

Dec. 3, 1957

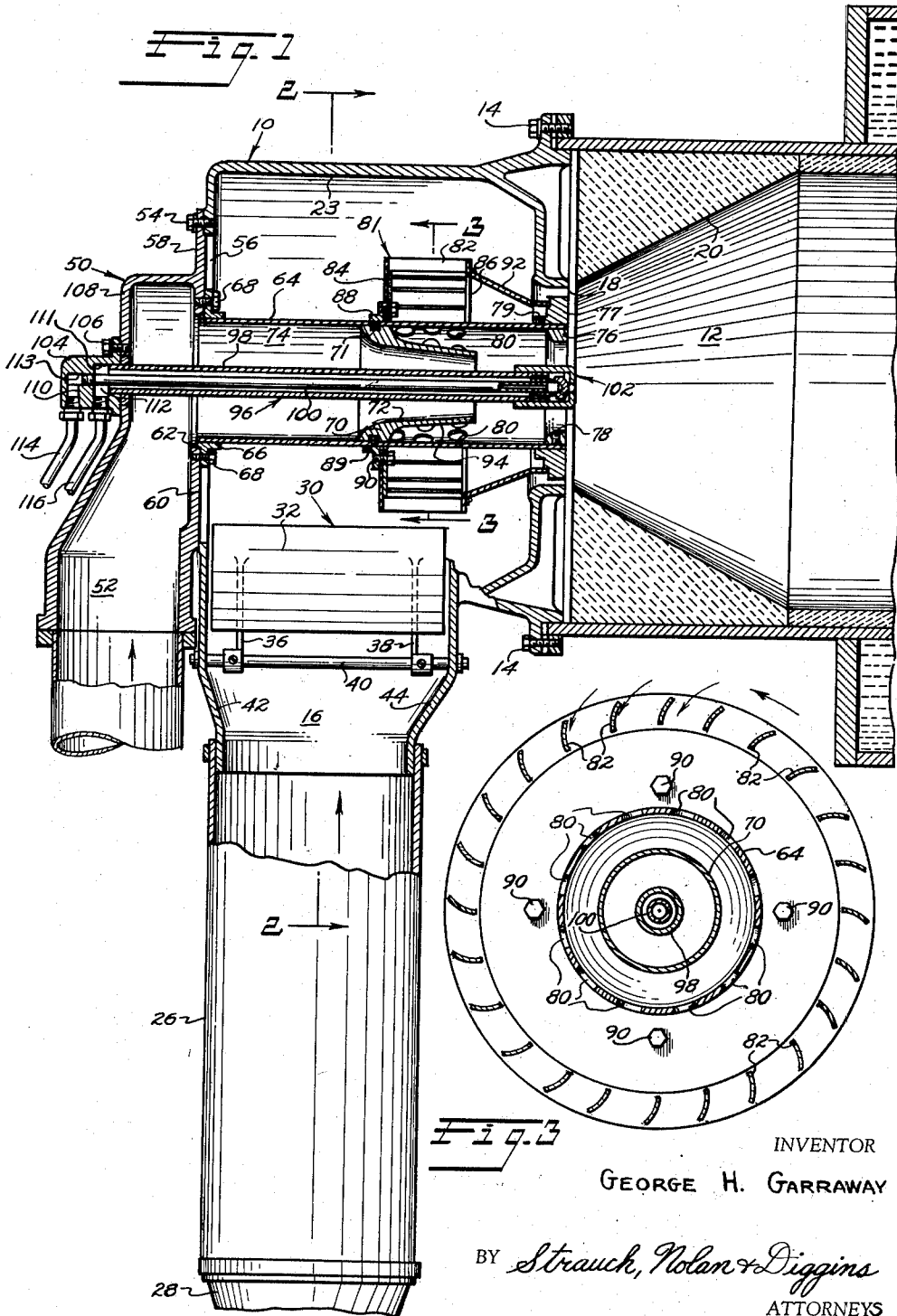
G. H. GARRAWAY

2,815,069

BURNER APPARATUS

Filed June 29, 1951

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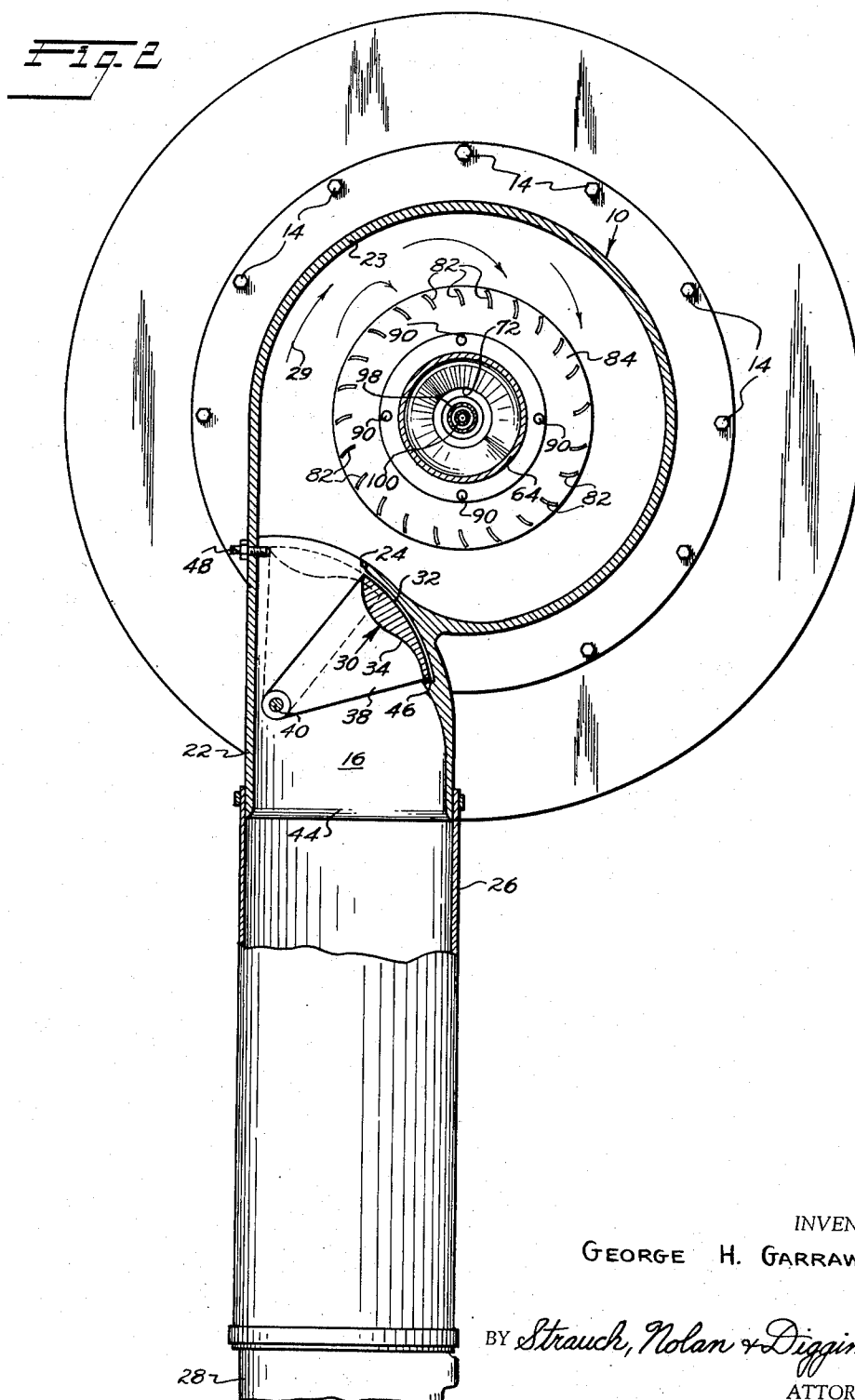
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BURNER APPARATUS

