

[54] HEAT EXCHANGING APPARATUS

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[58] Field of Search 165/8, 9, 10; 74/231 C

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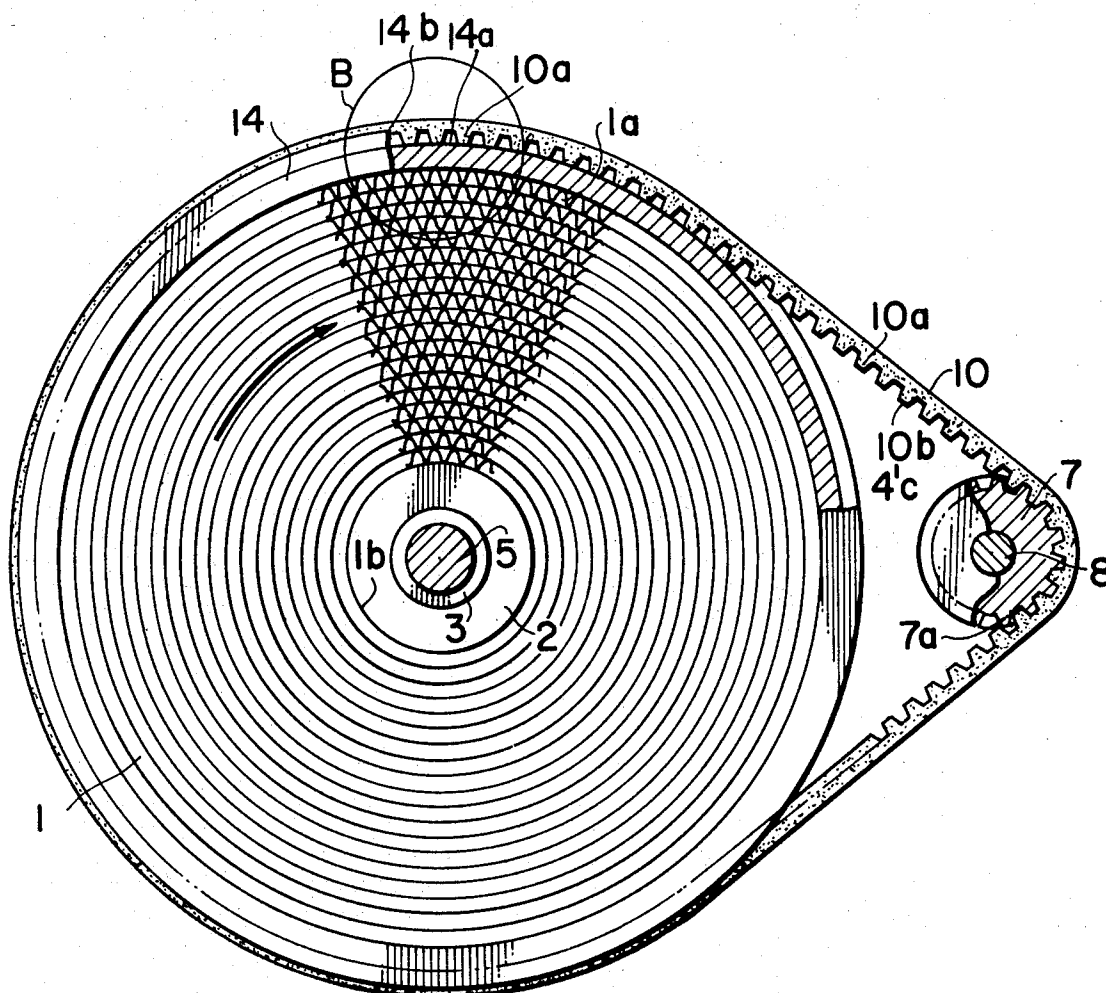
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[57] ABSTRACT

A heat exchanging apparatus having a disc-like body of a perforated material adapted to be rotated in heat transfer contact with fluid to be heat-exchanged. A driven ring secured to the outer peripheral surface of the disc-like body is driven by an endless belt which is driven by a gear wheel rotated with the teeth thereof being in meshing engagement with the teeth formed on the inner periphery of the endless belt. The latter is made of a resilient material whereby the variation in the rotational drive force of a power source and exterior vibration and shock are taken up by the resiliency of the belt for the stable and uniform rotation of said disc-like body and for the guard thereof against the exterior vibration and shock.

