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AIR-TO-AIR ENERGY EXCHANGE WHEEL AND METHOD OF FABRICATION

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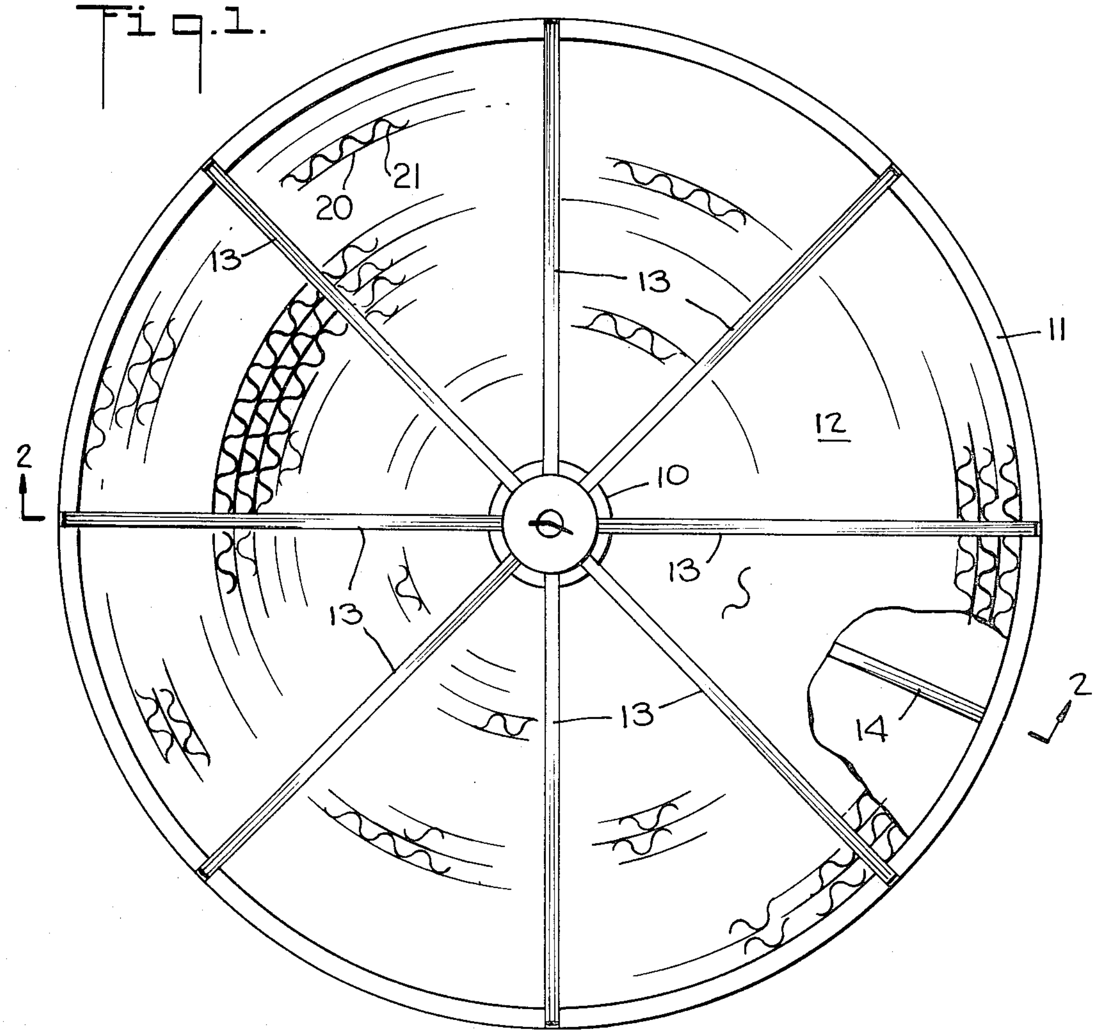
Fig. 1.



