United States Patent

Rohrs et al.

[15] **3,695,250**

[45] **Oct. 3, 1972**

[54] **ROTARY REGENERATIVE SPACE HEATER**

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[22] Filed: **Dec. 3, 1970**

[21] Appl. No.: **94,911**

[52] **U.S. Cl.**.....**126/110 R,** 165/5, 165/7, 165/10

[51] **Int. Cl.**.....**F24h 3/06**

[58] **Field of Search** .....126/110 R, 110 B; 165/5, 6, 165/7, 8, 9, 10

[56] **References Cited**

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Primary Examiner—Charles J. Myhre
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[57] **ABSTRACT**

A rotary regenerative type gas-fired space heater in which a line-type raw gas burner is mounted atop and fires downwardly within a combustion chamber, the bottom of which is in direct communication with one side of a low thermal mass regenerative heat exchange wheel. The burner, chamber and wheel are mounted within a housing partitioned to provide two vertically disposed, parallel air passages, the burner and chamber being in one passage and the horizontally disposed wheel extending into both and passing through the partition. High velocity air for both combustion and dilution is induced by an exhaust fan to enter openings in the housing and to flow upwardly through a space between the housing walls and the combustion chamber before mixing with the fuel and downwardly flowing combustion products which are then drawn by the fan through the heat exchange wheel and exhausted. Another fan located below the wheel in the other passage introduces air to be heated by drawing it in through bottom openings in the housing, projecting it upwardly through the wheel, and expelling it through an outlet grille at the top of the housing or into connected heated-air ducting.

17 Claims, 6 Drawing Figures

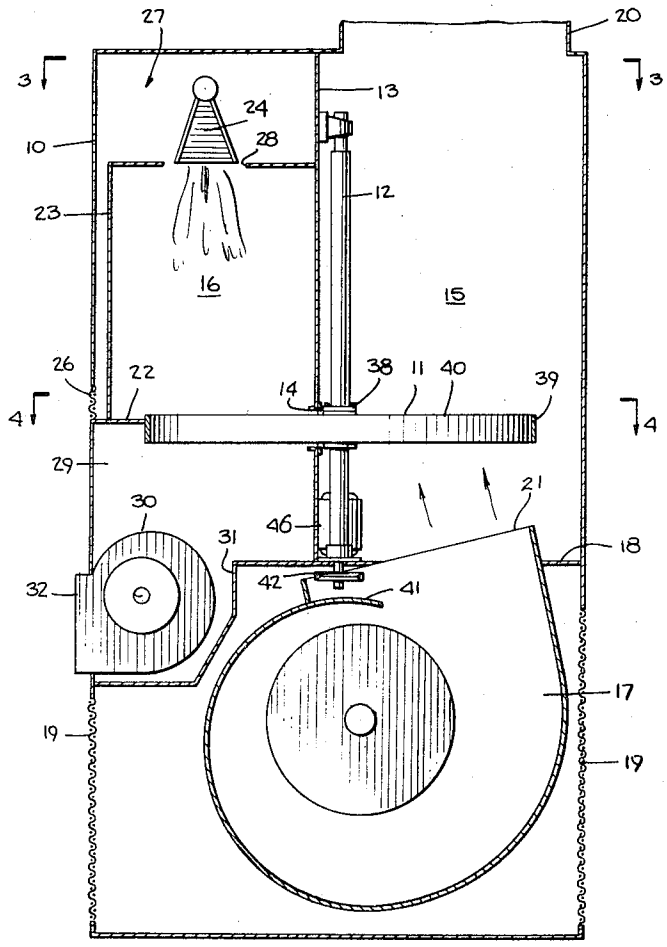

Fig. 1.

