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BURNER FOR LIQUID FUEL

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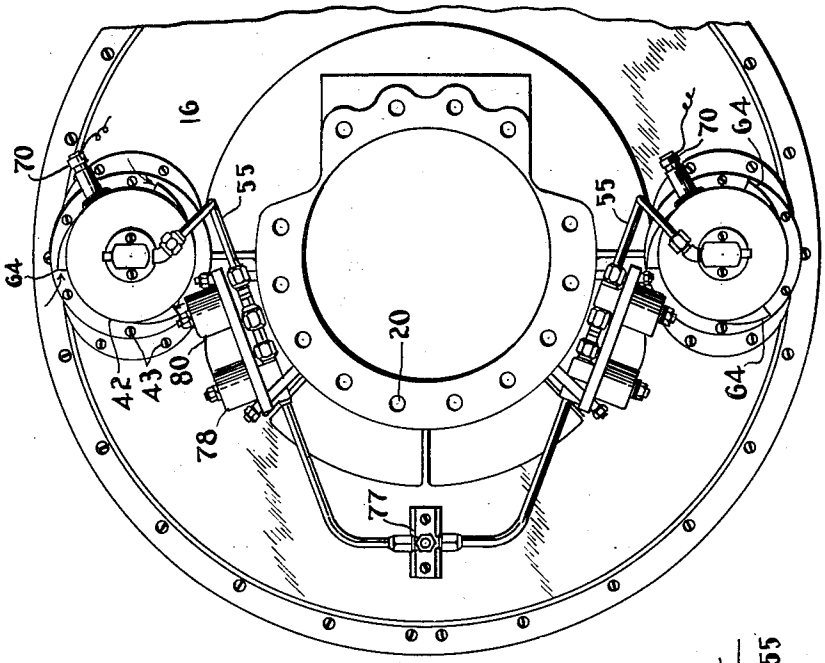


Fig. 2

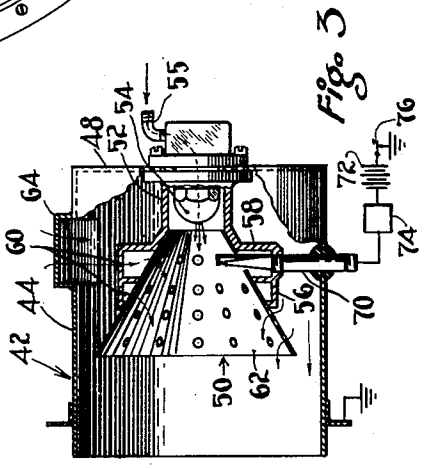


Fig. 3

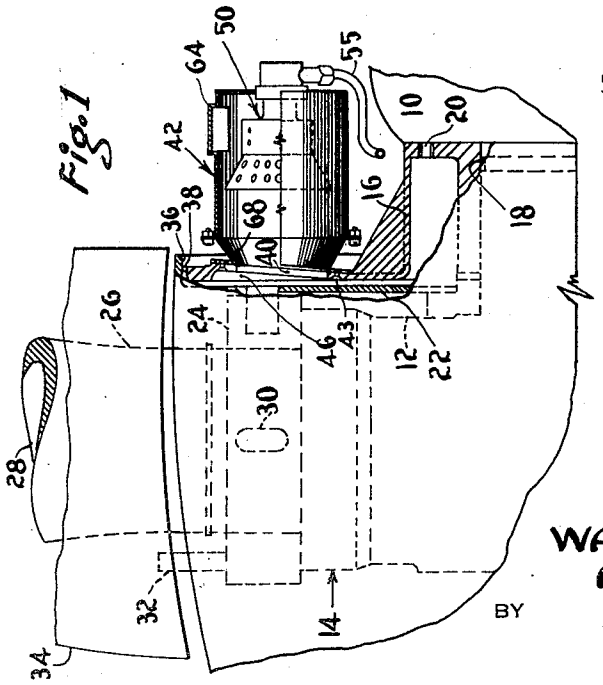


Fig. 1

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BURNER FOR LIQUID FUEL

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1

This invention relates to burners for liquid fuels. The burner of this invention is particularly adapted to produce a large quantity of fully blended gas comprising combustion products, in very small space. It is also adapted to mix the combustion products with additional air so that the mixed air and combustion products provide a hot gas of lower temperature than the combustion products alone.

