FIG. 6

FIG. 5
The present invention relates generally to a fluid fuel burner and more particularly to an improved burner for firing gaseous fuel, either alone or in combination with liquid fuel.

Multiple spud type gaseous fuel burners, of the type shown for example in U.S. Patent 3,032,097, for firing furnaces of vapor or steam generators have attained a high degree of reliability and may be operated over a wide load range. In the past, it has been customary that such burners be capable of stable operation over a load range of at least ten to one, even under the adverse low fuel gas pressure conditions discussed in the aforementioned patent. Such a wide range of operation normally requires reasonably accurate control of both the air and fuel flows, especially in the lower portions of the load range, to avoid incomplete combustion, flame instability or even total loss of ignition.

As the size of steam generating units (and therefore the number of burners per unit) increases, it becomes increasingly difficult for the operating personnel to give to each burner the time and attention required to ensure that the gas and air flow conditions are within the limits required for safe and stable operation, especially during periods when the load on the unit is being changed. Therefore, it has become very important that the gas burners be capable of stable and safe operation under conditions which heretofore were considered to be intolerable.

The trend toward completely automated burner control has placed even greater emphasis on burner stability under upset conditions since, in the event of a control equipment failure, the conditions existing in the ignition zone might conceivably be more extreme than would otherwise be possible. For example if, during a proposed load change from one to full load, the air flow to a burner increased but the fuel flow did not follow (due to a control failure), the resulting condition would be full load air with one-tenth load gas and the gas flame might readily be blown out. Therefore, recognizing that dangerous furnace conditions can be avoided by maintaining stable and complete ignition in each burner, where automated control is contemplated, the burner must be capable of stable operation under all conceivable fuel-air flow conditions that might result from failure of the burner controls.

The problems attendant on obtaining gas burner stability over a wide load range might best be explained in terms of the normal method of stabilizing ignition in a gas burner, i.e. creating a turbulent air-flow zone having eddy currents with maximum variations of air velocity and direction, into which the gaseous fuel is projected. In a gas burner having fixed discharged orifices, as the fuel input is varied over a 10 to 1 range, the gas supply pressure varies by a factor of almost 100, while the kinetic energy of the gas jets varies by a factor of almost 1000. Thus, the generating or projecting power of the gas jets into the air stream increases at a much greater rate than the gas input rate. This being true, it can be seen that it is extremely difficult to effectively project the gas jets into the same turbulent air stream at all load conditions. Of course, if the burner is being properly operated (either manually or by automatic control) so that the air flow and gas flow are maintained in their proper proportions over the load range, the effect of the high rate of kinetic energy change of the gas jets will be balanced for the most part by a corresponding change in kinetic energy in the air stream. However, when it becomes necessary to provide flame stability under extremely upset conditions, it can be seen that the high rate of increase of gas jet generating force, and the consequent problem of projecting the fuel into a given air stream, presents a formidable obstacle.

It is therefore an object of the present invention to provide a gaseous fuel burner wherein stable flame conditions may be maintained over a wide load range of burner operation and under extremely upset conditions. More particularly, it is an object of the present invention that this burner exhibit ignition stability under the upset condition of low fuel input and high air throughput, e.g. gas input corresponding to one-tenth burner load, and air throughput corresponding to full load.

A still further object of the present invention is to provide a multiple spud type gaseous fuel burner capable of operating either alone or in combination with a supplemental fuel such as oil.

The foregoing objects and other features and advantages are attained, according to the present invention by a burner arrangement that includes means for maintaining a high velocity stream of combustion supporting gas, such as air, and first and second shielding elements disposed laterally adjacent each other within the air stream for producing respectively first and second shielded turbulent ignition zones on their downstream sides. According to the invention, pressurized gaseous fuel is supplied to a fuel conduit having a discharge opening positioned to direct a jet of gaseous fuel laterally through the second zone and toward the first zone, whereby at low gaseous fuel pressure ignition stability is maintained primarily in the second zone and at high gaseous fuel pressure ignition stability is transferred so as to be maintained primarily in the first zone.