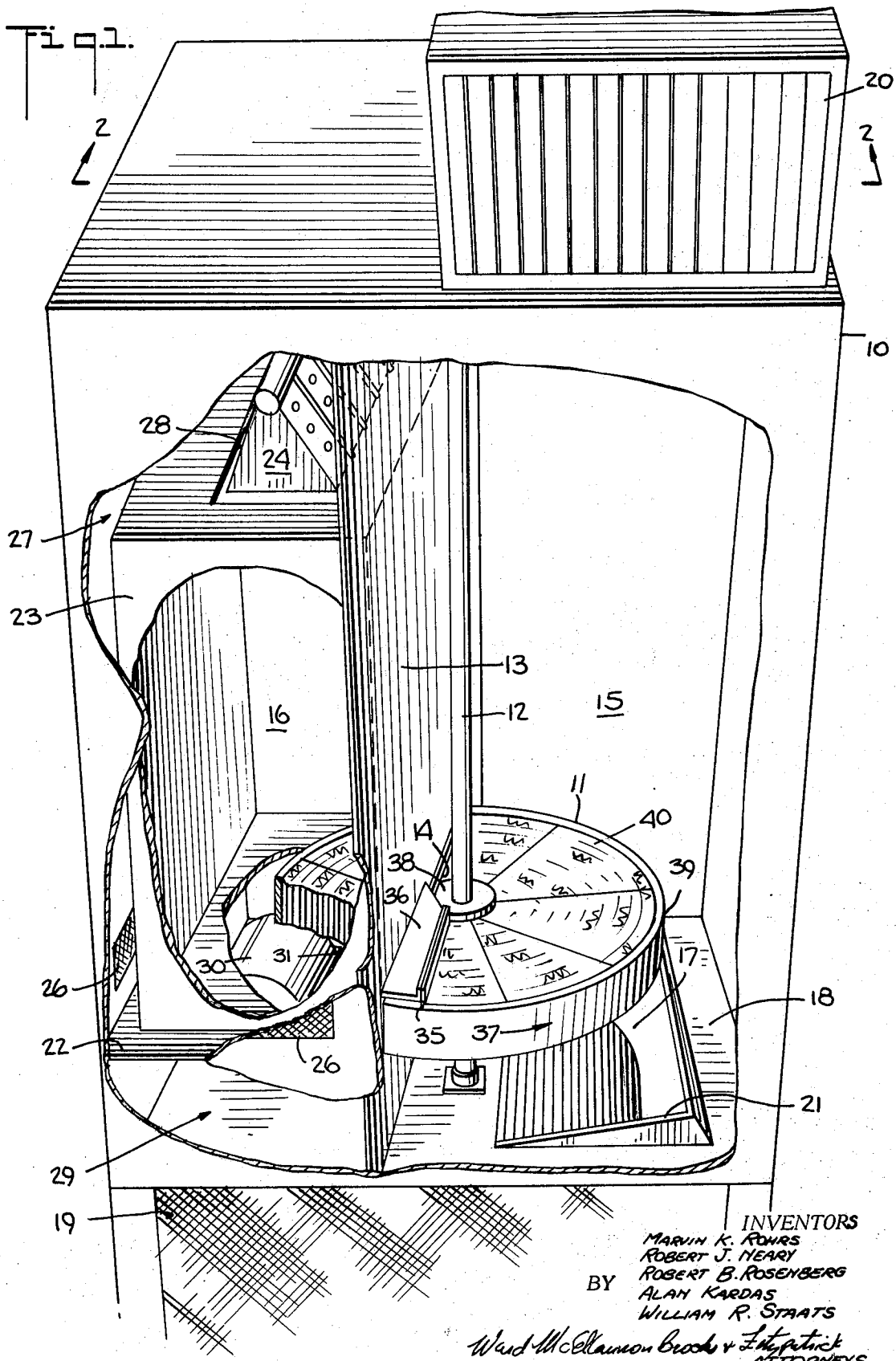

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Fig. 2.

