

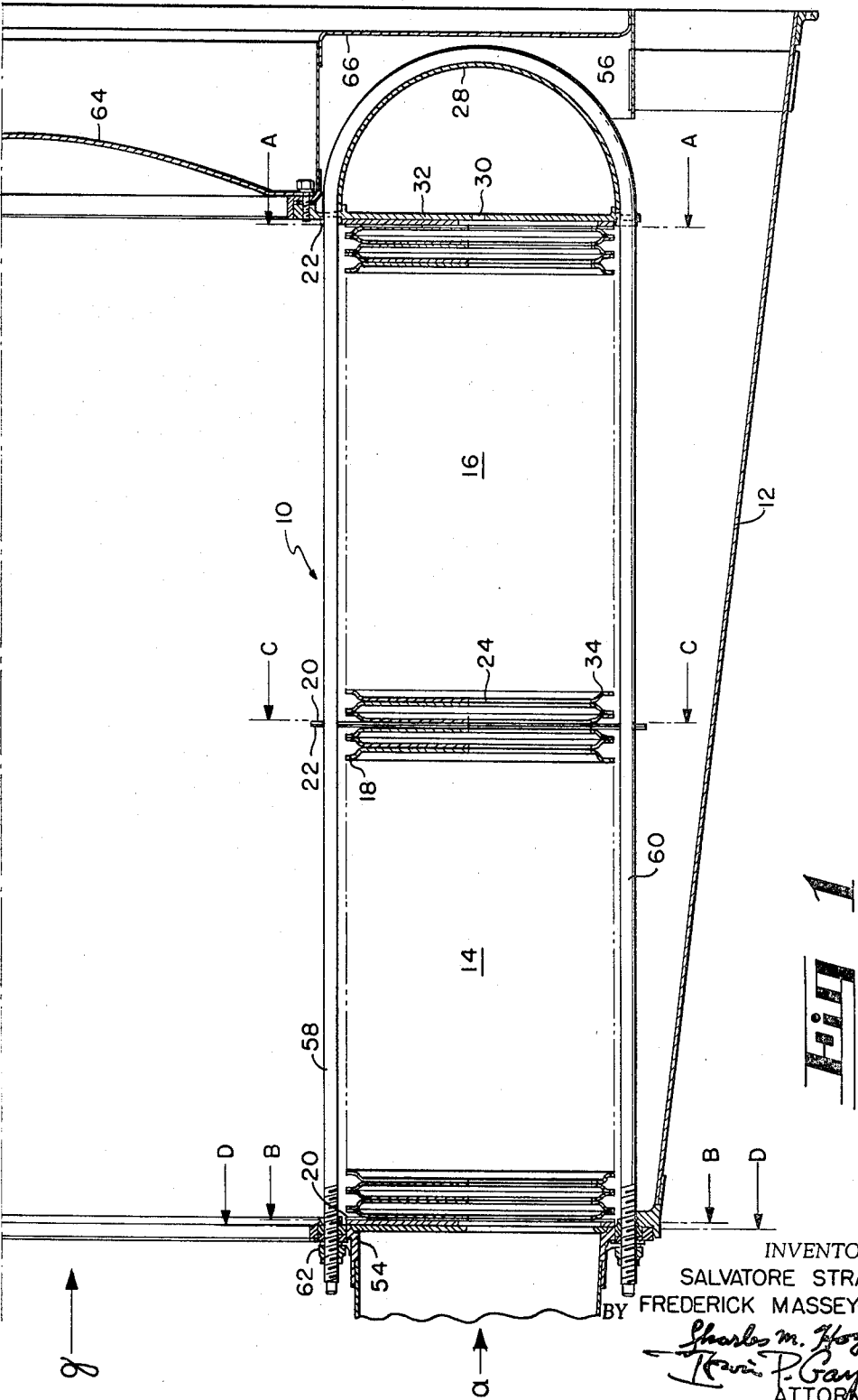
May 28, 1968

S. STRANITI ET AL
MOUNTING AND SUPPORT FOR THE STACKED SHEETS
OF A HEAT EXCHANGER

3,385,353

Filed Jan. 31, 1967

2 Sheets-Sheet 1



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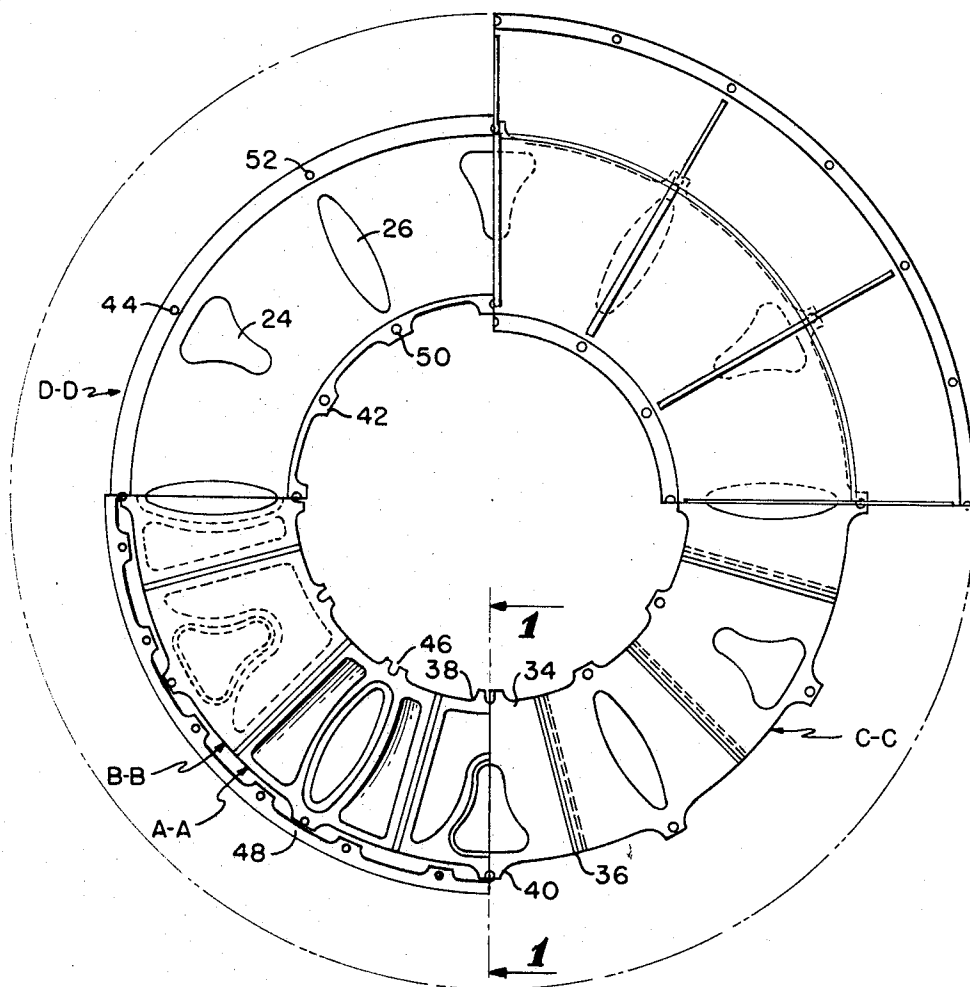


Fig 2

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MOUNTING AND SUPPORT FOR THE STACKED SHEETS OF A HEAT EXCHANGER

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Filed Jan. 31, 1967, Ser. No. 612,863

8 Claims. (Cl. 165—67)

ABSTRACT OF THE DISCLOSURE

A support for an annular bellows-type heat exchanger used as a regenerator for a gas turbine engine, the heat exchanger being made of a plurality of flexible thin sheets which are subject to thermal expansion in three dimensions: radial, circumferential, and axial. The center and each end of the bellows assembly is provided with a segmented support plate, each segment having opposed radially inwardly and outwardly extending projections. The end plate segments each have radially open slots while the center segments have holes for receiving the opposed legs of a U-bolt. One U-bolt is provided for each segment and provides the means for affixing the bellows assembly to the rear of turbine engine.

This invention relates to a novel arrangement for mounting and supporting the stacked sheets of a heat exchanger used as a regenerator for a gas turbine engine. The invention is specifically adapted for use in mounting and supporting an annular heat exchanger, of the type disclosed in the application of Stein and Straniti, Ser. No. 575,285 filed Aug. 29, 1966, to the exhaust of a gas turbine engine.

