

[54] **ROTARY HEAT EXCHANGER**

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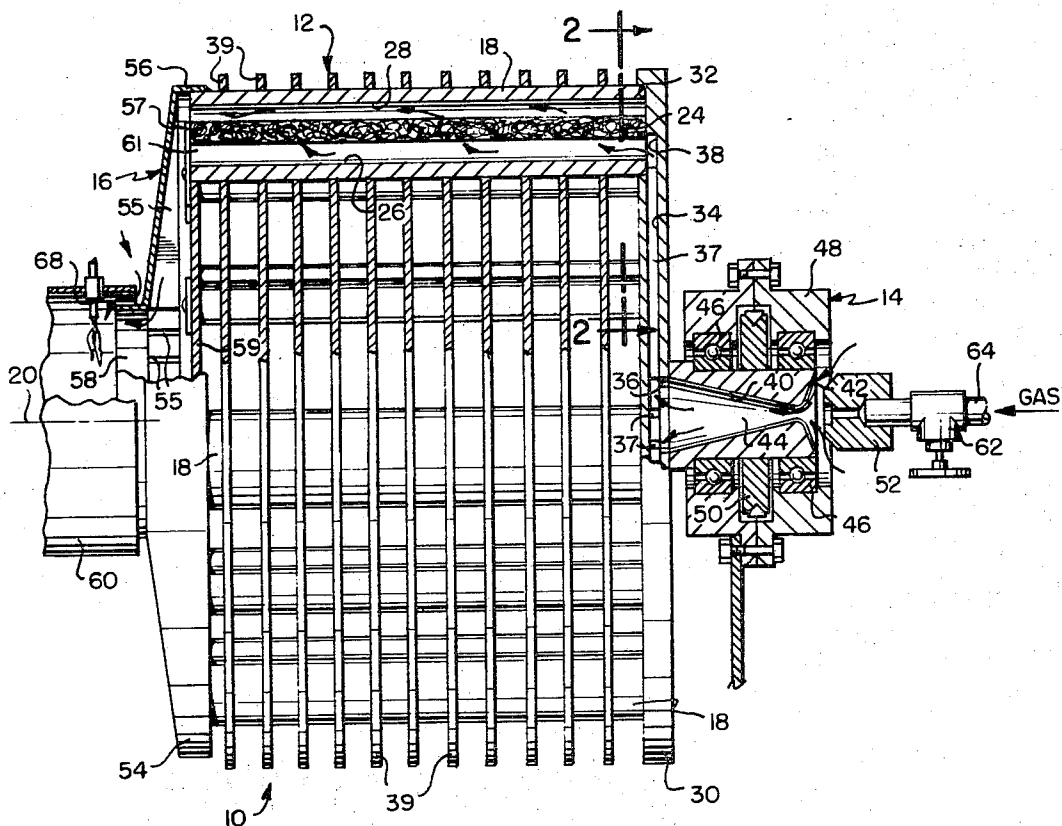
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