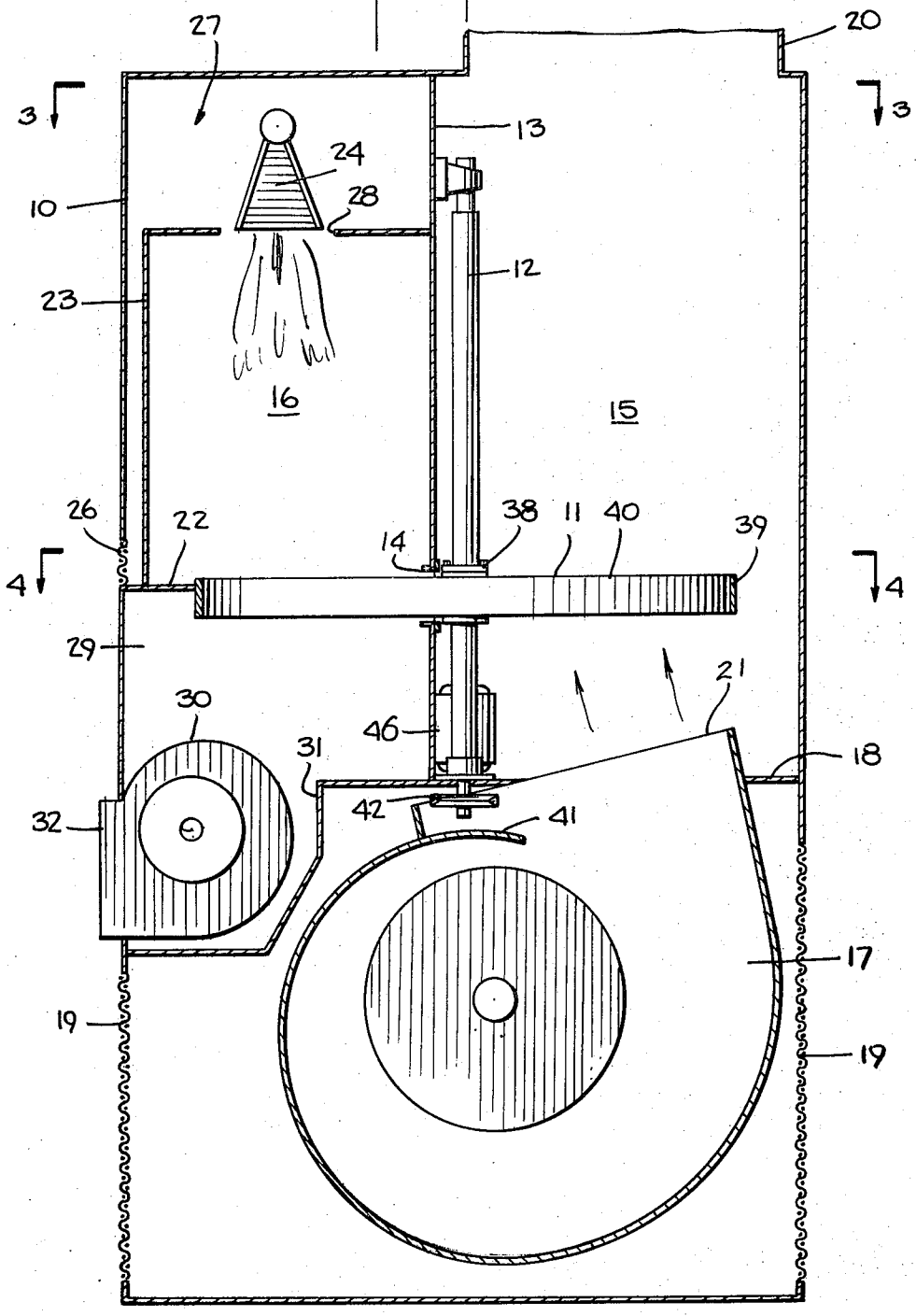

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Fig. 4.

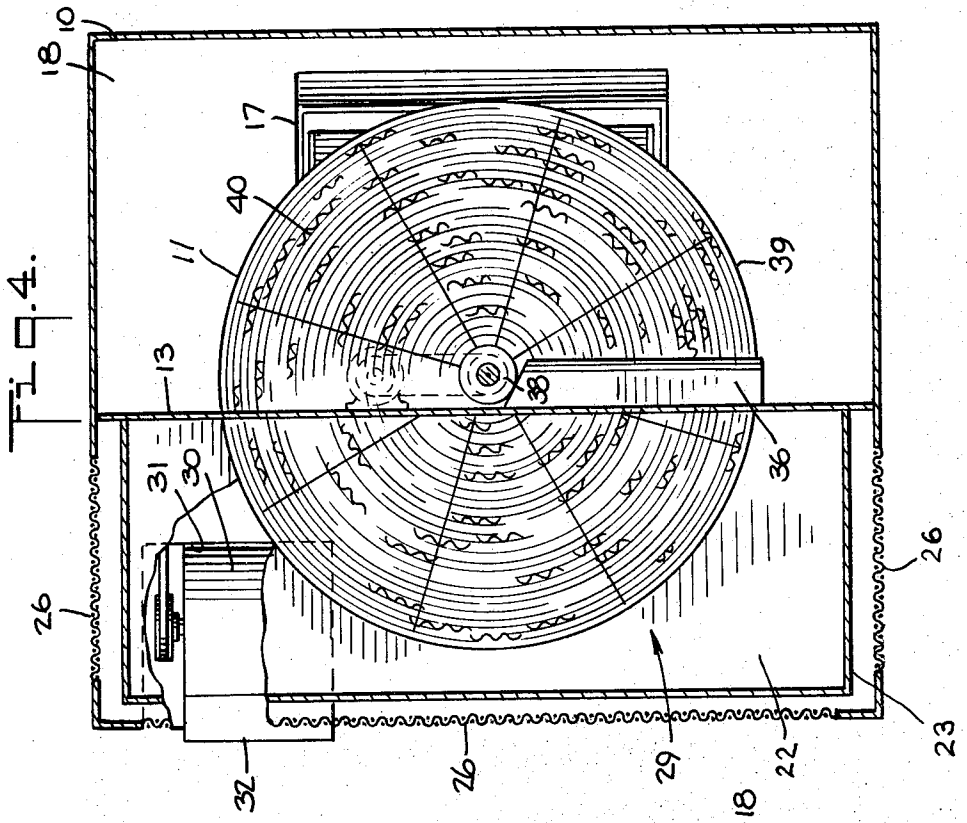

Fig. 3.