A burner of this type is suitable for various uses but is particularly adaptable for furnishing hot gas for the deicing of aircraft propellers. While the use of the burner of this invention is not limited to propellers, it is illustrated for use in conjunction with an aircraft propeller. The burner is shown as being directly mounted upon the stationary or non-rotating portion of an aircraft propeller but as part of the propeller assembly. Suitable provisions are made to adjust the temperature of the hot gas generated by the burner and to conduct the temperature-adjusted gas to the rotating portion of the propeller and into the propeller blades, and if desired, into other portions of the propeller assembly which may require heating.

An object of the invention is to provide a compact, safe and efficient direct liquid fuel heater system. A further object of the invention is to provide a combustion heater, specially adapted for use with propellers, wherein a high heat output may be secured from the heater and wherein the combustion products may be controlled to a velocity, temperature and volume appropriate for use with thermal anti-icing systems on propellers and wherein, furthermore, the combustion heater proper is of light weight and small compass to interfere as little as possible with weight and space considerations in a power plant installation, such considerations always being of major importance. Associated objects are to provide a burner which will not be subject to extinguishment at high altitudes, and which may easily be ignited at high altitudes as desired, and to provide a burner which will not present a fire hazard. Another object of the invention is to provide a propeller heating system which can be incorporated in existing types of propellers with minor modifications.

The invention is clearly disclosed in one preferred form in the attached sheet of drawings wherein it will be seen that a combustion heater, fed with fuel and air and provided with ignition means, is secured to a stationary portion of the propeller assembly. The combustion heater is fed with ambient air through one or more tangentially disposed inlet openings, the inducted air being divided to provide a primary air stream to support combustion and a secondary air stream to dilute and cool the combustion products whereby the latter may be led through passageways in the propeller system in large volume at relatively low temperature, and at low velocity, to the hollow propeller blades. Flow of gas through the heater and propeller is ordinarily induced by the centrifugal pumping action of the propeller, the products of combustion finally being exhausted to atmosphere through blade tip openings. One or more combustion heaters may be used in a propeller installation, depending upon the heat requirements to assure adequate propeller de-icing under the most unfavorable flight conditions likely to be encountered.

2

The above brief description is amplified below in connection with a specific description of the figures. The embodiment of the invention chosen for illustration is merely exemplary and is not intended to comprehend all modifications and variations to which the invention may be subjected. The particular features of novelty which characterize the invention will be pointed out in the claims annexed to and forming a part of this specification.

In the drawings, in which similar reference characters designate similar parts, Fig. 1 is a fragmentary side elevation of an aeronautical propeller, showing, partly in section, the combustion heater installation of this invention;

Fig. 2 is a rear elevation of a portion of a propeller showing the features of this invention in their installed position; and

Fig. 3 is an enlarged longitudinal section through a combustion heater of a preferred type.

The nose or driving end of a prime mover or gear box is shown at 10, the latter having extending therefrom a shaft upon which is mounted a propeller hub 12, such shaft and mounting being well known in the art and accordingly not being shown in detail. As part of a propeller assembly 14 of which the hub 12 forms a portion, a non-rotating back plate 16 is provided, the latter usually comprising a housing for a portion of the pitch changing mechanism of the propeller. This plate 16 is piloted as at 18 upon a portion of the propeller hub and is secured against rotation relative to the prime mover 10 as by studs 20. Upon the propeller hub 12 is secured a plate 22 including a plurality of openings, at least one for each propeller blade. A duct 24 embraces each of the several propeller

blades 26, the interior of each duct 24 communicating with a hollow 28 of the associated propeller blade through an appropriate blade opening 30. An arrangement such as that briefly described above is disclosed in greater detail in copending Chillson and Brigham application No. 691,125, filed August 16, 1946, and issued April 8, 1952, as Patent 2,592,118. In addition to the duct work described whereby hot gas may be conducted to hollow propeller blades, the ducts 24 may likewise be provided with conduits 32 leading to hollow blade embracing cuffs 34.