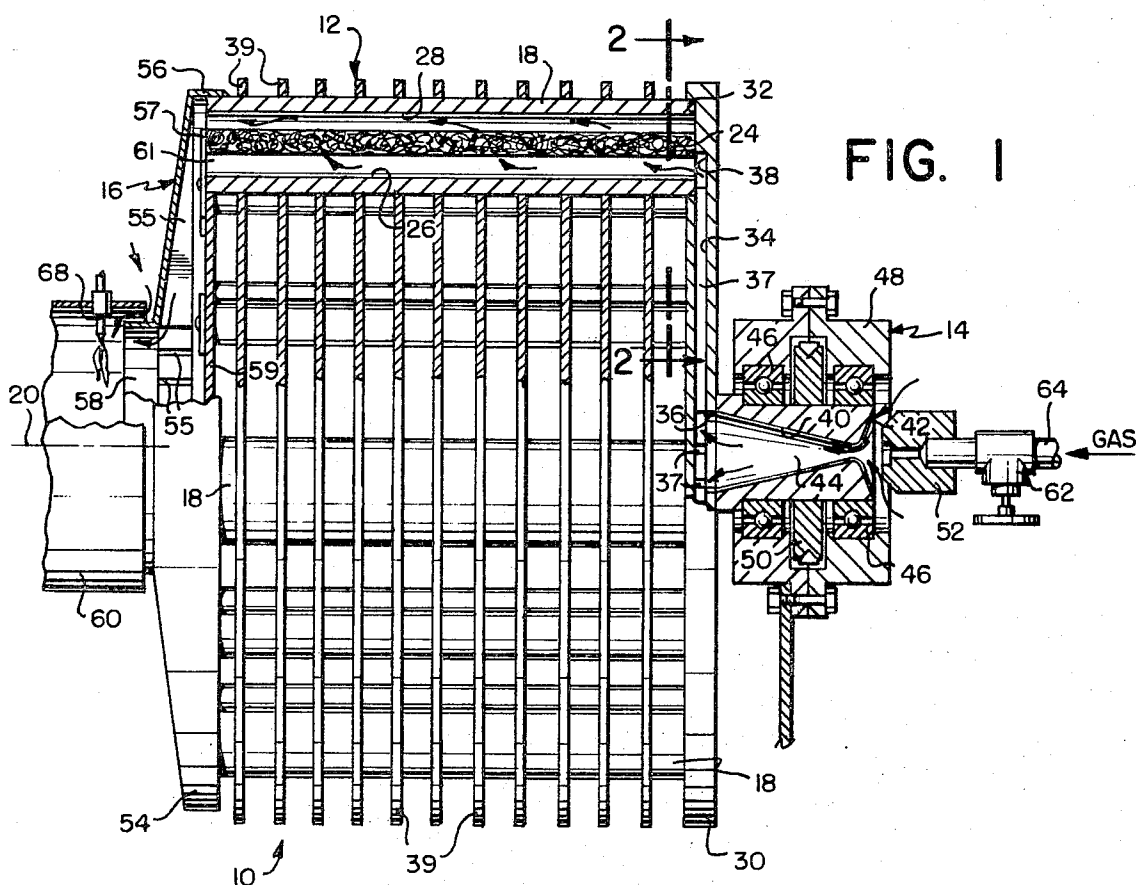
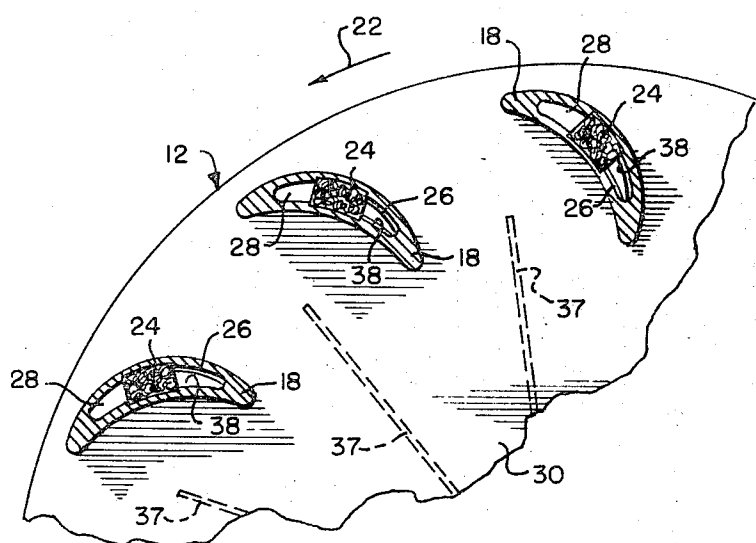
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[57] **ABSTRACT**

