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 Chicago, Ill.
 Continuation-in-part of application Ser. No. **741,738, July 1, 1968, now Patent No. 3,523,004.**

[50] Field of Search..... 431/115,
 116, 300; 126/116

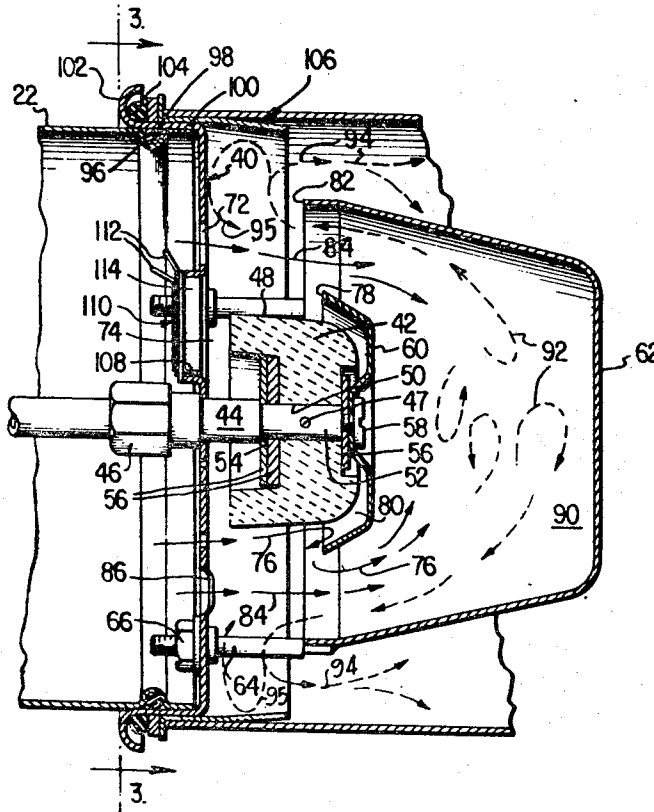
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[54] **RECIRCULATING FUEL BURNER**
 14 Claims, 6 Drawing Figs.

[52] U.S. Cl..... 431/116,
 431/300
 [51] Int. Cl..... F231 1/00,
 F231 7/00

ABSTRACT: The use of paired, concentric, axially spaced and nested coaxial cup-shaped members downstream of an apertured plate carrying a porous conical fuel wick to promote recirculation of the forced combustion air within the combustion chamber. Additionally, a spiral-type igniter is used in a position recessed from the combustion chamber and to which a short wicking material is extended for initiating combustion.



