Nov. 28, 1961 P. D. OWEN 3,010,449
HEATER COMBINATION
Filed July 15, 1955 2 Sheets-Sheet 1

FIG. 1

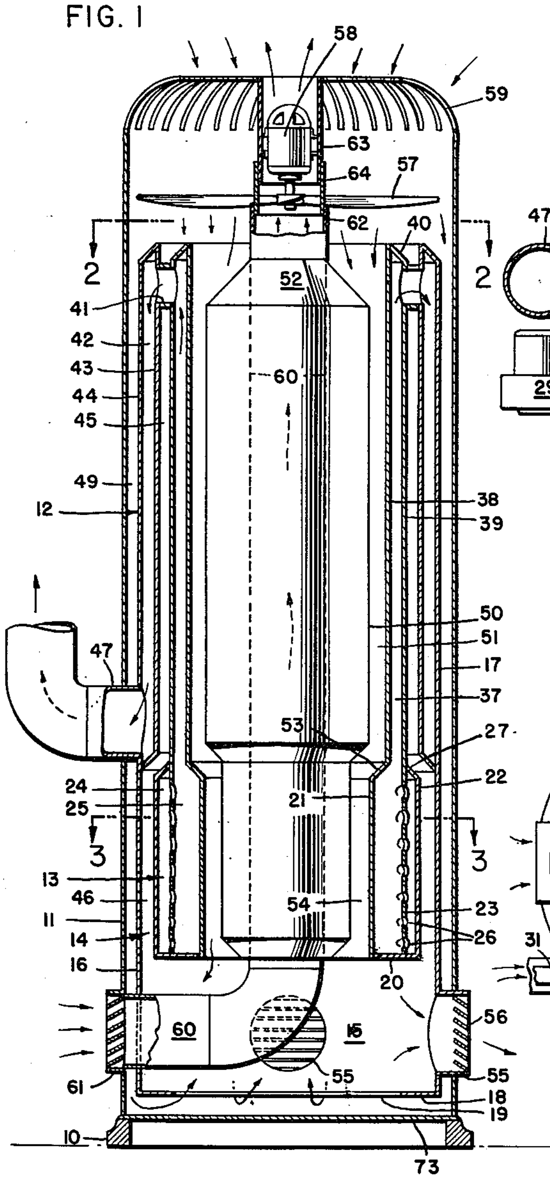


FIG. 2

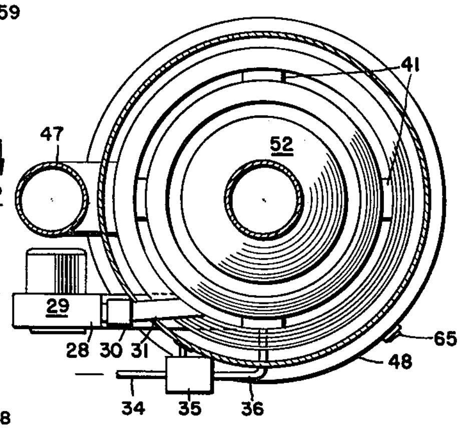


FIG. 3

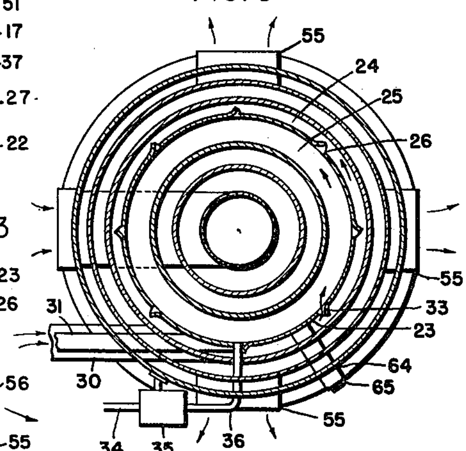


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FIG. 4

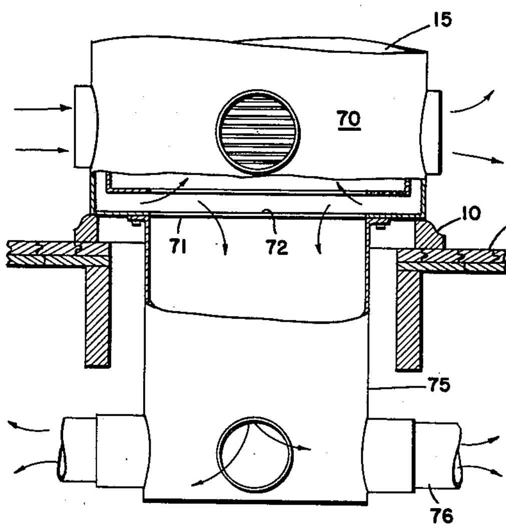



FIG. 5

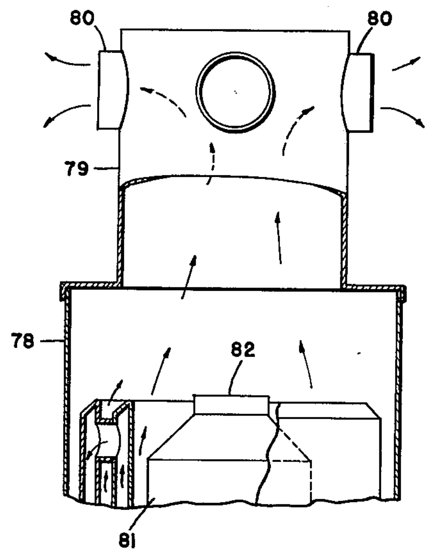
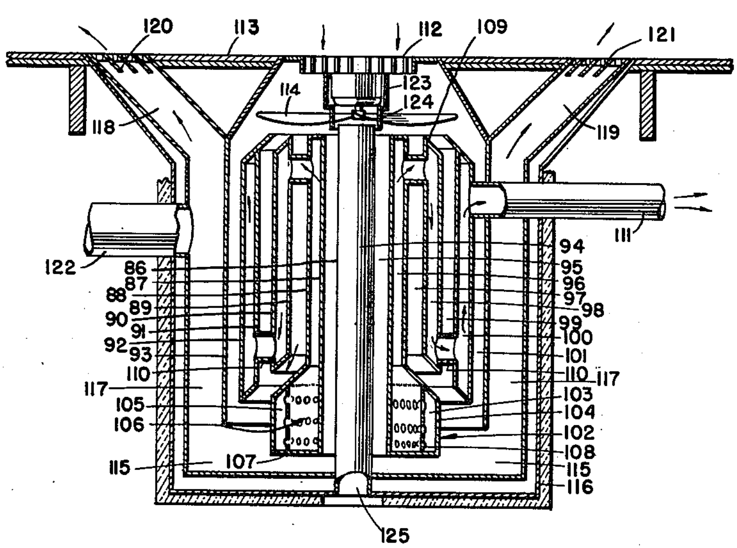



FIG. 6

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3,010,449

HEATER COMBINATION

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4 Claims. (Cl. 126—110)

The present invention pertains to combustion and heat transfer apparatus in the form of a heating unit and relates more particularly to a heating unit suitable for heating a fluid medium, such as air either to heat an individual room or for heating a fluid medium which may be conducted to remotely located rooms.

Conventional unit space heaters for heating individual rooms or small homes are usually direct-fired units that burn oil or other gaseous fuels in a pot-type combustion chamber or burner that is usually positioned at the base of the heater. During the combustion process the products of combustion usually rise in a stack-like cylindrical enclosure from the burning or combustion zone to heat a suitable heat transfer or thermally conductive surface forming the cylindrical enclosure of the unit so that by normal convection currents the surrounding air mass may be heated. More recently, however, several types of unit heaters have been employed which incorporate fans, either of the forced or induced draft type that are located to increase the rate of air flow over the heat transfer surfaces of a heater in order to circulate the warm air more positively through the room that is to be heated. In this manner of circulating the warm air currents, air stratification at the various room levels is appreciably reduced by setting up warm air currents throughout a room.

