

April 24, 1945.

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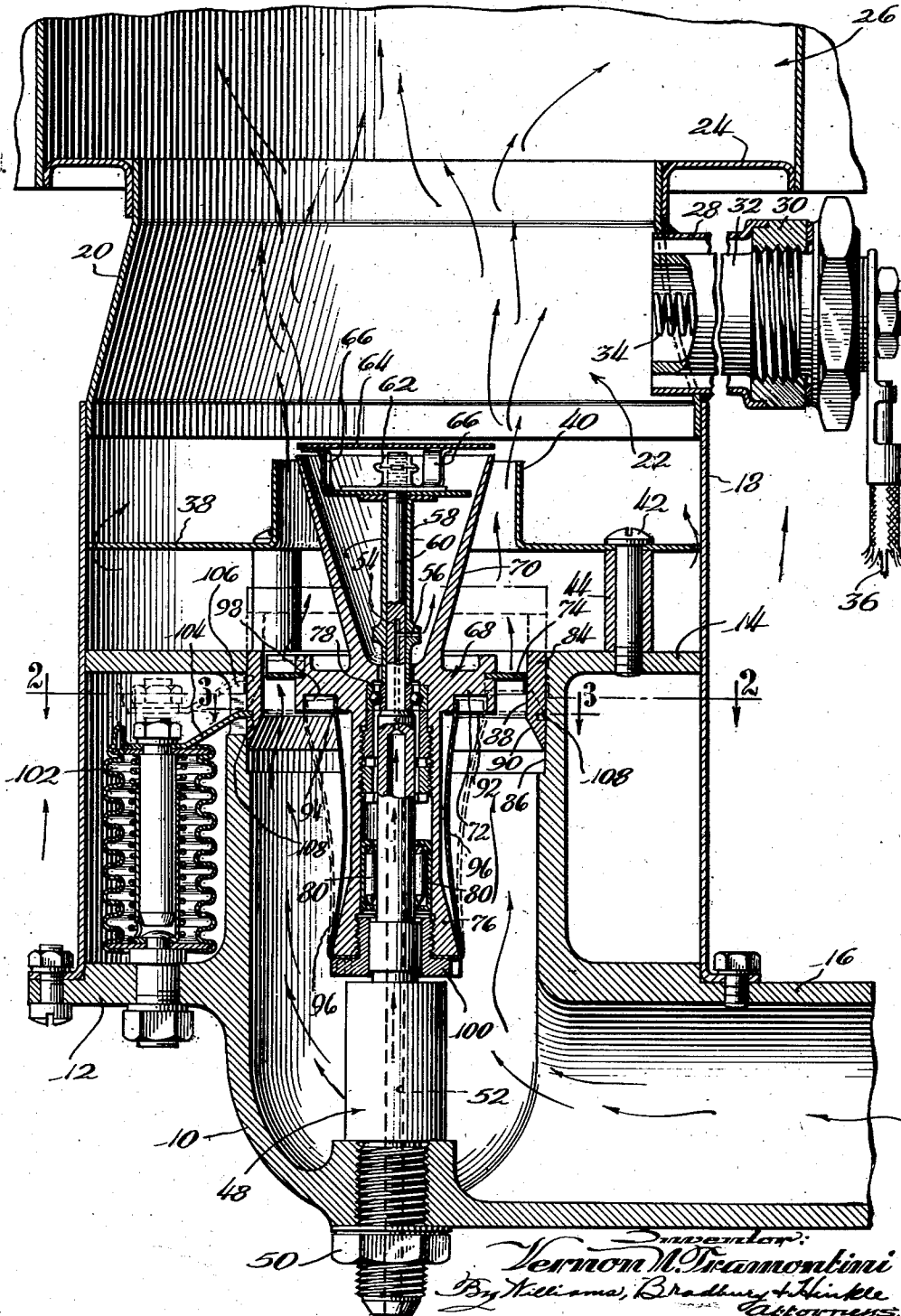
2,374,569

HEATER

Filed Nov. 15, 1943

2 Sheets-Sheet 1

Fig. 1.