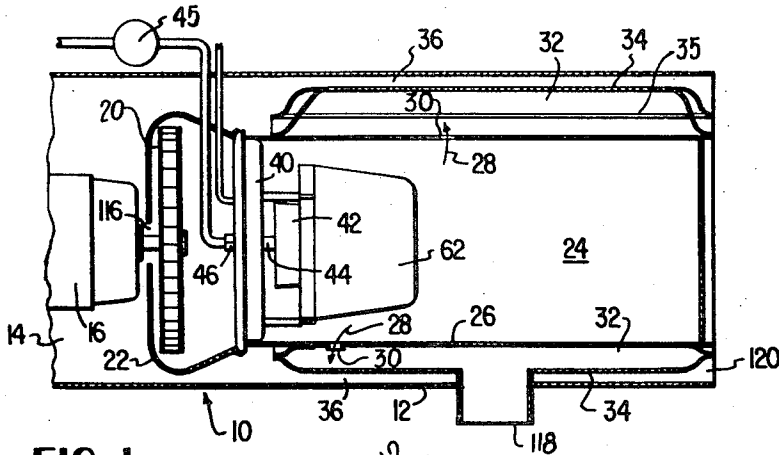


FIG. 1

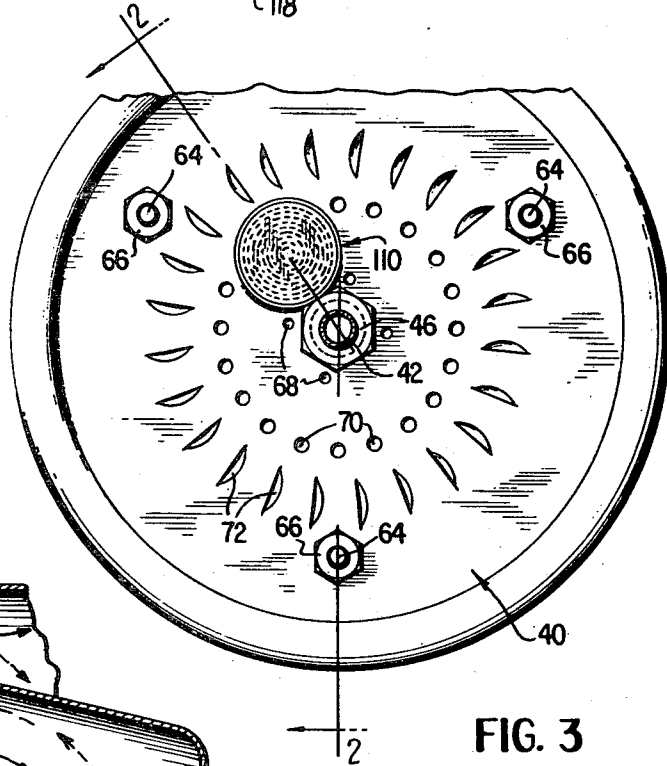
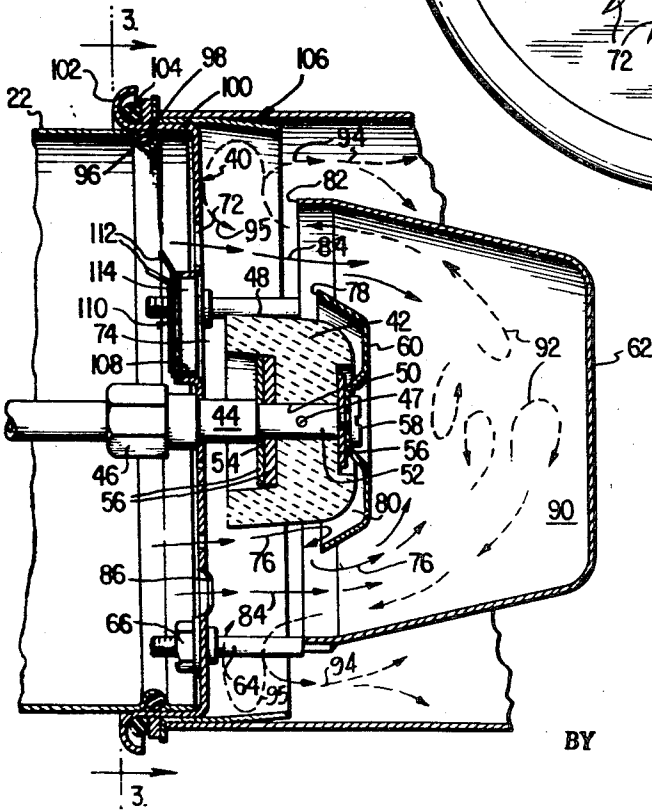


FIG. 2

FIG. 3



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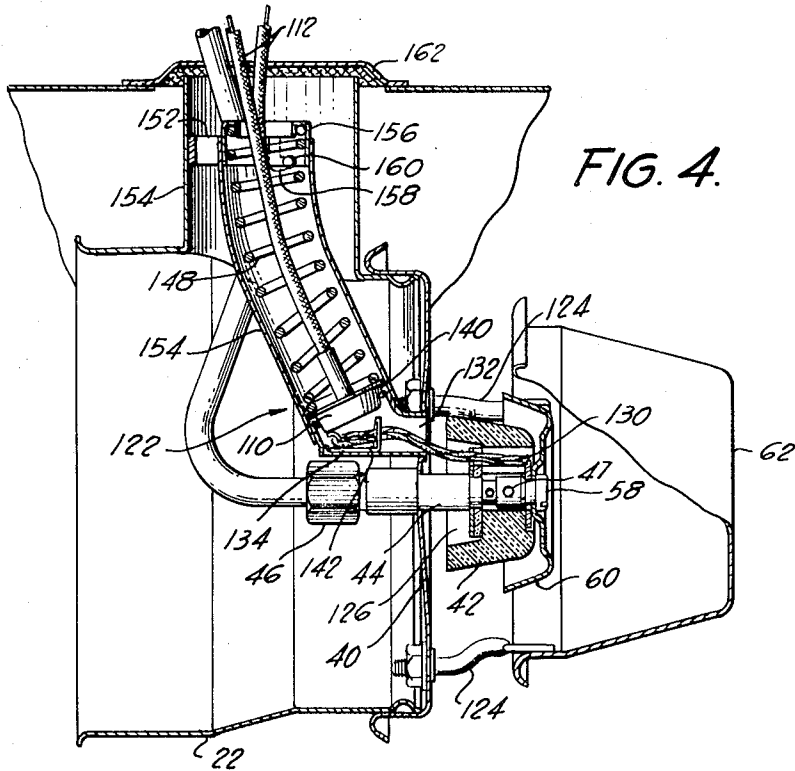


FIG. 4.