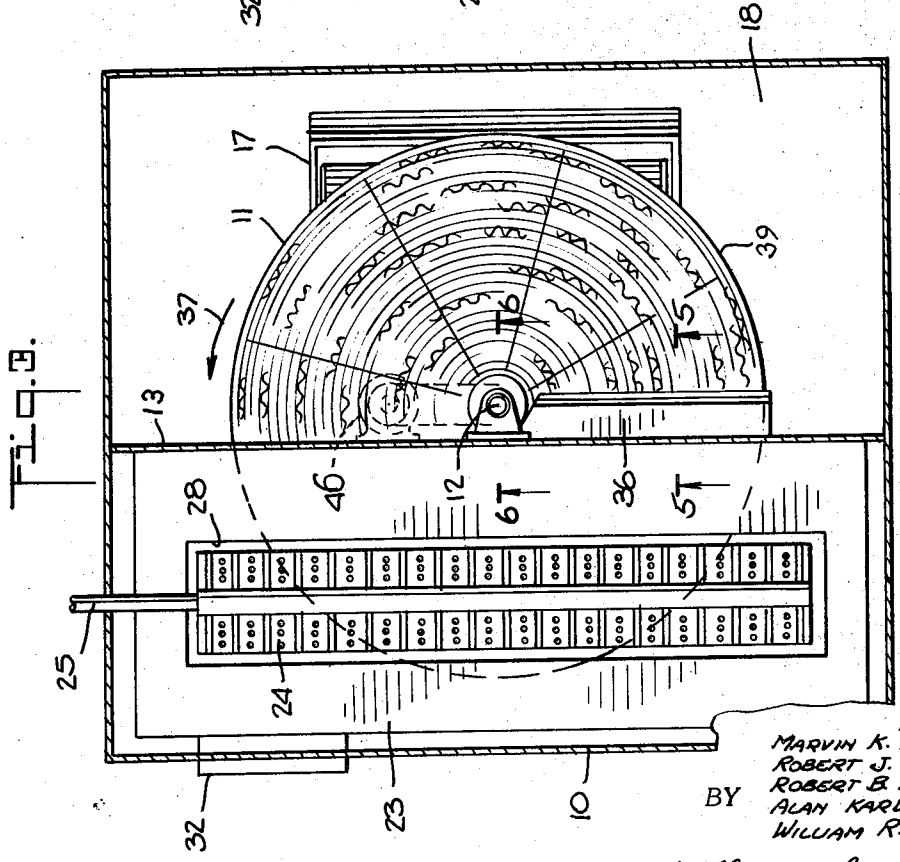

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Fig. 5.

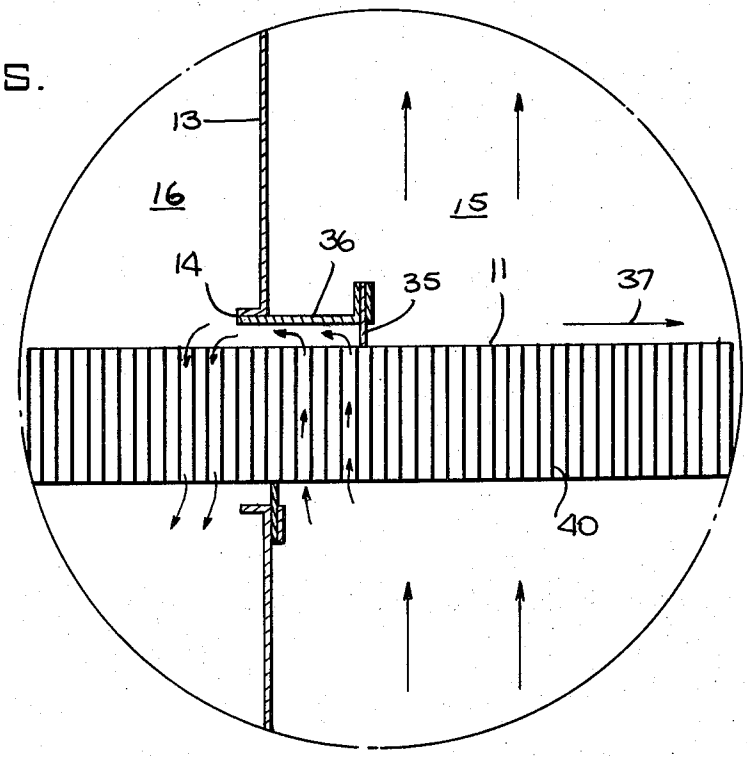
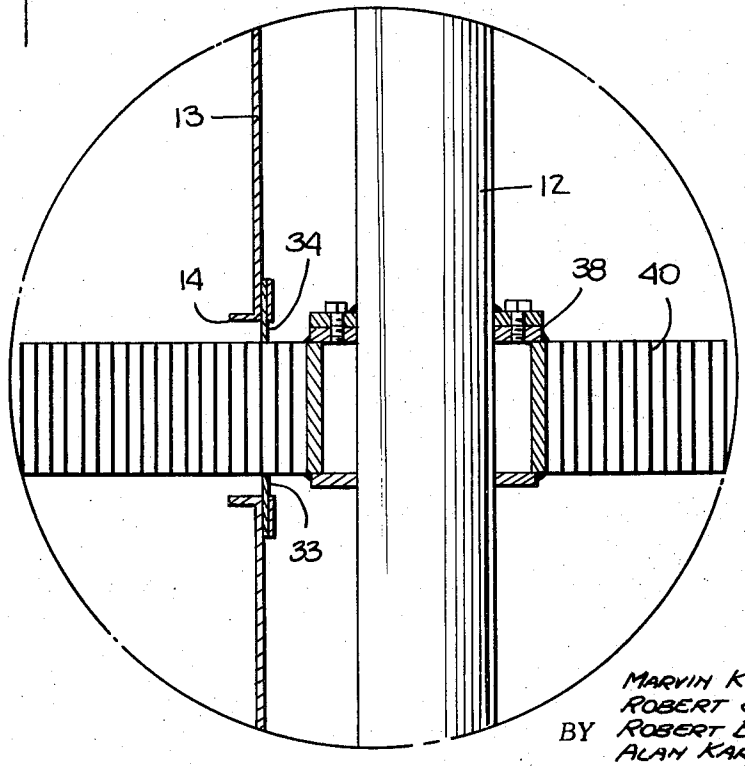


Fig. 6.