One of the primary objectives sought in the presently designed unit is to force a sufficient volume of air to "wipe" the heat transfer surfaces of the heater so that the resultant temperature of the air masses that are heated by coming in contact with the cylindrical shells of the heater are throughly mixed; thus the heated air discharged from the heater will not exceed approximately 175° F. Temperatures much in excess of this will usually be objectionable when forced directly into a small area and will certainly be destructive of floors, walls, and particularly tar-base floor coverings. Direct air currents heated to approximately 110–140° F. are extremely objectionable to individuals receiving a direct blast of the heated air. However, unless the heat transfer surfaces are increased appreciably in order to expose greater surface areas to heat the air flowing adjacent to the heat transfer surfaces the exit flue gases constituting the end products of combustion will leave the heater at a temperature far in excess of 450° F. During the combustion process with the correct proportion of excess air for complete combustion of the fuel being consumed, normally a 20° F. difference in exit gas temperature will result in a difference of approximately 1% change in over-all heater efficiency. To achieve greater overall efficiency by reducing the exit gas temperatures when using the conventional stack-type heating chambers requires unreasonably increased heat transfer surface areas. Some attempts have been made to increase the effective heat transfer surface areas in various aircraft heat exchangers by utilizing coiled tubes, spirally wound shells, and concentric shells. However, in each of the known applications utilizing an increased heat transfer surface there has been little, if any, progress made toward providing a combination of an increased heat transfer surface heat exchanger with a more efficient and effective means for burning the fuel during the combustion period.