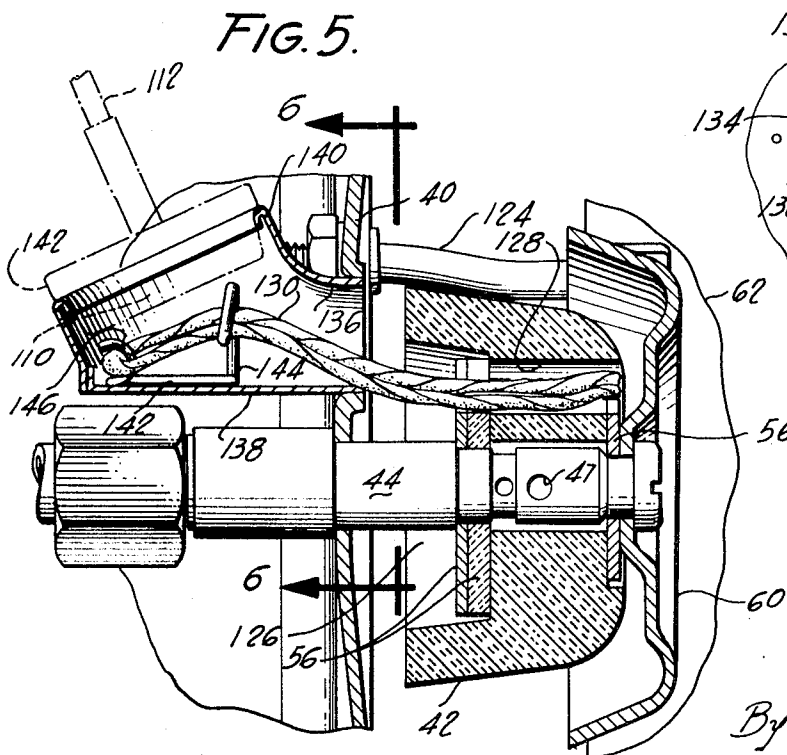


FIG. 5.

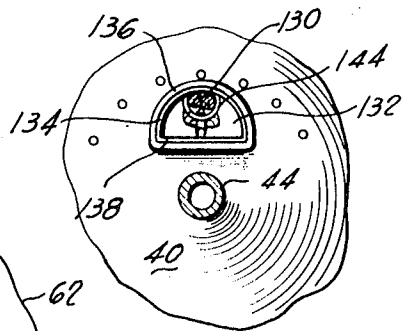


FIG. 6.

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RECIRCULATING FUEL BURNER

CROSS-REFERENCE TO RELATED APPLICATION

This application is a continuation-in-part application of application Ser. No. 741,738, filed July 1, 1968, now U.S. Pat. No. 3,523,004, and relates to forced air, liquid fuel burners employing ignition systems of the type described in our copending application Ser. No. 741,430, filed July 1, 1968, now U.S. Pat. No. 3,498,731, entitled "Electrical Ignition and Control System for Fuel Burner" and assigned to the common assignee.

Forced air liquid fuel burners conventionally include a blower at the forward end of the burner casing which forces combustion air towards the combustion chamber portion and about the fuel inlet means to promote rapid and efficient mixing of the fuel with the air and vaporization of the same prior to combustion of the fuel-air mixture in the combustion chamber. The degree of vaporization of the liquid fuel and mixing of the same with the forced combustion air not only determines the overall efficiency of the fuel burner, but also the ability of the fuel burner to burn a range of liquid fuels from heavy oils to lighter gasolines.

Attempts have been made to cause the pressurized air to swirl during its movement into the combustion chamber and about the liquid fuel delivery means. Some attempts have been made to redirect the combustion products along a reverse path to facilitate vapor pickup and more intimate mixing of the same with the combustion air prior to reaching the flame front in the combustion chamber. The reliability and efficiency of the liquid fuel burner is also dependent somewhat on the ability of the fuel and air mixture to be readily ignited especially when using heavy liquid fuel as diesel fuel, commonly known as DF2 or arctic grade fuel.