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ROTARY REGENERATIVE SPACE HEATER

The present invention relates to space heaters and, more particularly, to heaters of the indirect type.

The purpose of a space heater is to heat the air within a room, factory building, or other generally enclosed space. Thermal energy, either produced directly within the heater or obtained from some outside source, is transferred by the heater to the air to be heated. Some thermal energy is inevitably lost during the transfer step, and the problem has always been to keep such losses at a minimum. Countless different devices have been produced in the past, each one seeking to solve the problem of energy loss in a different manner.

The present invention is concerned with a fuel fired heater for environmental space. With such heaters it is usually essential that the products of combustion be isolated from the air to be heated in order to avoid pollution thereof. The construction must be such that in spite of a malfunction there is no risk of explosion. At the same time, thermal energy must be extracted from the products of combustion and transferred safely to the air to be heated.

In a typical conventional heater of the foregoing type, fuel is burned with the aid of a burner and the products of combustion are conveyed through flue tubes to an exhaust pipe or the like while the air to be heated is passed over the flue tubes. Such heaters are characterized by large thermal inertia.

With the foregoing in mind, it is an object of the present invention to provide a space heater of high efficiency, occupying a minimum of space, and light in weight. It is a further object to provide such a heater free from cold spots for condensation of moisture from flue gases, and having lower temperature flue product exhaust with concomitant reduction in fire and personnel hazards.

The invention is embodied in a rotary regenerative heat exchanger. Such heat exchangers have been used in the past for preheating and as thermal economizers. For example, in connection with the operation of turbine engines, the exhaust gases, after powering the main turbine motive element, are passed through a regenerative heat exchanger to extract heat therefrom and to transfer it to the incoming air being mixed with the fuel for powering the engine. This serves to economize on fuel by further utilizing energy which would otherwise be lost. In one instance, a small scale regenerative unit has been suggested as usable in extracting heat from the exhaust gases produced by an automotive turbine and transferring such heat to air circulated through the vehicle compartment. Regenerative heat exchangers have also been used as preheaters for space heating purposes, extracting heat from exhaust air and transferring it to either recirculated or make-up air which is subsequently further heated by an independent heater. In connection with the present invention, however, the rotary heat exchange wheel is directly associated with a combustion chamber for direct heating by the combustion products therefrom, i.e., a burner is provided for the specific purpose of producing combustion products which directly heat a regenerative energy exchange wheel which, in turn, heats the air supplied to the environmental space.

In accordance with the present invention, there is provided a space heater having a housing and a rotary heat exchange wheel mounted for rotation within the housing. Partitioning within the housing divides the housing into two discrete passages for conveying gaseous fluid through separate regions of the wheel in an axial direction. One of the passages interconnects an inlet and an outlet in the housing, and a fan disposed in the passage on the upstream side pushes air through the passage and wheel by which it is heated. A combustion chamber is disposed within the other passage on one side of the wheel, the chamber having an opening in communication with the wheel, and a fuel burner is located in communication with the chamber at a point spaced from the wheel. An exhaust fan on the downstream side of the passage draws the combustion products from the burner through the wheel and to the exterior of the housing. Seals between the wheel and the partitioning limit the leakage of air from the heated air side to the combustion chamber side. Although oil or gas can be used as a fuel, raw gas is presently preferred.

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

FIG. 1 is a perspective view with portions broken away for clarity of a space heater embodying the invention;

FIG. 2 is a vertical sectional view through the heater of FIG. 1 taken along the plane 2—2 therein;

FIG. 3 is a horizontal sectional view taken along the line 3—3 in FIG. 2;

FIG. 4 is a horizontal sectional view taken along the line 4—4 in FIG. 2;

FIG. 5 is an enlarged fragmentary vertical sectional view taken along the line 5—5 in FIG. 3; and

FIG. 6 is a view similar to FIG. 5 taken along the line 6—6 in FIG. 3.

