Aug. 25, 1970 R. W. SEABURY, JR 3,525,851

ELECTRIC-CYCLONIC HOT AIR FURNACE

Filed Dec. 28, 1967 3 Sheets-Sheet 1

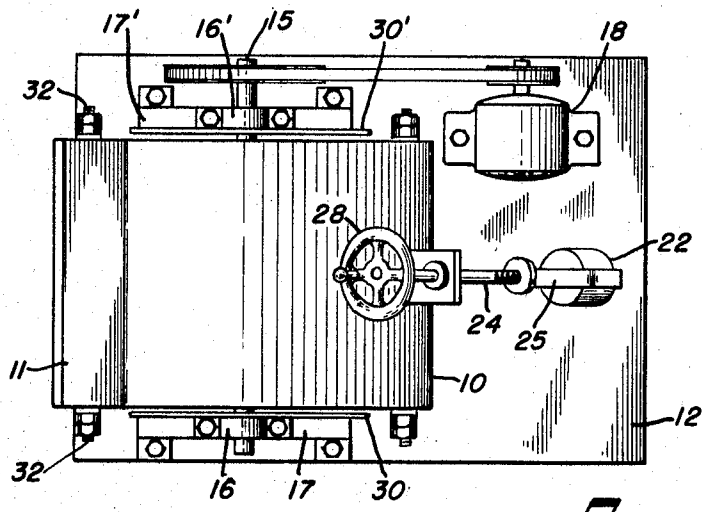


Fig-1

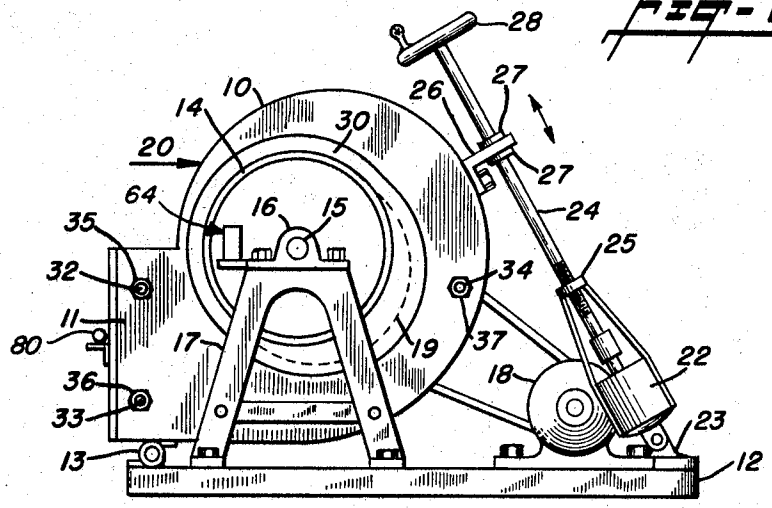


Fig-2

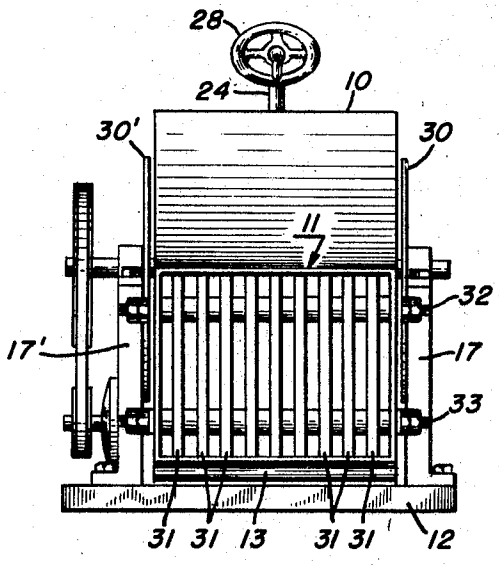


Fig-3

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ELECTRIC-CYCLONIC HOT AIR FURNACE

