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J. B. MELLETT ET AL

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RECIRCULATING FUEL BURNER

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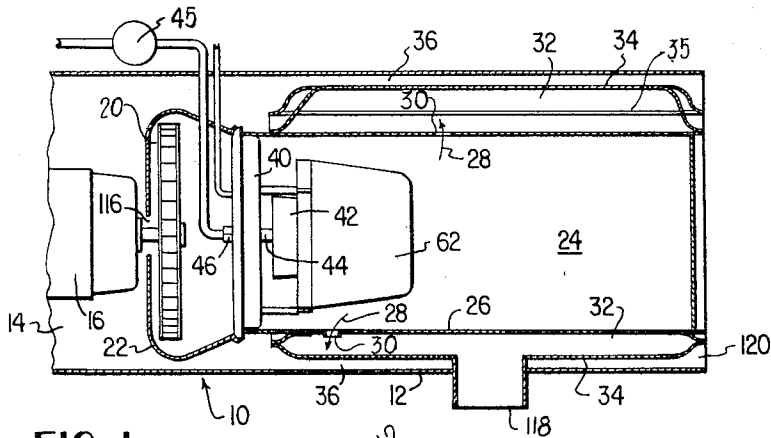


FIG. 1

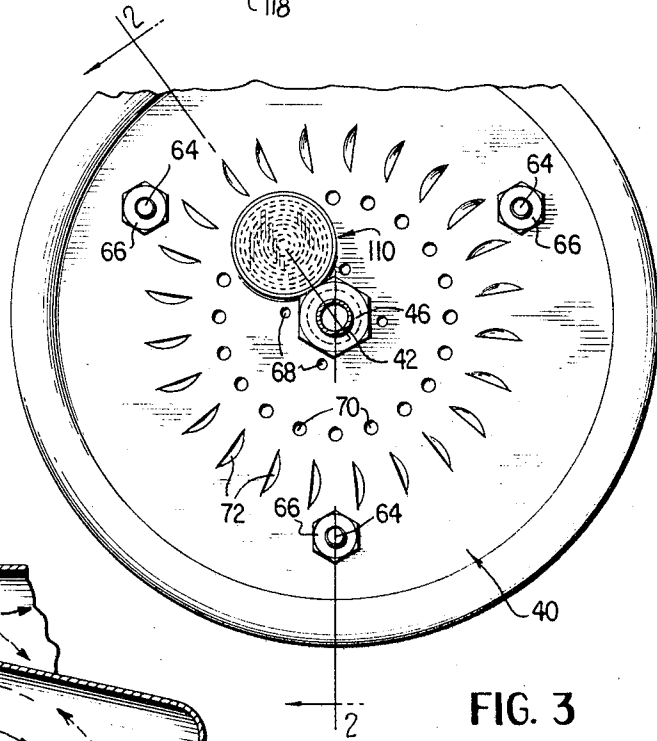


FIG. 2

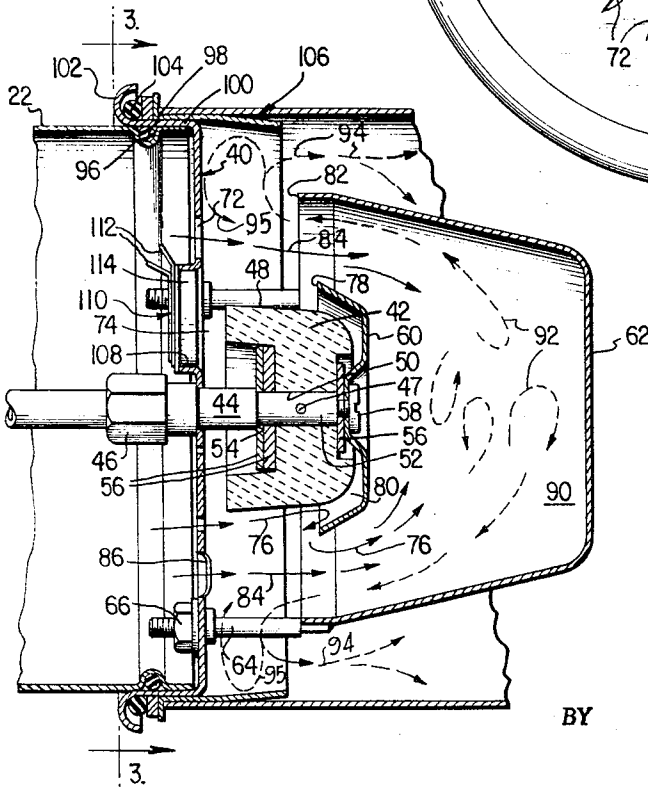


FIG. 3

INVENTOR

Jesse B. Mellett.
Tilford W. Sutterfield.