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

Referring now to the drawings, the heater comprises a housing 10 completely enclosing the unit. A rotary heat exchange wheel 11 is mounted for rotation on a vertical shaft 12 within the housing 10. A partition in the form of a vertical wall 13 extends across the housing intersecting the horizontal wheel 11 which passes through a rectangular opening 14 in the partition. The partition 13 divides the housing into two vertical passages 15 and 16 for conveying air or other gaseous fluid through separate regions of the wheel 11 in an axial direction. A centrifugal fan 17 is mounted in the passage 15 below a horizontal dividing wall 18 for causing air to flow upwardly through the passage 15 from the screened inlet openings 19 in the sides, preferably all four sides, of the bottom of the housing to an output distribution duct connection 20. The latter may be provided with a directional discharge grille as shown in FIG. 1. As best seen in FIG. 2, the fan 17 is canted slightly with its outlet 21 inclined to direct its output upwardly along a line intersection the axis of the wheel 11. It should be noted that the housing is of rectangular configuration while the wheel is circular. Canting the fan 17 causes it to direct its output substantially entire-

ly at the wheel 11 within the confines of the periphery of the wheel whereby most of the air moved by the fan passes through the wheel without the presence of a baffle surrounding the periphery of the wheel.

On the other side of the partition 13 there is located a horizontal baffle 22 in the plane of the wheel to isolate the upper section of passage 16 from the lower section thereof. Mounted above the baffle 22 is a combustion chamber 23 whose walls are spaced a short distance from the walls of the housing 10 as best seen in FIGS. 1 and 2. The combustion chamber 23 is open at its lower end communicating with so much of the wheel 11 as extends into the passage 16. A fuel burner 24 of the line type is mounted at the top of the combustion chamber in communication with the chamber so as to be spaced from the wheel 11. Fuel, in this case raw gas, is supplied to the burner 24 by an inlet pipe 25, best seen in FIG. 3. Burner 24 is preferably a high velocity airstream burner with a high turndown capability of the order of 20 to 1. Typical burners of this type are manufactured by Mid-Continent Metal Products Company and Maxon Premix Burner Company, both of which have been found satisfactory.

A series of screened openings 26 are located in the walls of the housing 10 adjacent the combustion chamber 23 on the three adjacent sides thereof near the horizontal baffle 22. Air enters through these openings 26 into the space between the walls of the housing and the walls of the combustion chamber 23 and is caused to flow upwards to the plenum area 27 above the combustion chamber 23. The combustion chamber 23 is provided with a profile plate having a restricted opening 28 surrounding the burner 24. The air admitted through the openings 26 to the interior of the housing 10, after reaching the plenum area 27, passes through both the burner and the restricted opening 28, admixing with the fuel, and diluting the combustion products from the burner 24. The mixture then flows down through the interior of the combustion chamber 23 passing through the wheel 11 into a compartment 29 below the baffle 22. From the compartment 29, the exhaust products are eliminated at high velocity by an exhaust fan 30 mounted in a well 31 and having an outlet 32 to which an exhaust duct can be connected.

As best seen in FIGS. 5 and 6, a seal is established between the partition wall 13 and the wheel 11 around the opening 14. The seal is formed by strips of metal foil 33, 34 and 35 clamped to the partition wall 13, as shown. It should be noted that strip 35 is clamped to the end of a horizontal extension 36 on one side of the wheel. The extension 36 forms a purge section providing for passage of air from the fan 17 through a portion of the wheel 11 into the passage 16 to mix with the combustion products therein. Since the wheel is arranged to rotate in the direction of the arrow 37 the cells of the wheel will be purged of combustion residue as it leaves the passage 16 to enter the air passage 15.

Up to this point nothing has been said concerning the construction of the wheel 11. This wheel is preferably constructed as described in the copending application of Marvin K. Rohrs and Robert Neary, Ser. No. 94,910,filed concurrently herewith for "AN AIR-TO-AIR ENERGY EXCHANGE WHEEL" and assigned to the same assignee as the present application. Thus, the wheel comprises a hub 38, a rim 39 concentric with the hub and spaced radially therefrom, a cellular filling in the form of a continuous spiral wrapping of alternating flat and corrugated metallic foil ribbons 40, e.g., stainless steel ribbon 0.002 inch thick, occupying the space between the hub and the rim permeable to air traveling parallel to the axis of the hub, and a series of angularly spaced radially extending spokes disposed flushly in opposite sides of the wheel. The spokes on the lower side of the wheel afford structural integrity by being secured to both the rim and the hub while those on the upper side retain the foil in place. To avoid wheel distortion at high temperatures, the spokes on the upper side preferably have one of their ends unsecured or "-floating". The wheel is characterized by an extremely low resistance to the passage of air therethrough while having an extremely low thermal mass. The construction is capable of withstanding the severe temperature conditions encountered in the system now being described without distorting. This feature combined with the flush surface of the wheel permits the establishment of a leak-limiting seal for substantially isolating the air being heated from combustion products.

Several features of the space heater are important to note. One is the fact that the air, sometimes referred to as dilution air, entering through openings 26 and passing through the space between the walls of the housing 10 and the combustion chamber 23, functions to cool the housing walls so as to comply with existing safety requirements eliminating risk of injury if someone should come in contact with the walls of the heater while it is operating, and eliminating any fire hazard.