3 Claims, 7 Drawing Figures



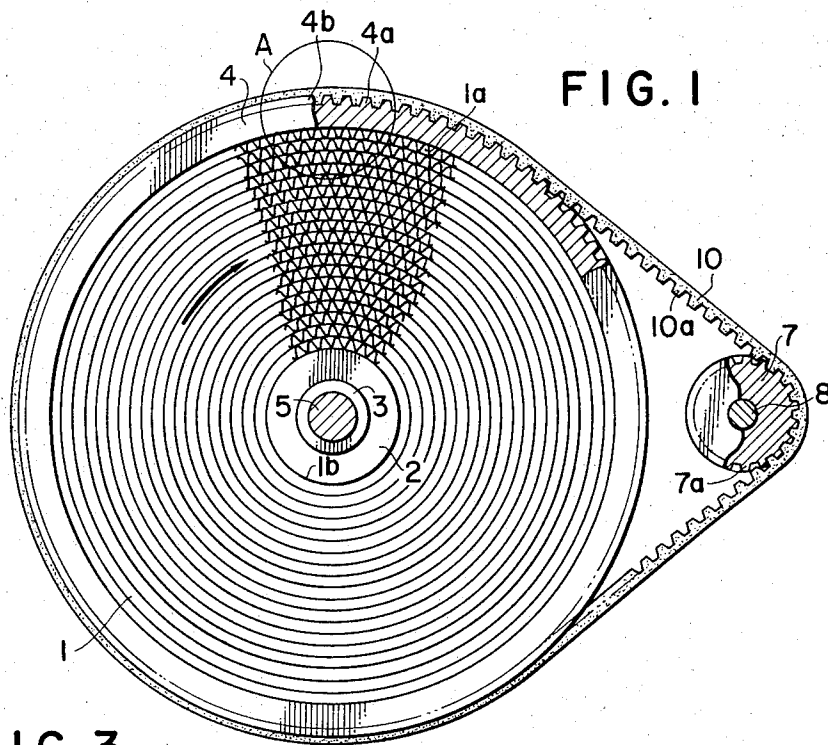


FIG. 1

FIG. 3

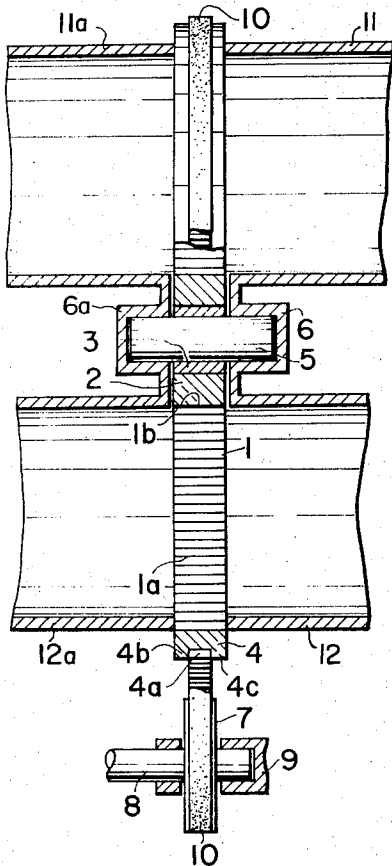
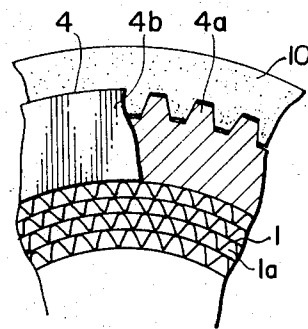