It is therefore a primary object of this invention to provide an improved liquid fuel burner of the recirculating type which burns fuel ranging from heavy oils to gasoline with increased efficiency.

It is the further object of this invention to provide an improved recirculating liquid fuel burner which is characterized by fast startup and ignition.

It is a further object of this invention to provide an improved recirculating liquid fuel burner which advantageously radiates the heat of combustion to a fuelled porous wick to increase vaporization of the fuel.

It is also an object of the present invention to provide an igniter assembly which contributes to improved reliability, economy and service.

Other objects of this invention will be pointed out in the following detailed description and claim and illustrated in the accompanying drawings which disclose, by way of example, the principle of this invention in the best mode which has been contemplated of applying that principle.

In the drawings:

FIG. 1 is a side elevation, partially in section, of the improved recirculating liquid burner of the present invention;

FIG. 2 is a sectional elevation of a portion of the apparatus of FIG. 3 taken about lines 2-2;

FIG. 3 is a rear elevational view of the improved recirculating apparatus or assembly;

FIG. 4 is a sectional view illustrating a recessed igniter assembly contributing to the reliability and service of the igniter;

FIG. 5 is an enlarged fragmentary sectional view illustrating a portion of the igniter assembly; and

FIG. 6 is a sectional view taken generally along the line 6-6 in FIG. 5.

In general, the apparatus of the present invention comprises an improved liquid fuel burner of the recirculating combustion products type. A blower at the air inlet end of the housing forces combustion air longitudinally therethrough. A transversely extending, apertured plate, downstream of the blower directs the air along prescribed paths relative to a conical ceramic wick which is carried coaxially of the apertured

plate on a downstream side thereof. Paired, concentric, axially spaced cup-shaped members are also positioned in nested fashion downstream of the porous conical wick with their open ends receiving the combustion air which passes through the plate and across the surface of the porous wick. The cup-shaped members reflect heat onto the porous wick surface to promote fuel vaporization and the recirculated combustion products insure efficient mixing of the vaporized fuel with the air during combustion.

An electrical resistance igniter comparable to an automobile cigar lighter in form, is carried by the aperture plate and in juxtaposition to the porous wick for igniting the fuel. The multiple turn resistance igniter, because of the flat spiral face, provides a large area of high heat to achieve initial fuel vaporization to promote rapid ignition, even when heavy fuel oils are burned.

Turning to the drawings, it is noted in FIG. 1 that the recirculating liquid fuel burner of the present invention may be appropriately employed in a vehicle to supply forced heated air. In this respect, the heater assembly 10 includes an outer cylindrical casing or housing 12 which carries at the upstream or air inlet end 14 a blower motor 16 including a combustion air blower 20. Shroud 22 overlies the blower 20 at the upstream end of the combustion chamber. A somewhat smaller cylindrical casing casing 26 defined principally the combustion chamber 24, the exhaust gases leave the combustion chamber as indicated by the arrows 28 through combustion chamber opening 30 into an annular channel 32 defined by a cylindrical casing 35 between the combustion chamber casing 26 and a third annular casing 34, of slightly larger diameter. Casing 34 is spaced inwardly from the main cylindrical casing member 12 to define a narrow annular passage 36 through which heated ventilating air indicated by arrows 38 is directed from the heater at the desired temperature exiting at outlet 120.

A transversely extending support plate 40 closes off the combustion chamber from the area immediately downstream of the blower of the combustion air blower 20. A conical, ceramic, coaxial wick 42 is carried centrally of the support plate 40. Fuel is supplied through a fuel inlet tube 44, and controlled by valve means 45 to wick 42. The inlet tube or spud 44 is coupled to the support plate, at the axis thereof, by coupling means 46. The spud 44 is provided with cross bored apertures 47 allowing the liquid fuel to permeate the porous ceramic wick 42. The fuel is vaporized on the surface as a result of the heat of combustion. Pressurized air in passing over the outer surface 48 of the ceramic wick, picks up the vaporized fuel and mixes with the same. The porous wick 42 is bored at 50 and is inserted onto the reduced diameter end 52 of the fuel inlet tube or spud 42 against shoulder 54. Wick retaining washers 56 sandwich the axial ends of the wick 42 while threaded screw 58 couples the wick and the wick retaining washer 56 to spud 42 and fixes a small diameter cup-shaped member 60 to the downstream end of the porous conical wick 42. Cup-shaped member 60 cooperates with a larger diameter cup-shaped member 62 to promote recirculation of the combustion products and increase mixing of the partially burned fuel with the moving combustion air. Both cup-shaped members 60 and 62 are simple stamped metal parts which are easily assembled. The small cup-shaped member 60 is spaced from the ceramic wick 42 both peripherally and axially for a short distance to promote recirculation of the air and removal of the vaporized fuel from the outer surface 48 of the wick. The larger cup-shaped member 62 is spaced downstream from the smaller cup-shaped member 60 and partially encircles the ceramic wick 42 while completely encircling the smaller cup-shaped member 60 to facilitate proper recirculation of the pressurized, moving combustion air. In this respect the wick 42 is partially nested within both the cup-shaped member 60 and the larger cup-shaped member 62, while the smaller cup-shaped member 60 is completely nested within axially and radially spaced from the larger outer cup-shaped member 62. The large cup-shaped member 62 is coupled to the transverse apertured plate 40 by means of a plurality of cup support legs