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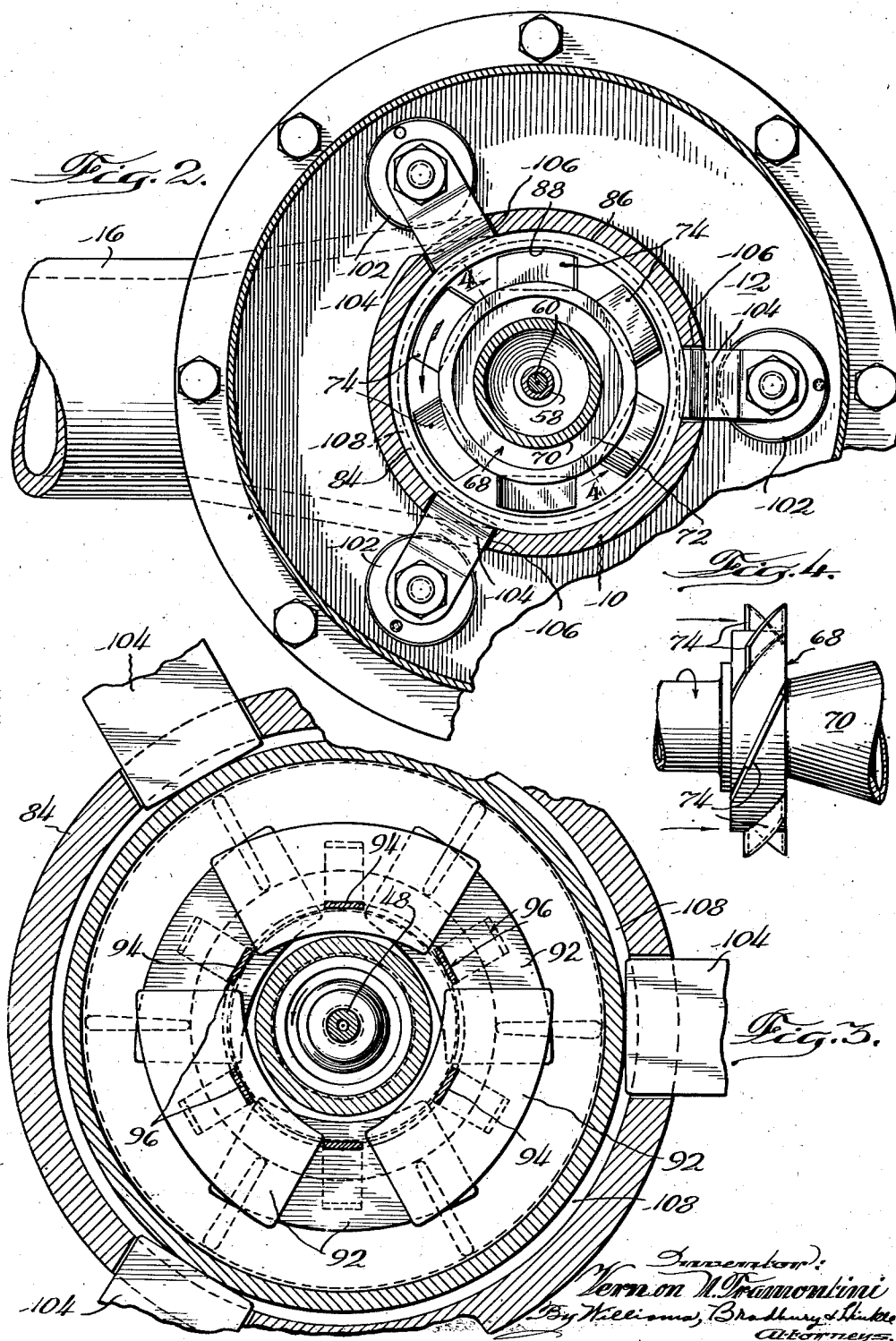
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UNITED STATES PATENT OFFICE

2,374,569

HEATER

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12 Claims. (Cl. 153—77)

My invention relates generally to heaters, and more particularly to improvements in liquid hydrocarbon burners especially adapted for use in aircraft heaters of the sealed combustion type.

It is an object of my invention to provide improved means for atomizing the fuel supplied to a sealed combustion chamber and to control the rate of supply of air for combustion.

A further object is to provide a liquid hydrocarbon burner with improved means responsive to variations in atmospheric pressure to control the rate of admission of combustion air to the combustion chamber.

A further object is to provide an improved burner and combustion chamber construction in which the rate of flow of air into the combustion chamber is automatically controlled conjointly by the pressure drop across the heater and the absolute pressure.