The rotary plate 22 is preferably provided with an annular flange 36 which surrounds the periphery of the stationary plate 16, a rotary seal 38 being provided between the two plates to prevent leakage of hot gas therebetween. The stationary plate 16 is provided with an opening 40, the border of the opening providing a mounting for a combustion heater 42 appropriately secured to the plate as by bolts or screws 43. The combustion heater shown in greater detail in Fig. 3 comprises a metallic drum or shell 44 of cylindrical form, the leftward end as shown being open so that the interior of the drum communicates with the cavity 46 (Fig. 1) formed between the plates 16 and 22. The rightward end 48 of the drum is closed as shown and provides a mounting coaxial with the drum, for a burner assembly 50.

The burner assembly includes a sleeve 52 secured to the drum end 48 and embracing a fuel nozzle 54, the latter being fed by means of a tube 55 with gasoline or other appropriate fuel. The burner assembly also includes a pair of jackets 56 and 58, preferably formed integrally with the sleeve 52, said jackets having openings such as 60 to receive air which enters the drum 44. Fitted within these jackets and secured adjacent the sleeve 52 is a perforate combustion cone 62, some of whose perforations match and communicate with portions of the chambers formed within the jackets 56 and 58. The diameter of the large end of the cone 62 is less than the diameter of the inside of the drum 44, leaving an annular space between the cone edge and the drum through which air may flow.

Close to the rear end of the drum 44 are disposed one or more tangential air louvres 64, also shown in Figs. 1 and 3, so that air may enter the drum tangentially to flow in a rotating swirl within the drum. The jackets 56 and 58 comprise an ignition housing in conjunction with the cone 62, by which the velocity of entering air is reduced, first by flowing through the small holes 60 into the jackets, and then by passing through the holes in the cone 62. This ignition air mixes with fuel sprayed from the nozzle 54, and is ignited, whereupon the mixture burns and propagates and spreads out within the cone 62. After this ignition, part of the swirling excess air outside of the jackets 56 and 58 passes through the holes in the larger end of the cone 62, retaining part of its turbulent swirl, to complete fuel combustion in a very small space. The temperature of the burning gases within the cone 62 will be of the order of 2000° F. This temperature is much too great to apply directly to the propeller ducting system and also is too great for contact with the burner shell 44. The remaining air entering through the inlet 64 whirls within the drum and passes leftwardly in a helical path as indicated in Fig. 3 around the edge of the cone, first to provide a layer of cool air to insulate the shell 44, and then to mix with and dilute the combustion gases. The air twisting around the end of cone 62 mixes with combustion gases. Dilution of the combustion gases by ambient air decreases the temperature and velocity of the mixed gases to a level which is appropriate for propeller de-icing.

The burner construction described allows of the entry of sufficient ambient air in a series of streams of increasing velocity to enable, first, fuel ignition, then, complete fuel burning and third dilution of the mixture, the diluting air sweeping a helical path within the burner at fairly high velocity to create high turbulence. This turbulence assists in the mixture of the hot and ambient gases downstream of the burner cone, the helical flow then changing to a slower axial flow at the burner outlet. Thus the velocity of the hot diluted gas into the propeller will be moderate—a desirable feature to avoid erosive effects upon the mechanism. The diluted combustion products pass from the leftward end of the burner as shown into the propeller ducting system previously described. If desired, a convergent outlet nozzle may be provided for the burner as shown at 68 in Fig. 1 to improve the mixing of ambient air and combustion products within the burner. The low velocity of air entering the combustion cone through jackets 56 and 58 assists burner starting at all altitudes where propeller icing may be encountered, and also is important in reducing the tendency of the burner fire to extinguish when oxygen supply may become marginal at high altitudes. Low velocity air is desirable for mixture with fuel sprayed from the nozzle 54 to enable positive ignition of the fuel-air mixture. After ignition, additional air is fed to enable complete combustion of the ignited fuel-air mixture substantially within the cone 58, the air up to this point being at a rate to make a substantially stoichiometric mixture with the fuel. If all combustion and diluting air were fed to the cone near the fuel nozzle, ignition would be difficult due to the high velocity and the cooling effect of the large mass of air, and burner blow-out would be a probability. Consequently, only enough air for combustion is fed to the burner first, at low velocity, to assure ignition and burning of the mixture. Then, as a separate step, the excess cooling and diluting air is added at the open end of the cone to cool the combustion gas to a temperature tolerable to the propeller structure yet high enough for de-icing purposes. This extra air also decelerates the hot gas by cooling, the initial combustion air having been accelerated by its burning with the fuel.