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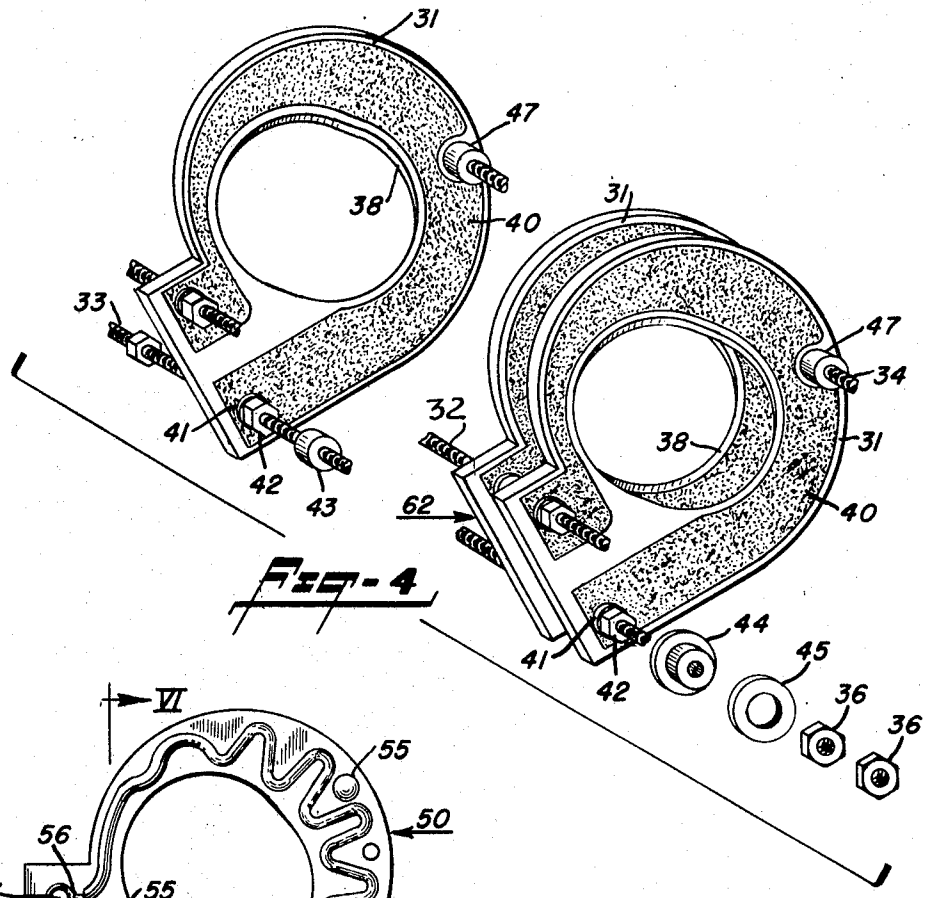


Fig-4

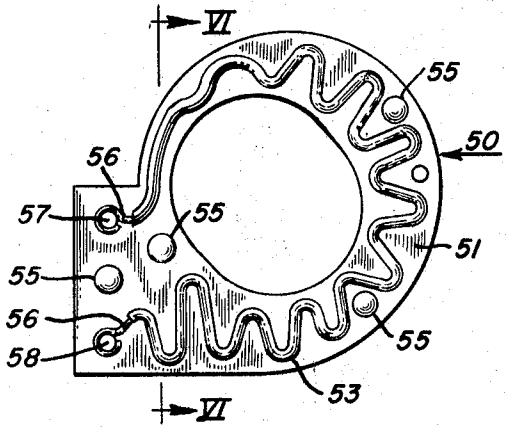


Fig-5

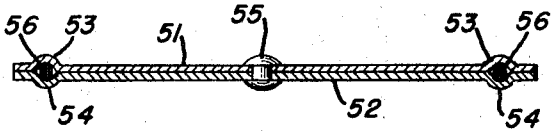


Fig-6

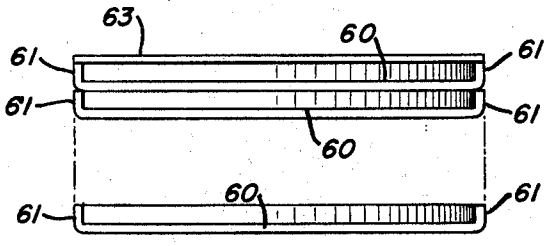


Fig-7

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ELECTRIC-CYCLONIC HOT AIR FURNACE