More particularly, the advantages of the multi-spud burner described herein are attained in combination with a furnace wall having a circular port formed therein and a burner wall spaced from the furnace wall to form a windbox therebetween to which superatmospheric pressure is supplied. The fuel burner comprises an air register of circular cross-section disposed within the windbox and arranged to discharge a whirling stream of high velocity air through the burner port. A vane impeller is disposed axially within the air stream adjacent the discharge port of the register for producing a centrally disposed first shielded turbulent zone on the downstream side of the impeller. A torus-shaped gaseous fuel supply manifold is disposed substantially axially with respect to the burner port and is connected for the supply of pressurized gaseous fuel to a plurality of fuel conduits or spud elements having their discharge ends arranged in a circular pattern about the impeller. Connected to each of the spud elements at a short distance from its distal end is a collar or shielding plate which is laterally adjacent and near to the impeller, the shielding plates being arranged to produce second shielded turbulent zones on their downstream sides. Each of the spud elements is formed with at least one discharge opening positioned to direct a jet of gaseous fuel laterally and through the second shielded zone formed by the respective collar and toward the first shielded zone on the downstream side of the impeller, whereby the primary ignition stability is maintained in the stream of the spud collars at low load conditions, and at high load conditions the primary ignition stability is transferred so as to be maintained in the zone on the downstream side of the impeller.

The various features of novelty which characterize the 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 ad-
vantages and specific objects attained by its use, reference should be had to the accompanying drawings and descriptive matter in which there is illustrated and described a preferred embodiment of the invention.

In the drawings:

FIG. 1 is a sectional side view of the gas burner of the present invention illustrated in conjunction with a liquid fuel atomizer assembly;

FIG. 2 is a furnace end view of the burner of FIG. 1 taken along line 2—2 of FIG. 1;

FIG. 3 is an enlarged furnace end view of the distal end portion of one of the gas spuds shown in FIGS. 1 and 2, this view being taken along line 3—3 of FIG. 4;

FIG. 4 is a view of the spud distal end taken along line 4—4 of FIG. 3;

FIG. 5 is a sectional side view of an alternate embodiment of the gas burner of the present invention wherein the gas supply manifold is disposed immediately behind the burner throat; and

FIG. 6 is a sectional side view of another alternate embodiment of the gas burner of the present invention wherein the gas supply manifold is located outside the windbox to facilitate removal of the gas spuds.

Referencing FIGS. 1 and 2, a burner 10 is arranged to fire through a circular port 11 formed in the water cooled wall 12 of a furnace chamber 13 of a steam generator. A burner front wall 14 is spaced from the furnace wall 12 to form therebetween a windbox 15 to which superatmospheric air is supplied from a suitable controlled source (not shown). The boundary walls of the port 11 include a short cylindrical section 25 connected at its discharge end with a flaring section 26 formed of suitable refractory material and at its inlet edge with the smaller diameter end of a frusto-conical section 27 connected with the annular front plate 22 of the cylindrical air register 20 which is suitably supported within the windbox 15 coaxially with respect to the port 11. The register 20 includes a circular back plate 21 spaced from the front plate 22, and a plurality of circumferentially arranged blades or vanes 23 pivotally mounted between the front and back plates 22 and 21 so as to be rotatable about their axes which are substantially parallel with the central axis of the port 11. Although no register operating mechanism is shown in the drawings, it will be appreciated that there are known mechanisms, operable from without the windbox 15, for rotating the register vanes 23 about their axes. By so manipulating the register vanes 23 the quantity of air passing through the register as well as the degree of spin imparted to the air can be regulated.

A fixed-position tubular sleeve 30, axially arranged with respect to the burner port 11, extends through the burner wall 14 and the register back plate 21 and terminates within the register 20. Slightly disposed within the sleeve 30 is a tubular distance piece 31 to which is attached a vaned impeller or defuser cone 32. Although the impeller 32 is preferably of the type disclosed in U.S. Patent 2,260,062 (FIGS. 8 through 11), it should be recognized that the function of this element is to disrupt the air flow stream so as to provide a shielded turbulent air zone on its downstream side, and that other elements could be designed to accomplish this same result.