BY

Norton Lessey
ATTORNEY

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3,523,004

RECIRCULATING FUEL BURNER

Jesse B. Mellett, Zionsville, and Tilford W. Sutterfield, Indianapolis, Ind., assignors to Stewart-Warner Corporation, Chicago, Ill., a corporation of Virginia

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14 Claims

ABSTRACT OF THE DISCLOSURE

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.

CROSS-REFERENCE TO RELATED APPLICATION

This application 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, 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 gasoline.

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 pick up 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 such as diesel fuel, commonly known as DF2.

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 start-up 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 fueled porous wick to increase vaporization of the fuel.

Other objects of this invention will be pointed out in the following detailed description and claims 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 drawing:

FIG. 1 is a side elevation, partially in section, of the improved recirculating liquid fuel 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; and

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

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 there-through. 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 down stream 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 26 defines 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 aperture 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

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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 member 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 forceably 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 air stream 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 air stream, towards the rear surface of the support plate 40 and the low pressure which exists on the outside of the jet stream as indicated by arrows 76.

Because of the low pressure created by the jet stream moving through the small holes, the portion of rearwardly moving air also tends to move back into the jet air stream 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 air stream has a partial spiral flow path which is introduced as a result of the louver configuration to promote fuel and air mixing. The air stream 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

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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 air flow and therefore moves back into the rear of the large cup-shaped member 62. Recirculation of the combustion products due to the primary air flow, secondary air flow 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 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 chamber 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.

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, and means for delivering liquid fuel to said porous wick member.

2. The assembly as claimed in claim 1 further including: a second, concentrically positioned cup-shaped member downstream and in nested fashion to said first cup-shaped member, said second cup-shaped member being spaced radially and axially outwards from the surface of said wick member, and radially and axially inwards of said first cup-shaped member to facilitate recirculation of combustion air.

3. The assembly of claim 1 wherein said transverse plate includes: a circumferentially arranged series of air apertures for directing primary air over the surface of said porous wick member, and a second circumferential series of apertures, radially outwards of said first series for directing secondary air into said first cup-shaped member.

4. The assembly as claimed in claim 2 further including: a circumferentially arranged series of apertures carried by said plate for directing primary air over the surface of said porous wick, said apertures being radially oriented intermediate of said porous wick surface and the rim of said second cup-shaped member.

5. The assembly as claimed in claim 4 further including: a second circumferentially arranged series of apertures carried by said plate, oriented radially beyond said first series intermediate of the rim of said first and second cup-shaped members for directing secondary air into said first cup-shaped member.

6. The assembly as claimed in claim 5 further including: louvers carried by said plate adjacent said secondary air apertures for achieving swirling of the secondary air downstream of said transverse apertured plate.

7. The assembly as claimed in claim 1 further including: a flat, electrical resistance coil in juxtaposition to said porous wick member for starting the vaporization of fuel from the wick member and for igniting vaporized fuel.

8. The assembly as claimed in claim 7 further including: means carried by said transverse apertured plate for supporting said flat resistance coil spaced upstream of said wick member, and longitudinally in line therewith.

9. The assembly as claimed in claim 1 wherein: said means for delivering liquid fuel to said porous wick member comprises a fuel delivery tube coaxially carried by said plate and passing therethrough, said wick member comprises a cone, coaxially carried on the end of said tube.

10. The assembly as claimed in claim 9 wherein the terminal end of said fuel tube, downstream of said plate is of reduced diameter, said porous conical wick member includes a central recess which receives said reduced diameter tube portion, and said portion includes apertured means for directing liquid fuel to said porous wick member.

11. The assembly as claimed in claim 10 further including: imperforate washers carried on respective downstream and upstream faces of said conical porous wick member for facilitating the outward radial movement of liquid fuel by capillary action.

12. The assembly as claimed in claim 11 further including: common coupling means for coupling said porous wick and said second cup-shaped member to the end of said tube and for maintaining said washers on either side of the porous wick member.

13. The assembly as claimed in claim 1 wherein: said transverse aperture plate includes a peripheral flange to facilitate coupling to said annular combustion chamber casing, said assembly further includes: sealing means carried between said peripheral flange and said combustion chamber casing for peripherally sealing the same.

14. The assembly as claimed in claim 13 further including: an annular air distribution plate sandwiched between said combustion chamber housing and said plate peripheral flange, the downstream end of said annular air distribution plate being inclined inwardly to direct exhaust gases, after the passage over the rim of the first cup-shaped member, downstream and toward the axis of the assembly.

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