It is, therefore, one of the primary objectives of the present invention to provide a compact space heater consuming liquid fuels with a maximum heat transfer surface area to effectively enclose an annular combustion burner in which fuel and combustion air may be supplied under pressure to produce circulatory flow of the products of combustion in the burner which will continue through at least part of a heat exchanger.

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Another object of the present invention is to provide a space heater in which there is a plurality of radially spaced cylindrical, tubular combustion-products chambers communicating with each other and spaced to provide longitudinal air passageways between the chambers and an annular combustion burner communicating directly with one of the cylindrical tubular chambers which will distribute the flow of the products of combustion to succeeding chambers, and a means for forcing an air mass to flow substantially longitudinally adjacent to the cylindrical flue gas chambers.

Yet another object of the present invention is the provision of a heater unit in which an annular combustion chamber may be supplied with combustion air to produce cyclonic turbulence in the combustion chamber so that the products of combustion may be conducted directly, with continuous circulatory movement from the annular combustion chamber to a cylindrical shell heat exchanger having a plurality of enclosed cylindrical chambers spaced radially from each other which chambers are surrounded by air that may be subjected to a draft to produce longitudinal air flow adjacent to the cylindrical heat transfer surfaces.

Yet another object of the present invention is the provision of an annular burner having means for introducing primary and secondary combustion air to produce circulatory flow of the air and products of combustion in the burner which will result in more complete fuel combustion and produce a swirling, scrubbing action of the combustion products that will flow directly into and longitudinally between radially spaced cylindrical heat transfer surfaces in a heat exchanger.

Still another object of the present invention is to provide a heating unit that may be readily accommodated for use as a low cost, highly efficient central source heating unit by providing a suitable plenum chamber and ducts for collecting warm air which will flow longitudinally along radially spaced substantially concentric heat transfer surfaces which surfaces are heated by the longitudinal and circulatory flow of flue gases in a heat exchanger.

A still further object of the present invention is the provision of a low cost, highly efficient heating unit having an annular combustion chamber and means for injecting primary and secondary combustion air into the combustion chamber to produce circulatory or cyclonic flow therein which flow will then carry the products of combustion, with some circulatory flow, directly into the inlet side of a series of radially spaced cylindrical chambers formed by radially spaced thermally-conductive shells, the respective chambers being sufficiently spaced from each other to provide for a longitudinal flow of air between chambers, preferably a forced flow, adjacent to thermally conductive shells of the cylindrical chambers.

A further object of the present invention is to provide a heating unit in which the process of combustion and flame propagation is sustained by injecting combustion air, primary and secondary, into an annular combustion chamber, to generate circulatory movement of the flue gases which may continue to flow with circulatory and longitudinal flow through a heat exchanger having spaced cylindrical chambers between which air may flow to be heated, and the air being heated may flow adjacent to the combustion chamber to preheat combustion air and fuel for combustion.

Further objects of the present invention are to provide a heating unit that is simple to manufacture, requires a minimum of maintenance during operation, and one that may be installed in a single room or used for a central heating system.

Other and further objects and many attendant advantages of this annular burner and heat exchanger combination will become more readily apparent as the invention becomes better understood from the following detailed description in connection with the accompanying drawings in which like characters of reference designate corresponding parts throughout the several views and wherein:

FIG. 1 is a vertical elevational view of a preferred embodiment of the present invention with a longitudinal section removed to illustrate the relationship of the combustion chamber to the spaced cylindrical shells;

FIG. 2 is a transverse sectional view taken substantially along the plane of line 2—2 of FIG. 1 and including a combustion air supply means and a fuel supply means;

FIG. 3 is a transverse sectional view taken substantially along the plane of line 3—3 of FIG. 1 including a combustion air duct and a fuel supply means;

FIG. 4 is a modified embodiment of FIG. 1 illustrating the present invention which may be used as a central heating unit by the addition of an auxiliary plenum chamber mounted to the base of the heater and including warm air ducts connected to the plenum chamber;

FIG. 5 is a further modified application of the present invention when employed as a central heating unit by mounting an auixiliary plenum chamber as a hood onto the top of the heater with take-off ducts leading from the plenum chamber;

FIG. 6 is a longitudinal sectional view of a further modification of the present invention for use as a floor supported heating unit having a take-off leading from the heating unit.