In the burner embodiment shown, an oil atomizer assembly 50 is removably housed within the distance piece 31 so that the atomizer tip 51 terminates adjacent the impeller 32. The atomizer assembly 50 may be of any suitable known type arranged to discharge from its tip 51 a substantially conical spray of finely atomized oil droplets, for example, the atomizer assembly disclosed in the aforementioned U.S. Patent 2,260,062 could be used in this burner.

A fuel supply tube 18 extends from within the register 20 across the windbox 15 and through the burner wall 14 and register back plate 22, thus providing means for visually monitoring ignition conditions of the burner 10. It will also be recognized that a suitable igniting torch (not shown) is provided to initiate the burning of fuel discharged from the burner 10 during start-up.

Disposed within the windbox 15 adjacent the register back plate 21 is a torus-shaped gaseous fuel manifold 40 which is connected for the controlled flow of pressurized gaseous fuel from the supply pipe 41. A plurality (8 in the embodiment shown) of spud elements 42 are each connected to the manifold 49 through elongated tubular fluid conduits 43 to tips 44, and extend through the register back plate 21 substantially parallel with the central axis of and toward the port 11. The chisel-faced spud tips 44 of the spud elements 42 terminate at approximately the juncture of the frusto-conical section 27 and the cylindrical section 25 with the port 11 and are equally spaced circumferentially about the impeller 32.

Referring particularly to FIGS. 3 and 4, each of the spud elements 42 has connected thereto at a short distance from the distal end thereof a collar or shielding plate 45, the function of which is to produce a shielded turbulent air zone on the downstream side thereof. The collars 45 are preferably formed with slots 45A to permit passage of cooling air to prevent overheating of the spud tips 44. Each of the spud elements 42 has formed therein a plurality (4 in the embodiment shown) of discharge orifices 46, two of which direct gas jets in diametrically opposite directions immediately downstream of the collar 45, and the remaining two of which are formed on opposite angular end faces of the spud tip 44 to project gas jets in the same plane as the first two and slightly forwardly thereof.

The spud elements 42 are oriented to project jets of gas toward the shielded turbulent zone downstream of the impeller 32, and preferably (as shown in FIG. 2) one pair of discharge orifices 46 of each spud element 42 is directed (as shown by the arrows 47) toward the impeller 32 at an angle of approximately 20°—25° from a radial line emanating from the center of the impeller 32 toward the individual spud element. The effect of this arrangement of spud elements is to project at least a substantial portion of the gas to be burned toward the shielded zone downstream of the impeller 32 in a direction substantially tangential thereto, while the remaining portion is projected into the outer throat area within the port 11.

With the above-described gas burner arrangement, when operating at high load conditions, the kinetic energy of the gas jets issuing from the impeller 32 is sufficient to project gas into the shielded turbulent zone formed in the downstream side of the impeller 32 where-
oil firing position. By thus positioning the impeller 32 downstream of the spud tips 44 when firing oil, the spraying of oil droplets on the spud tips 44 and the consequent coking of the oil and possibility of plugging of the gas discharge orifices 46 is avoided. The necessary positioning of the impeller 32 may be done mechanically or by a suitable operating mechanism 52, and the atomizer assembly 59 can be removed or retracted when firing only gas, to prevent overheating of the atomizer tip 51. It should be noted that sufficient lateral or radial clearance (see Fig. 2) is provided between the impeller 32 and the spud collars 45 so as not to obstruct movement to the impeller 32. It is important, however, that the spud collars 45 be near to the impeller 32 so that the air flowing therebetween does not completely dissipate the gas jets before they reach the shielded impeller ignition zone.

Testing of a full scale model (nominally 150 million B.t.u. per hour full load input rate) has indicated that the above-described gas burner arrangement exhibits ignition stability characteristics far superior to what has been obtainable heretofore on any known burner arrangements. The dimensions specified herein are not intended to limit in any way the scope of the invention, but are rather intended to be merely illustrative. In the model tested, the diameter of the cylindrical section 25 of the port was 33-inches, and the diameter of the impeller 32 was 14-inches, so that the central ignition zone occupied about one-fifth of the minimum port area. The 2-inch diameter spud elements 42 were provided with 4-inch diameter circular collars 45 secured 2-inches from the distal end of the spud elements 42, and they were circumferentially evenly spaced about a 19-inch diameter spud circle. The four discharge orifices 46 of each spud element 42 were 3/4-inch in diameter. Although spud type burners of prior design have generally used smaller orifices (usually 1/4-inch), in this gas burner, the larger orifices were found to be preferable because they produce gas jets having greater and more predictable projecting characteristics. The use of fewer large discharge orifices also reduces the cost of manufacturing of the spud elements 42 and reduces the possibility of fouling of the orifices.

