

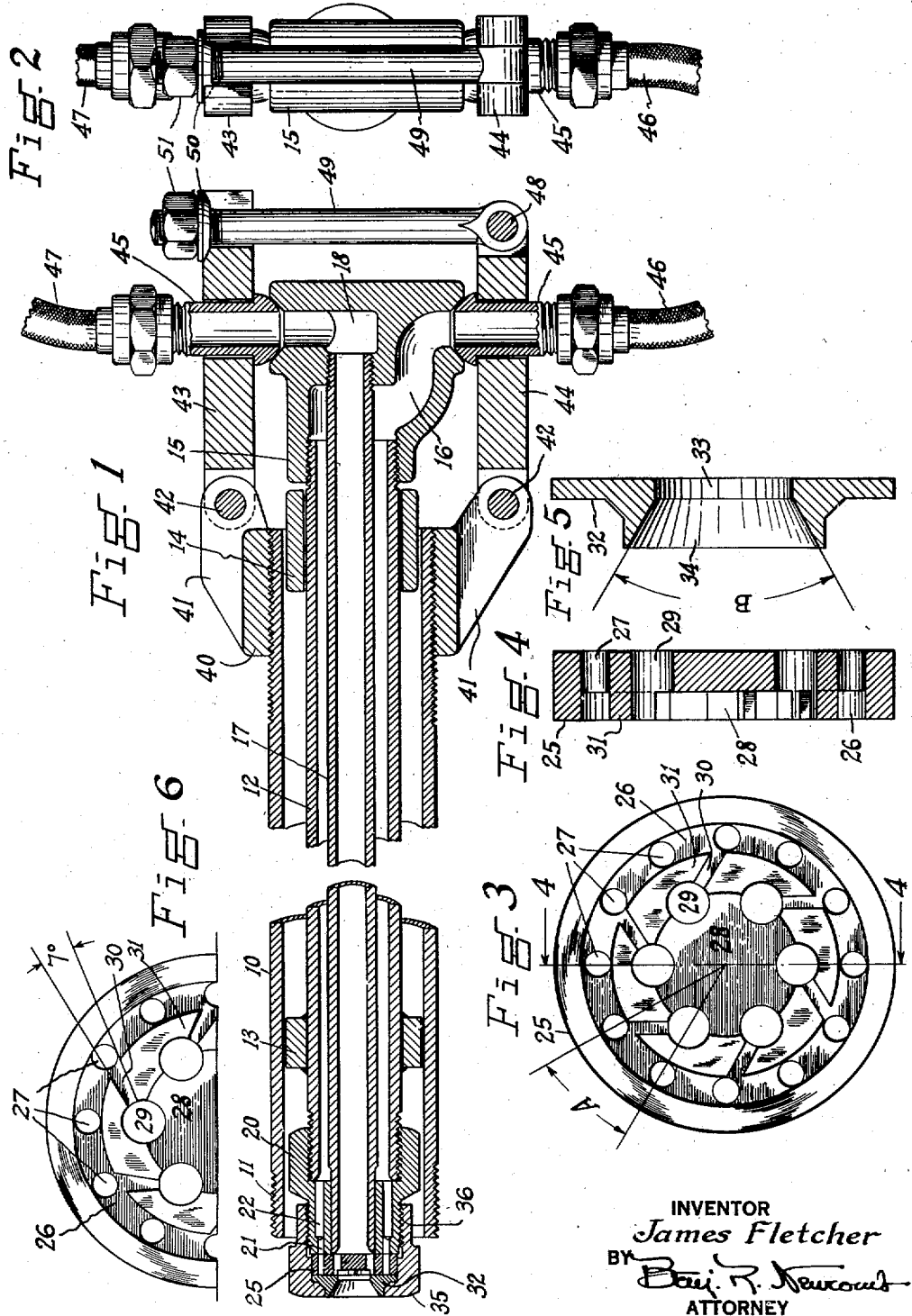
Nov. 6, 1934.