FIG. 2



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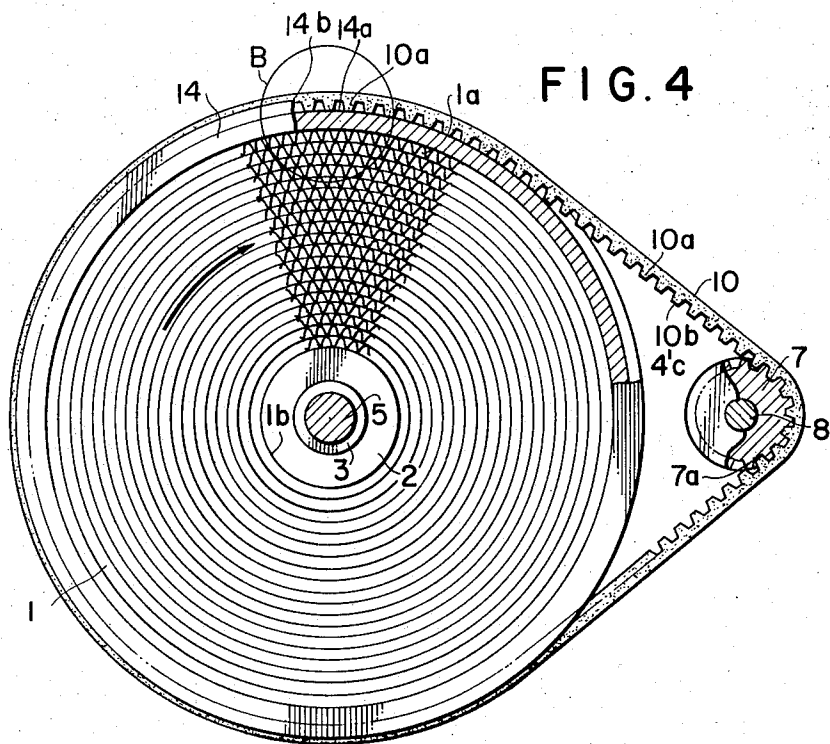


FIG. 6

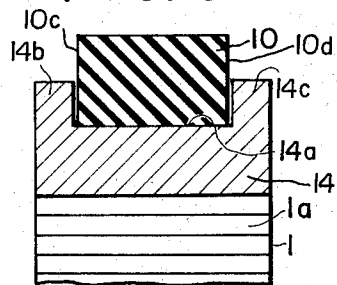


FIG. 7

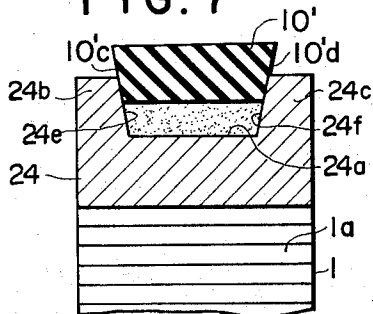
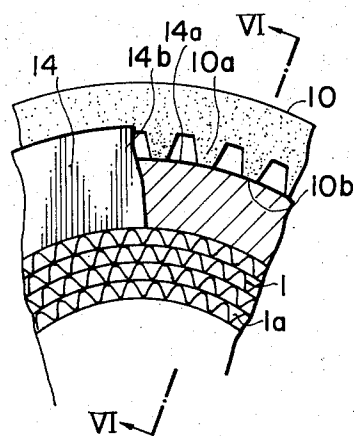


FIG. 5



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HEAT EXCHANGING APPARATUS

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a heat exchanging apparatus of the type that includes a disc-like body of a perforated material adapted to be rotated in heat transfer contact with heat exchanging media such as air and combustion products exhausted, for example, from a gas turbine engine for the heat exchange of the heat exchanging media.

2. Description of the Prior Art

As an example, a conventional heat exchanging apparatus of this kind and which is designed for use with a gas turbine engine has a disc-like body of a material, such as a ceramic material, which is perforated to pass therethrough air and combustion products from the gas turbine engine. In order that the disc-like body may be driven by a motor through torque-transmitting means such as chain or the like, the apparatus is provided with a drive ring disposed around the disc-like body and having thereon sprockets for driving engagement with the chain.

The conventional apparatus has a plurality of leaf springs mounted between the disc-like body and the drive ring to transmit the torque therefrom to the disc-like body and accommodate the thermal expansion of the members. Due to the provision of the torque-transmission leaf springs, the diameter of the disc-like heat accumulating and exchanging body effective for the heat exchange is extremely smaller than the diameter of the drive ring. For this reason, a conventional heat exchanging apparatus of this kind and which is designed to have a desired capacity is inevitably required to have a relatively bulky size as compared with the capacity thereof.