Other objects will appear from the following description, reference being had to the accompanying drawings, in which

Fig. 1 is a central vertical sectional view of the combustion chamber and air and fuel admission means constituting the burner portion of a sealed combustion type heater;

Fig. 2 is a fragmentary transverse sectional view taken on the line 2—2 of Fig. 1, rotated through an angle of 180°;

Fig. 3 is a fragmentary transverse sectional view taken on the line 3—3 of Fig. 1; and

Fig. 4 is a fragmentary detail showing the impeller for driving the atomizing cup.

While the apparatus is shown in Fig. 1 in a vertical position with the flow of air upward into the combustion chamber, it will be clear that the apparatus may be used in any desired position, provided the igniter is appropriately located in the combustion chamber.

In heaters, particularly those designed for use on aircraft, considerable difficulty has been encountered in maintaining an adequate but not excessive supply of air for combustion in the combustion chamber. This difficulty has been more pronounced in heaters in which the mixing of the fuel and air takes place substantially in the combustion chamber, that is, in which the fuel is sprayed directly into the combustion chamber. These difficulties are overcome in the burner of my invention by varying the effective size of the inlet port through which air is supplied to the combustion chamber in accordance with the velocity of air flow, and in addition, controlling the effective size of the air inlet port in response to variations in atmospheric pressure. Thus, when

the heater is used in an airplane, the volumetric flow is increased with increased altitude, while the gravimetric rate of air flow to the combustion chamber is kept substantially constant.

As shown in Fig. 1, the burner comprises a generally elbow-shaped induction pipe casting 10 having flanges 12 and 14. The casting 10 may have a tubular extension 16 for connection to a ram or blower, or other means for supplying air under pressure. A tubular sheet metal casing 18 is secured to the flange 12 and to the extension 16. The upper portion of the casing 18, together with a tapering sheet metal section 20, forms a combustion chamber 22. The upper end of the section 20 is welded or otherwise suitably secured to the end wall 24 of a heat exchanger 26. The latter may be of any suitable construction adapted to receive the products of combustion from the combustion chamber 22 and to transfer heat to ventilating air which flows upwardly past the combustion chamber and associated parts and through or around the heat exchanger 26.

An igniter supporting tube 28 projects through the section 20 and is suitably welded thereto, this tube having a threaded ring 30 secured thereto to receive an igniter shell 32. Within the igniter shell 32 is the usual hot wire igniter 34, the inner end of which is secured to the shell 32 and the outer end of which is suitably connected to a wire 36 which is insulated from the shell 32 and supplies energizing current to the igniter. Suitable thermostatic control means are preferably provided to cause energization of the igniter during starting, and in the event that the flame in the burner becomes extinguished.

A baffle 38, having a central opening surrounded by a flange 40, is secured to the flange 14 by a plurality of cap screws 42, being spaced therefrom by tubular separators 44 surrounding the cap screws. The peripheral edge of the baffle 38 has long narrow arcuate notches therein, to provide auxiliary ports for admitting air to the combustion chamber.

Fuel is supplied from a constant pressure source connected to the outer end of a nozzle member 48 which is rigidly secured to the casting 10 by a nut 50. The nozzle member 48 forms a spindle and has a central fuel conducting passageway 52 which terminates in a small diameter passageway 54 having a sidewardly directed portion registering with a flow metering discharge port 56 formed in a sleeve 58 surrounding the reduced diameter end portion 60 of the nozzle member 48. The sleeve 58 is clamped to the end portion 60 by means of a self-locking nut 62, which also serves

to secure in place a shield 64. The shield 64 is welded to a supporting spider 66, and the latter is clamped in position by the self-locking nut 62.

A rotor 68 includes a flaring atomizing cup 70, an impeller flange 72 carrying a plurality of impeller blades 74, and a sleeve portion 76. Within the sleeve portion 76 are located a ballbearing assembly 78 and a needle bearing assembly 80, thus providing for free rotation of the rotor 68 about the spindle portion of the nozzle member 48.