J. FLETCHER

1,980,132

LIQUID FUEL BURNER

Filed Dec. 6, 1932



INVENTOR
James Fletcher
BY *Paul R. Newcomb*
ATTORNEY

UNITED STATES PATENT OFFICE

1,980,132

LIQUID FUEL BURNER

James Fletcher, Akron, Ohio, assignor to The
Babcock & Wilcox Company, Newark, N. J., a
corporation of New Jersey

Application December 6, 1932, Serial No. 645,916

19 Claims. (Cl. 299—140)

My present invention relates to the construction and operation of liquid fuel burners, and particularly to liquid fuel burners in which the liquid fuel is atomized by a high pressure atomizing fluid. My improved fuel burner is especially adapted for burning low grade fuels, such as the heavy residual oils, tar, pitch, and acid sludge found in modern petroleum refineries. With such fuels, the problem of maintaining the burner in an operative condition is more complex than with higher grade liquid fuels, due to the increased tendency of the burner passages to be clogged by carbon and waste deposits.

The general object of my invention is the provision of a liquid fuel burner capable of effectively atomizing liquid fuel and maintaining desirable flame conditions over a wide range of fuel capacities. More particularly, the object of my invention is the provision of a liquid fuel burner capable of efficiently atomizing and burning low grade fuels of the character described over a wide range of fuel capacities. A further object is the provision of a liquid fuel burner in which low grade liquid fuels can be burned with a minimum of waste and carbon deposits in the fuel passages.

The various features of novelty which characterize my invention are pointed out with particularity in the claims annexed to and forming a part of this specification. For a better understanding of the invention, its operating advantages and specific objects attained by its use, reference should be had to the accompanying drawing and descriptive matter in which I have illustrated and described preferred embodiments of my invention.

Of the drawing:

Fig. 1 is a sectional elevation of one embodiment of my invention, certain parts being omitted or broken away for purposes of clarity;

Fig. 2 is an end view of the fuel burner illustrated in Fig. 1;

Fig. 3 is a front view on an enlarged scale of the sprayer plate shown in Fig. 1;

Fig. 4 is a section on the line 4—4 of Fig. 3;

Fig. 5 is a sectional elevation on an enlarged scale of the nozzle shown in Fig. 1; and

Fig. 6 is a partial view similar to Fig. 3 illustrating a modified form of sprayer plate.

The liquid fuel burner unit illustrated in Figs. 1 to 5 of the drawing comprises a tubular outer casing or distance piece 10 which in use is ordinarily slidably mounted on a stationary supporting structure. The forward end of the casing is threaded, as indicated at 11, for supporting a

suitable impeller (not shown) which directs a flow of combustion-supporting air relative to the discharge end of the burner, the impeller being advantageously positioned and the burner mounted substantially as shown in the prior Patent No. 1,602,180 to T. B. Stillman, granted Oct. 5, 1926. The fuel burner proper is slidably mounted in the casing 10, and consists of a barrel 12 extending axially within the casing 10 and spaced therefrom by longitudinally spaced centering collars 13 and 14. The rear end of the barrel 12 extends beyond the rear end of the collar 14 and is threaded into a body member 15, formed with a passage 16 therein connected to a suitable source of atomizing fluid, as hereinafter described. While various atomizing fluids may be used to advantage, steam is the most economical, and that term is generically used hereinafter to include any suitable atomizing fluid. Within and extending axially beyond the ends of the barrel 12 is a pipe 17 serving as the liquid fuel conduit of the burner. The rear end of the pipe 17 extends across the passage 16 and is connected with a separate passage 18 in the body member, the passage 18 being connected to a suitable source of liquid fuel, as hereinafter described.

The forward or discharge end of the burner is formed by a discharge head including a sprayer head 20 having its forward portion closely fitting around the slightly reduced forward end of the pipe 17 and a rear portion abutting and threaded on the forward end of the barrel 12. The forward end of the sprayer head has an annular recess 21 connected to the annular steam supply passage surrounding the fuel pipe 17 by a series of parallel passages 22 symmetrically arranged about the axis of the sprayer head. As illustrated in Fig. 1 the forward end of the sprayer head is co-extensive with the forward end of the pipe 17.