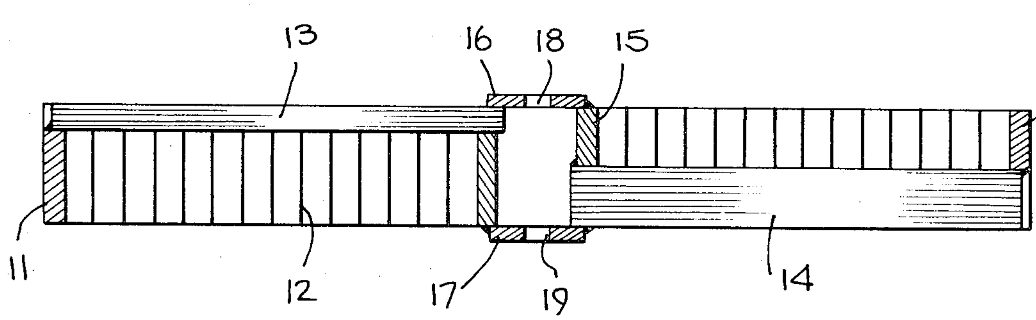


Fig. 2.

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AIR-TO-AIR ENERGY EXCHANGE WHEEL AND METHOD OF FABRICATION

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ABSTRACT OF THE DISCLOSURE

Alternating flat and corrugated ribbons of metal or other foil are wrapped continuously in a spiral around a central hub. When the appropriate diameter is attained the outer periphery is secured by a rim having an axial dimension equal to the axial dimension of the spiral wrapping. Angularly spaced metal spokes are inset in grooves in opposite faces of the wheel flush with such faces. The spokes on one side of the wheel are of substantial axial dimension for structural strength and are secured both to the rim and to the hub. Thinner spokes located on the opposite face of the wheel are generally permitted to float at one or both ends, although under certain circumstances both ends may be secured.

The present invention relates to an air-to-air energy exchange wheel and to the method of fabricating same.

Although the invention may have other uses, it was made in connection with an effort to improve the construction of metallic heat exchange wheels and will, therefore, be described in connection with such use. Heat transfer wheels are used in regenerative heating systems. The wheel is usually composed of a metallic material, or the like, constituting a matrix which is capable of absorbing thermal energy from a stream of hot air or gas and giving up the stored energy to a separate stream of air or gas to be heated. Heretofore, rotary regenerative units have been used as preheaters for combustion air for gas turbines and for similar heating purposes. They have also been used as economizers in connection with space heating equipment.

The wheels are generally exposed to wide ranges of temperature and, therefore, must be designed to accommodate substantial thermal expansion and resist deformation. They should be light in weight. They must be sufficiently rigid to withstand the fluid pressures, primarily dynamic, from the gas streams. The wheels also must be shaped so that suitable seals can be arranged to cooperate with their surfaces to isolate the two gas or air streams. Depending upon the thermal and other requirements, these wheels may be quite large in diameter. Thus, designing a satisfactory wheel is quite complicated.

In the United States patent application of Marvin K. Rohrs, Robert J. Neary, Robert B. Rosenberg, Alan Kardas and William R. Staats, Ser. No. 94,911 filed concurrently herewith for "A Rotary Regenerative Space Heater," and assigned to the same assignee as the present application, there is described a heating system employing a heat transfer wheel. The heating system is unique in that it provides an efficient combustion unit specifically for generating the hot gases which heat the wheel and then uses the wheel to heat air which is used directly in an environmental space heating capacity. The wheel on the combustion chamber side is exposed to a mixture of air and combustion products at a temperature of the order of 1300° to 1500° F. which mixture exits from the wheel at about 240° F. On the air heating side, the incoming air is generally at 70° F. and leaves at about 160° F.

In the particular example described in the aforesaid application, the wheel is arranged to be rotated at about 20 r.p.m. and has a diameter of a little over 3 feet and a thickness of only 3 inches.

With the foregoing in mind, it is an object of the present invention to provide an air-to-air energy exchange wheel with completely flush surfaces for efficient gaseous sealing. It is a further object of the invention to provide a wheel particularly suited for heat transfer and capable of withstanding without distortion the temperatures encountered in a heating system of the type described in the aforesaid application.

