May 28, 1957 E. D. PHILLIPS 2,793,686

AXIALLY ADJUSTABLE FUEL BURNER FOR FURNACES

Filed March 18, 1952 2 Sheets-Sheet 1

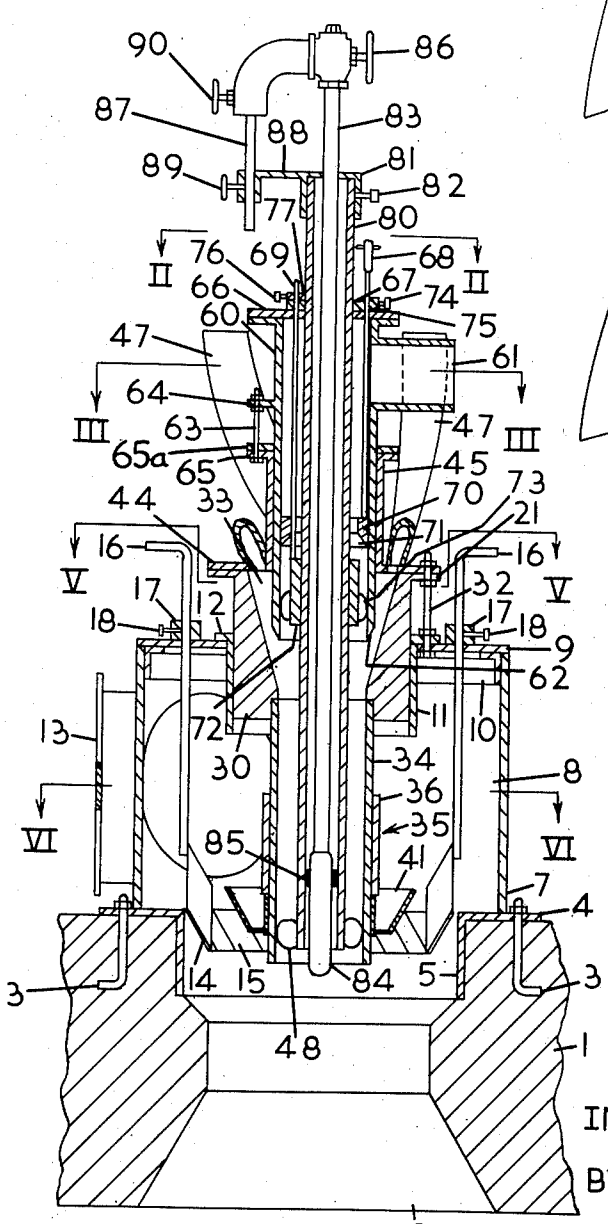


FIG. 1

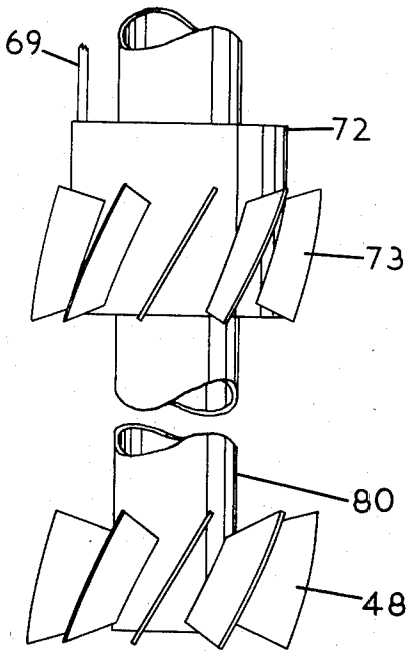


FIG. 7

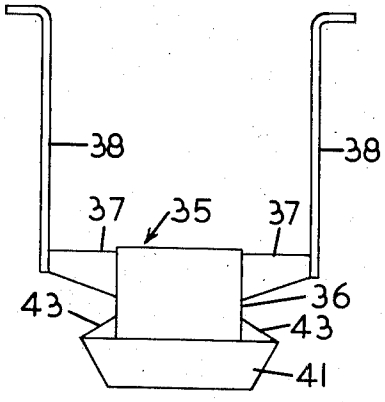


FIG. 8

INVENTOR
EVERETT D. PHILLIPS
BY

ATTORNEY

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AXIALLY ADJUSTABLE FUEL BURNER FOR FURNACES

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2 Sheets-Sheet 2

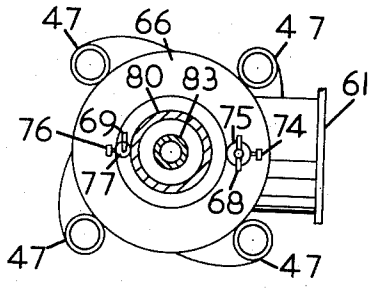


FIG. 2

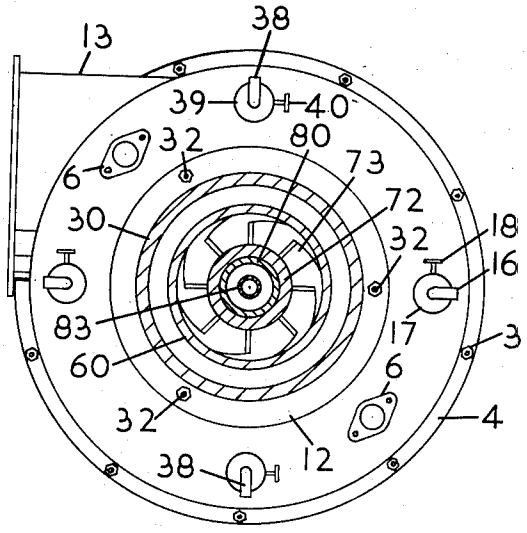


FIG. 5

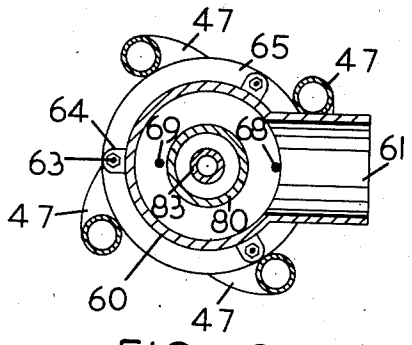


FIG. 3

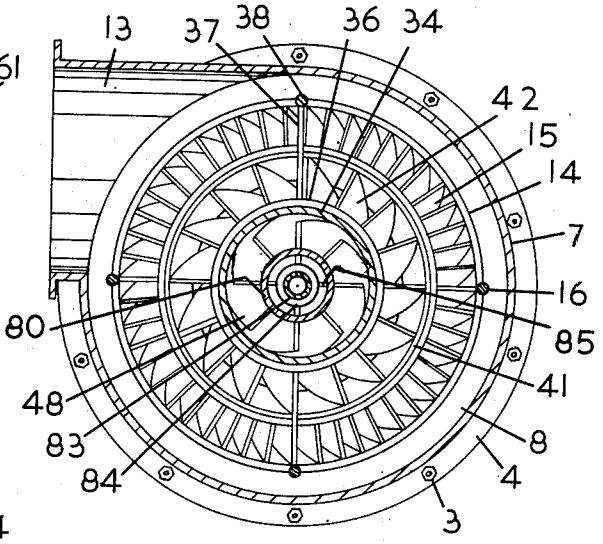


FIG. 6

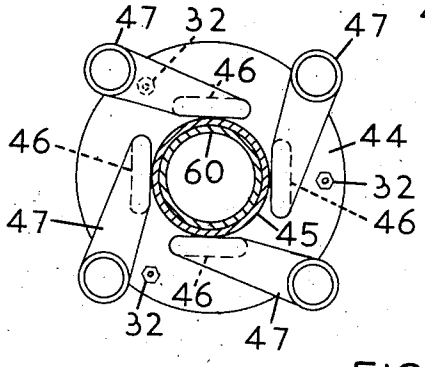


FIG. 4

INVENTOR
EVERETT D. PHILLIPS
BY

ATTORNEY

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2,793,686

AXIALLY ADJUSTABLE FUEL BURNER FOR FURNACES

Everett D. Phillips, Danville, Pa.; Rubye W. Phillips, executrix of said Everett D. Phillips, deceased

Application March 18, 1952, Serial No. 277,179

2 Claims. (Cl. 158—1.5)

This invention relates to furnace burners and more particularly to an improved design for a burner for industrial furnaces and boilers.

My invention is particularly designed to provide a burner capable of operation with oil, gas or powdered coal, depending upon the most economical fuel available in the location where the burner is installed. The general structure of the burner remains the same irrespective of the fuel utilized, the burner itself being made adjustable to meet the particular operating conditions necessary to obtain efficient combustion with each of the fuels. Thus, my invention is universally applicable as a single design for a packaged unit, eliminating the costs entailed by the necessity of constructing three different types of burners each specialized to the type of fuel with which it is to be used.