The discharge head also includes a sprayer plate 25 through which the steam is brought into atomizing relation with the liquid fuel. As shown in Figs. 1, 3 and 4, the sprayer plate has an annular recess 26 formed in its forward face in alignment with the recess 21 of the sprayer head and connected thereto by a series of symmetrically spaced ports or passages 27 arranged parallel to the axis of the sprayer plate. The central portion of the forward face of the sprayer plate is also counterbored to form a mixing chamber 28. The supply of liquid is delivered to the mixing chamber from the pipe 17 through a series of ports or passages 29 extending parallel to the axis of the sprayer plate and having their centers symmetrically spaced on the circumference of

the mixing chamber. The number of ports 27 provided is advantageously greater than the number of ports 29 to insure an adequate supply of steam to the recess 26 and a minimum steam pressure drop through the burner. The steam chamber or recess 26 is connected to the mixing chamber 28 by a series of steam discharge slots or nozzles 30 formed in the substantially annular wall 31 between the two chambers. Each discharge slot is arranged to extend radially from the periphery of a corresponding port 29 to the recess 26, opening thereto adjacent the point of entrance of a corresponding port 27. The slots 30 are all similarly angularly arranged relative to the circumference of the mixing chamber 28, the center line of each extending within but adjacent to the circumference of the mixing chamber. When so proportioned and the centers of the ports 27 at twice the distance of the ports 29 from the center of the mixing chamber, the angle A between the radii from the center of the mixing chamber through the centers of each port 29 and the corresponding port 27, will be approximately 28°. The slots 30 are preferably of rectangular cross-section with a width about half the diameter of the ports 29 and with their bottoms in the same plane as the bottoms of the recess 26 and mixing chamber 28.

The discharge head also includes a nozzle member 32 of substantially the same diameter as the sprayer plate 25, and having a plane rear surface abutting the forward side of the sprayer plate and defining the forward side of the steam chamber 28 and discharge slots 30. The machining operations required are thus mainly confined to the sprayer plate. As shown in Figs. 1 and 5, the nozzle has an axial discharge passage divided into a rear portion 33 aligned with the periphery and forming a continuation of the mixing chamber 28 and a forward conical portion 34 diverging from the forward end of the rear portion 33. I have found that the best flame conditions for a wide range of fuel capacities is obtained with a sprayer plate of the character described in conjunction with a nozzle of the character described having an included angle B of approximately 55°. The circumferential inner forward portion of the nozzle 32 is cut away to provide a seat for a cap member 35 which fits around the nozzle and sprayer plate and holds them in their intended positions relative to the sprayer head 20 and pipe 17. The rear end of the cap member 35 is internally threaded at 36 for engagement with the externally threaded forward portion of the sprayer head. When acid sludge is used as the fuel, the burner parts normally contacted thereby are preferably made of suitable acid-resistant alloys.

Periodic inspection and/or cleaning of the fuel burner is desirable and the present construction permits the retraction of the burner parts positioned within the casing 10 without disturbing the position of the latter. For this reason the steam and liquid fuel supply connections to the body member 15 are advantageously flexible and readily detachable from the body member. As shown in Figs. 1 and 2, the rear end of the casing 10 is externally threaded for engagement by an adjustable collar 40 having pairs of wings 41 on opposite sides thereof carrying pivot pins 42 for upper and lower clamp arms 43 and 44, respectively. The portions of the body member 15 at the rear ends of the passages 16 and 18 are beveled as indicated in Fig. 1 to receive the rounded ends of ball joint nipples 45 carried in the clamp arms 43 and 44. The nipples 45 are

threaded at their other end to provide a connection to flexible steam and liquid fuel supply lines 46 and 47, respectively. The free end of the clamp arm 44 carries a pivot pin 48 on which a clamp bolt 49 is mounted. The upper end of the clamp bolt is adapted to be received in the forked free end of the clamp arm 43 and is ordinarily held in that position by a washer 50 and clamp nut 51.

With the supply connections in their operating position, as shown in Fig. 1, inspection and/or cleaning of the burner parts is easily effected after the supplies of steam and liquid fuel have been cut off, by loosening the clamp nut 51 and swinging the clamp bolt out of engagement with the clamp arm 43. The clamp arms 43 and 44 may then be swung out of position carrying therewith the nipples 45. The burner parts within the casing 10 may then be withdrawn without disturbing the position of the latter.