Referring more particularly to the drawings there is shown in FIGS. 1 through 3 a heating unit which, in the form illustrated, may be used as a space heater for heating a small home or with some modifications, as is illustrated in FIGS. 4 and 5, may be employed as a central heating supply source from which heating unit supply ducts may conduct warm air to remote locations in a home. Broadly considered the present invention embodies an annular combustion chamber for receiving a liquid fuel at the base of the burner and a plurality of upright, concentric cylindrical shells that are spaced radially to form a first chamber into which primary and secondary combustion air may be supplied under pressure to produce cyclonic or circulatory air flow within a first chamber. The circulatory air flow will continue upon passing into a second chamber of the combustion chamber that houses the burner base for receiving the fuel for burning, the second chamber being spaced radially from and adjacent to the first chamber. The products of combustion from the combustion chamber flow directly into a heat exchanger comprising a number of right cylindrical shells that are spaced radially from each other to form a plurality of individual interconnected flue gas receiving chambers that are alternately spaced to provide intermediate air passageways in each of which passageways air may flow positively in parallel-flow, counter-flow or both parallel-flow and counter-flow with relation to the flow of the flue gases in the heat exchanger chambers. Air heated in the heat exchanger will commingle in a plenum chamber before distribution. The space heating unit illustrated in FIGS. 1 through 3 is mounted upright on a base **10** on which the outer cylinder heater casing **11** is positioned to enclose the main heat exchanger **12**, the combustion burner **13**, and the preheater **14** which constitutes a secondary heat exchanger.

The combustion burner or chamber **13** is spaced vertically above the base of the heating unit to provide for a warm air plenum chamber **15** that is positioned at the base of the unit. Plenum chamber **15** is formed by the lower section **16** of the cylindrical shell **17**, the baffle ring **18** mounted to the bottom of the shell **17**, and the lower portion of the burner **13**. The ring **18** has an opening **19** through which warm air may be admitted into the plenum chamber for commingling with other heated air to be discharged from the heater and to be described hereinafter.

Each of the shells constituting the combustion chamber section of the heater may be spaced radially so as to be substantially concentric to each other. The ring **20** provides a base for the annular burner trough formed by the inner cylindrical burner shell **21**, the outer shell **22** and the intermediate baffle shell **23**. Thus the spaced cylindrical shells form an outer chamber **24** into which the air for combustion, primary and secondary, may be introduced by suitable means, and an inner combustion zone **25** in which a fuel may flow or be injected by any conventional gravity feed system or controlled forced fuel system. The requisite supply of combustion air will be admitted into the combustion zone **25** through openings **26** in the wall of the baffle shell **23**. Openings **26** may be relatively small at the base of the shell **23** and gradually increase toward the top of the shell to provide for additional air above the initial flame. The top of the outer air chamber **24** is preferably encased, such as by a plate **27**, to preclude air infiltration or leakage, as the case may be, depending upon whether an induced or forced air system is employed for the combustion air supply.

In a preferred form of the invention the discharge end **28** of a motorized centrifugal forced draft fan **29** is mounted to the inlet side of the air supply duct **30** to supply the requisite primary combustion air under pressure to the fuel. The volume of primary air may be controlled by conventional adjustable baffles or an inlet orifice (not shown) that may be mounted either in the duct or the inlet of the fan. The air supply duct may be tapped to provide a branch duct **31** for supplying secondary combustion air preferably to enter the combustion chamber vertically above the primary air supply duct. Although a secondary air supply duct may be provided the gradually increasing openings in the shell **23** have provided a suitable supply of over fire air sufficient for complete combustion.

Combustion air supply duct **30** is tangentially secured to the outer shell **22** in order to cause cyclonic or circulatory air flow as the combustion air is introduced into the air chamber **24**. It is preferable that the opening **26** in the shell **23** be tangential or be made to extend tangentially through the shell **23** so as to provide a plurality of circumferential vanes or blades **33** adjacent to the opening **26** to produce a circulatory movement of the combustion air that flows into the air chamber. This circulatory air flow may be carried forth into the inner combustion zone **25** with but little diminution through the openings provided in the baffle shell. It will be readily apparent to those skilled in this art that the inlet air duct **30** may project radially into the chamber **24** and by insertion of suitable baffles or vanes, advantageously positioned, the incoming combustion air may be diverted to impart circulatory air movement within the chamber **24** which circulatory flow will carry over into the combustion zone **25**. Although the intermediate baffle shell **23** is quite desirable, combustion has been found to be satisfactory with this shell removed completely, provided, however, circulatory air flow will continue with a substantially uniform magnitude in the annular chamber.