2,815,069

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5 Sheets-Sheet 2



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Dec. 3, 1957

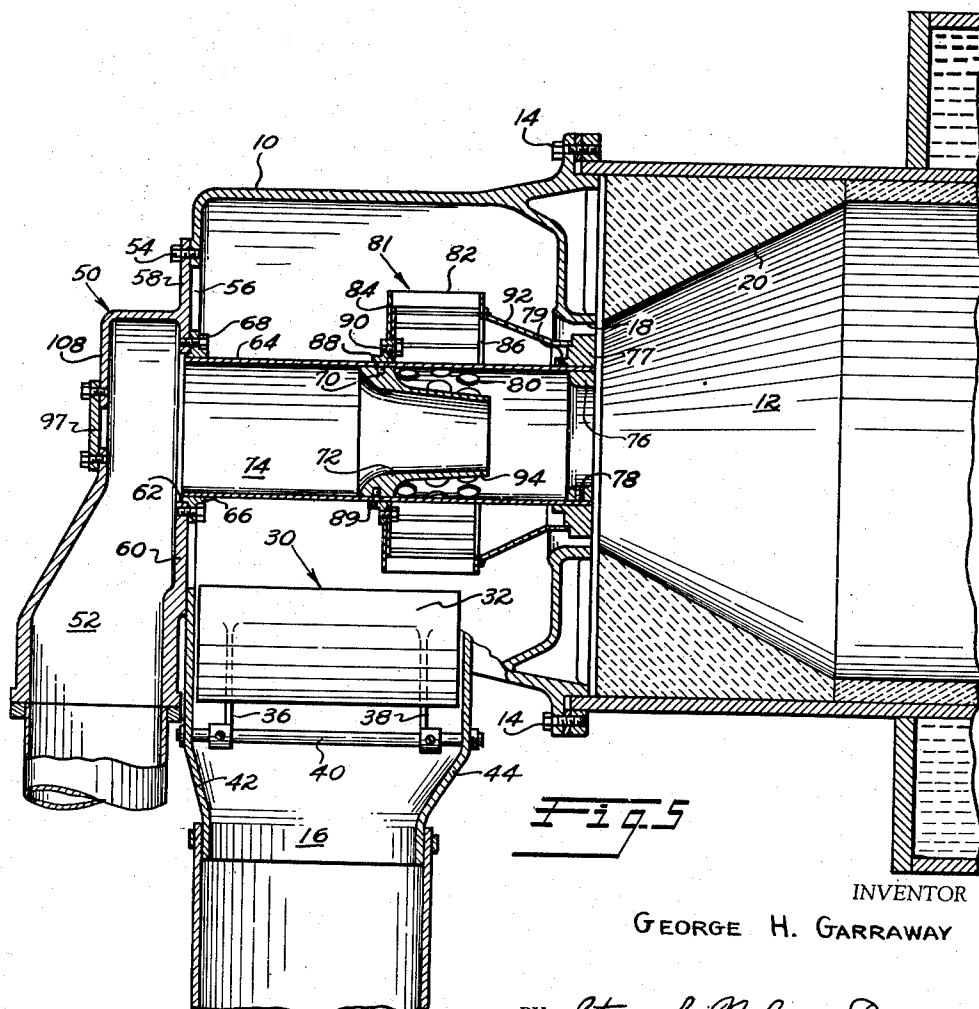
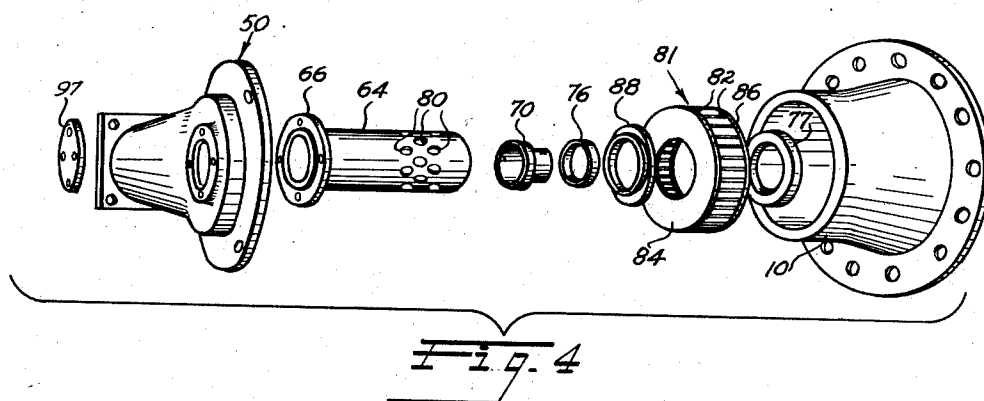
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BURNER APPARATUS

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5 Sheets-Sheet 3



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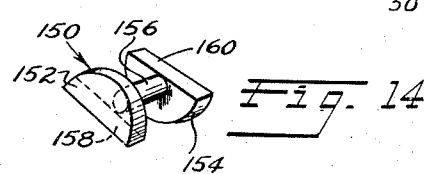
G. H. GARRAWAY