In operation with a fuel burner constructed as described, the liquid fuel, preferably preheated to decrease its viscosity and under a variable pressure, is delivered from the supply connection 47 through the passage 18 and the pipe 17 to the ports 29, the end of the pipe 17 being chambered to render the full area of the fuel ports effective. The straight fuel passages and avoidance of pockets therein will minimize the pressure drop and the deposit of material in the fuel passages. Steam, preferably at a pressure from 70 to 100 lbs. per sq. in. higher than the liquid fuel pressure, is delivered from the supply connection 46 through the passage 16 and barrel 12 to the ports 22 and annular recess 21 from which the steam is distributed to the steam ports 27 and annular chamber 26. The use of the annular port connecting recesses 21 and 26 insures an adequate supply of steam and substantially uniform distribution thereof to all of the steam discharge slots 30, with only a relatively low steam pressure drop through the burner. The liquid fuel during its passage to the point of atomization is thus surrounded by the atomizing fluid. This is particularly advantageous with low grade fuels as the discharge head of the burner is normally exposed to the radiant heat of the furnace and the high temperatures to which the discharge head would normally be heated tend to cause cracking of the liquid fuel and carbon deposits in the passages 29. By the present arrangement, the burner parts between the furnace and the passages 29 are continuously cooled by the steam and carbon deposits therein minimized.

The described arrangement of the steam discharge slots and fuel ports relative to the mixing chamber 28 has been found to be particularly effective in attaining the desired flame conditions. As the jet of fuel issues from each port 29, it is immediately swept up by the corresponding high velocity blast of steam cutting directly across the end of the fuel port. The force of the expanding steam effects a complete atomization of the issuing fuel. The several streams of the fuel and steam mixture entering the mixing chamber 28 at circumferentially spaced points have a whirling movement in the same direction about the periphery of the mixing chamber, insuring an intimate mixture of all of the fuel and steam particles. The whirling mass of steam and fuel particles passes out through the nozzle with practically no pressure drop therein in a conical spray having a spray angle normally less than 90°.

I have found that with a single sprayer plate and nozzle constructed and arranged as described, excellent atomization of 5° Baumé oil could be

obtained for all capacities from 500 to 3500 lbs. of oil per hour, the flame at all capacities being short, bright and sparkless. The changes in capacity were effected by varying the steam and liquid fuel pressures, the pressure differential between the steam and fuel being maintained within the range noted heretofore. With a lesser pressure differential, sparking tends to occur, indicating incomplete atomization, and with a greater differential, the flame tends to be blown away from the burner tip. No smoky or cloudy condition in the flame was observed, indicating that the fuel was not being blanketed by the steam and thus kept from freely combining with the combustion supporting air.

Substantially the same results were obtained with the modified form of sprayer plate illustrated in Fig. 6. That construction is identical with the sprayer plate construction heretofore described, except that the steam discharge slots in Fig. 6 have a 7° taper towards their discharge ends to somewhat reduce the steam pressure drop through the slots.

While in accordance with the provisions of the statutes I have illustrated and described herein the best forms of my invention now known to me, those skilled in the art will understand that changes may be made in the form of the liquid fuel burner disclosed without departing from the spirit of the invention covered by my claims, and that certain features of my invention may sometimes be used to advantage without a corresponding use of other features.

I claim:

1. A steam atomizing liquid fuel burner comprising a liquid fuel conduit, a discharge head at the discharge end of said conduit and including a circular mixing chamber, a series of ports connecting said liquid fuel conduit and said mixing chamber and having their centers symmetrically spaced on the circumference of said mixing chamber, a series of steam discharge slots terminating adjacent the bottom of said mixing chamber, each of said slots terminating adjacent to the periphery of one of said ports and arranged to provide a steam discharge across said port into said mixing chamber, and a discharge passage forming an unrestricted continuation of said mixing chamber.

2. A steam atomizing liquid fuel burner comprising a liquid fuel conduit, a discharge head at the discharge end of said conduit and including a circular mixing chamber, a series of ports connecting said liquid fuel conduit and said mixing chamber and having their centers symmetrically spaced on the circumference of said mixing chamber, a series of steam discharge slots, each of said slots terminating adjacent to the periphery of one of said ports and angularly arranged relative to the circumference of said mixing chamber sufficiently to provide a discharge across said port and within and adjacent to the circumference of said mixing chamber, and a discharge passage forming an unrestricted continuation of said mixing chamber.

3. A steam atomizing liquid fuel burner comprising an axial liquid fuel supply conduit, a concentric steam supply conduit, a discharge head at the discharge end of said conduits and including a circular mixing chamber centrally thereof, a series of ports connecting said liquid fuel conduit and mixing chamber and having their centers symmetrically spaced on the circumference of said mixing chamber, a series of steam discharge slots connected to said steam

conduit, each of said slots terminating adjacent the periphery of one of said ports and angularly arranged relative to the circumference of said mixing chamber sufficiently to provide a discharge across said port and within and adjacent to the circumference of said mixing chamber, and an axial flaring discharge passage forming an unrestricted continuation of said mixing chamber.