64, each threaded at their upstream ends and carrying suitable nuts 66.

The support plate 40 forms an important part of the present invention other than its function to support the ceramic wick 42 and the coaxial nested cup-shaped members 60 and 62. In order to facilitate proper vaporization of the fuel and mixture of the same with the forced combustion air, the transverse plate 40 is apertured in a manner best indicated at FIG. 3 to direct both primary and secondary air along desired circumferential but regularly spaced paths relative to these downstream elements. Combustion air under pressure from blower 20 moves through the apertured plate within three sets of circumferentially arranged apertures 68, 70 and 72. The four circumferentially arranged apertures 68 are spaced close to the fuel tube or spud 44 and directly behind the somewhat cup-shaped conical wick 42. The apertures or holes 68 provide minor amounts of combustion air for the area 74 between the porous wick 42 and the support plate 40. Primary combustion air of much greater magnitude is forcibly directed through the larger number of circumferentially arranged holes 70 which are spaced radially outward of the four holes 68, the holes 70 being positioned such that the air passing therethrough as indicated by arrows 76 moves along the outer surface 48 of the porous wick 42 but inwardly of the peripheral rim 78 of the smaller cup-shaped member 60. This gives rise to a jet airstream directly adjacent to the wick periphery, part of which goes around the back or rear surface 80 of the wick 42 between the small cup-shaped member 60 and the wick. The larger portion of this air, however, is caused to reverse itself along the outside of the incoming airstream, towards the rear surface of the support plate 40 and the low pressure which exists on the outside of the jetstream as indicated by arrows 76.

Because of the low pressure created by the jetstream moving through the small holes, the portion of rearwardly moving air tends to move back into the jet airstream carrying vaporized, partially burned fuel with it. These products of combustion, for reasons not known, act as a catalyst promoting burning of the vaporized fuel.

A certain portion of the air, of course, exits from the rim or peripheral edge 78 of the smaller cup-shaped member 60 and circulates within the area defined by the rim 82 of the second cup-shaped member 62. Here it mixes with the secondary combustion air entering the chamber through openings 72 formed by associated louvers 86 within the transverse plate 40. The circumferential array of louvers 86 and the apertures 72 is located radially beyond the series of apertures or holes 70 and between the peripheral rim 78 of the smaller cup-shaped member 60 and the peripheral rim 82 of the larger cup-shaped member 62. This airstream has a partial spiral flow path which is introduced as a result of the louver configuration to promote fuel and air mixing. The airstream identified by arrows 84 also creates a low-pressure area especially on the outward radial side thereof so that, as the burning mixture exits from the large cup 62, a portion of the products of combustion moves by way of arrows 95 back toward the support plate 40 and is reentrained into the secondary airflow and therefore moves back into the rear of the large cup-shaped member 62. Recirculation of the combustion products due to the primary airflow, secondary airflow and the positioning and the relationship of the first and second cup-shaped member with respect to the aperture plate 40 is extremely valuable in promoting maximum fuel and air mixing, uniformity of the same and resultant complete combustion. It further permits the heavy fuels to be burned without coking while the heat resulting from combustion is readily radiated back from the two cup-shaped members to aid in vaporizing the fuel at the surface of the wick.

Burning is achieved within the center 90 of the larger cup-shaped member 62 with the fuel and air mixture swirling in the fashion of arrows 92 prior to moving out of cup-shaped member 62 and into the combustion chamber proper 24 as indicated by the dotted arrow 94 by passing around the rim 82 of the large cup-shaped member 62.