Filed Dec. 28, 1967 3 Sheets-Sheet 3

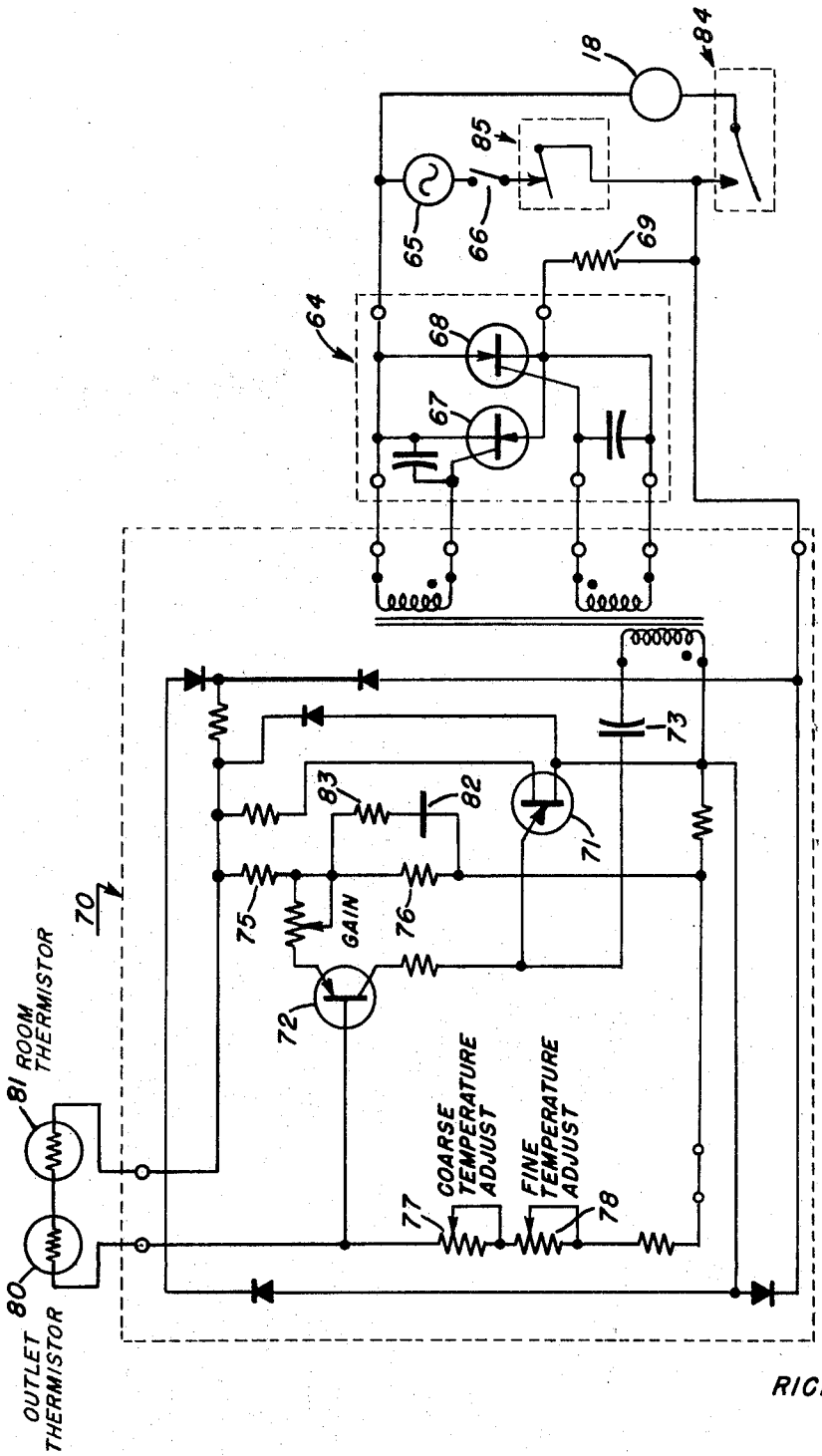


Fig-8

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3,525,851

ELECTRIC-CYCLONIC HOT AIR FURNACE

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Int. Cl. F24h 3/02; H05b 1/02
U.S. Cl. 219—370 9 Claims

ABSTRACT OF THE DISCLOSURE

A stack of spaced heat transfer members is disposed within the annular housing of a centrifugal blower having an elongated axial inlet opening and a tangential outlet opening. The heat transfer members have peripheral contours corresponding to the inside contour of the housing and each member carries electrical resistance elements connectable to a source of voltage. A squirrel cage rotor, aligned with the housing inlet opening, extends through aligned, elongated openings formed in the heat transfer members and the housing is mounted for adjustment relative to the rotor, thereby to control recirculation of the cyclonic air stream in the housing.

BACKGROUND OF THE INVENTION

The invention relates to apparatus for heating and propelling air and more particularly to space heating apparatus of the class comprising a blower arranged to move air over electrical heating elements.

Electrical air heaters of various constructions are available but the prior heaters have relatively low operating efficiency. Consequently, space heating by electricity has been too costly to gain widespread use except in areas of cheap or surplus power or areas having a mild winter climate. Even in industry, where convenience and other advantages can be afforded, electrical space heating is not specified where large amounts of make-up air are required in process uses. The construction and arrangement of prior electrical space heaters is such that there is considerable inefficiency in the transfer of the electrical resistance waste heat to the air stream which is impelled into the space to be heated. In apparatus made in accordance with this invention, the means for heating and impelling the air are combined in a single unit and so arranged that the operating efficiency is significantly higher than in apparatus heretofore available.

An object of this invention is the provision of apparatus for heating air by electrical resistance heat, which apparatus comprises a single unit for heating and impelling the air, thereby resulting in high operating efficiency.