My invention is designed to provide a burner capable of complete and rapid adjustment at the time of installation to the particular circumstances of the installation. Heretofore, conventional packaged burner designs provided a unit adapted to average operating conditions. These burners, however, were too inflexible and not adapted to modification to meet the special operating conditions frequently encountered at the time of installation. In order to effect the necessary modifications, these burners frequently had to be substantially rebuilt in the field. This rebuilding often entailed the shortening or lengthening of whole sections of the burner, removal of excess parts or the incorporation of entirely different sub-assemblies. The result was a burner consisting of a patchwork of modified parts and only partially adapted to the particular needs of the installation involved. Further, these field modifications, whether small or great, result in excessive installation costs as well as long and costly delays while the modifications are completed. These modifications necessitate an installation crew including not only an experienced combustion engineer but a crew of welders, sheet metal men and other mechanics in addition to the normal installation crew necessary to initially mount the burner on the furnace.

My invention entirely eliminates all of these installation difficulties by providing a unit of such design that its various parts are rendered rapidly and easily adjustable to meet each and every operating condition. My invention is characterized by components which may be adjusted to meet operating conditions with a minimum of tools and, if necessary, by a single installation man, thus, eliminating the expense of a large installation crew. Furthermore, the resulting burner does not consist of a patchwork of modified parts and thus is capable of greater efficiency in operation. Moreover, if so desired or required my burner can be lifted bodily and in a single unit from its housing 7 by removing nuts from bolts 3 and lifting out, with replacement being made in the reverse order. Where a furnace using two or more burners are in operation my burner can be removed and replaced without taking the furnace out of service. By reason of the built-in adjustment features the burner may be precisely adjusted

to its operating conditions to produce a maximum of combustion efficiency.

My burner permits economies in manufacture by consolidation of designs and elimination of the total number of parts necessary to meet all of the various operating conditions. Standardization of the various components of the burner is made possible.

These and other objects and advantages of my invention will be immediately seen by those acquainted with the problems of combustion engineering upon reading the following specification and the accompanying drawings.

In the drawings:

Figure 1 is a central, sectional view of my invention showing the burner mounted to the front of a furnace.

Figure 2 is a sectional view taken along the plane II—II of Figure 1.

Figure 3 is a sectional view taken along the plane III—III of Figure 1.

Figure 4 is a sectional view of my invention looking toward the furnace but showing only the relationship of the primary air inlets with respect to the remainder of the burner structure.

Figure 5 is a sectional view taken along the plane V—V of Figure 1.

Figure 6 is a sectional view taken along the plane VI—VI of Figure 1.

Figure 7 is an enlarged, fragmentary view of the means for regulating the primary and tertiary air flows.

Figure 8 is a view of the inner sliding secondary air control, rotated 90° about its central axis from its position in Figure 1.

In executing the objects and purposes of my invention, I have provided, adjacent the furnace wall, a secondary air chamber communicating with the throat of the furnace. Means are provided for causing the air to spiral as it enters the throat of the furnace. Concentrically within this secondary air chamber is a tube for conducting primary air into the throat where it will become intermixed with the secondary air for sustaining combustion. Means are provided within the primary air conduit for causing this air to spiral in the same direction as the secondary air. A tertiary air inlet is provided for introducing tertiary air to the primary air stream. The volume of secondary air entering the throat of the furnace is made adjustable as well as the point at which the secondary air is actually discharged from the secondary air chamber into the furnace throat. Similarly, the point of discharge of the primary air into the furnace throat is likewise adjustable axially of the burner. Valve means are provided for controlling the admission of tertiary air into the primary air stream and for causing this air to spiral as it enters the primary air stream. Further adjustment means is provided to regulate the mixing or turbulence of the primary air within the burner whereby a thorough dispersion of the fuel within the primary air is effected before it is discharged into the throat of the furnace. Concentrically of the entire burner structure is a pipe for introducing oil should this type of fuel be utilized instead of a solid fuel carried by the primary air. The quantity and point of introduction of secondary and primary air to the oil discharged from the pipe may be adjusted to assure maximum combustion efficiency. The oil may also be used as a starter or igniter for the burner when burning solid fuels.

