permitting relative angular tilting of said hub with respect to said member and shaft, a disc type heat exchanger matrix surrounding and secured to said hub, said matrix comprising a spirally wound stack of a flat sheet metal strip and a longitudinally corrugated thin sheet metal strip, said flat strip being anchored at one end to said hub and to itself at its other end, said sandwich construction providing axial fluid passages for the flow of gases at widely divergent temperatures and pressures therethrough in opposite directions from opposite sides of the matrix, the pressure gradient across said matrix resulting in said angular tilting of said hub on said barrel support, said angular tilting relieving said matrix and hub of stresses resulting from said pressure gradient, said hub comprising a pair of inner and outer coaxially mounted sleeve members, said outer member having a radially extending recess between axial end portions, said inner sleeve bearing surface being essentially straight.

2. A rotary heat exchanger for use in a gas turbine engine comprising, a shaft, a hollow hub member coaxially and rotatably mounted with respect to and surrounding said shaft and having an inner bearing surface, a center barrel-like support member rotatably mounted on said shaft and having an outer peripheral bearing surface engaging said hub inner surface permitting relative angular tilting of said hub with respect to said member and shaft, a disc type heat exchanger matrix surrounding and secured to said hub, said matrix comprising a spirally wound stack of a flat sheet metal strip and a longitudinally corrugated thin sheet metal strip, said flat strip being anchored at one end to a said hub and to itself at its other end, said sandwich construction providing axial fluid passages for the flow of gases at widely divergent temperatures and pressures therethrough in opposite directions from opposite sides of the matrix, the pressure gradient across said matrix resulting in said angular tilting of said hub on said barrel support, said angular tilting, relieving said matrix and hub of stresses resulting from said pressure gradient, including a rotatable ring gear surrounding the outer periphery of said matrix, and means secured

5

both to said matrix and gear for providing unitary movement thereof upon rotation of said gear, said matrix including at its outer periphery a pair of axially spaced flanges each comprising a spiral wound stack of flat and corrugated thin sheet metal strips, said flanges defining a central recess therebetween, said means securing said matrix to said gear comprising clip means secured to said matrix between the flanges.

3. A heat exchanger as in claim 2, said clip means being flexible for a yielding amount of said ring gear.

5

10

6

References Cited

UNITED STATES PATENTS

3,063,761	11/1962	Hoddy et al.	308—72
3,177,735	4/1965	Chute	74—446 X
3,190,350	6/1965	Chute	165—9
3,300,967	1/1967	Trapp	165—8 X

ROBERT A. O'LEARY, *Primary Examiner.*

A. W. DAVIS, *Assistant Examiner.*