4. A steam atomizing liquid fuel burner comprising a liquid fuel supply conduit extending axially of said burner, a steam supply conduit, a separable sprayer plate at the discharge end of said conduits and having a central circular mixing chamber, a series of ports connecting said liquid fuel conduit and said mixing chamber and symmetrically spaced about the circumference of said mixing chamber, a series of steam discharge slots in the forward face of said sprayer plate, each of said slots terminating adjacent to the periphery of one of said ports and arranged to provide a steam discharge across said port into said mixing chamber, and a nozzle contacting with the forward face of said sprayer plate and having an axial discharge passage forming an unrestricted continuation of said mixing chamber.

5. A steam atomizing liquid fuel burner comprising a liquid fuel supply conduit extending axially of said burner, a steam supply conduit, a sprayer plate at the discharge end of said conduits and having a central circular mixing chamber, a series of ports connecting said liquid fuel conduit and said mixing chamber and having their centers symmetrically spaced on the circumference of said mixing chamber, a series of steam discharge slots in the forward face of said sprayer plate, each of said slots terminating adjacent to the periphery of one of said ports and angularly arranged relative to the circumference of said mixing chamber sufficiently to provide a steam discharge across said port and within and adjacent to the circumference of said mixing chamber, and a nozzle contacting with the forward face of said sprayer plate and having an axial discharge passage forming an unrestricted continuation of said mixing chamber.

6. A steam atomizing liquid fuel burner comprising a liquid fuel supply conduit extending axially of said burner, a steam supply conduit surrounding said liquid fuel conduit, a sprayer plate at the discharge end of said conduits and having an outer series of ports opening into said steam conduit, a central circular mixing chamber, an inner series of ports connecting said liquid fuel conduit and said mixing chamber and having their centers symmetrically spaced on the circumference of said mixing chamber, a series of steam discharge slots extending between said inner and outer series of ports, each of said slots extending from the periphery of one of said inner ports to an outer port angularly spaced therefrom sufficiently to provide a steam discharge across said inner port and within and adjacent to the circumference of said mixing chamber, and a nozzle contacting with the forward face of said sprayer plate and having an axial discharge passage forming an unrestricted continuation of said mixing chamber.

7. A steam atomizing liquid fuel burner comprising a liquid fuel supply conduit extending axially of said burner, a steam supply conduit surrounding said liquid fuel conduit, a sprayer plate at the discharge end of said conduits and having an outer series of ports opening into

said steam conduit, a central circular mixing chamber, an inner series of ports connecting said liquid fuel conduit and said mixing chamber and having their centers symmetrically spaced on the circumference of said mixing chamber, a series of steam discharge slots in the forward face of said sprayer plate and extending between said inner and outer series of ports, each of said slots extending from the periphery of one of said inner ports to an outer port angularly spaced therefrom sufficiently to provide a steam discharge across said inner port and within and adjacent to the circumference of said mixing chamber, and a nozzle contacting with the forward face of said sprayer plate and having an axial discharge passage with a rear portion forming an unrestricted continuation of said mixing chamber and a forward flaring portion.

8. A steam atomizing liquid fuel burner comprising a liquid fuel supply conduit extending axially of said burner, a steam supply conduit surrounding said liquid fuel conduit, a sprayer head mounted on the inner end of said steam conduit and having a series of ports opening into said steam conduit, a sprayer plate at the inner end of said sprayer head and having an outer series of ports receiving steam from said sprayer head ports, a central circular mixing chamber, an inner series of ports connecting said liquid fuel conduit and said mixing chamber and having their centers symmetrically spaced on the circumference of said mixing chamber, a series of steam discharge slots in the forward face of said sprayer plate and extending between said inner and outer series of ports, each of said slots extending from the periphery of one of said inner ports to an outer port angularly spaced therefrom sufficiently to provide a steam discharge across said inner port and within and adjacent to the circumference of said mixing chamber, a nozzle contacting with the forward face of said sprayer plate and having an axial discharge passage with a rear portion forming an unrestricted continuation of said mixing chamber and a forward flaring portion, and a cap member removably mounted on said sprayer head and holding said sprayer plate and nozzle in position.