In the following description the terms "inwardly" and "outwardly" are frequently used and are to be taken to mean "inwardly" toward the furnace and "outwardly" away therefrom. The terms "externally" and "internally" are also frequently used and are to be taken to mean "internally" toward the axial center of the burner and "externally" away therefrom.

a. Secondary air

With specific reference to the drawings, the numeral 1 indicates a furnace wall having a throat 2 therein. Attached to the outward face of the furnace wall by the lug bolts 3 is an annular plate 4 having an inwardly extending collar 5 seated in the throat 2. Attached to the plate 4 is the cylindrical housing 7 for the secondary air chamber 8. It will be recognized that the housing 7 may be a square or polyhedron but a circular shape is more efficient and satisfactory. The outer end of the secondary air chamber 8 is closed by a removable cover 9 bolted to the angle 10. The cover has a large, concentric, circular opening through which passes the guide collar 11. The guide collar 11 extends a substantial distance into the secondary air chamber and is supported by its flange 12 nesting against the outer surface of the cover 9. The flange 12 is rigidly secured to the cover 9 by bolts, welding or other fastening means.

Air is admitted to the secondary air chamber 8 through the air intake port 13 which enters the secondary air chamber 8 tangentially, whereby a clockwise rotation of the air is initiated in the chamber. Intake port 13 is described as entering housing 7 tangentially, and housing 7 as being circular, also, the vanes in the various ports will be described as being designed for production of clockwise rotation. This orientation of the ports has been used to simplify the description and is not to be construed as a limitation. Actually, intake port 13 can have the same width as that of housing 7 and housing 7 can be square or even rectangular in shape. Further, both clockwise and counter-clockwise rotations will be used in different burners serving the same furnace. Under certain circumstances, both clockwise and counter-clockwise rotation may be used in the same burner.

Seated within the collar 5 is a conical ring 14 having a plurality of radially inwardly directed vanes 15 (Figure 6). The conical shape of the ring 14 is designed to urge the air inwardly. The vanes 15 are designed to urge the air to rotate clockwise as it passes through them. The ring 14 and the vanes 15 are movable axially of the collar 5 by means of the rods 16. Each of the rods 16 passes through a boss 17 having a thumb screw 18 for holding the rods in any particular position of adjustment (Figures 1 and 5).

A pair of access ports 6 are provided in the cover 9 (Figure 5). These ports 6 serve both as inspection windows and as openings through which the burner may be lighted. The ports 6 are closed by covers having transparent windows to permit inspection.

b. Primary air

Slidably seated within the guide collar 11 is the throat piece 30. The throat piece 30 has an outer flange 21 connected to the cover 9 by three bolts 32 (Figures 1 and 4). By reason of the bolts 32, the throat piece 30 may be telescopically adjusted with respect to the collar 11. The throat piece 30 has a concentric, conical passageway 33 of decreasing diameter toward the furnace. The inward end of the throat piece supports a tubular extension 34 extending inwardly into the opening in the collar 5. The collar 5 and the extension 34 are concentric.

Slidably mounted on the extension is the valve shaped piece 35 (Figures 1 and 8). The valve piece includes a cylindrical slide 36 surrounding the extension 34 and a pair of wings 37 to the ends of which are attached the adjustment rods 38. The rods 38 are spaced midway between the rods 16 (Figure 5). The rods 38 extend outwardly through bosses 39 mounted to the cover 9 (Figure 5). The rods are secured by thumb screws 40 set in the bosses 39. On the inward end of the slide 36 is a conical annulus 41 having its end of lesser diameter directed toward the furnace. The annulus 41 is concentric with the slide 36 and is spaced therefrom to create a tapered passageway therebetween. The slide 36 may extend only part way into vanes 42 on annulus 41. The greater diameter of the annulus 41 is such that it may pass through the

ring 14, the outer diameter of the annulus substantially corresponding to the inner diameter of the ring 14. The passageway within the annulus is equipped with inclined vanes 42 designed to urge the air passing therethrough to rotate clockwise (Figure 6). The vanes 42 are attached to the annulus and to an extension of the slide for rigid support. The annulus 41 itself is further anchored to the slide 36 by a pair of diametrically placed brackets 43 (Figure 8). The brackets 43 actually are specially shaped extensions of two or more of the vanes 42.

The outer end of the throat piece 30 is closed by a wide flange 44 secured to an outwardly extending, concentric, tubular sleeve 45. Externally of the sleeve 45 are four, equally spaced, elongated apertures 46 (Figure 4). These apertures communicate with the wide, outer end of the central passageway 33. To each of the apertures 46 is attached a tube 47. The tubes 47 extend outwardly from the flange 44 tracing a counter-clockwise, spiral path. As they extend outwardly, their shape changes from that of the elongated apertures 46 to that of a circle. During this transition in shape, the internal, cross-sectional area of the tubes remains the same, only the shape of the internal passageway changes. These tubes introduce the primary air to the burner and their outward, counter-clockwise, spiral path is designed to cause the air to circulate clockwise as it enters the passageway 33.