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BURNER APPARATUS

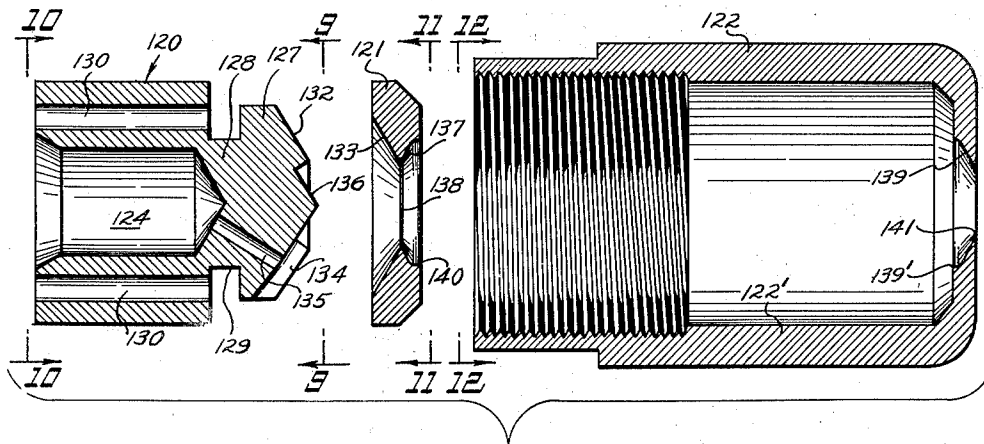
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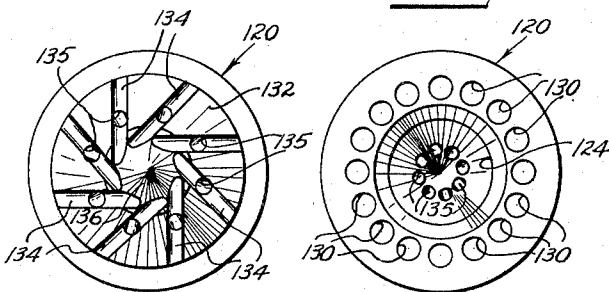
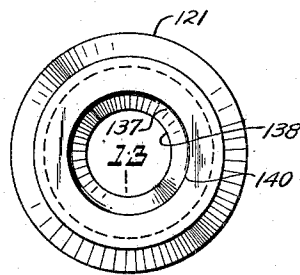


Fig. 9

Fig. 10



13
Fig. 11

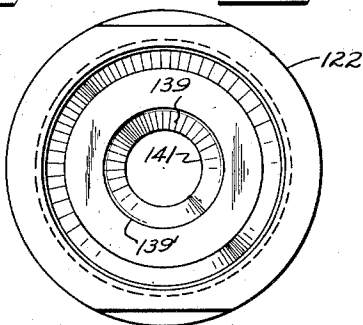


Fig. 12

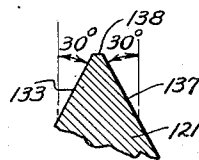


Fig. 13

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2,815,069

BURNER APPARATUS

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Application June 29, 1951, Serial No. 234,198

15 Claims. (Cl. 158—76)

This invention relates to improvements in fuel burner constructions and more particularly to improvements in fuel burners for use with relatively small capacity steam generating units of the type usually used for producing process steam and adapted to burn either liquid or gaseous fuel.

It is one of the primary objects of my invention to provide a fuel burner apparatus of an improved construction resulting in more efficient combustion of liquid fuels and the elimination of formation of carbon deposits in the fuel injector assembly and upon the internal walls of the steam generating unit.

In prior art liquid fuel injectors, much difficulty has also been encountered due to the formation of carbon deposits in the outlet orifice and fuel channels of the fuel nozzle. These carbon deposits result primarily from the coking of the liquid fuel remaining in the nozzle after the fuel supply has been shut off under the effect of the intense heat to which the end portion of the nozzle is subjected from the slowly cooling refractory lining of the furnace. During burner operation, the atomizing fluid and liquid fuel passing through the nozzle effectively dissipate the heat to which the end of the nozzle is subjected, but, upon termination of operation, the full intensity of the heat from the refractory furnace lining adjacent the nozzle outlet is effective to heat the nozzle. In such prior art fuel injectors, frequent cleaning of the fuel passages of the nozzle is necessary to eliminate this carbon accumulation.

It is, accordingly, a further important object of this invention to provide a liquid fuel injector of an improved construction by which accumulation of carbon deposits in the nozzle passages is eliminated.

More specifically, it is an important object of this invention to provide a liquid fuel injector of an improved construction wherein heat transfer channels and heat transfer blocks are utilized to prevent heating of the walls of the fuel channels within the nozzle sufficiently to produce carbon deposits and to effect transfer of the heat to which the nozzle is subjected to members of the burner assembly where the heat can be dissipated without producing coking of the fuel.

A further object of this invention is the provision of liquid fuel injector assembly of an improved construction wherein the heat to which the nozzle is subjected during burner operation is utilized for additional preheating of the atomizing fluid such as air or steam to produce more efficient overall burner operation.

In prior art fuel injectors, certain difficulty has also resulted from the tendency, after the burner has been shut off, of the liquid fuel remaining in the fuel conduit leading to the nozzle to run out slowly onto the refractory lining of the combustion chamber or into the atomizing fluid supply passages of the nozzle. The accumulation of fuel, resulting from this leakage, produces poor burner starting conditions and inefficient overall operation resulting in the initial injection of unatomized liquid fuel and the burning of fuel directly on the furnace walls.

A still further important object of this invention is, therefore, to provide a liquid fuel injector of an improved construction wherein leakage of fuel from the fuel supply pipe through the fuel passages of the nozzle is prevented after termination of burner operation.

More specifically it is an object of this invention to provide a fuel injector of an improved construction including a fuel stop which prevents leakage of fuel from the fuel supply conduit when the fuel supply is cut off but which does not inhibit fuel flow during burner operation.

These and other important objects of this invention will become apparent as the description thereof proceeds in reference to the accompanying drawings wherein corresponding reference numerals designate like parts throughout the several views and wherein:

Figure 1 is partially sectional view of a burner assembly according to the invention adapted to burn alternatively either liquid or gaseous fuel;

Figure 2 is a sectional view of that assembly taken along the line 2—2 of Figure 1;

Figure 3 is a sectional view chiefly illustrating the air guide structure within the air plenum taken along the line 3—3 of Figure 1;

Figure 4 is an exploded perspective view showing the several parts of the burner assembly adapted for use with gaseous fuel;

Figure 5 is a sectional view of the burner assembly as adapted for use only with gaseous fuel;

Figure 6 is a vertical sectional view of a fuel burner apparatus adapted to burn liquid fuel only;

Figure 7 is an enlarged vertical sectional view of the liquid fuel injector of the burner apparatus of Figures 1 and 6;

Figure 8 is an enlarged exploded view in section of the core, cap, and body members of the nozzle assembly of the fuel injector of Figure 7;

Figure 9 is a front end view of the nozzle assembly core member;

Figure 10 is a rear end view of the nozzle assembly core member;

Figure 11 is a front end view of the nozzle assembly cap;

Figure 12 is a rear end view of the nozzle assembly body member;

Figure 13 is a fragmentary sectional view of the nozzle assembly taken along the lines 13—13 of Figure 11; and

Figure 14 is a perspective view of the liquid fuel stop of the fuel injector of Figure 7.