A rotary heater including a rotor assembly mounted for rotation about an axis, the assembly having a plurality of parallel hollow blades. Combustible gas is supplied to the interior of the blades where it interacts with a catalytic element fixed therein. As the rotor assembly rotates the gas is raised to the ignition temperature whereupon combustion occurs within the interior of each blade. The rotating blades draw ambient air over their exterior thereby heating it.

20 Claims, 2 Drawing Figures





ROTARY HEAT EXCHANGER

BACKGROUND OF THE INVENTION

This invention relates generally to heat exchangers and more particularly to rotary heaters wherein a heated fluid is caused to flow through a plurality of hollow blades.

Many rotary type heaters include a rotor assembly having a plurality of fixed hollow blades extending around and parallel to the rotor's axis of rotation. The blades are suitably configured and oriented so as to induce ambient air to flow over the blades of the rotor assembly upon rotation thereby functioning as a combined heater and fan.

In prior art heaters, of the type shown for example in U.S. Pat. No. 3,347,059 to N. Laing, granted Oct. 17, 1967, a preheated liquid or gas, such as water or steam is caused to flow within each hollow blade from an entrance to an exit side. The heated fluid flowing through the blades caused the temperature of the outer surfaces of the blades to rise thereby warming the air flowing over the blade exterior as the rotor assembly was rotated.

In most of these rotary heaters, the heat energy is added to the heating fluid before it enters the rotating blades. In other words, the water is raised to a high temperature or is vaporized prior to entering the interior of the rotor assembly blades. This particular characteristic of prior art rotary heat exchangers necessarily involves several disadvantages. A separate fluid heating system (e.g., boilers, condensers, etc.) external to the heat exchanger is necessary in most cases. Such systems are bulky and prevent the development of a compact, relatively portable heat exchanger unit. Further, the temperature to which the internal fluid can be raised, and, consequently, the potential heating capability of the heat exchanger is limited by the characteristics of the utilized, e.g., the specific heat of a particular liquid.

Another type of heater generally referred to as a catalytic heater, has been used in various recreational, agricultural and industrial applications where the characteristics of simple design, portability, and the ready availability of fuels is desired. Such heaters comprise a pad formed of a catalytic metal, usually one of the platinum group metals, the pad being positioned within a housing in back of a protective screen. A hydrocarbon fuel is fed into the housing and comes into intimate contact with the pad. The catalyst permits combustion of the hydrocarbon fuels at a much lower temperature than otherwise possible. To begin operation, fuel is heated within the housing until it reaches a temperature at which catalytic combustion occurs whereupon a relatively flameless combustion occurs on the surface of the fibers of the catalyst pad.

Such heaters have the advantages of nearly complete combustion of gases with no emission of harmful fumes, are light in weight and result in a suppressed flame. However, an efficient catalytic heater apparatus for use in forced air heating applications is not available.

SUMMARY OF THE INVENTION

Accordingly, one object of this invention is to provide a new and improved rotary heater.

Another object of the invention is to provide a rotary heater wherein energy is added to the fluid medium while the medium is within the rotor assembly blade.

Yet another object of the invention is the provision of a new and improved rotary heater wherein the fluid medium is a combustible fluid.

Still another object of the invention is to provide a new and improved rotary heater wherein a catalytic reaction is provided within the blades of the rotor to aid in fuel combustion.

A further object of the instant invention is to provide a new and improved rotary heater which is relatively compact, inexpensive to manufacture and safe in operation.

In accordance with a preferred embodiment of this invention, these and other objects are obtained by providing a rotor assembly mounted for rotation about an axis, the assembly comprising plurality of hollow blades extending across the rotor assembly parallel to the axis. Each blade has a catalytic element disposed within its interior which reduces the oxidation temperature of any one of certain combustible fuels when such fuel interacts with the catalyst. As the rotor assembly rotates, a suitable fuel is caused to enter within the interior of each of the rotor blades and interacts with the catalytic element disposed therein. Ignition means are provided whereby the fuel is ignited within the blades. Due to the interaction with the catalytic elements, the ignition temperature of the fuel is considerably lower than it would normally be. By virtue of the rotation, ambient air is inducted to flow over the blade surfaces thereby becoming heated.

DESCRIPTION OF DRAWINGS

A more complete appreciation of the invention and many of the attendant advantages thereof will be readily appreciated as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings wherein:

FIG. 1 is a view in partial section of the rotary heat exchanger of the present invention; and

FIG. 2 is a view taken in section along line 2—2 of FIG. 1 illustrating the cross-section of the heat exchanger blades and the catalytic elements disposed therein.