An object of this invention is the provision of electrical space-heating apparatus wherein the heat-generating elements are distributed around the rotor of a centrifugal blower.

An object of this invention is the provision of space heating apparatus, comprising a stack of spaced heat-transfer members disposed within a housing, electrical heat-generating elements carried by each of the members and connectable to a source of voltage, a squirrel cage rotor passing through aligned holes formed in said members and means mounting the housing for adjustment relative to the rotor thereby to control the recirculation of the air stream within the housing.

An object of this invention is the provision of a space heating system comprising a centrifugal type blower having electrical heater elements distributed around the rotor, a heat sensor positioned at the blower outlet and a heat sensor positioned at a remote point and in the space to be heated, and an electrical controller connected between the heat sensors and the heater elements, said controller varying the electrical power supplied to the heater elements in proportion to the sum of the ohmic resistance of the two heat sensors, which sensors have different response characteristics and operating temperature ranges.

The above-stated and other objects and advantages of the invention will become apparent from the following description when taken with the accompanying drawings showing several modifications of the invention. It will be understood, however, that the drawings are for purposes of illustration and are not to be construed as defining the scope or limits of the invention, reference being had for the latter purpose to the claims appended hereto.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings wherein like reference characters denote like parts in the several views;

FIG. 1 is a top plan view of air heating and impelling apparatus made in accordance with this invention;

FIG. 2 is a side elevational view thereof;

FIG. 3 is a front elevational view thereof;

FIG. 4 is a fragmentary, exploded isometric view showing the heat transfer plates carrying electrical heater elements;

FIG. 5 is a side elevational view showing a heat transfer plate made in accordance with another embodiment of the invention;