The burner as described is provided with an ignition system as represented by a spark or glow plug 70 secured in the jacket 52 and passing into the interior of the cone 62. Such plug may be energized in the usual manner by a power source 72, a coil 74 if necessary, and a control switch 76.

Referring briefly to Fig. 2, two combustion burners 42 are shown disposed substantially symmetrically on opposite sides of the axis of the propeller, these heaters being fed from a common fuel source through a fitting 77, the fuel source normally being disposed in a stationary portion of the aircraft with which the propeller is associated and including a pump to feed the fuel under pressure to the nozzle 54. Fig. 2 likewise shows a solenoid valve arrangement in each fuel feed line 55 leading from the fitting 77. One solenoid 78 operates a restricted fuel valve in the line 55 for mixture control, while the other

solenoid 80 operates as an on-off valve. Thereby the solenoids 78 and 80 may be energized selectively to yield operating conditions with no fuel flow, partial flow, and full flow. Alternatively, the solenoids and ignition systems may be so arranged in a fashion well known in the prior art so that the ignition system may be cut off when the burner becomes hot and when self-ignition can be produced by the operating burner. Also, various safety features may be incorporated in the system to cut off fuel should a burner blowout occur, and to shut down the burner system in case of malfunctioning of any relevant portion of the fuel, ignition, or propeller components.

Essentially, the invention above described comprehends improvements in burner design for use with propellers, as well as the incorporation of direct fired burners on a portion of the propeller assembly. The invention thus distinguishes over previous systems where extensive duct work is required to conduct heat from an available source in the aircraft to the propeller with consequent increases in weight and complexity of installation.

An advantage flows from the use of direct combustion heaters on a propeller in that the propeller may be heated at will without dependence upon the operating condition of a power plant when used as a heat source or from a separate burner installation which may be used for sundry other purposes such as heating the airplane proper. It may further be noted that induction of air into the burner system herein described is afforded if desired by the rotation of the propeller proper. The burner installation is intended to be used with hollow propeller blades wherein a vent hole is provided in the tip of each propeller blade. The propeller blade in operation acts as a centrifugal pump, pumping air longitudinally through the blade from its root toward its tip. The burner air intakes 64 are open to provide air to the burner at slightly less than ambient pressure due to the forced induction caused by the centrifugal pumping action of the propeller blades. Alternatively, air feed to the burner may be by a ram system, and the hot deicing gas may be bled from the blades by other means than blade tip vents.

By the stationary mounting of the burners as part of the propeller assembly, rotating fuel seals are avoided since the fuel nozzles 54 of the burners may be supplied with fuel from the fixed fuel conduits such as 55 which may be led, with quick detachable connections interposed, to a fuel source carried on the aircraft. The connector 77 shown in Fig. 2 for instance may be a quick detachable connection so that the propeller in its entirety, and with the heaters installed, may be removed bodily from the aircraft power plant after separation of the connection 77 and of the ignition wires to the burners which themselves may be separable through quick disconnect plugs mounted adjacent the engine nose.

Though but a single embodiment illustrating the invention has been illustrated and described, it is to be understood that the invention may be applied in various forms. Changes may be made in the arrangements shown without departing from the spirit or scope of the invention as will be apparent to those skilled in the art and reference should be made to the appended claims for a definition of the limits of the invention.