Since kerosene or other similar combustible hydrocarbons, usually designated as No. 1 or No. 2 fuel oil, are normally consumed in the conventional space heaters, the use of these fuels is intended for illustrative purposes only and not for limitations since gaseous fuels may be used with very satisfactory results. Oil that may be stored in a remotely located reservoir or in a tank mounted to the heater may be supplied to the combustion chamber through the feed line **34** which conducts the oil flow to a fluid flow control means **35**, either in the nature of a fuel pump or float type carburetor, depending upon whether the system is a forced feed or gravity flow system. The requisite fuel oil supply will flow from the flow control means **35** into the fuel line **36**. The line **36** will conduct oil from the fluid flow control means **35** and introduce the oil into the trough at the base of the combustion chamber **25**. Obviously, where it is desirable in some applications an oil dispersion or an atomizing means may be used in the end of the inlet line to divide the flow of oil. This will be particularly applicable to a forced feed system. However, very satisfactory combustion rates and fuel consumption have been obtained by utilizing a pool of oil that is retained in the bottom of the burner. During the combustion process air under circulatory flow will be supplied to the combustion zone **25** furnishing the requisite primary and secondary air supply and the products of combustion constituting the flue gases will leave the inner chamber **25** vertically having a circulatory and helical flow. The combustion products will flow directly into the first hollow cylindrical chamber **37** of the heat exchanger **12**. The first cylindrical chamber **37** is formed by the vertically reaching inner cylindrical shell **38** and the outer shell **39** concentric with the inner shell **38** and radially spaced therefrom to provide a suitable cross-sectional flow area that will not appreciably impede the flow of gases or increase the frictional drop or draft loss in the heat exchanger with the normal mass flow of flue gases at the corresponding combustion temperatures and flow rate. The top end of the chamber is sealed by the ring **40** which will tend to divert the flow of flue gases through the interconnecting flue gas ducts **41** that are circumferentially spaced about the top periphery of the chamber **37** to communicate with the next succeeding flue gas receiving chamber **42**.

Chamber **42**, formed substantially similar to chamber **37**, is provided with an inner cylindrical shell **43** and a concentric radially spaced outer cylindrical shell **44**. Flue gas receiving chambers **37** and **42** are radially spaced from each other to form a cylindrical air passageway **45** therebetween that extends longitudinally adjacent to the flue gas chambers **37** and **42**. Thus air passing between the chambers **37** and **42** will contact the heat transfer surfaces of the inner shell **43** of chamber **42** and the outer shell of chamber **37**. By providing an offset at the bottom of the heat exchanger in the embodiment illustrated in FIG. 1, the air mass flowing in the passageway **45** may be deflected so as to pass between the outer shell **22** of the combustion chamber and the lower section **16** of the cylindrical shell **17**. This lower section surrounding the combustion chamber constitutes a secondary heat exchanger which will be referred to as a pre-heater **46** for heating the combustion air and the fuel in the combustion chamber.

Air passing downwardly through the passageway **45** will be subjected on one side, against shell **39**, to the counterflow of the mass of flue gases within the chamber **37** and to parallel-flow, against shell **43**, of flue gases from within chamber **42**. This mass of air passing in the air passageway **45** will be heated and will pass into the preheater section **46** where it will preheat the oil in the base of the burner as well as heat the air for combustion within the air chamber **24**.

The products of combustion may be exhausted at the base or the bottom of the chamber **42** through the exhaust flue gas line **47**. Suitable baffles and dampers as well as stack temperature control and draft regulating devices (not shown) may be installed in the flue gas exhaust line **47** to regulate the effective draft and to correlate it to the burning rate of the fuel.

The cylindrical cabinet enclosure **11** envelopes the heat exchanger **12** and the combustion chamber **13** and forms an outer air passageway **49** between the enclosure **11** and the outer shell **44** which passageway will extend for substantially the length of the heater. Air passing downwardly in this passageway **49** will have a parallel-flow heat transfer rate with the flue gases within the chamber **42**. Air heated in passageway **49** will flow into the base of the heater and through opening **19** in the ring **18** to enter the plenum chamber **15**.

A central cylindrical air deflector **50** extends axially for substantially the length of the heat exchanger and the combustion chamber. The diameters of the upper and lower portions of the air deflector **50** are sufficiently less than the inside diameters of the heat transfer shell **38** and the combustion chamber shell **21**, respectively, to provide an additional passageway **51** for heating air as an air mass is displaced downwardly through this passageway. Air in passageway **51** will have a counter-flow heat transfer coefficient with the gases within chamber **37**. The top of the deflector **50** may be provided with a frustoconical baffle **52** in order to distribute the flow of air introduced into the passageway **51**.