FIG. 6 is a cross-sectional view taken along the line VI—VI of FIG. 5 and drawn to an enlarged scale;

FIG. 7 is an end view showing a stacked arrangement of heat transfer plates of a different construction; and

FIG. 8 is a circuit diagram of apparatus for controlling the electrical power supplied to the heater elements.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to FIGS. 1–3, there is shown a centrifugal blower having an annular housing **10** terminating in a tangential outlet opening **11** and pivotally supported on a base **12** by an elongated hinge **13**. A conventional, squirrel cage rotor **14** has a shaft **15** rotatable in bearings **16**, **16'** carried by the spaced, A-frame supports **17**, **17'** which are bolted to the base. A drive motor **18**, secured to the base, has its shaft coupled to the rotor shaft by means of pulleys and a belt. In a conventional, centrifugal blower, the rotor, having an axial length substantially equal to the width of the housing, is in alignment with two circular openings formed in the side walls of the annular housing **10**, said openings having a diameter corresponding to that of the rotor. These circular openings constitute the axial inlet of the blower. Upon rotation of the rotor, air is drawn into the housing through these openings and is impelled out of the tangential outlet opening **11**. In accordance with this invention, the two inlet openings are of generally oval shape as shown by the dotted line **19** in FIG. 2, thereby to afford a certain amount of angular displacement of the housing **10** about the axis of the hinge **13** and relative to the fixed position of the rotor. When the housing is in the position shown in FIG. 2, the rotor is disposed close to the short radius wall **20** of the housing, thereby resulting in a minimum recirculation of the cyclonic air stream around the annular housing. When the housing is rotated in a counter-clockwise direction, as viewed in FIG. 2, the rotor is positioned further away from such housing wall, thereby resulting in increased recirculation of the internal air stream.

The angular adjustment of the blower housing, for purposes which will be explained hereinbelow, can be effected manually or automatically. A motor **22** has its housing pivotally connected to a bracket **23**, secured to the base, and its drive shaft connected to a partially-

threaded rod **24**. The threaded, lower portion of the rod passes through a threaded hole formed in the upper end of a generally U-shaped bracket **25** which is secured to the motor housing. The upper portion of this rod passes through an elongated slot formed in an L-shaped bracket **26** which is secured to the annular housing **10**. A pair of bushings **27** are disposed on opposite sides of the bracket **26** and are secured to the rod, as by set screws. It will be apparent that the housing can be displaced, relative to the rotor, either by rotation of the handle **28** or by energizing the motor **22** from a remote point. A pair of flat, oval shaped baffle plates **30**, **30'** are secured in fixed positions to the respective A-frame supports **17**, **17'** and overlie the two oval openings formed in the side walls of the blower housing. Formed in each baffle plate is a circular opening corresponding to the diameter of the rotor. In the drawings, the baffle plates are shown spaced somewhat from the housing side walls for clarity of disclosure. In the apparatus, these plates are in flush engagement with the side walls thereby to effectively close-off those portions of the oval openings which are not in alignment with the rotor, through-out the range of angular adjustment of the blower housing. Disposed within the blower is a stack of spaced heat-transfer members having peripheral contours matching the inside contour of the blower housing, the forward ends of such plates **31** being visible in the front elevational view of FIG. 3. These plates are secured in fixed position by means of three threaded stacking rods **32–34** and nuts **35–37**.