What is claimed is:

1. A liquid fuel burner comprising a substantially cylindrical shell closed at one end and delivering combustion products from the other, having a coaxial fuel nozzle in the closed end and a tangential air entry in the shell near said closed end, a perforated wide-angle combustion cone secured within and coaxial with the shell, the outside of said cone and the inside of said shell defining therebetween an air swirl chamber, the large end of said cone facing away from said closed end, and the edge of the large cone end defining with the shell an annular air passage through which part of the swirling air passes, and means including the cone perforations for feeding a part of said swirling air in said chamber through the cone perforations at the small end of the cone near said shell closed end, and means for feeding another part of the air through the cone perforations at a larger diameter part of said cone, both said means for feeding including hollow annular jackets embracing and secured to the cone, having openings therein connecting said swirl chamber with some of the cone perforations.

2. A liquid fuel burner comprising a substantially cylindrical shell closed at one end and delivering combustion products from the other, having a coaxial fuel nozzle in the closed end and a tangential air entry in the shell near said closed end, a perforated wide-angle combustion cone secured within and coaxial with the shell, the outside of said cone and the inside of said shell defining therebetween an air swirl chamber, the large end of said cone facing away from said closed end, and the edge of the large cone end defining with the shell an annular air passage through which part of the swirling air passes, and means including the cone perforations for feeding a part of said swirling air in said chamber through the cone perforation at the small end of the cone near said shell closed end, and means for feeding another part of the air through the cone perforations at a larger diameter part of said cone, both said means for feeding including a plurality of separate hollow annular jackets of different size, axially spaced and embracing and secured to the cone, said jackets having openings connecting said swirl chamber with part of the cone perforations.

3. A liquid fuel burner comprising a substantially cylindrical shell, closed at one end, having a tangential air entrance toward the closed end thereof to impose a swirling motion upon air admitted to the shell, a sleeve within and concentric with said shell, secured to the shell closure, comprising a nozzle receptacle adjacent said closure and comprising a plurality of axially spaced annular hollow jackets, a fuel nozzle in said receptacle, said sleeve having openings in its exterior to admit air to said jackets, a wide-angle perforate combustion cone fitted to and carried by said sleeve with its small end near said nozzle, part of the perforations of said cone registering with said jackets to admit air therefrom to the interior of said cone to support combustion of fuel fed through said nozzle, said sleeve and cone openings being of small and a large collective areas respectively to yield a slow flow of air to the cone from the jacket nearest the nozzle and an increased flow of air from the jacket farther from the nozzle, said cone having perforations free of said jackets of collectively large area, toward its larger open end, to pass air directly from the exterior of said cone to the interior thereof, and the edge of the large end of said cone defining with the interior of said shell an annular passage of still larger area for the swirl-

ing passage of air from said air entrance, for diluting the combustion products flowing from said cone upon ignition of fuel and air therein.

4. A liquid fuel burner particularly adapted for aircraft utilization comprising a substantially cylindrical casing having a tangential air entrance thereto toward an end of the casing, that end being closed, a member secured to and concentric with the casing closure having a central opening, a fuel nozzle disposed in said opening, said member comprising a portion flared outwardly and including tandem hollow air jackets, said jackets having peripheral openings for passage of air thereto from said casing, a perforate cone seated in said member having its small end adjacent said nozzle opening and its large end close to said casing and defining therewith an annular air passage to pass part of the air from the air entrance directly to a downstream part of said casing, said cone perforations being disposed to register with the jackets of said member whereby part of the air from said air entrance passes into said jackets and passes therefrom through said perforations to mix with fuel issued from said nozzle.

5. A liquid fuel burner particularly adapted for aircraft utilization comprising a substantially cylindrical casing having a tangential air entrance thereto toward an end of the casing, that end being closed, a member secured to and concentric with the casing closure having a central opening, a fuel nozzle disposed in said opening, said member comprising a portion flared outwardly and including tandem hollow air jackets, said jackets having peripheral openings for passage of air thereto from said casing, a perforate cone seated in said member having its small end

adjacent said nozzle opening and its large end close to said casing and defining therewith an annular air passage to pass part of the air from the air entrance directly to a downstream part of said casing, said cone perforations being disposed to register with the jackets of said member whereby part of the air from said air entrance passes into said jackets and passes therefrom through said perforations to mix with fuel issued from said nozzle, said jacket peripheral openings being of a size to pass casing air at relatively low velocity to the interior of said cone while higher velocity casing air passes through the annular air passage around said cone.

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