In the aforesaid Stein and Straniti patent application the heat exchanger uses very thin sheets formed into a bellows-type construction. The turbine exhaust gas flows externally of the bellows and is directed axially along the center of the annulus and radially between adjacent pairs of sheets, while the turbine compressor air flows in a tortuous path within the bellows. Because the sheets forming the annular bellows construction are made of very thin, highly flexible material, the structure requires a sturdy support. On the other hand, because of the high heat transfer efficiency of the construction, there are extreme temperature gradients between the various portions of the structure, and hence the structure undergoes considerable expansion and various thermal stresses. This invention provides the means for supporting the heat exchanger structure while at the same time accommodating radial, axial, and circumferential expansion due to the existing temperature gradients.

An object of this invention is to provide a plurality of circumferentially spaced U-bolts in combination with segmented support plates for supporting a flexible, annular bellows-type heat exchanger, said U-bolts and segmented plates providing rigid support while at the same time permitting radial, axial, and circumferential expansion.

For further objects and advantages of this invention reference should now be made to the following detailed specification and to the accompanying drawings in which:

FIGURE 1 is a cross-section of one-half of the annular heat exchanger utilized in accordance with this invention; and

FIGURE 2 is an end view of the heat exchanger viewed from the rear with sections taken at a plurality of different segments indicated as A—A to D—D in FIGURE 1.

The heat exchanger, generally indicated at 10, is used as a regenerator for a gas turbine engine, the exhaust

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gases being used to preheat the compressed air. The heat exchanger is shown positioned within an outer cone assembly 12 which also provides an exhaust gas duct and part of the support for the heat exchanger.

The heat exchanger 10 is made up of two matrices 14 and 16, the various elements of which are shown somewhat schematically since the heat exchanger per se is fully described in the aforementioned application of Stein and Straniti. Each matrix 14 and 16 is constructed from convoluted corrugated annular disks 18 made of thin metallic heat conducting sheets which are stacked and welded together, the resulting hollow cylindrical matrices 14 and 16 being virtual bellows assemblies. Support plates, generally indicated at 20 and 22, are affixed to the end disks 18 of each of the matrices which are aligned in tandem.

As seen in FIGURE 2, each annular sheet 18 comprises inlet and outlet ports 24 and 26 alternately positioned around the annulus of each sheet. As may be best understood from a study of the aforementioned Stein and Straniti patent application, the bellows assembly is fabricated by arranging the sheets 18 in pairs, welding the inner and outer peripheries of each pair, and welding the peripheries of the ports 24 and 26 to the peripheries of the adjacent ports in adjacent pairs. The support plates 20 and 22 are provided with ports corresponding to and aligned with the ports 24 and 26.

The ports 24 and 26 in the end support plate 22 are closed by means of a semi-torus shell 28. However, holes 30 in the flat end wall 32 provide for pressure balancing between the matrices and the semi-torus shell 28.

Each support plate 20 and 22 is comprised of a plurality of arcuate segments 34, one segment for each port 24 and 26. The segments 34 are positioned around the entire periphery of its respective sheet, a small gap 36 being provided between the various segments. The segments 34 on the forward and rear end sheets 18 are provided with inner and outer integral projecting lugs 38 and 40, respectively, while the abutting center segments 34 are provided with projections 42 and 44. It will be noted that the projections 38 and 40 are provided with slots 46 and 48, respectively, while the projections 42 and 44 are provided with holes 50 and 52, respectively.

The heat exchanger assembly 10 with the support plate 22 segments 34 of the matrix 14 is face mounted against a forward mounting support casing 54 by means of a plurality of U-bolts 56 positioned around the entire annulus of the heat exchanger. The legs 58 and 60 of each U-bolt 56 bridge the inner and outer peripheries of the torus shell 28 and extend through the slots 46 and 48 and the holes 50 and 52 of the aligned segments. The ends of the forward mounting support casing 54 by means of nuts 62.

Exhaust gases *g* flow from the gas turbine engine into the central hollow portion of the annular heat exchanger 10, the end of which is closed by means of rear end walls 64 and 66, and then radially past the exterior of the bellows assembly, and then exhaust through the duct 12. Compressed air *a* from the gas turbine compressor section enters the regenerator at the ports 24 following the tortuous path throughout the length of the regenerator and ultimately returning to the outlet 26 where it is then directed to the combustion chamber (not shown). The exhaust gases *g* and the compressed air *a* are kept physically separated, but very efficient heat exchanging takes place through the sheets, and it was found that large temperature gradients exist between the inner and outer diameters of the annular matrices. The mounting arrangement disclosed in accordance with this invention accommodates the requirement for the considerable non-linear expansion and, in addition, provides an extremely