DESCRIPTION OF THE PREFERRED EMBODIMENT:

Referring now to the drawings wherein like reference characters designate identical or corresponding parts throughout the several views, and more particularly to FIG. 1 thereof, the rotary heater generally denoted as 10, is shown as having a rotor assembly 12 associated at one end with combination fuel supply and mounting apparatus 14 and exhaust apparatus 16 on the other end.

The rotor assembly 12 comprises a plurality of hollow rotor blades 18 mounted in parallel around the rotor axis of rotation denoted by phantom line 20. Each rotor blade 18 has a convex-concave configuration as shown in FIG. 2. The concave sides of the blades face the direction of rotation of rotor assembly 12 as depicted by the arrow 22 in FIG. 2. This orientation causes ambient air to be drawn over the outer surfaces of each blade upon rotation of the assembly.

Disposed within each blade is a quantity of catalytic material. The catalytic material is shaped to form an element 24 which extends for at least a partial distance and preferably across the entire length of the interior of each blade 18. As is explained in greater detail below, when a suitable fuel passes over each blade containing the catalytic element 24 and interacts therewith, the combustion of such fuel will take place at a temperature substantially lower than would otherwise be possible. This provides advantages which are also described below.

In the preferred embodiment of the invention, hydrocarbon type fuels are burned and a catalytic material is employed which permits combustion of such fuels at much lower temperatures than normal. For example, using propane gas as fuel, combustion can take place in the presence of the catalytic material at about 400°C., as compared to about 1,000°C at which temperature propane normally oxidizes. The various catalytic materials employed in the present invention include any one of a number of platinum group metal catalysts supported on various substrates to produce catalytic burning surfaces. Such materials include for example the type manufactured by Matthey Bishop, Inc. of Malvern, Pa., known as Cataheat.

In the preferred embodiment, the catalytic element 24 is formed of any one of a number of suitable materials such as Kanthal (an iron-chromium-cobalt alloy), and Nichrome (a nickel-chromium alloy) or steel which is plated with one of the platinum group metal catalysts. Element 24 comprises a wire mesh or screen formed from fibres of one of these coated materials fairly compactly bound. As best seen in FIG. 2, each element 24 has a substantially rectangular cross-section. A pair of opposed sides of element 24 are fixed to respective inner blade surfaces along the entire length of the blade.

The catalytic elements 24 are disposed within the hollow blades so that a pair of opposed sides of element 24 are fixed to respective opposed inner blade surfaces along the entire length of each blade 18, thereby also extending over the entire height of the hollow area within the blade. Thus, the blade interior is divided by the catalytic elements into first and second chambers 26 and 28. Since the catalytic element 24 is essentially a wire screen or mesh, little resistance to fluid communication between the first and second blade chambers 26 and 28 is presented. By virtue of the positioning of the catalytic elements 24 any fluid which moves from chamber 26 to chamber 28 (as will be described below) must necessarily encounter the fibre surfaces of the catalytic element 24. Each of the blades 18 is constructed in the same manner.

The rotor assembly 12 includes an end plate 30 having a plurality of recesses 32 along its perimeter shaped identically to and receiving the ends of rotor blades 18. The end plate 30 is hollow, the area formed therein constituting a fluid distribution manifold 34. More particularly, the distribution passage includes a central aperture 36 formed in the outwardly facing wall of plate 30 comprising an entrance into the manifold area. A plurality of smaller apertures 38 (only one shown) are formed in the inwardly facing wall of plate 30, each aperture 38 opening into an inner end of a respective recess 32. By virtue of apertures 38 being located in the inner portion of recesses 32, any fluid which passes through manifold 34 will exit through an aperture 38

into a first blade chamber 26 of a respective blade. In other words, a fuel mixture introduced into the fluid distribution manifold 34 through central aperture 36 would travel outwardly within the end plate 30 into the first blade chamber 26 of each rotor blade 18. Radial vanes 37 are provided within the manifold 34, each vane extending from a point adjacent to central aperture 36 to a point adjacent each small aperture 38 to prevent fluid vortices from forming during operations.

A plurality of annular shaped fins 39 having cutouts in the shape of blade cross sections formed around the periphery of the fins, are positioned over the blades 18 and act as additional heat transfer surfaces during operation of the heat exchanger.