Another object of the invention is to provide an economical method of fabricating such a wheel.

Briefly describing a preferred embodiment of the invention, there is provided an air-to-air energy exchange wheel having a metal frame comprising a hub and a concentric outer rim. The frame supports a cellular filling or matrix formed by spirally wrapping around the hub alternate corrugated and flat metal foil ribbons having a width equal to the axial dimension of the rim. The filling is capable of transferring energy from air-to-air and occupies the space between the hub and the rim. It is permeable to air traveling parallel to the axis of the hub. The frame further comprises a first group of radially extending angularly spaced spokes disposed in corresponding grooves in the filling on one side of the wheel, and a second group of radially extending angularly spaced spokes disposed in corresponding grooves in the filling on the other side of the wheel, both sets of grooves preferably being also formed in the hub and rim. The spokes in both instances are set flush with the corresponding opposite faces of the wheel represented by the rim and matrix. The spokes in the first group are secured at both ends to the rim and hub, respectively, and the spokes in the second group may be secured, preferably only at one end to either the rim or the hub while the unsecured end remains floating.

In accordance with a further aspect of the invention, there is provided a method of forming a wheel of the aforesaid type which comprises the steps of spirally wrapping about a metal hub alternating flat and corrugated foil ribbons until the desired diameter is obtained. The wrapping is secured by disposing a metal rim therearound. Thereafter, a plurality of angularly spaced radial slots are produced across the foil wrapping, and preferably across the hub and rim, on both sides of the wheel. The slots are produced with a depth substantially less than the axial dimensions of the foil wrapping and at no point sever a turn of the foil wrapping. A metal spoke is then inserted in each slot so that it is flush with the wheel surface. All of the spokes are secured on one side of the wheel at both ends to the hub and rim, respectively, and on the other side of the wheel all of the spokes may be secured, preferably at only one end to either the rim or the hub.

The invention will be better understood after reading the following detailed description of a presently preferred embodiment thereof with reference to the appended drawings in which:

FIG. 1 is a top plan view, partly broken away, of a wheel constructed in accordance with the invention; and

FIG. 2 is a transverse sectional view taken along the line 2—2, in FIG. 1.

The same reference numerals are used throughout the drawings to designate the same or similar parts.

Referring now to the drawings, it will be seen that the wheel in its preferred form consists of a hub **10**, a rim **11**, a matrix filling **12**, a plurality of radial spokes **13** angularly spaced on the upper face of the wheel, and another plurality of angularly spaced radial spokes **14** on the lower face of the wheel. The hub 10 is formed from a tubular or cylindrical metal piece 15 to the ends of which are secured caps 16 and 17 containing the apertures 18 and 19, respectively. The apertures 18 and 19 provide for inserting a shaft on which the wheel may be mounted.

As seen in FIG. 1, there are 8 radial spokes on the upper face of the wheel. While not shown in the drawing, it is to be understood that an equal number of spokes 14 are located on the lower side of the wheel staggered centrally between the corresponding spokes 13 on the upper side of the wheel. The relationship can be seen through the section of matrix that has been broken away in FIG. 1.

The wheel is produced by first taking the hub element 15 and securing to it one or more pairs of ribbons, one of which is a flat ribbon 20 while the other is a corrugated ribbon 21. These ribbons may be made of metallic foil. In the present case, stainless steel has been used satisfactorily, having a thickness of .002 inch. The width of the ribbons should be equal to the width of the rim to provide an overall flush surface. The pair of foils having an end secured to the hub member 15 is wrapped spirally thereabout until the desired diameter for the wheel is attained. Then the surrounding rim 11, which is preferably of stainless steel, is assembled to retain the wrapping in place. Now holding the subassembly in a suitable fixture, grooves are ground or cut with an abrasive wheel across the hub member 15, the matrix 12, and the rim 11 to accommodate both the spokes 13 and 14. The spokes are then installed, the depth of the grooves being such as to accommodate the spokes flushly in the surface of the matrix. Next, the spokes 14 are welded or otherwise secured to the hub member 15 and to the rim 11 at their respective ends. The spokes 13, as shown, are similarly secured at their outer ends to the rim 11 but left free or floating to elongate with a sliding fit in the grooves in the hub member 15. Next, the end plates or caps 16 and 17 are welded to the cylindrical member 15, taking care to avoid welding to the inner ends of the spokes 13.