The lighter fuels, because of the wick and cup arrangement, vaporize much sooner than in ordinary burners because of the relatively high heat provided by the second cup-shaped member 62 at the back end of the wick. Because this fuel vaporizes quickly, it does not crack as ordinarily would occur where it is subjected to high surface heat before it had a chance to vaporize and burn. In effect, therefore, both the high heat content and the recirculation provided by the cups enhance burning of the heavy fuels while the lighter fuels are permitted to burn without cracking, vastly extending the range of fuels which are advantageously burned within the assembly of the present invention.

Shroud 22 which forms the combustion air inlet housing terminates in a peripheral groove 96 which receives an annular sealing member 98 which seals the combustion air inlet housing to the burner. Plate 40 is provided with a peripheral flange 100 which is reversely turned at 102 and carries an annular sealing member 104 to provide in conjunction with combustion chamber housing or casing 26, and burner mounting and air distribution plate 106, a burner to combustion chamber seal. It is noted that the burner mounting and air distribution plate 106 which is sandwiched between the flange portion 100 of the transverse support plate 40, and the slightly larger diameter combustion chamber casing member 26, has an inwardly inclined downstream portion which tends to deflect the air downstream and inward as it passes over the lip 82 of the large cup-shaped member 62.

As mentioned previously an important element of the improved assembly resides in the use of an ordinary automobile cigar lighter in the form of a spiral electrical resistance heater coil as a means for starting vaporization and for igniting the fuel. In this respect, the transfer support plate 40 is provided with an enlarged diameter aperture 108 which received a disc-like spiral electrical resistance heater element 110, from the rear of which protrudes a pair of electrical leads 112 allowing suitable connection to a source of electrical energy (not shown). The resistance coil 114 itself faces downstream and is spaced slightly from the porous wick member 42 to readily ignite the fuel. Preferably, the cigar-type resistance heater coil is made of a wire which comprises an alloy of aluminum, iron, chromium, cobalt and tantalate, and is manufactured and sold by the Kanthal Corporation of Bethel, Conn. Since the flat spiral face provides a large area of high heat intensity in ready contact with the wick, the fuel vaporization and ignition is rapid and assured. This is in contrast with the prior art methods employing either spark electrodes or a helical-type resistance igniter. In the helical resistance-type heater, it is only the last loop of the helix that has considerable contact with the vaporized fuel, affording some unreliability especially when the fuel comprises a heavier fuel oil.

During operation, with the blower motor 16 operating, air is drawn into the housing 12, preferably by a ventilating air fan (not shown) near the air inlet of the blower assembly. A part of the air is drawn into the combustion air blower 20 through the opening 116 in the center of the blower housing 22 and is forced into the primary and secondary air openings 68, 70 and 72 at the upstream end of the heat exchanger. The primary combustion air flows over the surface 48 of the porous wick 42 to rapidly remove vaporized liquid fuel therefrom and mix it readily with the combustion air. Momentary energization of the igniter or spiral resistance heater 110 through leads 112 achieves immediate ignition of the fuel air mixture with burning being carried on within the area 90 within the cup-shaped member 62. Mixture of the fuel and air is enhanced, and recirculation insured by the presence of the small and larger cup-shaped members 60 and 62 at the downstream end of the porous wick member 42. After ignition the hot gases flow into chamber 24 against the incoming secondary combustion air which insures complete combustion of the fuel carried thereby. The hot gases of combustion after circulating within chamber 24, pass readily through the annular passage of the heat exchanger and out through the exhaust tube 118 at the bottom of the heater. Obviously, the ventilating air which moves longitudinally through the small annular passage 36 is

efficiently heated prior to discharge through the downstream end 120 of the assembly.

The apparatus of the present invention is particularly applicable to the heating of ventilating air for a vehicle; however, the improved recirculating air, liquid fuel burner has application to many other fields requiring burners which operate efficiently with liquid fuels ranging from heavy oils to light gasolines.

In FIG. 4 an improved igniter assembly is illustrated therein by the reference character 122 for use in a heater assembly such as 10 and those parts similar or identical to those shown in heater 10 are given the same reference characters.

Thus, a support plate 40 is provided having a plurality of spaced openings as previously described. A plurality of studs such as 124 extend from the rim of a cup-shaped member 62 and are bolted to the support plate 40 to carry the cup-shaped member 62. The burner cup or member 62 as shown in FIG. 4 is provided with a short peripheral bead or flange extending radially outwardly with the terminating edge of the flange extending downstream.