Reference now is made to FIG. 4 showing three of the heat-transfer plates **31**, said plates having formed therein aligned, openings **38**, corresponding in shape and size to the oval openings which are formed in the side walls of the blower housing. These plates may be made of any suitable material which is an electrical insulator, a good heat conductor and capable of withstanding the maximum temperature for which a particular air heater is designed. Preferably, the plates are made of enameler's steel having a vitreous coating fired onto both surfaces thereof. Fired onto the surfaces of these coatings are resistive conductive paths **40** having a predetermined pattern. Specifically, the conductive paths have a maximum cross-sectional area in the region where the peripheral surface of the plate is of the larger radius and a minimum cross-sectional area where such surface is of the smaller radius. Referring to the threaded stacking rod **33** (see also FIG. 3), this rod passes through aligned holes formed in the plates, which holes also extend through enlarged terminal areas of the conducting paths. Each plate is clampingly secured to the rod by means of front and back nuts and flat, metal washers, only the forward washers **41** and nuts **42** being visible in this particular view. Thus, one end of each of the conductive paths is electrically connected to the rod **33**. If desired, an increased spacing of the plates is obtained by metal bushings **43** carried by the rods and positioned between adjacent plates. An insulator bushing **44** and washer **45** are provided for the forward end of the rod, said bushing having a shank which passes through a hole formed in the side wall of the blower housing and said washer being positionable on the protruding portion of the shank, all for the purpose of electrically insulating this end of the rod from the blower housing. A similar insulator bushing and washer is provided for the other end of the rod. The plates are similarly secured to the stacking rod **32** which rod is electrically connected to the other ends of the conductive paths and is provided with insulator bushings and washers as described. These two rods, together with the described metal spacer bushings and fastening nuts, serve to maintain the plates in a stack formation with a desired spacing between the plates, and also as terminals for connecting the parallel-connected conductive paths to a source of voltage. The third rod **34** also passes through aligned holes formed in the plates and carries spacer bushings **47** to maintain the plates in a plane substantially normal to the axis of the rotor. It will be noted that the conductive paths are spaced from these bushings and, therefore, the rod **34** need not be electrically isolated from the blower housing.

Reference now is made to FIGS. 5 and 6 showing a single heat transfer member **50** of a different construction and particularly adapted for use when relatively higher output temperatures are required. Here, the heat transfer member **50** comprises a pair of aluminum plates **51** and **52** having complementary, embossed channels **53** and **54** formed therein and secured together, as by a plurality of rivets **55**. An insulated, resistance alloy wire **56** is disposed within the matching channels and has ends extending through openings formed at the ends of the channel **53**. The insulation is removed from the projecting ends of the wire and the bare ends are formed into loops, generally concentric with the holes **57** and **58**, for electrical connection to the two stacking rods **32** and **33** shown in FIG. 4.

Another construction of the heat transfer members is shown in FIG. 7. Here, each of the plates, identified by numeral **60**, has offset edges forming integral flanges **61**. These plates preferably are made of enameler's steel and the both flat surfaces of each plate have vitreous coatings fired thereon. Fired onto the coatings are conductive paths such as the conductive paths shown in FIG. 4. Also, the plates are provided with aligned oval openings for receiving the rotor and aligned holes for receiving the stacking rods. The flange of each plate extends around the entire periphery thereof except at the straight edge thereof, such edge corresponding to that identified by the numeral **62** in FIG. 4. Thus, when a plurality of such plates are secured together in a stack formation, the plate flanges form an enclosure eliminating the need for a separate annular housing. A flat end plate **63**, also carrying a conductive path on the inner surface thereof may be positioned at the end of the stack for purposes of appearance.

In an electric air heater and impeller constructed and arranged as herein described, the heat transfer surfaces are placed where the air to be heated is the most dense by virtue of its being compressed within the annular housing. This greatly contributes to the heat transfer efficiency. Water vapor can be introduced at the center of the cylindrical rotor to further condition the air for greater heat transfer efficiency. Also, since the heat transfer surfaces are contained within the housing, it can be appreciated that control of air recirculation within the housing, by means of the described variable adjustment of the housing relative to the rotor, provides a wide range of adjustment of the percent output air volume, thereby to effect a greater heat transfer to meet specific conditions, such as changing input air temperature and a variable air volume output to match an increasing gradient heat loss as measured by an outdoor heat sensor.