Moreover, the disc-like body of the conventional apparatus is supported in position from the drive ring by virtue of the face to face pressure contacts of the leaf springs with the peripheral surface of the disc-like body at a plurality of localized portions or spots thereon. In order that the disc-like body may withstand the localized pressure contact of the body with the leaf springs, the disc-like body is required to have an increased mechanical strength. This is important in view of the fact that the disc-like body is usually made of a ceramic material which has a mechanical strength normally less than that of a metal.

Furthermore, the torque imparted to the leaf springs from the drive ring so as to drive the disc-like body tends to cause the leaf springs to have buckling deformation produced therein due to compression imparted to the leaf springs by the drive ring and the disc-like body. The production of the buckling deformation functions to take up or absorb at least a part of the torque to be transmitted to the disc-like body with a disadvantageous result that the leaf springs have an unstable torque transmission characteristic.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide an improved heat exchanging apparatus of the class specified in the above and which has a relatively smaller size as compared with a relatively large disc-like heat accumulating and exchanging body.

It is another object of the present invention to provide an improved heat exchanging apparatus specified in the above and which is not adversely influenced by the thermal expansion of the components of the apparatus.

It is a further object of the present invention to provide an improved heat exchanging apparatus of the class specified in the above and in which variation in the rotational drive force of a drive source and exterior vibration and shock are substantially prevented from being imparted to the disc-like heat accumulating and exchanging body for the uniform and stable rotation thereof.

It is a further object of the present invention to provide an improved heat exchanging apparatus of the class specified in the above and which is simplified in construction and thus can be manufactured at an inexpensive cost.

So as to achieve the above objects, there is provided according to the present invention a heat exchanging apparatus comprising a disc-like heat accumulating and exchanging body having axial perforations for passing flows of heat exchanging media therethrough, a gear wheel adapted to be driven by a drive source, and an endless belt having teeth formed on the inner periphery thereof, the endless belt extending around the gear wheel and the disc-like body with the teeth of the belt being in meshing engagement with the teeth of the gear wheel and the inner periphery of the endless belt being in driving engagement with the outer periphery of the disc-like body whereby the endless belt rotates the disc-like body to bring the circumferential portions thereof into successive heat transfer contact with the heat exchanging media for thereby continuously performing heat exchange therebetween.

The heat accumulating and exchanging body may advantageously include a driven ring secured to the outer peripheral surface thereof. The driven ring may preferably be formed with a circumferential groove in the outer peripheral surface so that the endless belt can be engaged in the groove with the inner peripheral surface of the belt being in frictional driving engagement with the bottom surface of the groove. The groove may preferably be defined by a pair of annular flanges extending radially outwardly from the opposite side edge portions of the peripheral surface of the driven ring. The flanges may have their opposite inner surfaces converging radially inwardly of the driven ring so that the converging inner surfaces of the flanges have an additional frictional driving engagement with the side faces of the endless belt. The bottom surface of the circumferential groove may be provided thereon with teeth for driving meshing engagement with the teeth on the inner peripheral surface of the endless belt.

The disc-like heat accumulating and exchanging body may preferably be made of a ceramic material perforated to allow the heat exchanging media to be passed therethrough. The material of the heat accumulating and exchanging disc-like body, however, is not limited to the ceramic material and, may be other material having small thermal expansion coefficient, such as stainless steel, glass or the like. The perforations in the heat accumulating and exchanging body may have any appropriate cross-sectional shape such as, for example, polygonal, circular or wavy or corrugated configuration so long as the perforations can pass through the heat exchanging media which normally are

in the form of fluids. The driven ring secured to the outer peripheral surface of the disc-like body may preferably be made of a ceramic material having a thermal expansion coefficient substantially equal to that of the disc-like body.

The endless belt may advantageously be made of a heat-resistant and resilient material such as, for example, a mixture of rubber and plastic material.

The above and other objects, features and advantages of the present invention will be made apparent from the following description with reference to the accompanying drawings.

DESCRIPTION OF DRAWINGS

FIG. 1 is a partial sectional front view of an embodiment of the heat exchanging apparatus according to the present invention;

FIG. 2 is a fragmentary partial sectional view of the apparatus illustrating in larger scale the section of the apparatus surrounded by a circle A in FIG. 1;

FIG. 3 is a partial sectional plan view of the apparatus which is installed for practical operation;

FIG. 4 is a view similar to FIG. 1 but illustrating a second embodiment of the apparatus of the invention;

FIG. 5 is a view similar to FIG. 2 but illustrating the section of the second embodiment surrounded by a circle B in FIG. 4;

FIG. 6 is a cross-section as taken along line VI—VI in FIG. 5; and

FIG. 7 is a view similar to FIG. 6 but illustrating a modification to the second embodiment of the invention.