A fuel inlet spud 44 extends through the central axis of plate 40 and coupling means 46 couples a fuel inlet pipe to the spud. A ceramic wick 42 is located adjacent the end of spud 44 and cross bored apertures 47 in spud 44 serve to deliver fuel from the spud to the wick. The wick 42 is provided with a central recess 126 at one end in which a pair of washers 56 are seated for butting the wick 42, which is clamped on spud 44 together with a small diameter cup-shaped member 60 by means of a screw 58.

A small axially extending opening 128 is provided in the ceramic wick 42 along the vertical axis and above the mid-plane of the wick 42 and is aligned with openings in the washers 56 for receiving several strands 130 of a loop of conventional wicking material. The strands 130 extend upstream from the member 60 through an opening 132 in the support plate 40. Opening 132 is located above the central axis and along the vertical axis of the support plate 40 so that it is generally aligned with opening 128.

The igniter assembly 122 comprises a sheet metal housing 134 having semiannular wall 136 extending upstream from opening 132 and whose end is welded to plate 40 in alignment with the opening 132 with the ends of the semiannular wall 136 connected by a flat wall 138 aligned with a straight portion of opening 132. The walls 136 and 138 at the ends opposite opening 132 terminate in a short annular wall section 140 extending both upwardly and upstream. The upper end of wall 140 terminates in a radially inwardly and downwardly directed flange 142 for receiving an igniter 110 having a spiral electrical resistance heater element 114 and similar to the igniter previously described but having a cup-shaped wall which fits snugly within the flange on wall 140 and an annular rear wall 142, which overlaps wall 140 and butts against the end of wall section 140.

A wick support or retainer 142 of wire fastened to the flat wall 138 has an upwardly extending leg 144 at the end adjacent opening 132 terminating in a loop for supporting the wick strands 130 in front of the igniter 110 and a hooklike leg 146 at the opposite or upstream end around which the strands 130 are looped so that the strands are held a short distance in front of the igniter 110.

The igniter is biased into the opening defined by wall 140 by a helical spring 148 received in wall 142, which spring together with the igniter leads 112 and are enclosed in an annular housing 150 whose lower end telescopes over the wall 140. The housing 150 together with the fuel inlet pipe for spud 44 extend upwardly through appropriately sealed openings in a shroud 22 serving a similar function to the previously described shroud 22 but having a slightly different configuration.

The housing 150 is secured at its upper end by legs such as 152 to a wall 154 extending upwardly from and externally of the shroud 22 for enclosing the housing 150 between the shroud and the outer wall 12. A cup-shaped wall or cap 156

fits telescopingly in the upper end of housing 150 for restraining the end of spring 148 to apply a force for holding the igniter in the opening defined by wall 140. J-shaped slots such as 158 in the upper end of housing 150 permit the cap 156 to be retained in position in response to the insertion of a rod or projections 160 on cap 156 in the slots and rotation of the cap to place the projections 160 in the hook portion of slots 158 and effect a bayonet-type connection.

A central aperture in the backwall of cap 156 permits the electrical leads 112 to be extended from the igniter 110 through a suitable opening in a removable cover plate 162 carried on the outer burner wall 12 to a suitable power supply.

Thus, access to the igniter 110 for easy servicing or replacement is provided by simply removing the cover plate 162 usually after leads 112 are detached from the power source. The cap 156 is rotated to align the rod 160 with the vertical straight leg of the J-slots 158 to permit withdrawal of cap 156 and spring 148 from housing 150. The igniter 110 may then be lifted by means of the leads from housings 150 and 154 and either serviced or replaced as the case may be. The igniter 110 and spring 148 are then simply positioned in housing 150 and the cap 156 replaced to cause the spring 148 to hold the igniter 110 in position and the cover plate replaced.

In the arrangement shown in FIGS. 4 and 5 the strands 130 of wicking material conduct fuel to the igniter 110 in its recessed position so that the igniter may initiate the combustion cycle. When a flame is established by the igniter in housing 134 a small jet of flame extends through the opening 132 and ignites the fuel transmitted through wick 42 to ignite the main flame. With the main flame in operation, the fuel is vaporized relatively rapidly and does not soak back through strands 130 and into the area in front of the igniter 110, so that area stays dry and free of carbon. Since the igniter 110 is relatively remote from the main area of combustion and is located in an area from which heat is conducted, it cools rapidly after combustion is initiated since the flame is transferred from the housing 134 with consequent extension of the igniter life.