The construction and configuration of the heat transfer surfaces will vary with the output temperature desired and the heater will vary in size with the volume of air required and the B.t.u. output. One heater made in accordance with this invention has an overall size of approximately 1½ cubic feet, a 90,000 B.t.u. output rating and a 1500 cubic feet per minute volume at 150° F. controlled air. Such unit had a total heat transfer surface of more than 80 square feet. The large heat transfer area of the unit, positioned in the dense air stream, permits operation of the heat-generating elements at a relatively low power level so that the maximum temperatures of these elements is about 180° F. In contrast, systems having small heat transfer areas, such as hot wire grids positioned in an air duct, require the generation of high heat levels, and at such heat levels contaminants in the air stream produce objectionable odors.

A further substantial reduction of the electrical power required by a heater made as herein described is achieved

by controlling the power supplied to the heater elements by a proportional type controller rather than by an on-off thermostat. A conventional proportional control circuit is shown in FIG. 8 to which reference now is made. In this circuit, the numeral **65** identifies a 115 volt, A.C. voltage source to which the circuit is connected upon closure of the line switch **66**. Two silicon controlled rectifiers **67** and **68** are connected as full wave rectifiers between the voltage source and the resistive load **69**, which load represents the parallel-connected electrical heater elements carried by the heat-transfer plates and disposed within the blower housing. These rectifiers operate as phase-controlled switches and are mounted on a suitable heat sink to form a separate unit **64**, which unit preferably is positioned in the air stream entering the centrifugal blower. For example, the heat sink may include a suitable mounting bracket provided with two holes whereby the sink can be secured to the support **17** (FIG. 2) by means of the bearing mounting bolts. The other components of the control circuit, enclosed within the dotted lines **70**, are contained within a suitable housing which can be placed at any convenient location.

The firing of the silicon controlled rectifiers **67** and **68** is controlled by the output pulses of a unijunction transistor **71** connected to a variable gain amplifier comprising the transistor **72** which controls the charging of the capacitor **73**. The transistor **72** has its input electrodes connected across the output diagonals of a four-arm bridge comprising the fixed resistors **75**, **76**, the variable resistors **77**, **78** and two, series-connected thermistors **80** and **81**. The bridge is compensated for ambient temperature changes by a compensating resistor **82** and a fixed resistor **83** connected across the bridge arm **76**. It is here pointed out that the thermistor **80** is mounted at the outlet of the blower, whereas the thermistor **81** is mounted at a remote point in the room being heated.

The thermistors **80** and **81** are selected to provide predetermined changes in ohmic-resistance over temperature ranges of 100–200° F. and 50–80° F., respectively. Generally, the thermistors are selected to allow automatic increase or decrease in the controlled heater output temperature of approximately ±20° F. in opposition to a ±10° F. rise or fall in the room temperature. Under selected temperature conditions, at the two thermistors these thermistors will have a known total resistance, and the bridge resistors **77** and **78** are adjusted to provide a balanced condition of the bridge under these conditions. Upon a decrease in the temperature at the room thermistor **81**, its resistance increases thereby unbalancing the bridge in a direction such that the voltage at the base of the transistor **72** decreases, causing more base and collector current to flow. This charges up the capacitor **73** more quickly and the unijunction transistor **71** will fire the silicon controlled rectifiers earier in each cycle of the A.C. voltage wave, thereby increasing the power supplied to the heater elements. Increasing power is applied to the heater elements until the total resistance of the two thermistors is equal to that at which the bridge was balanced. Thus, the control circuit supplies only the exact amount of electrical power to the heater elements to maintain a given output air temperature and to vary such temperature between a high and low limit in proportion to the amount the room temperature is below the temperature desired, as may be due to variable heat load or variable heat loss. Two safety switches **84** and **85** are mounted on one of the heat transfer plates contained within the blower. The switch **84** is a thermal actuated, normally-open switch which turns on the rotor motor **18** when heat is being supplied to the room, and the switch **85** is a normally-closed, over temperature switch which opens one of the power leads to shut down the entire system if a failure occurs in the temperature sensing circuit or if the rotor fails to rotate.