A variable aperture sleeve 84 is mounted for sliding movement in a finished bore 86 formed at the upper end of the casting 10, this sleeve having a cylindrical bore 88 for the reception of the impeller 72, 74, and a beveled inlet surface 90. The bore 88 and beveled surface 90 of the sleeve 84 form part of a valve mechanism for controlling the rate of flow of air into the combustion chamber. The remaining portion of this control means is provided by a plurality of segmental shutters 92 which, as best shown in Fig. 3, are six in number and overlap one another. Each of the shutters 92 has a slot 94 formed therein for the reception of a prestressed leaf spring 96. The ends of the leaf springs 96 project into guiding and motion limiting recesses 98 formed in the impeller flange 72. The leaf springs 96 are preferably formed as arms of a spider-like element, and are clamped to the sleeve 76 by a bushing 100 which is threaded in the end of the sleeve.

The position of the sleeve 84 is determined by a plurality of aneroid bellows 102, one end of each of which is rigidly secured to the flange 12, and each of which carries at its other end an arm 104 which projects through a suitable elongated slot 106 formed in the wall of the casting 10, the extremity of each of the arms 104 fitting into a groove 108 formed in the outer surface of the sleeve 84. Thus, as the atmospheric pressure decreases, the bellows 102 will expand and move the sleeve 84 upwardly.

In the operation of the apparatus, air under pressure is supplied to the inlet extension 16 of the casting 14 and flows in the direction of the arrows past the impeller blades 74, causing the rotor assembly 68 to commence rotation. At the same time, fuel under relatively constant pressure, is supplied through the passageways in the nozzle member 48 and is discharged through the port 56 in the sleeve 58. Due to the centrifugal force resulting from the rotation of the rotor assembly 68, the fuel will flow upwardly along the walls of the conical atomizing cup 70 in a thin film, and will be flung from the brim of the atomizing cup 70 in very small droplets. These atomized particles of fuel will traverse the combustion air flowing through the annular space between the flange 40 and the external wall of the atomizing cup 70, and will be thoroughly and substantially uniformly mixed with the incoming air to provide a combustible mixture. This mixture will be ignited by the electric igniter 34, and due to the accurate proportioning of the air and fuel, substantially complete combustion will take place within the combustion chamber 22 and within the inlet end portion of the heat exchanger 26.

If the pressure of the air supplied to the inlet extension 16 of the casting 10 is higher than that required to produce the flow of a weight of air adequate for complete combustion of the fuel, the rotor assembly 68 will be accelerated to such high velocity that the centrifugal force acting upon the shutters 92 will be sufficient to overcome the preloading of the leaf springs 96 and the shutters 92 will move outwardly, partially to obstruct the

annular space between the impeller flange 72 and the wall of the bore 88. Such outward movement of the shutters 92 will reduce the rate of air flow to the combustion chamber, and thus cause a reduction in the speed of rotation of the rotor assembly 68. The shutters 92 will thus tend to assume a position in which the air flow into the combustion chamber is maintained at a predetermined rate. Since the shutters 92 overlap one another, and since they are pressed against each other and against the lower surface of the impeller flange 72, there will be a certain amount of friction impeding their movement, and these frictional forces will operate to damp the movement of the shutters and prevent hunting.

Since the energy available for the rotation of the rotor assembly 68 is proportional to the density of the air and the square of the velocity, it will be apparent that at higher altitudes the air would be supplied to the heater at a reduced gravimetric rate if no means were provided to make compensation for the reduction in density due to altitude. In the apparatus disclosed herein, such compensation is obtained by moving the sleeve 84 upwardly as the atmospheric pressure decreases. Upward movement of the sleeve 84 brings the beveled surface 90 of the sleeve into the plane of the shutters 92. Since the outward movement of the shutters is limited by the engagement of the ends of the leaf springs 96 with the ends of the recesses 98, it will be clear that the shutters will be progressively less effective to reduce the air flow as the sleeve 84 is raised. The slope of the flaring surface 90 of the sleeve 84 and the dimensions of the bellows 102 are such as to compensate correctly for the reduced density of the air at lower atmospheric pressure, with the ultimate result that irrespective of the pressure drop across the heater, and irrespective of reductions in atmospheric pressure, the air will be supplied to the combustion chamber at a substantially constant gravimetric rate adequate to secure complete combustion of the fuel, which is likewise supplied at a constant rate.