A burner of improved construction which is adapted to burn effectively either liquid or gaseous fuels is disclosed in Figure 1. In this burner, means are provided for surrounding a centrally injected stream of fuel with a mass of axially flowing primary air sufficient for initial combustion and with a spiraling mass of secondary air sufficient to complete combustion. When liquid fuel such as oil is used, the fuel is atomized and sprayed into the primary air stream in the combustion chamber to assure proper intermixing, whereas, when gaseous fuel is used, the primary air and gaseous fuel are intermixed in a premixing chamber prior to introduction into the combustion chamber. The air flow guide structure is such that the relative proportion of primary to secondary air may be set by the proper selection of the size of rings controlling the size of the primary and secondary air orifices for maximum rating of the boiler and such that the total quantity of air supplied may be reduced for operation at a fraction of such maximum rating without disturbing either the established air pattern or the relative proportion of primary to secondary air.

In this burner structure, a housing providing a main air chamber or plenum 10 is fixed to the end of the fire or combustion chamber 12 of a boiler as by bolts 14. Air plenum 10 is generally cylindrical in cross section, as shown in Figure 2, having a downwardly open air inlet port 16 and an axially open outlet port 18 through its end adjacent the combustion chamber as shown in Figure 1. Outlet port 18 is coaxially aligned with a frusto-conical wall 20 of the refractory lining of the combustion chamber and with the generally cylindrical contour of air plenum 10. As is best shown in Figure 2, the internal surface of wall 22 of the inlet port 16 is tangential to the inner cylindrical surface 23 of the air plenum 10, the space between wall 22 and the edge 24 of the interrupted cylindrical wall of the air plenum defining the maximum possible opening of the inlet port.

Inlet port 16 is connected by a suitable flexible air duct 26 to the outlet 28 of a blower (not shown) in a conventional manner. In this structure, the stream of incoming air is introduced under pressure at substantially constant velocity into the air plenum 10 through inlet passage 16, forming a moving layer or film of air adjacent wall 22 of a radial thickness equal to the distance between wall 22 and edge 24. This air stream entering the plenum 10 tangential to the cylindrical wall 23 will follow a generally circular path around the cylindrical wall 23 as indicated by the arrow 29 in Figure 2.

Means are provided for controlling the volume of incoming air by varying the thickness of the air stream entering the inlet along wall 22 without disturbing the tangential flow of the incoming air stream. A throttle valve, which may be adjusted to vary the size of the opening at 24, is disclosed as a plate member 30 having an arcuate outer surface 32 and an inner surface 34 suitably curved or streamlined as shown to produce minimum turbulence of the passing air stream. Plate member 30 is suitably fixed to pivot arms 36 and 38 which are in turn fixed to a pivot shaft 40 journaled in the walls 42 and 44 of the inlet passage 16 as shown in Figure 1. Any suitable control linkage for positively positioning shaft 40 may be provided. Such linkage is actuated by a throttle valve control means (not shown) which will also control the quantity of fuel introduced into the burner in a conventional manner. By this valve structure, the quantity of air introduced into the air plenum may be varied in accordance with the load upon the burner without substantially modifying the input velocity of air into the air plenum at the throttle valve. The air input velocity is controlled at approximately 65 feet per second (a tolerance of +10% to -15% being permissible). Since the control means for plate member 30 forms, per se, no part of this invention, it has neither been shown or described.

Since, as is shown in Figure 2, shaft 40 is parallel to wall 22, plate member 30 may be swung toward wall 22 to reduce the opening of the inlet port 16. Suitable stops are provided to limit the travel of plate member 30, a shoulder 46 being formed integrally with the inlet port wall establishing the maximum open position of this inlet throttle valve while an adjustable stop 48 limits the closing of the inlet valve. Because plate member 30 moves toward wall 22, the thickness of the air stream and thereby the quantity of incoming air may be reduced without disturbing the tangential inflow of the air stream while the input air velocity is maintained approximately constant. Since the air pressure within the air plenum 10 is greater than that within the fire chamber 12 due both to the draft of the furnace and to the air input blower, the air stream flowing into the air plenum and travelling circumferentially therearound, substantially spirals toward the outlet port 18.

As shown in Figure 1, a gas plenum housing 50 having a radial inlet port 52 is secured as by bolts 54 to the outer end of the air plenum 10 opposite its outlet port 18. That end of the air plenum 10 is formed with a large opening 56 for which the flange portion 58 of the gas plenum 50 serves as a cover. The wall 60 of the gas plenum 50 is formed with an opening 62 therethrough in axial alignment with the outlet port 18. A tubular member 64, having a flange 66 affixed thereto at one end, is secured to the wall 60 of gas plenum at the opening 62 as by bolts 68. Tubular member 64 extends from the wall 60 coaxially through the air plenum 10 to the outlet port 18. A primary air baffle 70, which is fixed within the tubular member 64 as by set screws 71, is formed internally with an annular surface of revolution 72 converging toward the outlet port 18. The rear portion 74 of tubular member 64 and the throat of primary air baffle 70 together form a gas nozzle assembly for directing the flow of gaseous fuel from the gas plenum 50 toward the combustion chamber 12 through the center of the outlet port 18. This is clear in Figure 5. The cross sectional area of the nozzle formed by surface 72 is so proportioned relative to the gaseous fuel supply pressure that the exit velocity of the gaseous fuel is between 29 and 60 feet per second at maximum load.

Air guide structure is provided within the air plenum 10 for segregating the air circulating therein into primary and secondary air streams surrounding the centrally injected fuel to supply the air necessary for combination. The primary air stream for initial combustion enters the combustion chamber 12 through the forward portion of the tubular member 64, ahead of baffle 70, while the secondary air stream constituting the remaining air necessary for complete combustion enters through port 18 around the outside of tubular member 64. The cross-sectional area of the primary orifice is determined by the internal diameter of a toroidal body 76, known as a primary air ring, mounted within the inner end of nozzle member 64 as by screws 78. The cross-sectional area of the secondary air orifice is fixed by a toroidal body 77, known as the secondary air ring, secured around the inner end of the tubular member 64 adjacent outlet port 18, as by set screws 79.