While the invention has been particularly shown and described with reference to a preferred embodiment, it will be understood by those skilled in the art that the foregoing and other changes in the form and details may be made therein without departing from the spirit and scope of the invention.

What is claimed is:

1. In a fuel burner assembly including casing means forming a combustion chamber and blower means for forcing combustion air longitudinally therethrough, the improvement comprising: a transverse, apertured plate for directing combustion chamber inlet air along prescribed longitudinal paths, a first cup-shaped member coaxially positioned downstream of said plate with the open end thereof directed toward said incoming combustion air, a ceramic wick coaxially carried by said assembly on the downstream side of said plate, within said cup-shaped member and spaced axially and radially therefrom, means for delivering liquid fuel to said porous wick member, and an electrical resistance coil for igniting said fuel lying in a plane located axially upstream from said plate.

2. The assembly claimed in claim 1 wherein a strand of wicking material connects fuel from said ceramic wick to said igniter.

3. The assembly as claimed in claim 1 in which said resistance element comprises a spiral turn of aluminum, iron, chromium, cobalt and tantalate alloy wire.

4. In the assembly as claimed in claim 1, means for communicating fuel through said plate to said igniter.

5. The assembly claimed in claim 2 in which said communicating means comprises an opening in said plate and a first housing extending at one end from said plate opening and having an opening for receiving said igniter at a position spaced from said plate opening.

6. In the assembly claimed in claim 5, a spring for biasing said igniter toward said housing opening, a second housing encircling said spring and having one end telescopingly received by said first housing and encircling each electrical lead ex-

tending to said igniter, the opposite end of said housing accessible from a position external said casing, and a cap for said housing other end biased by said spring into locked position and rotatable for disengagement from said other end to facilitate removal of said spring and igniter from said other housing.

7. In a fuel burner assembly having a wall defining a combustion chamber and blower means for driving air in a stream from one end of said chamber toward the other end, the improvement comprising a plate adjacent said one end of said chamber with said plate having a plurality of apertures therein at one radial distance from the axis of said plate and with a second plurality of apertures therein at a different radial distance from said axis for passing combustion air, a fuel inlet conduit passing through the axis of said plate and terminating in said chamber, a wick in said chamber and extending radially from said conduit, means for communicating fuel from said conduit to said wick, a shield spaced adjacent the downstream end of said wick and having a greater radial dimension than said wick, a cup-shaped member spaced downstream from said shield and extending radially beyond said shield with the open end of said cup facing upstream, and a coil located upstream of said plate and spaced from said plate for igniting the fuel transmitted from said conduit to said wick.

8. In the assembly claimed in claim 7, a strand of wicking material extending from said wick through said plate to a position adjacent said coil.

9. In the assembly claimed in claim 7, housing means extending through said airstream, and manually movable means in said housing means for retaining said coil in said plane and operable for enabling withdrawal of said coil through said housing to a position external said assembly.

10. In a fuel assembly having a wall defining a combustion chamber and blower means for driving air in a stream from one end of said chamber toward the other end, the improve-

ment comprising a plate adjacent said one end of said chamber, means associated with said plate for passing both combustion air and fuel into said chamber to develop a flame in said chamber, a coil of electrical resistance wire arranged solely in a spiral to initiate said flame, and means detachably fixing said coil upstream from said plate.

11. In a fuel burner assembly having a wall defining a combustion chamber and blower means for driving air in a stream from one end of said chamber toward the other end, the improvement comprising a plate adjacent said one end of said chamber, means associated with said plate for passing both combustion air and fuel into said chamber upstream of said plate to develop a flame in said chamber, a coil of electrical resistance wire arranged solely in a spiral to initiate said flame and located upstream of said plate, and means for passing fuel from said chamber through said plate to the vicinity of said coil.

12. The assembly claimed in claim 11 in which said means for passing fuel to said chamber includes a wick in said chamber, and said means for passing fuel through said plate comprises an opening in said plate, a housing having an open end connected to said opening, and a wicking material interconnected with said wick and extending through said opening into said housing.

13. The assembly claimed in claim 12 in which said coil of spiral wire is located adjacent the end of said housing opposite said open end.

14. In the assembly claimed in claim 7, housing means communicating with the end of said housing opposite said open end and extending through said airstream, manually movable means in said housing means for retaining said spiral coil adjacent the end of said housing opposite said open end and operable for enabling withdrawal of said spiral coil through said housing to a position external said assembly.

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