In the alternate embodiments of Figs. 5 and 6, similar parts to those of the above-described main embodiment are provided with the same identifying numbers. Except for the arrangement of the gas supply system, the burners of Figs. 5 and 6 are identical to the burner shown in Figs. 1 through 4, and the above-described features and advantages are common to all of the embodiments.

In the embodiment of Fig. 5, a gas supply line 61 delivers gaseous fuel from a controllable source (not shown) to the annular gas supply manifold 60 disposed immediately outside the frusto-conical section 27 of the burner port 11. A plurality of spud elements 62 are connected to the manifold 60 and extend radially inwardly into the burner throat through openings formed in the frusto-conical section 27. The ends of the spud elements 62 are formed with right angle bend portions 62A so that the distal ends of the spud elements 62 are oriented similarly to those shown in Figs. 3 and 4. In this arrangement, the spud drilling and the placement of the collars 45 with respect to the impeller 32 may be exactly the same as described above in relation to the main embodiment and the same stable operating characteristics will prevail. With an arrangement of this type, however, it is preferable that the number of spud elements 62 be less than in the above-described main embodiment, to avoid unnecessary increase in burner draft loss or an upset of the burner air flow pattern because of the extension of the spud elements 62 through the annular throat portion of the burner normal to the air flow.

In the embodiment of Fig. 6, the gas supply line 71 delivers gaseous fuel from a controllable source (not shown) to the ring type gas supply manifold 70 disposed outside of the burner front wall 14. A plurality of tubular spud sleeves 77 extend from the front wall 14 and through the register back plate 71 and terminate with an outwardly extending collar portion 75 which is similar in construction and is similarly located with respect to the impeller 32 as the collars 45 in the main embodiment. The spud elements 72 in this arrangement, extend through the spud sleeves 77 and are detachably connected by flanged couplings or other suitable connecting means to the ring manifold 70 in a manner similar to that shown, for example, in U.S. Patent 2,826,249. It should be noted that the spud drilling in this embodiment is similar to that shown for the main embodiment, and that the function of the collar portion 75 is similar to that of the collars 45 of the main embodiment. The primary advantage of this embodiment is that the spud elements 72 may be removed from service for cleaning or replacement from outside the windbox 15 without removing the vapor generator from service.

While in accordance with the provisions of the statutes there is illustrated and described herein a specific embodiment of the invention, those skilled in the art will understand that changes may be made in the form of the invention covered by the claims, and that certain features of the invention may sometimes be used to advantage without a corresponding use of the other features.