These air rings 76 and 77, being secured on tubular member 64 only by set screws 78 and 79, are readily removable from the air guide structure. The relative proportion of primary to secondary air is controlled entirely by the relative sizes of the primary and secondary air rings 76 and 77 which provide accurate annular metering orifices. Air rings 76 and 77 are of such relative size, that the primary air stream constitutes from 40 to 55 percent of the total combustion air and the primary and secondary air orifices are of such size that the average of the primary and secondary air discharge velocities is between 140 and 200 feet per second at maximum burner rating.

The primary air enters tubular member 64 through a series of holes 80 through the walls thereof forwardly of the area at which the gas nozzle 70 is fixed. Air is directed radially through these holes 80 by a stationary air compressor assembly 81 having an annular row of longitudinally extending guide vanes or air scoops 82, which are supported in fixed position between a pair of annular supports 84 and 86. This stationary air compressor assembly 81 is mounted coaxially on the tubular member 64 by a ring 88 which is secured thereto by any suitable means such as set screws 89 and which is secured to the support 84 as by bolts 90. A cone 92 is mounted between support 86 and secondary air ring 77. Cone 92 provides a flow directing surface for the secondary air, and structurally it reinforces the assembly.

As previously pointed out, the air within the air plenum 10 is circulating in a spiral air pattern within the gen-

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erally cylindrical air plenum 10 from the inlet port 16 toward the outlet port 18. As viewed in Figure 3, this circulation is in a counterclockwise direction. A portion of this circulating air will strike the stationary air scoops 82 and be directed radially inward through the holes 80 of tubular member 64.

The dissipation of the velocity of the air so directed will result in greater air pressure within the compressor assembly 81 and within tubular member 64. The aggregate cross-sectional area of the holes 80 must be considerably greater than that of the opening through the primary air ring 76, being in the order of from fifty to seventy-five percent greater, a range of from sixty-five to seventy-five percent being preferable. There being no substantial pressure differential between the exterior and interior surfaces of the shell of tubular member 64, the relative proportion of the primary and secondary air is controlled by the sizes of the primary and secondary air rings 76 and 77. The external surface 94 of the gas nozzle 70 is a smooth surface of revolution converging toward the outlet port 18, the nozzle 70 being of such length that surface 94 extends slightly beyond the forwardmost of the holes 80 and of such size that the velocity of the primary air toward the primary air orifice is approximately one hundred five feet per second at maximum burner load, the effective annular primary air metering area defined between the orifice end of surface 94 and the internal wall of member 64 being in the range of 33 to 50 percent greater than the cross-sectional area of the primary air outlet orifice. Surface 94 thus serves as a primary air baffle to redirect the radially entering primary air in an annular, expanding air stream flowing axially toward the fire chamber 12 through primary air ring 76.

The component parts described thus far constitute the structure of the gaseous fuel burner. A view showing these elements assembled for use with gaseous fuel only is shown in Figure 5, this structure differing from that of Figure 1 solely in the omission of the liquid fuel injector assembly 96 and its replacement by a cover plate 97. When gas is burned, the gaseous fuel passes from the gas plenum 50 through the tubular member 64 and the nozzle 70 toward the orifice formed by primary air ring 76. The annular primary air stream enters the forward end of tubular member 64 and flows axially over surface 94 toward the primary air ring orifice.

The portion of tubular member 64 forwardly of the smaller end of nozzle 70 serves as a premixing chamber for the primary air and the gaseous fuel to insure the necessary intermixing of fuel and air before the stream reaches the combustion zone within the fire chamber 12. This premixing of air and fuel occurs within tubular member 64 and at the primary air ring 76. The internal cross-sectional area of the portion of member 64 forming the primary air or premixing chamber in front of nozzle 70 is preferably from 50 to 75 percent greater than the cross-sectional area of the primary air outlet orifice defined by ring 76 in order to maintain proper air and fuel velocities for optimum premixing. In order to assure proper mixing and proper gaseous fuel velocities, the cross-sectional area of the discharge end of nozzle 70 is from 65 to 77 percent of said primary air outlet orifice cross-sectional area.

A suitable igniter (not shown) is provided near the mouth of outlet port 18. As the charge of intermixed gaseous fuel and primary air is introduced into the fire chamber it is further surrounded with a spiralling mass of secondary air which intermixes with the expanding burning fuel to insure complete combustion thereof.

Liquid fuel injection

As mentioned at the outset, the burner assembly of Figure 1 is adapted to burn either liquid or gaseous fuel. When liquid fuel is to be used in the combination burner of Figure 1, the gas supply is merely cut off below port

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52. In order to introduce liquid fuel into the fire chamber in a form suitable for combustion, the liquid fuel injector 96, now to be described, which is provided for injecting the liquid fuel in the form of an atomized spray into the center of the primary air stream, may be coupled for use with the previously described air guide structure without the gaseous fuel injector. Such an arrangement is shown in Figure 6.

When the burner assembly is so modified, a cover member 50' is secured as by bolts 54 to the outer end of the air plenum 10 opposite its outlet port 18 over the large access opening 56 in lieu of the gas plenum 50. The interior wall 60' of the cover member 50' is formed with recess 62' therein in axial alignment with the outlet port 18, and the tubular member 64, having the flange 66 affixed thereto, is secured to the wall 60' of cover member 50' at the recess 62' by the bolts 68. Tubular member 64 extends from the wall 60 coaxially through the air plenum 10 to the outlet port 18. The primary air baffle 70 is fixed within the tubular member 64 by the set screws 71 and is formed internally with the annular surface of revolution 72 converging toward the outlet port 18, as previously described in reference to Figures 1 and 5. The air guide structure, which is identical with that shown in Figures 1 and 5, functions in the manner previously set forth.

As mentioned at the outset, in order to attain efficient fuel combustion and eliminate the formation of carbon on the refractory and heat transfer walls of the combustion chamber, liquid fuel is preferably injected into the combustion zone in the form of a short bushy flame. An example of the dimensions of such a flame as compared with the dimensions of a combustion chamber will perhaps best illustrate what is meant by a short bushy flame.

In an eighty horsepower boiler of the type illustrated, which is one of many to which the present invention is applicable, the combustion chamber formed by the heat transfer surfaces is in the form of a cylinder approximately ninety inches long and approximately twenty inches in diameter. For such a combustion chamber, a coaxially introduced short bushy flame at maximum burner load, for example, twenty-four gallons of fuel per hour, would preferably have an overall length of from fifty-five to sixty inches from the nozzle discharge orifice, the flame starting within an inch or less from the nozzle. At the nozzle end of the flame it would preferably have a diameter of approximately eight inches and gradually increase in diameter to approximately eighteen inches at a distance of about forty inches from the nozzle. As the load upon the burner is reduced below maximum, the flame dimensions are reduced proportionately.