It has been found satisfactory for the particular use described in the aforesaid copending application to make the spokes 13 of stainless steel, and the spokes 14 of hot rolled steel, while the members 15, 16 and 17 of the hub are made from carbon steel.

Further describing a specific example, a wheel has been constructed having an outer diameter of 37½ inches and a thickness of 3 inches. The spokes 14 were formed from ⅛ inch stock with a height in the axial direction of 1½ inches. The spokes 13 were formed from ⅛ inch stock with a height in the axial direction of ½ inch. Thus, the spokes 14 have a height three times the height of the spokes 13. By staggering the spokes on opposite sides of the wheel, it will be seen that the minimum axial extent of the matrix at any point is 1½ inches, i.e., the difference between the 3-inch thickness of the wheel and the 1½ inch depth of the spokes 14. If the spokes on opposite sides were permitted to be in registration, the minimum axial dimension of the matrix would be reduced to 1 inch. Thus, staggering the spokes provides for a stronger wheel construction.

The construction described above was found to withstand the severe temperature conditions encountered in the system described previously without appreciably distorting. It was discovered that in the combustion area where the wheel is exposed to the hot gases the temperature of the wheel at the surface approaches 1200° F. while the temperature drops abruptly within the matrix so that it is of the order of 300° F. only one inch below the surface. Thus, the spokes 14 which are of substantial dimension and provide for the rigidity of the wheel are essentially shielded from severe temperature changes. On the upper face of the wheel the spokes 13 are provided solely for retaining the matrix which would normally deform telescopingly in the absence thereof due to thermal expansion. However, because the radially inner ends of the spokes 13 are left unsecured, the spokes can expand without distorting the wheel.

While the present invention has been described with reference to a specific embodiment of an air-to-air energy exchange wheel for transferring heat, it may also be applied to a total heat transfer wheel where the matrix includes a hygroscopic material. A typical wheel of this type could be made from asbestos coated with a hygroscopic material.

Although it is convenient to cut the grooves in the rim and matrix and hub all at the same time, it is also possible to mill the grooves in the rim and hub member 15 beforehand and subsequently cut the grooves in the foil 12 with an abrasive wheel after assembly with the rim 11 and hub member 15.

Under certain conditions it may be found that the upper spokes bind and distort the rim even though the spokes are floating relative to the hub. In such case it may be preferable to have the rim ends of the spokes free and the hub ends secured. If means are provided for preventing the upper spokes from slipping completely out of the rim or hub such spokes may be installed with both ends floating or unattached. Alternatively, under less adverse conditions, the upper spokes may be secured at both ends to both the rim and the hub.

Various changes in construction are contemplated which those skilled in the art will appreciate without departing from the true spirit of the invention, as defined in the appended claims.

What is claimed is:

1. An air-to-air energy exchange wheel comprising a hub, a rim concentric with said hub and spaced radially therefrom, a cellular filling of means for transferring energy from air-to-air occupying the space between said hub and said rim permeable to air traveling parallel to the axis of said hub, said filling being a continuous spiral wrapping of flat and corrugated ribbons of heat absorbing material and having opposite faces flush with opposite edges of said rim, a first group of radially extending angularly spaced spokes extending between said hub and rim and disposed in corresponding grooves in said filling on one side of said wheel flush with the face of said filling and edge of said rim, a second group of radially extending angularly spaced spokes extending between said hub and rim and disposed in corresponding grooves in said filling on the other side of said wheel flush with the face of said filling and edge of said rim, said spokes and corresponding grooves on said one side and on said other side each having a depth substantially less than the axial dimension of said filling, the spokes in said first group being secured at both ends to said rim and hub, respectively, and mean retaining the spokes in said second group flushly in said corresponding grooves for preventing displacement of said filling axially of said wheel during use of said wheel.