As the air continues downwardly through the passageway **51** it will be deflected by the converging section **53** of the combustion chamber and then will enter the passageway **54** on the side adjacent to the burner wall **21**. Air leaving passageway **54** will enter the plenum chamber **15** wherein it will be mixed with other warm air that flows into the plenum chamber from passageways **45** and **49**. Finally, the resulting warm air mass within the plenum chamber **50** will be distributed to the surrounding area through the circumferentially spaced radially extending warm air outlets **55**. Each outlet may be provided with adjustable dampers or vanes **56** which may be regulated to distribute the warm air to the desired room level.

Longitudinal air flow in the passageways **45**, **49**, and **51** may be produced by means of a forced draft propeller type fan **57** that is driven by an electric motor **58** which is supportingly suspended from the open grating-type heater hood **59**. By subjecting the air surrounding the hood to a reduced pressure the fan will induce the flow of relatively cool air at the top of the heater and force the mass of air to flow into the various passageways **45**, **59**, and **51** in the heat exchanger. Although a propeller type fan is illustrated in FIG. 1 to produce the flow of air through the heater, it will be readily apparent that for some installations a centrifugal fan having a suitable designed outlet scroll may be used with equal effectiveness.

To protect the motor, the motor windings, and the motor winding insulation from excessive heat particularly when the heating unit is in operation and the fan is not operating, a central duct **60** is positioned longitudinally through the heater within the central deflector **50**. Duct **60** is provided with inlet **61** at the base of the heater to admit air and an outlet **62** at the top of the heater that is directly in line with the fan motor to discharge or vent the duct. There is sufficient stack height in the central duct **60** to induce a flow of air from the floor level through the duct **60** in order to cool the fan motor appreciably whenever the fan ceases to rotate. The motor **58** may be suspended in the motor casing **63** which is supported from the heater hood **59**. A sleeve **64** is attached to rotate with the propeller fan and will conduct the flow of air between the top portion **62** of the duct **60** directly through to the casing **63**.

A light off port **64** is provided in the base of the combustion chamber that is normally sealed by a removable cap **65** through which port the fuel in the base of the burner may be ignited. For some installations in which automatic ignition is desired conventional electrodes and the transformer-type ignition units may be provided. The present unit lends itself to automatic controls for lighting as well as the conventional safety devices normally mounted on more costly central heating installations.

It is contemplated that in place of mounting a forced draft fan in the heater dome to force the air downwardly through the heater for heat transference with the heat surfaces, an induced draft fan may be installed in the base of the heater to induce air to flow longitudinally through the air passageways. Furthermore an induced draft fan may be mounted in the hood to induce the flow of air upwardly, however, with this modification the heat transfer flow coefficients will be modified somewhat by being changed from parallel-flow to counter-flow and from counter-flow to parallel-flow.

In FIG. 4 there is depicted the lower section **70** of a modified form of the present heating unit that is illustrated in FIG. 1, however, the base of the heater is provided with an opening **71** within the base plate **72** which opening is not provided in the plate **73** of FIG. 1. This change will be incorporated in those heating units that are to be employed as a central heating unit so that the warm air may be distributed from the plenum chamber **15** into an auxiliary plenum chamber at the base of the unit.

A portion of the floor **74** beneath the base **10** of the heater may be removed to accommodate the extended casing **75** which will be fastened to the base plate **72** to form the auxiliary plenum chamber. Air subjected to the positive pressure of the forced draft fan that is located at the top of the heating unit will cause the flow of air passing through the heat exchanger to be heated and will collect the air in the plenum chamber **15**. Flow of the warm air will then continue into the auxiliary plenum chamber **75** from which a number of lead-off ducts **76** may be distribute the warm air to the desired areas which are remotely located from the heater.

For those central heating installations in which the heating unit must be installed upright on a base or concrete surface, the dome **78** of the heater may be provided with a casing **79** which forms a top auxiliary plenum chamber and is substantially similar to that illustrated in FIG. 4. As shown in FIG. 5, air may be forced upwardly by means of a forced draft fan (not shown) and then the warm air may be distributed from the auxiliary plenum chamber through the ducts **80** to remote areas from the heater. In this particular application the opening in the central deflector **81** may be sealed by the plate **82** since cooling air for a hood-mounted fan is not required.

To provide the requisite need for increased overall efficiency in the commonly referred to "floor furnaces" the heating unit illustrated in FIG. 6 shows an application of the basic structure of the present inventive concept to a heating unit that may be installed beneath the floor of a room so that warm air may be supplied to the room in which the heating unit is installed as well as to remote locations.