9. A sprayer plate for liquid fuel burners having a central circular mixing chamber formed therein, a series of ports symmetrically spaced about the circumference of said chamber, and a plurality of discharge slots formed therein, each of said slots extending substantially transversely to one of said ports to provide a discharge directly across said port.

10. A sprayer plate for liquid fuel burners comprising a counterbored portion forming a central circular mixing chamber in one face thereof, a series of ports symmetrically spaced about the circumference of said chamber, and a plurality of discharge slots formed therein, each of said slots extending from the periphery of one of said ports and arranged to provide a discharge therefrom across said port and within the circumference of said mixing chamber.

11. A sprayer plate for liquid fuel burners comprising a counterbored portion forming a central circular mixing chamber in one face thereof, a series of ports having their centers symmetrically spaced on the circumference of said chamber, and a plurality of discharge slots formed in the mixing chamber face, each of said slots extending from the periphery of one of said ports and angularly arranged relative to the circumference of said chamber sufficiently to provide

a discharge therefrom across said port within and adjacent to the circumference of said mixing chamber.

12. A sprayer plate for liquid fuel burners comprising a counterbored portion forming a central circular mixing chamber in one face thereof, an inner series of ports having their centers symmetrically spaced on the circumference of said chamber, an outer series of ports concentric with said inner series, and a plurality of discharge slots formed in the mixing chamber face of said plate and extending between said inner and outer series of ports, each of said slots extending from the periphery of one of said inner ports to one of said outer ports.

13. A sprayer plate for liquid fuel burners comprising a counterbored portion forming a central circular mixing chamber in one face thereof, an inner series of ports having their centers symmetrically spaced on the circumference of said chamber, an outer series of ports concentric with said inner series, and a plurality of discharge slots formed in the mixing chamber face of said plate and extending between said inner and outer series of ports, each of said slots extending from the periphery of one of said inner ports to an outer port angularly spaced therefrom sufficiently to provide a discharge therefrom across said inner port and within and adjacent to the circumference of said mixing chamber.

14. A sprayer plate for liquid fuel burners comprising a counterbored portion forming a central circular mixing chamber in one face thereof, a series of ports having their centers symmetrically spaced on the circumference of said chamber, an annular recess formed on said face and surrounding said series of ports, and a plurality of discharge slots formed in said face and extending between said series of ports and said annular recess, each of said slots extending from the periphery of one of said inner ports to said recess and angularly arranged relative to said circumference sufficiently to provide a discharge therefrom across said port and within and adjacent to the circumference of said mixing chamber.

15. A sprayer plate for liquid fuel burners comprising a counterbored portion forming a central circular mixing chamber in one face thereof, an inner series of ports having their centers symmetrically spaced on the circumference of said chamber, an outer series of ports concentric with said inner series, and a plurality of discharge slots of inwardly decreasing cross-sectional area formed in the mixing chamber face of said plate and extending between said inner and outer series of ports, each of said slots extending from the periphery of one of said inner ports to an outer port angularly spaced therefrom sufficiently to provide a discharge therefrom across said inner port and within and adjacent to the circumference of said mixing chamber.

16. A steam atomizing liquid fuel burner comprising a discharge head having a discharge opening and a mixing chamber of substantially circular cross-section communicating with said discharge opening, a series of liquid fuel ports opening through the bottom of said mixing chamber at points symmetrically spaced relative and adjacent to the circumferential wall of said mixing chamber, a series of discharge slots symmetrically arranged relative to said mixing chamber and having their discharge ends opening thereto in substantially the plane of said