A flame of this general configuration produces optimum combustion conditions in a minimum space. The liquid fuel injector of the present invention, hereinafter to be described in detail, in cooperation with the air guide structure previously described produces a flame having the foregoing short bushy configuration and may be used with combustion chambers having other than a cylindrical cross-sectional configuration to attain similarly advantageous combustion conditions.

It is to be understood that the foregoing flame dimensions are merely illustrative of what is meant by a flame which is short and bushy relative to the length and cross-sectional dimensions of a combustion chamber and that such dimensions will vary in accordance with the load and load capacity of the burner.

The liquid fuel injector assembly 96, which is constructed according to the present invention and which is adapted to produce a short bushy flame such as that described above, includes a pair of concentric tubes 98 and 100, on the fire chamber end of which is mounted an atomizing nozzle assembly 102 and on the other of which is mounted an oil and atomizing fluid inlet fixture 104. This fixture may be of the form shown but is preferably of the form disclosed in application Serial No. 213,068

filed on February 28, 1951 by Garraway and Kirkup for Fuel Flow Control, now Patent No. 2,753,927. Fuel injector assembly 96 is rigidly supported in its coaxial position within tube 64 by fixture 104 which is secured by bolts 106 to the rear end of the cover plate 50'. Fixture 104 is formed with inlet ports 110 and 112 which are connected by suitable conduits 114 and 116 to a source of liquid fuel such as fuel oil and to a source of pressurized atomizing fluid, such as air or steam respectively. Fixture 104 is provided with an end bore 111 into which atomizing fluid inlet port 112 opens, and at the bottom of bore 111 a reduced threaded bore 113 opens into oil inlet port 110. Tube 100 has its outer end threaded to interfit with bore 113 so that all oil entering the assembly is delivered into tube 100. The surrounding tube 98 extends tightly into bore 111 to communicate directly with atomizing fluid inlet port 112. Tube 98 is mounted on fixture 104 by a piloting flange 118 which is suitably secured to the exterior of tube 98 and mounted on fixture 104 as by screws 119. If desired, flange 118 may be integral with tube 98. Suitable cutoff and control valves (not shown) are provided in the inlet conduits 114 and 116 in a conventional manner to control the flow of fuel and pressurized atomizing fluid. The fuel control valves are actuated with the air throttle valve in accordance with the load on the boiler while that for the atomizing fluid remains in its initially adjusted position regardless of the load.

Nozzle assembly

Compressed air from conduit 98 atomizes the oil from conduit 100 at the nozzle assembly 102 to spray the oil in fine particles into the fire chamber 12. The structure of the nozzle assembly 102 is of the improved type which is shown in Figures 7 to 13. As shown in Figure 7, the nozzle assembly 102 consists primarily of three members: a cylindrical core member 120, an annular disc shaped cap member 121, and a hollow cylindrical body member 122. In their assembled position, core 120 fits snugly with the cylindrical inner wall 122' of body 122, and cap 121 is clamped within the body member between the core 120 and the end wall of body member 122, the relative axial position of these members being maintained by the abutment of the rear end of core member 120 against the end of atomizing fluid tube 98 when the body member 122 is tightly secured upon tube 98 by the threaded connection 123 therebetween.

The core member 120, as is best shown in Figures 8 and 10, is formed with a central end bore 124 into which the forward end of the fuel tube 100 snugly projects. A flexible O-ring 126 preferably formed of rubber is provided in an annular groove 126' on tube 100 to prevent leakage between the oil passage and the atomizing fluid passage through tube 98. Core 120 is provided with a reduced head 127 connected to its cylindrical main portion by a further reduced neck 128 formed by an annular groove 129. A plurality of small parallel bores 130 concentrically arranged about the longitudinal axis of the core provide atomizing fluid passages from tube 98 into groove 129 and annular chamber 131 within the body surrounding head 127.

The end of head 127 and the adjacent side of cap 121 are formed with mating conical surfaces 132 and 133 respectively which are tightly held in contact in the assembly. A plurality of atomizing fluid conducting slots 134 are cut in surface 132 of the head, and a plurality of inclined oil conducting passages 135, one for each slot, are formed through the neck and head of the core for connecting bore 124 with the slots 134 intermediate the ends of latter. All of slots 134 are arranged at the same radial angle with respect to the axis of the core, each being perpendicular to a radius of the core and since they are formed in conical surface 132 they are all inclined axially at the same angle with respect to the core axis. At its tip, head 127 is cut back to provide a conical face 136 adjacent the ends of slots 134.

As illustrated in Figure 8, slots 134 have gradually decreasing cross-sectional area until they intersect the oil passages 135 and are then of constant cross-section for the remainder of their lengths.

On the end opposite converging surface 133, cap 121 is formed with a diverging smooth annular surface 137, and an annular orifice 138 having a narrow flat lip is formed therebetween. Surface 137 is a surface of revolution described by a curved line moving about the longitudinal axis of the cap. The end wall of body 122 is formed with a similar converging smooth surface of revolution 139, the edge 139' of which, in the assembly, is a smooth continuation of edge 140 of surface 137. The edge 141 of surface 139 defines the exit orifice of the nozzle assembly 102.

As illustrated in Figure 7, surfaces 137 and 139 define in the assembly a toroidal mixing dome 142 symmetrical about the nozzle axis and into which a plurality of streams of mixed oil and atomizing fluid are tangentially directed to produce an expanding swirling atomized fuel mixture within dome 142 that spirals out through the orifice 141.

As pointed out at the outset, in order to avoid fuel impingement on the heat transfer surfaces or the refractory material of the furnace lining and to produce complete combustion of the fuel in a short chamber, it is necessary to inject the liquid fuel into the furnace combustion zone in the form of a fine mist and in such a manner as to produce a short bushy flame. I have discovered that this desired result may be produced by properly controlling the relation of the pressure of the atomizing fluid, the relative proportion of the atomizing fluid to the injected fuel, the velocity of the atomizing fluid at the point of intermixture with fuel, and the exit velocity of fuel and atomizing fluid mixture from the nozzle. The last two of these factors are controlled by the proper proportioning of the size of the passages through the nozzle in relation to the first two factors. In order to produce an axially short flame, the exit velocity of atomizing fluid and fuel mixture must be low, in the range of 325 to 400 feet per second. I have discovered that to produce such an exit velocity the velocity of the atomizing fluid at the point of intermixture with the liquid fuel should be between 650 and 800 feet per second, the optimum being approximately 725 feet per second and variations in velocity beyond this range resulting in inefficient burner operation or impingement of fuel on the surrounding surfaces. The atomizing fluid velocity at the point of intermixture with the liquid is controlled by proportioning the total cross-sectional area of the atomizing fluid jet passages in accordance with quantity of atomizing fluid necessary at the rated capacity of the burner.