Having now described the invention, those skilled in this art will be able to make various changes and modifications without thereby departing from the scope and spirit of the invention as set forth in the following claims.

What is claimed is:

1. Air heating an impelling apparatus comprising,

(a) a generally annular housing having an elongated axial inlet opening and a tangential outlet opening,

(b) a stack of spaced heat transfer members disposed within the housing and having formed therein elongated openings aligned with the said inlet opening,

(c) an electrical resistance element carried by each of said members,

(d) means for connecting all of the electrical resistance elements to a voltage source,

(e) an air impelling rotor aligned with said inlet opening and extending through the aligned openings of the heat transfer members, and

(f) means for selectively angularly displacing the housing relative to the rotor in a plane normal to the rotor axis.

2. The invention as recited in claim **1**, wherein the heat transfer members comprise flat plates lying in a plane substantially normal to the rotor axis, said plates being made of an insulating material and having peripheral contours corresponding to the inside contour of said housing, and wherein the resistance elements are conductive paths fired onto the surfaces of each plate.

3. The invention as recited in claim **1**, wherein the heat transfer members comprise metal plates lying in a plane substantially normal to the rotor axis and having peripheral contours corresponding to the inside contour of said housing, said plates having vitreous coatings formed thereon, and wherein the resistance elements are conductive paths fired onto the vitreous coatings.

4. The invention as recited in claim **1**, wherein each of the heat transfer members comprises two plates having peripheral contours corresponding to the inside contour of said housing, said plates having complementary channels formed therein, and wherein the resistance element is an alloy wire disposed in the channels.

5. The invention as recited in claim **1**, wherein the means for connecting the resistance elements to a voltage source comprises a pair of metal rods extending through aligned holes formed in the heat transfer members and the side walls of said housing, and means electrically connecting each rod to a corresponding end of the resistance elements.

6. The invention as recited in claim **1**, in combination with a pair of resistance-type temperature sensors, one positioned at the outlet opening of said housing and the other positioned at a remote point in the space to be heated, and a proportional type controller having its input circuit connected to said temperature sensors and an output circuit connected to the resistance elements, said controller varying the electrical power supplied to the resistance elements in proportion to changes in the resistance of said sensors.

7. An electrical space heating system comprising,

(a) a centrifugal blower having a generally annular housing having an elongated axial inlet opening and a tangential outlet opening, and a squirrel cage rotor axially-aligned with the inlet opening,

(b) a stack of spaced heat transfer members disposed within the housing and having peripheral contours corresponding to the inside contour of the housing, said members lying in a plane normal to the rotor axis and having formed therein elongated openings aligned with said inlet opening and through which the said rotor extends,

(c) electrical resistance elements carried by each of the heat transfer members,

(d) a pair of terminal means connecting all of the resistance elements in parallel,

(e) means for selectively angularly displacing the housing relative to the rotor in a plane normal to the rotor axis,

(f) a first thermistor disposed at the said outlet opening and connected in series with a second thermistor positioned in the space to be heated,

(g) a proportional type electrical control circuit connected between the said thermistors and the said terminal means, said circuit supplying electrical power to the resistance elements in proportion to changes in the resistance of the thermistors,

(h) a drive motor coupled to the rotor, and

(i) means energizing said motor when power is being supplied to said resistance elements.

8. The invention as recited in claim 7, wherein the said control circuit includes power rectifiers operated as phase-controlled switches and connected to the said terminal means, said rectifiers being mounted on a heat sink positioned at the said inlet opening.

9. The invention as recited in claim 7, wherein the heat transfer members comprise metal plates having a vitreous coating formed on both surfaces thereof, wherein the said resistance elements are conductive paths fired onto the coatings, each such path terminating in ends at the said outlet opening, and wherein the said terminal means comprises a pair of spaced rods passing through

aligned openings formed in the heat transfer members and the housing, each rod being electrically connected to corresponding ends of the conductive paths.

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U.S. Cl. X.R.

165—122; 219—501, 364, 543, 376, 365; 338—319