Due to the preloading of the leaf springs 96, the rotor assembly 68 will have to attain a predetermined minimum speed before the shutters commence moving outwardly partially to obstruct the air inlet passageway. For example, the preloading of the springs may be such, relative to the mass of the shutters 92, that outward movement of the shutters will not take place until a speed of 9,000 R. P. M. is attained. By way of further illustration, the springs 96 may be of such dimensions that they will continue to flex outwardly as the speed of rotation increases to 10,500 R. P. M.; at which speed the shutters will have moved outwardly to the maximum extent. Thus, the speed range of the rotor assembly may be relatively limited, thereby to secure accurate regulation of the rate of air flow into the combustion chamber.

It will be noted that all of the air flowing into the combustion chamber flows past the impeller blades, thus improving the response of the apparatus to changes in air flow rate, as compared with structures in which changes in pressure differential across the heater control the opening of a by-pass, or control a flow obstructing valve.

The major portion of the air passing the impeller blades flows through the annular space inside the flange 40 of the baffle 38. The baffle 38 is provided with long narrow arcuate notches along its periphery, so that a limited quantity

of air may flow past the edge of the baffle into the combustion chamber, as indicated by the arrows, and thus increase the turbulence in the combustion chamber.

The shield 64 prevents the entrance of heated gases from the combustion chamber into the atomizing cup 70, and reflects radiant heat from the combustion chamber so that carbonization of the liquid fuel film along the inner wall of the atomizing cup is prevented. Since the shield is connected to the nozzle member by three arms of the spider 66, the rate of heat conduction to the nozzle extension 60 and its sleeve 58, will be relatively low. Thus the end portion 60 and the sleeve 58 remain sufficiently cool to prevent vaporization of the fuel flowing through the passageway 54 and port 56. Likewise, the transmission of excessive heat to the bearing assembly 78 is prevented. The flow of cool air past the outer surface of the atomizing cup 70 keeps the latter from becoming overheated.

Since the tendency of the fuel is to break up into droplets at the rim of the atomizing cup, and, due to centrifugal force, the droplets tend to traverse the annular space through which the majority of combustion air is flowing, a very intimate and uniform mixture of the atomized fuel and air is obtained.

Due to the segmental shape of the shutters 92, and due to the fact that they overlap one another, they are effective, as they are swung radially outwardly, progressively to decrease the effective cross sectional area of the air inlet passageway. Because of their simplified construction and arrangement, the shutters may move independently of one another and thus provide an averaging effect should one of the shutters fail to move outwardly smoothly as the speed increases.

While I have shown and described a particular embodiment of my invention, it will be apparent that numerous variations and modifications thereof may be made without departing from the underlying principles of the invention. I therefore desire, by the following claims, to include within the scope of my invention, all such variations and modifications by which substantially the results of my invention may be obtained through the use of substantially the same or equivalent means.

I claim:

1. In a liquid hydrocarbon fuel burner, the combination of a source for supplying liquid fuel at a substantially constant pressure, a nozzle member having a flow metering outlet port, an atomizing cup of generally conical conformation surrounding said nozzle adjacent said port, antifriction means for mounting said atomizing cup for rotation, means having a passageway to direct flow of air past the outer surface of said atomizing cup, impeller blades located in the path of flow of air, said impeller blades being secured to said atomizing cup to cause rotation thereof upon flow of air, and means rotated with said atomizing cup and operable in response to centrifugal force to decrease the effective size of said passageway, said means being restrained by preloaded resilient means so as to have a limited effective operating range.

2. In a heater adapted for the heating of aircraft in which the pressure and density of the combustion air may vary considerably due to variation in speed and altitude of the aircraft,

the combination of means forming a combustion chamber, an inlet passageway for conducting air for combustion to said combustion chamber, a fuel supply nozzle, an atomizing element mounted for rotation with respect to said nozzle and receiving fuel therefrom, means forming a passageway for conducting combustion air past said atomizing element into said combustion chamber, an impeller in said passageway carried by said atomizing element and operable to rotate the latter at high speed upon flow of air through said passageway, a shutter mechanism carried by said atomizing element and actuated by centrifugal force in a direction to move to a position at least partially closing said passageway, preloaded resilient means to resist movement of said shutter mechanism until the speed of rotation of said atomizing member exceeds a predetermined minimum, and means to supply fuel at a constant rate to said nozzle.