Optimum atomization of the liquid fuel is produced when the ratio by weight of atomizing fluid to fuel is 0.2 to 1.0 at maximum burner rating, the minimum practical ratio being 0.18 to 1.0. A ratio above 0.2 to 1.0 produces no undesirable results other than requiring increased size of atomizing fluid passages within the injector assembly but produces no significant improvement in atomization of the fuel.

The ratio of the total cross-sectional area of atomizing fluid jet passages at the point of intermixture with the liquid fuel to the nozzle exit orifice cross-sectional area is preferably in the order of 1 to 2 produce optimum operating results.

As applied to the nozzle structure shown in Figures 8 to 12, the cross-sectional area of slots 134 at their juncture with passages 135 is such that a velocity of atomizing fluid at that point is within the range of 650 to 800 feet per second, a velocity of 725 feet per second at that point producing optimum results. The atomizing fluid supply pressure is maintained substantially constant throughout the operating range of the burner so that these velocities remain substantially constant to maintain optimum fuel atomization. The fuel supply rate is of course varied

in accordance with the load upon the burner. The cross sectional area of the outlet orifice at edge 141 is approximately twice the aggregate cross-sectional area of the several slots 134 at their points of juncture with passages 135, a range of from 1.65 to 1.0 to 2.3 to 1 constituting the range of practical proportions. Such an outlet orifice size produces the desired exit velocity range of from 325 to 400 feet per second. The cross section area of the opening of cap 121 at edge 138 is preferably from 1.35 to 1.25 times the area of the orifice defined by edge 141 of body member 122.

In order to prevent coking of liquid fuel in the slots 134 and passages 135 of the nozzle after burner operation is terminated, it is necessary to prevent transmission of heat from the refractory lining 29 of the furnace to the walls defining these fuel channels. In the past, efforts have been made to prevent this heat transmission by shielding the nozzle from the refractory lining and by retracting the nozzle from the furnace. Neither of the solutions has proved to be completely satisfactory. I have solved this problem by providing a nozzle of such construction and formed of such suitable materials that heat transmission paths are formed by the nozzle assembly for rapidly conducting heat from the nozzle to the air plenum walls for dissipation and that heat blocks are formed to prevent transmission of heat from the heat transmission channels to the walls within the nozzle which define the fuel channels.

The heat transmitting paths are defined in the injector 96 of the present invention by body member 122, the end portion of which is subjected to the heat from the refractory furnace lining, and by conduit 98 which are both formed of metals which transmit heat readily. Conduit 98 is preferably formed of red brass or aluminum and body member 122 is preferably formed of beryllium copper due to its high thermal conductivity, machineability and to the fact that it will retain sharp machined edges over long periods of use. Core 120 and cap 121 are both formed of a non-corrosive material having a low coefficient thermal conductivity to inhibit transmission of heat from body member 122 to the surfaces defining the fuel channels. Stainless steel has been found to be particularly suitable for this purpose. The engaged threaded portions of conduit 98 and body member 122 are longer than required by the structural strength requirements to provide a large area of contact for heat transfer between the two members. The transfer of heat to conduit 98 preheats the atomizing fluid during burner operation and results in more efficient overall operation.

As previously pointed out, certain difficulties have also resulted in prior art devices from the slow leakage of oil from the end of the oil supply tube into the atomizing fluid passages and out of the nozzle into the furnace after termination of burner operation. In order to eliminate this leakage, I have provided a fuel stop 150 in an enlarged end bore 151 of the conduit 100 which permits substantially free flow of fuel under pressure but which prevents leakage of fuel from the conduit when the pressurized liquid fuel supply is cut-off. The fuel flow dam 150 is shown in perspective in Figure 14. Flow dam 150 consists of an upper segmental disc 152 and a lower segmental disc 154 coaxially aligned and joined by a small cylindrical portion 156. The stop 150 is mounted within the end of conduit 100 in such a position that the chordal surfaces 158 and 160 are horizontal. Segmental disc 152 abuts against the annular end wall 161 of bore 151 to maintain proper axial alignment between flow dam 150 and conduit 100 during assembly. The arcuate surfaces of the segmental discs 152 and 154 are joined in sealed relation to the internal wall of conduit 100 as by soldering to prevent leakage of oil and air between the conduit wall and the arcuate surfaces.

During burner operation, the liquid fuel flows under surface 158, upwardly around the sides of the cylindrical portion 156 and over surface 160 into end bore 124 of core 120. When the fuel supply is cut-off, lower segmental disc 154 prevents leakage of the fuel from the bottom half of conduit 100 and the upper segmental disc 152 prevents entrance of air, steam, or other liquid displacing material into the top half of conduit 100. Fuel flow over the surface 160 is prevented because the atmospheric pressure of the air exerted upon the horizontal fuel surface between discs 152 and 154 on each side of the cylindrical portion 156 is sufficient to overcome the fluid pressure head produced by the portion of the fuel in the conduit 100 behind disc 152 but above the level of chordal surface 160.

As previously pointed out, the velocity values given for the gaseous fuel flow and primary and secondary air flow, with the exception of the air input velocity to the air plenum, are for maximum rated load of the burner. These velocities will be proportionately lower at lower loads but, due to the improved nature of the combustion air and gaseous fuel flow guide structure previously described, the same efficient air and fuel patterns will be maintained throughout the wide operating range of the burner. For example, the standard Power Boiler Output Test of the American Society of Mechanical Engineers has shown that the efficiency of the disclosed burner increases from 83.5% at maximum load to 89% at one-third of maximum load.

I have, therefore, disclosed a fuel burner adapted to burn either liquid or gaseous fuels individually or alternatively and which maintains a high level of combustion efficiency throughout its operating range.

The invention may be embodied in other specific forms without departing from the spirit or essential characteristics thereof. The present embodiments are therefore to be considered in all respects as illustrative and not restrictive, the scope of the invention being indicated by the appended claims rather than by the foregoing description, and all changes which come within the meaning and range of equivalency of the claims are therefore intended to be embraced therein.