The combination fuel supply-mounting apparatus 14 includes a nozzle 40 mounted along axis 20 having an inlet 42 and a diffuser section 44. The nozzle is rigidly attached to the outwardly facing wall of the end plate 30 such, for example, as by welding so that diffuser 44 overlies and fluidly communicates with central aperture 36. The nozzle is rotatably mounted in a pair of ball bearings 46 which themselves are mounted in a pillow block 48. A pulley 50 is fixed to the nozzle 40 and may be driven by suitable means, such as an electric motor. Upon rotation of the nozzle 40, the rotor plate 30 and, consequently, the rotor assembly 12 is rotated.

A gas orifice 52 connected to a source of a suitable hydrocarbon fuel, for example, propane gas, is positioned adjacent to the inlet 42 of nozzle 40 but is slightly spaced therefrom.

Combined fuel exhaust and ignition apparatus 16 operatively associated with the rotor assembly at its left end as depicted in FIG. 1 comprises a funnel-shaped member 54 having an enlarged end terminating in lip 56 fixed to the other ends of rotor blade 18 such, for example, as by welding. The reduced end of funnel-shaped member 54 is similarly terminated in lip 58 which is disposed within an exhaust pipe 60. Radial vanes 55 similar to those in manifold 34 may be provided to prevent formation of fluid vortices.

The open end 61 of the first blade chamber 26 in each blade opposite from the end in communication with aperture 38 is fluidly sealed by positioning a plate 57 thereover and attaching it by conventional means such as bolts to the end of each blade. A solid circular plate 59 is disposed at the left end of the rotor assembly as seen in FIG. 1, between the blades 18 having a circumference defined by the distance between the innermost points on blades 18. Plate 59 is fixed in position, for example, by welding it to extending portions of plates 57.

In operation, the rotor assembly 12 is rotated by suitable means rotating pulley 50. As the assembly rotates, upon opening a valve 62 in gas supply line 64, a hydrocarbon gas such as propane enters into nozzle 40 from orifice 52. As the gas flows through the orifice and enters nozzle 40, air is drawn into inlet 42 as a result of the reduced pressure existing at the nozzle throat. The air and gas mix together in the diffuser section 44 and then advance through the fluid distribution manifold 34 through apertures 38 into the first blade chamber 26 of each rotor blade 18. As a result of the relatively nonexistent flow resistance existing along the length of the first blade chamber 26, the unburned gas-air fuel mixture easily fills the chamber. Since the catalytic element is formed of a mesh or screen structure as described above, the gaseous fuel mixture begins to prog-

ress through and come into intimate contact with the catalytic surface thereof. Note that since end 61 of first blade chamber 26 is sealed by plate 57, the fuel mixture under pressure must progress into second blade chamber 28.

In order for the gas-air mixture to react within the blade chambers, the catalyst and fuel must reach a temperature of about 400°C (assuming propane gas). A preferred method for obtaining such temperatures is to allow the air-fuel mixture to advance from the second chamber into the funnel shaped member 24 into exhaust 60. This necessarily occurs since the only exit for the fuel mixture is the open end of the second blade chamber 28 which communicates with the funnel 54. At the entrance of exhaust pipe 60, a pilot light 68 is provided. The pilot light ignites the air-fuel mixture and the flame propagates back into the second blade chamber 28 of each blade 18. A suppressed flame continues to burn at the interface of the second blade chamber 28 and the catalytic member 24. In a short time the catalytic member reaches the operating temperature (about 400°C.) whereupon the oxidation reaction is sustained and hence combustion takes place at about 400°C or slightly higher. While combustion is taking place within the blades the entire rotor assembly is rotating. Such rotor assembly is designed as described above so that when rotating it acts as a cross flow fan or a centrifugal fan. The rotor in conjunction with a shroud (not shown) casing acts to propel air (or any other gas) over the exterior of the blades 18 thus heating the air. The fins 39 placed over the blades enhance the heat transfer.

The life of the catalytic system, apart from physical damage, has proven to be the life of the catalyst. Thus, such factors as the quality of the fuel and the impurities which may be absorbed on the active catalytic sites affect the life of the system.