DESCRIPTION OF PREFERRED EMBODIMENTS

The present invention will be described hereunder with reference to the accompanying drawings which illustrate embodiments of the invention as being applied, by way of example, to a gas turbine engine. It is, however, to be understood that the application of the invention is not limited to a gas turbine engine.

The same reference numerals indicate similar members of the apparatus throughout the embodiments of the invention.

Referring first to FIGS. 1 to 3 of the drawings, there is shown a first embodiment of the heat exchanging apparatus according to the present invention. The apparatus shown includes a disc-like heat accumulating and exchanging body 1 of a ceramic material having a small thermal expansion coefficient. The body 1 is formed therein with a plurality of axial perforations 1a for passing therethrough air and combustion products exhausted from a gas turbine engine. The body 1 is also provided therein with a central axial bore 1b into which a bushing 2 of a ceramic material preferably having a thermal expansion coefficient substantially equal to that of the body 1 is fitted and secured to the body 1 by means of a cement. A bearing 3 of a carbonic metal is fitted into the bushing 2 and secured to the inner peripheral surface thereof by means of a cement.

The body 1 may preferably be provided with a ring gear 4 of a ceramic material having a thermal expansion coefficient substantially equal to that of the body 1 and extending around the same and secured to the outer peripheral surface thereof by means of a cement. The ring gear 4 has teeth 4a provided on the outer periphery thereof in its entirety at equal interval. The gear 4 also has a pair of flanges 4b and 4c provided on the

outer periphery of the ring in such a manner that the flanges extend radially outwardly from the opposite side edge portions of the outer peripheral surface of the ring gear 4 with the circumferential row of the teeth 4a disposed between the flanges 4b and 4c, as will be best seen in FIG. 3. The flanges 4b and 4c serve as guides for a driving belt to be described later.

The assembly consisting of the disc-like body 1, the bushing 2, the bearing 3 and the ring gear 4 is rotatably mounted on a fixed shaft 5 extending through the bearing 3 and mounted on supports 6 and 6a which in turn are secured to an appropriate machine frame, not shown.

The apparatus also includes a gear wheel 7 of a diameter smaller than the ring gear 4 and having gear teeth 7a provided on the entire outer periphery thereof. The gear wheel 7 has a central drive shaft 8 extending therethrough and fixed thereto for rotation with the gear wheel. The drive shaft 8 is drivingly connected to a motor such as the gas turbine engine or another separate electric motor, not shown, through a conventional speed reduction gear, if required, so that the drive shaft 8 is actuated to drive the gear wheel 7. The shaft 8 is journaled by a fixed bearing 9 on a machine frame (now shown).

An endless drive belt 10 of a resilient and heat-resistant material such as, for example, a mixture of rubber and a plastic material and having a series of teeth 10a provided on the inner peripheral surface thereof extends under tension around the ring gear 4 and the gear wheel 7 to drivingly interconnect them by virtue of the meshing engagement of the teeth 10a of the belt 10 with the teeth 4a and 7a of the ring gear 4 and gear wheel 7, respectively.

The ratio of the number of the teeth of the ring gear 4 with respect to that of the gear wheel 7 may preferably be determined such that the ring gear 4 is rotated together with the disc-like body 1 at 20 r.p.m. In addition, the axis of the gear wheel 7 is preferably so positioned with respect to the axis of the ring gear 4 that the endless belt 10 engages the ring gear 4 in the parts of the outer peripheral surface thereof substantially corresponding to three quarters of the entire circle thereof.

For practical operation, the apparatus is installed in such a manner that the general radial plane of the heat accumulating and exchanging body 1 extends transversely of the flows of air and combustion products of a gas turbine engine through two pairs of axially aligned conduits 11 and 11a and 12 and 12a, respectively, so that the flows are passed through the axial perforations in the disc-like body 1.