2. An air-to-air energy exchange wheel according to claim 1, wherein the spokes in said second group are secured only at one end while the unsecured ends remain floating.

3. An air-to-air energy exchange wheel according to claim 1, wherein said cellular filling comprises a spiral wrapping of corrugated metal foil medium.

4. An air-to-air energy exchange wheel according to claim 2, wherein said filling, said rim and said second group of spokes are all formed from stainless steel, said hub is formed from carbon steel, and said first group of spokes is formed from hot rolled steel.

5. An air-to-air energy exchange wheel according to claim 2, wherein the height of the spokes in said first group in the axial direction is of the order of 3 times the corresponding height of the spokes in said second group.

6. An air-to-air energy exchange wheel according to claim 2, wherein the angular positions of the spokes in said first group are staggered relative to the angular positions of the spokes in said second group.

7. An air-to-air energy exchange wheel according to claim 2, wherein said cellular filling is in the form of

a continuous spiral wrapping of alternating flat and corrugated metallic foil ribbons; and wherein the height of the spokes in said first group in the axial direction is of the order of 3 times the corresponding height of the spokes in said second group.

8. An air-to-energy exchange wheel according to claim **7**, wherein said filling, said rim, and said second group of spokes are all formed from stainless steel, said hub is formed from carbon steel, and said first group of spokes is formed from hot rolled steel.

9. The method of forming an air-to-air energy exchange wheel which comprises the steps of spiral wrapping about a metal hub alternating flat and corrugated ribbons of heat absorbing material until the desired diameter is obtained, securing the wrapping by disposing a metal rim therearound having an axial dimension equal to that of said ribbons, producing a plurality of angularly spaced radial slots extending across the wrapping on both sides of the wheel, said slots having a depth substantially less than the axial dimension of the wrapping and at no point severing a turn of the wrapping, inserting a metal spoke extending between said hub and said rim in each slot so that it is flush with the wheel surface, securing all of the spokes on one side of the wheel to the hub and rim, respectively, and securing all of the spokes on the other side of the wheel at least to the rim or the hub.

10. The method according to claim **9**, wherein said slots are produced to also extend across the hub and rim on both sides of said wheel.

11. The method according to claim **10**, wherein the slots are produced, at least in the wrapping, by cutting with an abrasive wheel.

12. An air-to-air energy exchange wheel comprising a hub, a rim concentric with said hub and spaced radially therefrom, a spirally wound matrix of corrugated material for transferring energy from air-to-air occupying the space between said hub and said rim permeable to air traveling parallel to the axis of said hub, said matrix having opposite faces flush with opposite edges of said rim, a first group of radially extending angularly spaced spokes extending between said hub and said rim and disposed in a first set of corresponding grooves in said matrix on one side of said wheel flush with the face of said matrix and edge of said rim, a second group of radially extending angularly spaced spokes extending between said hub and said rim and disposed in a second set of corresponding grooves in said matrix on the other side of said wheel flush with the face of said matrix and the edge of said rim, the grooves of said first and second sets of grooves being of a depth substantially less than the axial dimension of said matrix, the spokes of said first group being secured to said hub and said rim, respectively, and the spokes of said second group being secured at one end and further being retained flush with said matrix face by retaining means overlying said spokes thereby permitting radial expansion of said spokes.

13. An air-to-air energy exchange wheel according to claim **12** wherein the axial height of said first set of spokes is greater than the axial height of said second set of spokes, the sum of said heights being less than the height of said rim.

14. The air-to-air energy exchange wheel of claim **1** wherein said heat absorbent material comprises asbestos.

15. The air-to-air energy exchange wheel of claim **1** wherein said heat absorbent material comprises asbestos treated with a hygroscopic material.

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