What is claimed and desired to be secured by United States Letters Patent is:

1. In a liquid fuel atomizing injector assembly, a conduit for supplying liquid fuel; a surrounding conduit for atomizing fluid formed of metal having a high coefficient of thermal conductivity; a core member formed of metal having a low thermal conductivity coefficient, provided with separate liquid fuel and atomizing fluid passages connected to said conduit and having an end abutting the discharge end of said fuel conduit; a cap member seated on the end of said core member and being formed of metal having a low thermal conductivity coefficient; a body member formed of metal having a high thermal conductivity coefficient surrounding said cap and core members, and secured to said atomizing fluid conduit to clamp said members in tight assembly against the ends of said conduits, said cap and body members having mating recesses formed in their adjacent surfaces defining a mixing dome coaxial with said members, said body member having an orifice formed therethrough coaxial with said dome, slots in the contacting surfaces of said cap and core members providing atomizing fluid introduction passages into said dome, and oil introduction passages in said core intersecting said introduction passages intermediate their ends.

2. The combination as defined in claim 1 wherein said atomizing fluid conduit is formed of aluminum.

3. The combination as defined in claim 1 wherein said atomizing fluid conduit is formed of red brass.

4. The combination as defined in claim 1 wherein said body member is formed of beryllium copper.

5. The combination as defined in claim 1 wherein said core and cap members are formed of stainless steel.

6. The combination as defined in claim 1 wherein said body member is formed of beryllium copper, said cap and core members are formed of stainless steel, and said atomizing fluid conduit is formed of red brass.

7. A fuel injector assembly for a liquid fuel burner comprising an atomizing fluid supply tube, an oil supply tube positioned concentrically therein to define an oil passage through the latter and an annular air passage therebetween, an atomizing nozzle assembly mounted on said tube at one end containing passages for intermixing the oil and atomizing fluid and discharging a spirally mist of intermixed atomizing fluid and oil particles for injection into a burner, flow dam means in the end of said oil supply tube adjacent said nozzle for preventing the entrance of gas into the upper portion thereof when the burner is inoperative, and means intermediate said first means and the discharge end of said oil supply tube for preventing the leakage of oil from the lower portion of said tube when the burner is inoperative.

8. In a liquid burner, a fuel injector comprising a fuel atomizing nozzle, a fuel supply conduit and an atomizing fluid supply conduit connected thereto at their discharge ends, and a fuel flow dam fixedly mounted within the discharge end of said fuel supply conduit for preventing leakage of fuel therefrom into said nozzle while the burner is inoperative, said dam comprising a plate member of substantial depth blocking the lower portion of the channel of said conduit.

9. In a liquid fuel burner, a fuel injector comprising a fuel atomizing nozzle, a fuel supply conduit and an atomizing fluid supply conduit connected thereto at their discharge ends, and a fuel flow dam mounted within the discharge end of said fuel supply conduit for preventing leakage of fuel therefrom into said nozzle while the burner is inoperative, said fuel supply conduit being tubular in form and supported in a horizontal position and said fuel flow dam comprising an upper and a lower segmental disk mounted concentrically and in axially spaced relation within the discharge end of said fuel supply conduit, the chordal surfaces of said segmental disks being horizontal, the plane of the chordal surface of said upper disk being slightly below the plane of the chordal surface of the lower disk, and the arcuate surfaces of said disks being fixed in sealed relation to the internal wall of said conduit.

10. In a liquid fuel burner, a fuel injector comprising a fuel atomizing nozzle, a fuel supply conduit connected at its discharge end to said atomizing nozzle, and a fuel flow dam mounted in fixed relation within the discharge end of said fuel supply conduit for preventing leakage of fuel therefrom into said nozzle while the burner is inoperative, said dam comprising a plate member of substantial depth blocking the lower portion of the channel of said conduit.

11. In a liquid burner, a fuel injector comprising a fuel atomizing nozzle, a horizontally extending fuel supply conduit connected at its discharge end to said nozzle, flow dam means in the end of said fuel supply conduit adjacent said nozzle for preventing the entrance of gas into the upper portion thereof when the burner is inoperative, and flow dam means intermediate said first means and the discharge end of said fuel supply conduit for preventing the leakage of fuel from the lower portion of said conduit when the burner is inoperative.

12. A liquid fuel injector comprising a fuel supply conduit, an atomizing fluid conduit, a fuel atomizer at the outlet of said conduits embodying intersecting fuel and fluid passages to effect fuel atomization, means for preventing leakage of fuel from said conduit into said atomizer after termination of burner operation, a thermal shield enveloping said atomizer passage intersection and comprising inner and outer layers of relatively low and relatively high thermal conductivity material respectively, and means thermally isolated from said conduit for con-

ducting heat from said shield outer layer and dissipating said heat in a region remote from said atomizer.

13. A fuel injector assembly for use in a fuel burner comprising a fuel atomizer formed of low thermal conductivity material and formed with intersecting fuel and atomizing fluid channels to effect fuel atomization, a conduit for directing fuel to said atomizer fuel channel, a conduit for directing atomizing fluid to said atomizer atomizing fluid channel, a shield of high thermal conductivity material enveloping said atomizer, and means forming a high thermal conductivity path extending between said shield and a region of the burner remote and substantially cooler than the region of said atomizer and adapted to transfer heat from said shield to said cooler burner region for dissipation.

14. In combination with a fuel burner structure, a liquid fuel injector comprising a fuel supply conduit, means formed of low thermal conductivity material at the outlet end of said conduit for atomizing fuel discharged from said fuel conduit outlet end, and shield means formed of material of higher thermal conductivity than the material of said atomizing means enveloping said atomizing means, and a body of metal of relatively high thermal conductivity connected at one end to said shield means and extending therefrom to a region of said burner structure remote from said atomizer and substantially cooler than the region of said atomizer and adapted to conduct heat from said shield to said burner structure region.

15. For use in a refractory lined furnace; a liquid fuel burner including an atomizing fuel injector comprising a fuel supply conduit and a fuel atomizer at the outlet end of said conduit; and means for preventing coking of fuel in said atomizer and conduit due to furnace refractory lining heat after termination of burner operation comprising means formed of material of relatively low thermal conductivity defining a first shield about the fuel passages in said atomizer; and means formed of material of relatively high thermal conductivity defining a second shield positioned about said first shield so as to be normally interposed between the refractory lining when in operative position, and said first shield, said atomizer and the outlet end of said conduit; and means, formed of material of relatively high thermal conductivity connected to said second shield and thermally isolated from said conduit for forming, when in operative position, a heat transmission path between said second shield and a relatively large heat dissipating body portion of the burner located in the relatively cool zone remote from the refractory lining.

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