In operation, the torque imparted from the motor to the drive shaft 8 rotates the gear wheel 7. The torque is then transmitted from the gear wheel 7 to the ring gear 4 by virtue of the meshing engagement of the teeth 10a with the teeth 7a and 4a of the gears 7 and 4. The ring gear 4 is therefore rotated together with the disc-like body 1, the bushing 2 and the bearing 3 about the axis of the fixed shaft 5 at a speed, for example, 20 r.p.m.

The circumferential portions of the disc-like heat accumulating and exchanging body 1 are successively brought into heat transfer contact with the combustion products exhausted from a gas turbine engine and flowing through the pair of conduits 12 and 12a so that the circumferential portions of the disc-like body 1 are suc-

cessively heated by the combustion products. The heated circumferential successive portions are then brought into heat transfer contact with the air flowing through the pair of conduits 11 and 11a so that the air flow extracts and absorbs the heat from the heated successive portions of the disc-like body 1 to thereby continuously carry out the heat exchange between the flows of the air and combustion products flowing through the pairs of conduits 11 and 11a and 12 and 12a.

The use of the heat-resistant and resilient driving endless belt 10 is advantageous in that the belt absorbs or at least weakens, by virtue of the resiliency of the belt, an exterior vibration which otherwise might be directly imparted to the ring gear 4 and the disc-like body 1 from the gear wheel 7. In addition, any large amount of variation in the rotational drive due to any irregularity of the rotation of the drive motor is taken up by the resiliency of the endless belt 10 so that the same transmits a regularized or constant rotational drive force to the ring gear 4 to prevent the same from otherwise being subjected to a large amount of variation in the torque imparted thereto.

The heat accumulating and exchanging body 1, the bushing 2 and the ring gear 4 are expanded by the heat of the combustion products passing through the disc-like body 1 and through the pair of conduits 12 and 12a

because the combustion products are at an elevated temperature which is normally higher than 600°C. Since the body 1, the bushing 2 and the ring gear 4, however, are made of ceramic materials having substantially equal to thermal expansion coefficients, the members are caused to have thermal expansions at the same rate with a resultant advantage that there is not produced any gap or clearance between the members due to the thermal expansions thereof.

FIGS. 4 through 6 illustrate a second embodiment of the invention which is substantially identical with the first embodiment except that the second embodiment employs a driven ring 14 in place of the ring gear 4. More specifically, the driven ring 14 is preferably made of a material the same as the material of the ring gear 4 of the preceding embodiment. The driven ring 14 is secured to the outer peripheral surface of the disc-like heat accumulating and exchanging body 1 and has a pair of flanges 14b and 14c, as best seen in FIG. 6, similar to the flanges 4b and 4c of the preceding embodiment. The flanges 14b and 14c define therebetween a groove whose bottom surface 14a is planar, as shown in FIG. 5, contrary to the toothed bottom surface 4a of the groove in the peripheral surface of the ring gear 4 of the preceding embodiment.

The endless belt 10, which is in driving engagement at its teeth 10a with the teeth 7a of the gear wheel 7, is in frictional driving contact at the end faces 10b of the teeth 10a with the planar bottom surface 14a of the groove defined between flanges 14b and 14c of the driven ring 14 to transmit the drive force from the gear wheel 7 to the driven ring 14. The belt 10 has side faces 10c and 10d which may be slightly spaced from the inner surfaces of the flanges 14b and 14c.

The second embodiment is advantageous in that it employs a simplified construction and thus can be manufactured at an inexpensive cost while the simplified construction is sufficiently operable to transmit the necessary torque. In addition, in a case where a drive force excessive to the rotational capability of the disc-

like body 1 should be imparted by the ring wheel 7 to the endless belt 10, the excessive part of the drive force is taken up by the relative sliding movement of the endless belt 10 with respect to the bottom surface 14a of the groove in the peripheral surface of the driven ring 14.

FIG. 7 illustrates a further modification which comprises a driven ring 24 having a pair of flanges 24b and 24c which have their inner surfaces 24e and 24f radially inwardly converging toward the center of the ring to define therebetween a groove of generally V-shaped cross-section, as will be seen in FIG. 7. A modified endless belt 10' of a cross-section substantially complementary to the V-shaped cross-section of the groove has radially inwardly tapering side faces 10'c and 10'd in frictionally driving engagement with the inner surfaces 24e and 24f of the flanges 24b and 24c of the driven ring 24, in addition to the frictional driving engagement of the end faces of the teeth of the belt with the bottom surface 14a of the driven ring 24, to thereby transmit thereto the drive force from the drive source.