firm lightweight support for the regenerator. The U-bolts 56, spaced around the annulus, provide secure support of the heat exchanger elements to the forward mounting support casing 54. By engaging the segments of the end mounting plates at the slots 46 and 48 while engaging the center mounting plates at the holes 50 and 52, as the matrices expand radially, radial expansion of the assembly at its center is accommodated by the deflection of the legs 58 and 60, while radial expansion at the ends is accommodated by permitting limited relative movement of the legs 58 and 60 in the slots. Furthermore, because each of the plates 20 and 22 has been formed in segments with spaces 36 between the segments, the end sheets can expand circumferentially. Expansion in an axial direction is accommodated by the flexible sheets themselves. Thus the invention provides for the firm mounting of the regenerator while at the same time permitting expansion or contraction in all directions. Moreover, expansion in an axial direction increases the pressure between the abutting support plates 20 and 22 to increase the seal between the matrices 14 and 16.

It will be apparent to persons skilled in the art that various modifications and adaptations of this invention are available. For example, the matrices 14 and 16 may be constructed as one unit with the support plates 20 and 22 made integral. Thus, the heat exchanger would have the same overall length and would receive support in exactly the same manner as in the embodiment described but would actually be made out of one integral assembly instead of two stacked assemblies.

What is claimed is:

1. In a heat exchanger for a gas turbine engine said heat exchanger being constructed of a stack of thin flexible annular metal sheets assembled to provide an annular bellows assembly, a support rigidly connecting said heat exchanger to said gas turbine engine, and permitting expansion of said exchanger, said support comprising:

one plate attached to each end of said heat exchanger, each of said plates being comprised of a plurality of spaced segments, each of said segments having radially inwardly and radially outwardly extending slotted projections;

a U-bolt for each segment, said U-bolts being circumferentially spaced around the periphery of said annular bellows, the legs of a U-bolt bridging the inner and outer peripheries of the annulus of said bellows and passing through aligned slotted projections; and means for securing the ends of the legs of said U-bolts to said gas turbine engine.

2. The invention as defined in claim 1, and a semi-torus shell positioned on one end of said bellows assembly, the U of said U-bolts engaging said torus.

3. The invention as defined in claim 2 and a fluid passage between said bellows assembly and said semi-torus to balance the pressures therebetween.

4. The invention as defined in claim 3 wherein said

bellows assembly is positioned within a cone-shaped duct, the exhaust end of said annular bellows being closed, whereby gases pass axially through the center of the bellows assembly across the sheets and rearward through said duct.

5. In a heat exchanger for a gas turbine engine, said heat exchanger being constructed of two aligned abutting stacks of thin flexible annular metal sheets assembled to provide an annular bellows assembly, a support rigidly connecting said heat exchanger to said gas turbine engine, and permitting expansion of said exchanger, said support comprising:

one plate attached to the sheet at each end of said heat exchanger and at least one plate disposed between the sheets at the abutment of said stacks, each of said plates being comprised of a plurality of spaced segments, each of said segments having radially inwardly and radially outwardly extending projections, the projections on the plates at the ends of said heat exchanger being provided with radial slots and the projection on the plate at the abutment being provided with holes;

a U-bolt for each segment, said U-bolts being circumferentially spaced around the periphery of said annular bellows, the legs of the U-bolt bridging the inner and outer peripheries of the annulus of said bellows and passing through aligned slots and holes in said projections;

and means for securing the ends of the legs of said U-bolts to said gas turbine engine.

6. The invention as defined in claim 5, and a semi-torus shell positioned on one end of said bellows assembly, the U of said U-bolts engaging said torus.

7. The invention as defined in claim 6, and a fluid passage between said bellows assembly and said semi-torus to balance the pressures therebetween.

8. The invention as defined in claim 7 wherein said bellows assembly is positioned within a cone-shaped duct, the exhaust end of said annular bellows being closed, whereby gases pass axially through the center of the bellows assembly across the sheets and rearward through said duct.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,385,353

May 28, 1968

Salvatore Straniti et al.

It is certified that error appears in the above identified patent and that said Letters Patent are hereby corrected as shown below:

Column 2, line 51, after "The ends of" insert -- the U-bolt legs 58 and 60 are threaded and are secured to --.

Signed and sealed this 7th day of October 1969.

(SEAL)

Attest:

Edward M. Fletcher, Jr.

Attesting Officer

WILLIAM E. SCHUYLER, JR.

Commissioner of Patents