3. The combination set forth in claim 2, in which said shutter mechanism comprises a plurality of segment shaped sheets overlapping one another in normal position and said preloaded resilient means comprises a plurality of leaf springs each operatively connected to one of said shutter sheets resiliently to hold the latter toward the axis of rotation of said atomizing element.

4. In an aircraft heater, the combination of a fixed nozzle member having a spindle portion provided with a discharge port, an atomizing cup mounted for free rotation on said spindle portion, means forming a combustion air conducting passageway around said atomizing cup, a plurality of impeller blades secured to said atomizing cup and extending across said passageway, speed responsive means for decreasing the effective area of said passageway as the speed of rotation of said atomizing cup exceeds a predetermined minimum value, and atmospheric pressure responsive means for increasing the effective area of said passageway as the atmospheric pressure decreases.

5. The combination set forth in claim 4, in which a movable sleeve having a non-uniform diameter bore forms the external wall of said passageway, and in which said atmospheric pressure responsive means comprises aneroid bellows operatively connected to said sleeve for moving the latter upon changes in atmospheric pressure.

6. The combination set forth in claim 4, in which the external wall of a portion of said passageway is formed by a movable sleeve having a varying diameter bore, in which said speed responsive means comprises a plurality of centrifugally operating shutters cooperating with said sleeve to determine the cross sectional area of the passageway through said sleeve, and in which said atmospheric pressure responsive means comprises an aneroid bellows connected to said sleeve for moving the latter upon changes in atmospheric pressure.

7. In a liquid hydrocarbon fuel burner, the combination of a source for supplying liquid fuel at a substantially constant pressure, a nozzle member having a flow metering outlet port, an atomizing cup of generally conical conformation surrounding said nozzle adjacent said port, antifriction means for mounting said atomizing cup for rotation, an air passageway surrounding said cup, a source of air under pressure connected to said passageway, impeller blades located in the path of flow of air, said impeller blades being

secured to said atomizing cup to cause rotation thereof upon flow of air from said source through said passageway, and means conjointly responsive to the atmospheric air pressure and the speed of rotation of the atomizing cup for controlling the flow of air to said passageway.

8. In a heater having a combustion chamber, means forming an annular passageway for conducting air under pressure to said combustion chamber, an atomizing cup having impeller blades in said annular passageway, said atomizing cup being mounted for free rotation, means to supply fuel to the inside of said atomizing cup, means to shield said atomizing cup from the heated gases in said combustion chamber, and a baffle extending across said combustion chamber and having an opening to provide an annular port surrounding the combustion chamber end of said atomizing cup, and having a plurality of openings along its periphery for admitting air for combustion to said combustion chamber.

9. In an aircraft heater, the combination of a nozzle member having a spindle portion provided with a discharge port, an atomizing cup mounted for free rotation on said spindle portion, means forming a combustion air conducting passageway around said atomizing cup, a plurality of impeller blades secured to said atomizing cup and extending across said passageway, and speed responsive means for decreasing the effective area of said passageway as the speed of rotation of said atomizing cup exceeds a predetermined minimum value.

10. In an aircraft heater, the combination of a nozzle member having a spindle portion provided with a discharge port, an atomizing cup

mounted for free rotation on said spindle portion, means forming a combustion air conducting passageway around said atomizing cup, a plurality of impeller blades secured to said atomizing cup and extending across said passageway, and atmospheric pressure responsive means for increasing the effective area of said passageway as the atmospheric pressure decreases.

11. In an aircraft heater, the combination of a nozzle member having a spindle portion provided with a discharge port, an atomizing cup mounted for rotation on said spindle portion, means forming a combustion air conducting passageway, an impeller in said passageway rotated at a speed changing with the rate of mass flow of air through said passageway, a driving connection between said impeller and said atomizing cup to rotate the latter, and means responsive to the speed of rotation of said impeller for decreasing the effective cross sectional area of said passageway as the speed of rotation of said impeller exceeds a predetermined minimum value.

12. In an aircraft heater, the combination of a nozzle member having a spindle portion provided with a discharge port, an atomizing cup mounted for rotation on said spindle portion, means forming a combustion air conducting passageway, an impeller in said passageway rotated at a speed changing with the rate of mass flow of air through said passageway, a driving connection between said impeller and said atomizing cup to rotate the latter, and means to increase the effective cross sectional area of said passageway as the atmospheric pressure decreases.

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