The heat exchanger **85** of FIG. 6 is provided with concentric shells **86** through **93**, inclusive, that radially spaced to form flue gas receiving chambers **96**, **98**, and **100** and air passageways **94**, **95**, **97**, **99**, and **101**. The combustion chamber **102** is located at the lower extremity of the heat exchanger and comprises the air chamber **103**, formed by the outer shell **104** and the intermediate baffle shell **105**, and the combustion zone **106**, formed by the intermediate baffle shell **105** and the lower section of the shell **87**, and the base ring **107** of the burner on which liquid fuel may be retained within the combustion chamber.

As in FIGS. 1 through 3 the intermediate baffle shell **105** may be provided with openings **108** through which combustion air may enter into the combustion zone **106**. The requisite forced draft fan for supplying combustion air (not shown) and the fuel flow control means (not shown) in this modification may be substantially similar to that of the previously described embodiment. The same principle of combustion applicable to the above described unit applies to this unit in that the air for combustion is to be supplied tangentially or is made to flow with circulatory movement in the burning zone and the heat exchanger. The products of combustion will flow directly from the combustion zone into the chamber **96**, from chamber **96** through the interconnecting ducts **109** into the chamber **98** and then downwardly to the interconnecting ducts **110**, and then upwardly through chamber **100** to the flue gas exhaust line **111**.

The grille lattice **112** suitably supported at the level of the floor **113** will permit room air that is relatively warm to flow therethrough so that the motorized fan **114** may displace this air mass longitudinally through the air passageways **95**, **97**, **99**, and **101**. Suitable air deflectors are incorporated in the heat exchanger section of the heater as well as in the surrounding casing to provide for unidirectional flow of air through the heater. The heated air masses passing through the various air passageways will be forced to commingle within the lower chamber **115** of the heater before distribution. The chamber **115** of the heater is formed by the heater casing which surrounds the heat exchanger. The casing **116** may be insulated with a suitable material in order to prevent undue heat losses from the floor installed heating unit.

The floor furnace operates so that heated air will be forced to rise through the warm air chamber **117** to flow into the ducts **118**, **119** which lead to the floor registers **120** and **121** that are provided with suitable dampers in order to control the flow of warm air. The registers are installed beneath the floor and are protected by a suitable floor grille. To conduct warm air to other room locations it is merely necessary to provide a warm air duct **122** that may be tapped to receive warm air from the air chamber **117**.

The central tubular shell **86** together with the motor guard **123** that is mounted to the grille **112** and the sleeve **124** protect the motor from excessive heat by permitting air to rise through the inlet **126**, as by an induced draft, in order to cool the motor, as previously described for the first embodiment.

In each of the embodiments illustrated the flue gases within the flue gas chambers are subjected to a positive pressure generated by the forced air fan which supplies the air for combustion and in each case a swirling circulatory movement of the flue gases that is initially imparted in the combustion air chamber provides a wiping or scrubbing action on the interior of the flue gas retaining shells. This action tends to reduce the accumulation of soot or carbon on the heat transfer surfaces maintaining a uniform and constant heat transfer rate. When desirable auger baffles or deflectors (not shown) may be introduced into at least one of the flue gas chambers in order to cause a continuous helical flow of the flue gases. Similarly an auger baffle may be installed in an air passageway to produce helical air flow.

In operation the forced air fan for supplying combustion air may produce a sufficient positive pressure in the flue gas chambers to force the flue gases through the various chambers. However, in the majority of the installations some stack draft will provide for flue gas exhaust through the stack.

Although the heating units above described are particularly suitable for heating air, it is within the scope of this invention that with minor structural modifications to the heater shown in FIG. 1 the structure of this unit may be utilized to make a water heater or a forced hot water heating unit for a forced hot water circulatory system. This structural modification to the heating unit may be made by enclosing the warm air passageways so as to be water tight. The central deflector **50**, the plenum chamber **15**, as well as the fan and additional accessories may be eliminated so as to provide for increased water storage volume throughout the entire unit. Of course, should the general design of the heater be modified for employment as a water heating unit the overall length of the flue gas chambers within the heat exchanger may be increased and the hood of the unit will be enclosed to provide a rather large volume water dome.

The usually high overall efficiency and heat transfer rates obtained in a heater of this type may best be explained by the combustion process that takes place within the combustion zone and the flue gas receiving chambers. For perfect combustion the requisite amount of oxygen must be supplied for union with all of the oxidizable constituents of the fuel and utilizing during the combustion process all of the oxygen so supplied. Providing a long circuitous path for the travel of the products of combustion in the heat exchanger permits the oxygen and the oxidizable products in the fuel to combine at the requisite high temperatures that are conducive to perfect combustion. However to have complete combustion, which requires the oxidization of all the combustible constituents of the fuel, does not necessarily require the utilization of all of the oxygen supplied. Although combustion may be complete it may not be perfect and the more nearly complete combustion can be made to approach perfect combustion, the less will be the losses encountered due to combustion. The real measure then for the efficiency of combustion is to be found in the relations existing between the amount of air theoretically required for the burning of any fuel and the amount of air actually supplied for combustion.