- mixing chamber bottom, each slot being arranged substantially tangential to said mixing chamber and terminating adjacent to and directed across the discharge end of a corresponding fuel port, means for supplying a liquid fuel under pressure to said liquid fuel ports, and means for supplying steam at a substantially higher pressure than said liquid fuel to said discharge slots.
- 10 17. A steam atomizing liquid fuel burner comprising a discharge head having a central discharge opening and a central mixing chamber of substantially circular cross-section communicating with and symmetrically arranged relative to said discharge opening, a series of liquid fuel ports opening through the bottom of said mixing chamber at points symmetrically spaced relative and adjacent to the circumferential wall of said mixing chamber, a series of discharge slots symmetrically arranged relative to the circumference of said mixing chamber and having their discharge ends opening through the circumferential wall of said mixing chamber with the bottoms of said slots arranged in substantially the plane of said mixing chamber bottom, each slot being arranged substantially tangential to said mixing chamber and terminating adjacent to and directed across the discharge ends of a corresponding fuel port, means for supplying a liquid fuel under pressure to said liquid fuel ports, and means for supplying steam at a substantially higher pressure than said liquid fuel to said discharge slots.
18. A sprayer plate for liquid fuel burners having formed therein a central chamber of substantially circular cross-section, a series of liquid fuel ports opening through the bottom of said chamber at points adjacent to the circumferential wall of said chamber, and a series of discharge slots arranged about the circumference of said chamber and having their discharge ends opening thereto in substantially the plane of said chamber bottom, each slot being arranged substantially tangential to said chamber and terminating adjacent to and directed across the discharge end of a corresponding fuel port.
19. A sprayer plate for liquid fuel burners having a central mixing chamber of substantially circular cross-section formed in one face thereof, a series of liquid fuel ports opening through the bottom of said mixing chamber at points symmetrically spaced relative and adjacent to the circumferential wall of said mixing chamber, and a series of discharge slots formed in said mixing chamber face and symmetrically arranged about the circumference of said mixing chamber and having their discharge ends opening through the circumferential wall of said mixing chamber with the bottoms of said slots arranged in substantially the plane of said mixing chamber bottom, each slot being arranged substantially tangential to said mixing chamber and terminating adjacent to and directed across the discharge end of a corresponding fuel port.

JAMES FLETCHER.

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CERTIFICATE OF CORRECTION.

Patent No. 1,980,132.

November 6, 1934.

JAMES FLETCHER.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 2, first column, line 47, strike out the word "inner"; and in the same line, after "forward" insert the word end; and page 3, second column, line 1, claim 3, after "adjacent" insert the word to; and that the said Letters Patent should be read with these corrections therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 19th day of March, A. D. 1935.

(Seal)

Leslie Frazer
Acting Commissioner of Patents.

- mixing chamber bottom, each slot being arranged substantially tangential to said mixing chamber and terminating adjacent to and directed across the discharge end of a corresponding fuel port, means for supplying a liquid fuel under pressure to said liquid fuel ports, and means for supplying steam at a substantially higher pressure than said liquid fuel to said discharge slots.
- 10 17. A steam atomizing liquid fuel burner comprising a discharge head having a central discharge opening and a central mixing chamber of substantially circular cross-section communicating with and symmetrically arranged relative to said discharge opening, a series of liquid fuel ports opening through the bottom of said mixing chamber at points symmetrically spaced relative and adjacent to the circumferential wall of said mixing chamber, a series of discharge slots symmetrically arranged relative to the circumference of said mixing chamber and having their discharge ends opening through the circumferential wall of said mixing chamber with the bottoms of said slots arranged in substantially the plane of said mixing chamber bottom, each slot being arranged substantially tangential to said mixing chamber and terminating adjacent to and directed across the discharge ends of a corresponding fuel port, means for supplying a liquid fuel under pressure to said liquid fuel ports, and means for supplying steam at a substantially higher pressure than said liquid fuel to said discharge slots.
18. A sprayer plate for liquid fuel burners having formed therein a central chamber of substantially circular cross-section, a series of liquid fuel ports opening through the bottom of said chamber at points adjacent to the circumferential wall of said chamber, and a series of discharge slots arranged about the circumference of said chamber and having their discharge ends opening thereto in substantially the plane of said chamber bottom, each slot being arranged substantially tangential to said chamber and terminating adjacent to and directed across the discharge end of a corresponding fuel port.
19. A sprayer plate for liquid fuel burners having a central mixing chamber of substantially circular cross-section formed in one face thereof, a series of liquid fuel ports opening through the bottom of said mixing chamber at points symmetrically spaced relative and adjacent to the circumferential wall of said mixing chamber, and a series of discharge slots formed in said mixing chamber face and symmetrically arranged about the circumference of said mixing chamber and having their discharge ends opening through the circumferential wall of said mixing chamber with the bottoms of said slots arranged in substantially the plane of said mixing chamber bottom, each slot being arranged substantially tangential to said mixing chamber and terminating adjacent to and directed across the discharge end of a corresponding fuel port.

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