Another feature resides in the proportioning of the capacity of exhaust fan 30 relative to the burner 24 such that, even if the flame should become extinguished, or if an ignition malfunction should occur, while gas flow is at a maximum, sufficient air will be forcefully admixed with the escaping gas to keep the mixture well below the explosion point. Another purpose of the dilution air is to reduce the temperature of the combustion products such that as they enter the wheel 11 they are below 1500° F. Preferably, the temperature of the combustion products as they enter the wheel should be within the range of 1100° to 1500° F. In the present example, the dilution and combustion air is caused to flow from the plenum 27 past the burner 24 at a velocity of approximately 3,000 ft. per minute.

In a typical embodiment of the present invention utilizing a wheel having a diameter of approximately 3 ft. and a thickness of about 3 inches, rotating at 20 RPM, the temperature of the flue air after passing through the wheel 11 into the compartment 29 is below 275° F, e.g., on the order of 250° F. This is well below the temperature normally found in the flue exhaust from known space heaters.

While not shown in the drawings, suitable electric motors are provided for driving the fans 17 and 30. If desired, a single motor may be employed for powering the two fans.

For the purpose of driving the wheel 11, a motor 40 is mounted in the passage 15 above the baffle wall 18 with its shaft projecting through the wall 18 into the space below. This assumes that the fan 17 is of a size

such as to provide sufficient space between its cut-off sheet 41 and the baffle or wall 18. The end of the shaft of the motor 40 projecting below the wall 18 will be provided with a pulley in known manner and may be belt-connected to a corresponding pulley 42 on the lower end of the shaft 12. If sufficient space is not available below the wall 18, the drive connection may be established above the wall. In the latter case it is essential that a belt be employed having a separable junction or link for the purpose of installation.

Utilizing a wheel 11 constructed as described in the aforesaid copending application, it has been found unnecessary to locate a baffle in the passage 15 between the walls of the housing 10 and the periphery of the wheel. This is due to the fact that the pressure drop through the wheel is sufficiently low as to permit most of the air to pass through the wheel while only a minor proportion bypasses the wheel.

The foil sealing strips 33, 34 and 35 may consist of 0.002 inch thick stainless steel foil, the same as used in the matrix of the wheel. The foil strips are adjusted to contact or even flex against the flush surface of the wheel. Since the combustion side of the heater within the passage 16 is always under a negative pressure with respect to the heated air stream side in passage 15, there is no possibility of contamination of the heated air stream by combustion products. If desired, the metal foil seals may be replaced by any suitable resilient heat resistant sheet material.

Numerous changes in construction will occur to those skilled in the art. For example, the single recirculating air blower or fan 17 may be replaced by twin fans mounted on a common axis side by side. The foil matrix of the wheel 11 may be replaced by a mesh heat transfer media. However, in this case, the increased resistance of the mesh may require the insertion of a baffle within the passage 15 between the walls of the housing and the periphery of the wheel. This will result in reduced efficiency due to increased air flow losses. While a line type burner is preferable because of its turndown capability, other types of burners may be employed for special purposes. If necessary, a forced draft fan may be employed within the passage 16 in conjunction with the induced draft fan 30. However, the air pressure within the passage 16 should not be permitted to rise above that within the passage 15.

While mounting the fan 30 within the heater produces a compact economical structure, it may be found desirable under certain circumstances to use an externally mounted fan. The same is true of the fan 17.

Having described the presently preferred embodiment of the invention, it is to be understood that numerous additional changes may be made therein as will occur to those skilled in the art without departing from the true spirit of the invention as defined in the appended claims.

What is claimed is:

1. A space heater comprising a housing, a rotary heat exchange wheel mounted for rotation within said housing, partition means within said housing intersecting said wheel and dividing the housing into two passages for conveying gaseous fluid through separate regions of said wheel in an axial direction, inlet and outlet means in said housing communicating with opposite ends of one of said passages, means for causing air to flow through said one passage and wheel from said inlet means to said outlet means, a combustion chamber disposed within the other passage on one side of said wheel, said chamber having an opening in communication with said wheel and said other passage having an exhaust opening on the other side of said wheel, a fuel burner in communication with said chamber at a spaced location spaced from said wheel, means for supplying fuel to said burner, means for causing combustion products from said burner to flow through said wheel and to the exterior of said housing by way of said exhaust opening, and seal means between said partition means and said wheel for substantially preventing leakage of heated air from said one passage into said other passage.

2. A space heater according to claim 1, wherein said means for causing the flow of combustion products through said wheel includes means permitting the flow of dilution air past said burner and into said combustion chamber to mix with the combustion products from said burner.

3. A space heater according to claim 2, wherein said burner is gas fired, and said means permitting the flow of dilution air is constructed to permit such flow in sufficient quantity to reduce the temperature of the combustion products as they enter the wheel to below 1500° F.

4. A space heater according to claim 3, wherein said wheel has a thermal capacity and is rotatable at a speed sufficient to reduce the temperature of the flue products as they leave the wheel to below about 275° F.