By providing a maximum heat transfer surface area in the form of cylindrical shells through which shells the products of combustion may flow with circulatory movement there is sufficient time to permit more complete combustion at the requisite high temperatures in the first flue gas chamber. The proper proportioning of the heat transfer surface enables the air flowing past the heat transfer surfaces to be sufficiently heated to cool the exiting flue gases at maximum combustion rates to very low exit gas temperature without causing condensation in the heat exchanger.

Obviously many modifications and variations may be made in the construction and arrangement of the combustion chamber and the heat exchanger in the light of the above teachings without departing from the real spirit and purpose of this invention. It is therefore to be understood that within the scope of the appended claims many modified forms of structure as well as the use of mechanical equivalents may be reasonably included and modifications are contemplated.

What is claimed is:

1. A space heater comprising a combustion chamber having an inner, an intermediate, and an outer shell, each of said shells being concentrically supported about a common axis, and spaced radially from each other to form an air chamber between the intermediate and outer shells, and a combustion zone between the intermediate and inner shells, said intermediate shell being provided with rows of openings which extend therearound and also vertically to pass combustion air from the air chamber into the combustion zone, means for supplying air to the air chamber under pressure, said air supply means being positioned to produce circulatory air flow in the air chamber of sufficient magnitude to carry-over the circulatory flow into the combustion zone, means for supplying fuel to the combustion zone, a primary heat exchanger mounted above the combustion chamber and including concentric cylindrical shells spaced radially to form a flue gas passageway therebetween, the axis of the heat exchanger shells coinciding with the axis of the chamber shells, said flue gas passageway communicating directly with the combustion zone to receive flue gases therefrom, a heater housing enclosing the combustion chamber and the heat exchanger, said housing forming an annular air passageway between the housing and a heat exchanger shell, said combustion chamber and heat exchanger being supported in the housing vertically above the base of the housing to provide a warm air receiving plenum chamber below the combustion chamber, a secondary heat exchanger being formed around the combustion chamber to preheat the air for combustion as air flows downwardly from said primary heat exchanger, means for causing air to flow through the primary and secondary heat exchangers into the plenum chamber whereupon the air will be commingled and distributed from the plenum chamber.

2. The combination set forth in claim 1, in which all of said cylindrical shells are mounted about a common axis to provide a tubular core, a central deflector in said tubular core to form an annular air passageway within the outer periphery of the core forcing air flowing in the passageway to wipe the inner surface of the heat exchanger shell and the inner cylindrical shell surface of the combustion chamber before reaching the plenum chamber.

3. A space heater comprising an outer cylindrical heater housing, an outer shell, an intermediate shell, and an inner shell concentrically supported and radially spaced from each other to form an air chamber between the outer and intermediate shells and a combustion zone between the inner and intermediate shells, and a tubular passageway concentric with the inner shell, said chamber being provided with a top outlet for the combustion zone and a base enclosure for the air chamber and combustion zone, a plenum chamber beneath the combustion chamber and enclosed by the heater housing, means for supplying combustion air to the air chamber to produce circulatory air flow therein, said intermediate shell having openings therein and deflector means associated with said openings to divert air from the air chamber into the openings to admit air into the combustion zone, means for supplying fuel to the combustion zone, a heat exchanger for receiving the products of combustion from the outlet of the combustion zone, said heat exchanger including a plurality of spaced cylindrical shells to form alternately flue gas receiving chambers and air passageways, said tubular passageway extending upwardly through the heat exchanger, one of said flue gas chambers receiving the products of combustion directly from the combustion zone, said flue gas chambers being interconnected to each other, said air passageways extending longitudinally and communicating with the plenum chamber, a flue gas exhaust line for removing flue gases from the flue gas chambers, means for producing a continuous flow of air through the air passageways, said air flow means being mounted at the top of said heater and including a fan and a motor to rotate said fan, said tubular passageway extending longitudinally through the heat exchanger and the combustion zone inner shell to permit the free flow of cooling air to surround the fan motor, and said plenum chamber having outlets to distribute air heated in the heat exchanger.

4. The combination set forth in claim 3, in which said plenum chamber is provided with an interconnecting secondary plenum chamber, said secondary plenum chamber having outlets to receive warm air ducts to distribute air heated in the heater to remote locations.

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