The embodiments of the invention have been described and illustrated as preferably employing driven rings 4, 14 and 24, respectively. The present invention, however, does not necessarily require such driven rings. The disc-like heat accumulating and exchanging body 1 of the invention can be driven by an endless belt which is directly drivingly engaged with the outer peripheral surface of the disc-like body 1 to effectively transmit the torque thereto from the drive source.

It will be particularly appreciated that the driving gear wheel driven by a drive motor is in driving meshing engagement at the teeth thereof with the teeth on the inner periphery of the endless belt. This feature of the invention not only makes it possible for the apparatus to employ a minimized distance between the axes of the disc-like body and the driving gear wheel, but also enables the driving gear wheel to be of a smaller diameter such as, for example, one fifth the diameter of the driven ring, with a resultant advantage that a compactness of the apparatus is achieved.

The resiliency of the endless belt not only advantageously imparts uniform and levelled torque to the disc-like body regardless of varied torque from the drive motor, but also is effective to prevent the teeth of the driven ring gear from being subjected to localized or concentrated stress with a resultant advantage that the driven ring gear is not required to be made of a metal but can be made of a material the same as that of the disc-like body. This advantageously eliminates the use of leaf springs such as those employed in conventional apparatus of this kind so as to deal with disadvantageous differentiated thermal expansions of members, so that the apparatus of the invention is provided with a relatively larger effective heat exchanging area as compared with relatively smaller size and compact design of the apparatus.

The resilient belt imparts a radially inwardly directed resilient force to the outer peripheral surface of the disc-like body. The belt, moreover, is somewhat deformable due to the resiliency of the belt. This enables the disc-like body not to need its teeth machined with the same accuracy as those which are intended for use with a chain, with a resultant advantage that the apparatus of the invention can be manufactured at a reduced cost.

Furthermore, the apparatus of the invention has simplified construction and compact design for easy operation and manipulation. Thus, the apparatus can be advantageously used with a gas turbine engine installed on an automobile in which the installation and operation or manipulation of the heat exchanging apparatus must be effected in an extremely limited space.

What is claimed is:

1. A heat exchanging apparatus for use with a gas turbine engine, said apparatus comprising
a disc-like heat accumulating and exchanging body of ceramic material having axial perforations for passing flows of heat exchanging media therethrough,

a gear wheel adapted to be driven by a drive source,

said disc-like body including a driven ring of ceramic material having a thermal expansion coefficient similar to that of said disc-like body and being secured to the outer peripheral surface of said disc-like body,

said ring having a circumferential groove with a planar bottom surface which has a circumference several times larger than the circumference of said gear wheel,

and a heat resistant and resilient endless belt having teeth formed on the inner periphery thereof,

said endless belt extending around said gear wheel and therefrom straight to and around said groove with the teeth of said belt being in meshing engagement with the teeth of said gear wheel and in fric-

tional engagement with at least said planar bottom surface of said driven ring,
the peripheries of said ring and gear wheel being spaced closely apart a predetermined distance so that, in conjunction with the said relative circumferences of the groove bottom surface and gear wheel, said belt frictional engagement with said bottom surface is in the area of three-fourths of the groove circumference, whereby said endless belt rotates said disc-like body to bring the circumferential portions thereof into successive heat transfer contact with said heat exchanging media for thereby continuously performing heat exchange therebetween.

2. A heat exchanging apparatus as claimed in claim 1, in which said driven ring has a pair of flanges extending radially outwardly from the opposite peripheral edge portions of the outer peripheral surface of said ring to define said circumferential groove between said flanges, a substantially smooth bottom surface in frictional driving engagement with the inner periphery of said endless belt, said disc-like body having a diameter sufficiently greater than that of said gear wheel to enable torque to be transmitted from said endless belt to said disc-like body by the friction therebetween.

3. A heat exchanging apparatus as claimed in claim 2, in which said flanges have inner surfaces converging radially inwardly of said driven gear, said endless belt having side faces in frictional driving engagement with said inner surfaces of said flanges.

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