5. A space heater according to claim 1, wherein said combustion chamber has walls spaced inwardly from the exterior walls of said housing, and wherein said means for causing the flow of said combustion products comprises means for admitting dilution air to the space between said chamber walls and said housing near the plane of said wheel, said space providing a flow passage for said dilution air along the outside of said chamber and leading to said burner whereby said walls of said housing and chamber are cooled by said dilution air.

6. A space heater according to claim 1, wherein said wheel comprises a corrugated media having axially aligned corrugations providing low resistance to the passage of air through said media, and wherein said means for causing air to flow through said one passage comprises a fan positioned in said one passage so as to direct its output substantially entirely at said wheel within the confines of the periphery of the wheel whereby most of the air moved by the fan passes through said media corrugations, the periphery of said wheel within said one passage being spaced from the surrounding walls of the passage without substantial obstruction.

7. A space heater according to claim 6, wherein said one passage has a rectangular cross-section in the plane of said wheel, and said fan has its outlet inclined with respect to the axis of said wheel to discharge air towards said wheel and generally away from the space between said wheel periphery and said surrounding walls of the passage.

8. A space heater according to claim 2, wherein said burner is of the high turndown, high velocity airstream line type, and said combustion chamber is provided with a restricted opening around said burner.

9. A space heater according to claim 1, wherein said wheel is mounted with its axis vertical, said partition means extends in the vertical direction, said combustion chamber is positioned above said wheel, said means for causing air to flow through said one passage comprises a fan positioned below said wheel, said outlet means are located adjacent the top of said housing, and said inlet means are located in the side walls of said housing substantially adjacent the bottom thereof.

10. A space heater according to claim 9, wherein said other passage provides a compartment below said wheel, and said means for causing combustion products from said burner to flow through said wheel comprises an exhaust fan mounted in said compartment in communication with said exhaust opening.

11. A space heater according to claim 10, wherein said exhaust fan and the first said fan are both driven by a common motor.

12. A space heater according to claim 9, wherein a motor for driving said wheel is mounted in said one passage between said fan and said wheel.

13. A space heater according to claim 1, wherein said wheel comprises a corrugated metal foil media having flush faces and a low resistance to the axial passage of air therethrough, and said seal means comprises lengths of resilient sheet material supported by said partition means in sliding contact with said wheel.

14. A space heater according to claim 13, wherein said lengths of sheet material consist of metal foil having thickness which is substantially the same as that of the foil in said foil media.

15. A space heater according to claim 1, wherein said combustion chamber has walls spaced inwardly from the exterior walls of said housing; said burner is of the raw gas type; said means for causing the flow of said combustion products includes means for admitting dilution air to the space between said chamber walls and said housing walls near the plane of said wheel, said space providing a flow passage for said dilution air along the outside of said chamber and leading to said burner whereby said walls of said housing and chamber are cooled by said dilution air; said wheel is mounted with its axis vertical; said partition means extends in the vertical direction; said combustion chamber is positioned above said wheel; said means for causing air to flow through said one passage comprises a fan positioned in said one passage below said wheel; said outlet means are located substantially adjacent the top of said housing; said inlet means are located in the side walls of said housing substantially adjacent the bottom thereof; said wheel comprises a corrugated metal foil media having flush faces and a low resistance to the axial passage of air therethrough, said fan having its outlet inclined with respect to the axis of said wheel to direct substantially its entire output of air towards the wheel substantially within the confines of the periphery of the wheel; said other passage provides a compartment below said wheel; said means for causing combustion products from said burner to flow through said wheel comprises an exhaust fan mounted in said compartment in communication with said exhaust opening; and said seal means comprises lengths of resilient sheet material supported by said partition means in sliding contact with said flush surfaces of said wheel.

16. A space heater according to claim 1, further comprising means for purging products of combustion from portions of said wheel as said portions pass from said other passage to said one passage.

17. A space heater comprising a housing, a rotary heat exchange wheel mounted for rotation within said housing, partition means within said housing intersecting said wheel and dividing the housing into two passages for conveying gaseous fluid through separate regions of said wheel, inlet and outlet means in said housing communicating with opposite ends of one of said passages, a combustion chamber opening to the other passage on one side of said wheel, said other passage having an exhaust opening on the other side of said wheel, a fuel burner in communication with said chamber at a location spaced from said wheel, means for supplying fuel to said burner, and means for causing air to flow through said one passage and wheel from said inlet means to said outlet means of said one passage and for causing combustion products from said burner to flow through said other passage and said wheel to said exhaust opening of said other passage.

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UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,695,250 Dated October 3, 1972

Inventor(s) Marvin K. Rohrs, Robert J. Neary, Robert B. Rosenberg, Alan Kardas, William R. Staats

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

Title page, line [73] Assignee: "Arco-Flow Dynamics, Inc." corrected to read --Aero-Flow Dynamics, Inc.--

Column 6, line 8, first word "spaced" is deleted.

Signed and sealed this 20th day of February 1973.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents

FORM PO-1050 (10-69)

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