It is to be understood that only the preferred embodiments has been described above. For example, other methods of igniting the fuel-air mixture than the one described may be employed. Similarly, various other ways of fuel distribution into the rotor blades may be employed. Further, liquid hydrocarbon fuels may also be employed within the scope of the invention.

What is claimed is:

1. A rotary heater comprising:

a rotor assembly mounted for rotation including a plurality of blades constructed and positioned to act as fan blades during rotation of the rotor assembly, each blade being hollow to form a chamber therewithin;

means for supplying fluid to each blade chamber during rotation of the rotor assembly;

means for oxidizing the fluid after the fluid has entered within the blade chamber during rotor assembly rotation and for causing heat energy to be liberated from the fluid within the chamber thereby raising the temperature of the blades;

means for venting the blade chamber of the oxidized fluid during rotor assembly rotation; and

means for rotatably supporting and rotating the rotor.

2. A rotary heater as recited in claim 1, wherein the fluid is a hydrocarbon gas and air mixture and the oxidizing means includes means for igniting the gas-air mixture within the blades.

3. A rotary heater as recited in claim 2, wherein the igniting means is a pilot light disposed within the venting means.

4. A rotary heater as recited in claim 1, wherein the oxidizing means includes an element formed from a catalytic material disposed within each blade chamber adapted to interact with the fluid supplied into the blade chamber and means for igniting the fluid while within the blade chamber.

5. A rotary heater as recited in claim 4, wherein the catalytic element extends substantially across the entire length of each of the blade chambers.

6. A rotary heater as recited in claim 5, wherein the igniting means includes a pilot light disposed within the venting means.

7. A rotary heater as recited in claim 6, wherein the catalytic material comprises a wire mesh formed of metallic fibers plated with one of the platinum group metals.

8. A rotary heater comprising, a rotor mounted for rotation about a rotor axis, support means for rotatably mounting the rotor, a plurality of hollow blades fixed to the rotor and extending thereacross parallel to the rotor axis, a catalytic element formed of metallic fibers coated with a catalytic material positioned within the interior of each hollow blade substantially extending across the blade interior dividing each interior into fluid inlet and outlet chambers, means for supplying fluid to the fluid inlet chamber of each blade, means for venting the blade interiors fluidly communicating with the fluid outlet chamber of each blade interior, means for oxidizing the fluid within the blade so that heat energy is liberated from the fluid within the blade, and means for rotating the rotor.

9. A rotary heater as recited in claim 8, wherein the fluid supply means comprises a rotor end plate rotatable with the rotor rigidly connected to one end of each of the plurality of blades, the plate having fluid passages interiorly formed therein whose ends communicate between one end of the fluid inlet chamber of each of the blades and a central aperture formed in the rotor end plate.

10. The rotary heater as recited in claim 9, wherein the other end of the fluid inlet chamber is sealed.

11. The rotary heater as recited in claim 9, wherein the fluid supply means further comprises a nozzle having an exit end disposed adjacent to the rotor plate aperture and its entrance end communicating with a source of combustible gas.

12. A rotary heater as recited in claim 11, wherein the nozzle is rotatably mounted and rigidly connected to the rotor end plate.

13. The rotary heater of claim 8, wherein one end of each blade outlet chamber communicates with the fluid outlet passage and the other end of said outlet chamber is sealed.

14. A rotary heater as recited in claim 8, wherein the fluid outlet passage comprises a funnel-shaped member having an enlarged end enclosing the open ends of the fluid outlet chambers.

15. A rotary heat exchanger as recited in claim 14, wherein the funnel-shaped member has a reduced end disposed within an exhaust pipe, said pipe having a pilot light disposed therein.

16. A rotary heater as recited in claim 8, wherein the catalytic material is a platinum group metal.

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17. A rotary heater as recited in claim 16, wherein the metallic fibers are formed of steel.

18. The rotary heater of claim 16, wherein the metallic fibers are formed of a nickel-chromium alloy.

19. The rotary heater as recited in claim 16, wherein 5

the metallic fibers are formed of a iron-chromium-cobalt alloy.

20. The rotary heater of claim 8, wherein the fluid is a hydrocarbon gas-air mixture.

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