What is claimed is:
1. In combination with a furnace wall having a circular burner port including a smooth-walled, converging frusto-conical section formed therein and a burner wall spaced from said furnace wall to form a windbox therebetween to which superatmospheric air is supplied, a gaseous fuel burner comprising an air register of circular cross-section disposed within said windbox and having a discharge end adjacent and opening to the frusto-conical section of said burner port, said air register being arranged to discharge a whirling stream of high velocity air through said burner port, an impeller plate disposed axially within said frusto-conical section to define an annular space therebetween positioned adjacent the discharge end of said register for producing a centrally disposed first shielded turbulent zone downstream airflow-wise of said impeller plate, a plurality of collar plates disposed in a circular pattern within said annular space for producing second shielded turbulent zones downstream airflow-wise of said collar plates, each of said collar plates being contiguous to the inner periphery of said annular space and radially adjacent to said impeller plate, said collar plates being in a plane normal to the axis of and spaced downstream airflow-wise of said impeller plate, a gaseous fuel manifold, means for supplying pressurized gaseous fuel to said manifold, a plurality of fuel conduits connected to said manifold, each of said conduits extending into a corresponding one of said second zones and having a discharge opening formed therein, said discharge opening being positioned downstream airflow-wise of said collar plates to direct a jet of gaseous fuel laterally through its corresponding second zone toward said first zone, whereby at low gaseous fuel pressure ignition stability is maintained primarily in said second zones and at high gaseous fuel pressure ignition stability is transferred so as to be maintained primarily in said first zone.
2. In combination with a furnace wall having a circular burner port including a smooth-walled, converging frusto-conical section formed therein and a burner wall spaced from said furnace wall to form a windbox therebetween to which superatmospheric air is supplied, a gaseous fuel burner comprising an air register of circular cross-section disposed within said windbox and having a discharge end adjacent and opening to the frusto-conical section of said burner port, said air register being arranged to discharge a whirling stream of high velocity air through said burner port, a vaned impeller plate disposed axially within said frusto-conical section to define an annular space therebetween positioned adjacent the discharge end of said register for producing a centrally disposed first shielded turbulent zone downstream airflow-wise of said
impeller plate, a liquid fuel atomizer assembly extending substantially from outside said windbox substantially axially through said register and having its discharge end positioned to direct a conical spray of atomized fluid fuel axially into and through said first zone, a plurality of collar plates disposed in a circular pattern within said annular space for producing second shielded turbulent zones downstream airflow-wise of said collar plates, each of said collar plates being contiguous to the inner periphery of said annular space and radially adjacent to said impeller plate, a gaseous fuel manifold, means for supplying pressurized gaseous fuel to said manifold, a plurality of fuel conduits connected to said manifold, each of said conduits extending through a corresponding one of said collar plates and having a multiplicity of discharge openings formed therein, said discharge openings being positioned downstream airflow-wise of said collar plates to direct a jet of gaseous fuel laterally through their corresponding second zones toward said first zone, the discharge openings in said fuel conduits being sized and positioned so that at least a substantial portion of the total gaseous fuel input to the burner is directed toward said first zone, whereby at low gaseous fuel pressure ignition stability is maintained primarily in said second zones and at high gaseous fuel pressure ignition stability is transferred so as to be maintained primarily in said first zone.

3. In combination with a furnace wall having a circular burner port including a smooth-walled, converging frusto-conical section formed therein and a burner wall spaced from said furnace wall to form a windbox therebetween to which superatmospheric air is supplied, a gaseous fuel burner comprising an air register of circular cross-section disposed within said windbox and having a discharge end adjacent and opening to the frusto-conical section of said burner port, said air register being arranged to discharge a whirling stream of high velocity air through said burner port, a vanned circular impeller plate disposed axially within said frusto-conical section to define an annular space therebetween positioned adjacent the discharge end of said register for producing a centrally disposed first shielded, turbulent zone downstream airflow-wise of said impeller plate, a plurality of collar plates disposed in a circular pattern within said annular space for producing second shielded turbulent zones downstream airflow-wise of said collar plates, each of said collar plates being contiguous to the inner periphery of said annular space and radially adjacent to said impeller plate, a gaseous fuel manifold, means for supplying pressurized gaseous fuel to said manifold, a plurality of fuel conduits connected to said manifold, each of said conduits extending through a corresponding one of said collar plates and having a multiplicity of discharge openings formed therein, said discharge openings being positioned downstream airflow-wise of said collar plates to direct a jet of gaseous fuel laterally through their corresponding second zones toward said first zone, the discharge openings in said fuel conduits being sized and positioned so that at least a substantial portion of the total gaseous fuel input to the burner is directed toward said first zone, whereby at low gaseous fuel pressure ignition stability is maintained primarily in said second zones and at high gaseous fuel pressure ignition stability is transferred so as to be maintained primarily in said first zone.

4. The combination according to claim 1 wherein said fuel manifold is disposed within said windbox between said register and said burner wall, and said fuel conduits extend through said register substantially parallel to the central axis of the burner.

5. The combination according to claim 1 wherein said fuel manifold is disposed outside of said windbox, and said conduits are detachably connected to said manifold and extend through said windbox and said register substantially parallel to the central axis of the burner.

6. The combination according to claim 1 wherein said fuel manifold is disposed within said windbox immediately adjacent said furnace wall, and said fuel conduits extend radially into said air stream and are provided at their distal ends with a substantially right angle bend.

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