The primary air is again caused to spiral by the vanes 48 on the inward end of the hereinafter described central tube 80.

c. Tertiary air

Telescopically received through the sleeve 45 is the cylindrical, tertiary air duct 60. The duct 60 is provided with an inlet port 61 adjacent its outward end. The duct is of such length that it projects through the sleeve 45 into the passageway 33. Its inward end is beveled at 62 to permit it to form a seal against the converging, internal walls of the throat piece 30. The duct 60 is adjustable axially of the burner, its position being controlled by the bolts 63 (Figures 1 and 3). The bolts 63, at their outer ends engage the lugs 64 extending radially from the duct and, at their inner ends, engage the radially extending flange 65 on the outward end of the sleeve 45. An annular buffer ring 65*a* rests above but is separate from flange 65 and is slidably and axially mounted in relation to flange 65, bolts 63, and duct 60. The annular buffer ring 65*a* has an outside diameter equal to the outside diameter of flange 65. The outward end of the duct 60 is closed by the annular cap 66 and a sealing ring 67. Slidably mounted through the cap 66 are a pair of control rods 68 and 69. The control rod 68 extends a substantial distance into the duct 60 and on its end mounts a valve ring 70. The valve ring has a large, central opening entering, at its inward end, into the conical valve seat 71. The damper ring 70 is slidable axially of the duct 60, its position being controllable by means of the control rod 68. Inwardly of the damper ring 70 is the annular block 72. The annular block 72 is slidably mounted on the hereinafter described central tube 80. The block 72 is adjustable axially of the duct 60, its position being controllable by means of the control rod 69. About the inward end of the block 72 are arranged a plurality of equally spaced, inclined fins 73 (Figure 7) designed to impart clockwise rotation to the tertiary air before this air is discharged from the duct 60. The position of the control rod 68 is secured by the set screw 74 in the boss 75. The position of the control rod 69 is secured by the set screw 76 in the boss 77.

d. Igniting equipment

Passing centrally down through the entire burner, including the duct 60, the throat piece 30 and the extension 34 is a central tube 80. The central tube 80 projects outwardly beyond the cap 66 and at its end has a removable cap 81, secured to the central tube 80 by the set screw 82. Extending co-axially through the central tube 80 is a

pipe 83 having a nozzle 84 on its inward end. The nozzle is supported against radial movement by the spacer 85. The pipe 83, at its outward end, is provided with a valve 86. A support conduit 87 for the pipe 83 parallels the pipe 83 and passes through the arm 88 of the cap 81. The conduit 87 is locked to the arm 88 by the screw 89. Normally, the liquid fuel supplied by the pipe 83 is atomized by means of steam. Both the oil and the steam are introduced to the pipe 83 at its outward end through flexible hoses (not shown). The valves 86 and 90 provide individual control for the steam and the fuel.

OPERATION

The fundamental principles of operation of my improved burner are basically the same as those of existing conventional burners, the primary differences lying in the operation of the burner at the time it is installed and in the manner in which the operation of the burner is carried out when the burner is complete and functioning.

At the time the burner is installed, the primary consideration is the adjustment of the burner to meet the operating conditions of the particular installation. It is at this point that the structure of my burner appears as a most important advancement since it permits practically unlimited adjustment. Preferably, the burner is partially disassembled at the time of installation by removing all of that structure extending outwardly from the secondary air chamber 8 except the throat piece 30. In this stripped down condition, the secondary air chamber may be mounted to the furnace wall by means of the lugs 3 passing through the annular plate 4. With the secondary air chamber 8 in place, the remainder of the structure may be attached by bolting the sleeve 45 to the throat piece 30. After this has been done, the necessary attachments may be made to the primary, secondary and tertiary air leads and the pipe 87 may be connected to a suitable source of liquid or gaseous fuel. The burner can be installed completely assembled, if the circumstances warrant it.

At this point the burner is installed but the important process of adjusting the burner to provide satisfactory combustion must now be made. Heretofore, at this point, great time was lost and extended difficulties were encountered because the burners were incapable of making the necessary adjustments to meet the particular combustion requirements of each individual installation.

To provide satisfactory combustion, it is essential not only that a proper air and fuel ratio be obtained but it is essential that the fuel be thoroughly intermixed with the air to produce complete combustion. It is also necessary that the shape and velocity of the fuel-air stream be regulated to produce a flame of satisfactory shape. Further, it is essential that the point of combustion, that is, the point of ignition of the fuel-air mixture be properly located within the burner ring or throat of the furnace. If this point of ignition of the fuel-air mixture is located too deeply within the furnace, it may result in injury to the walls of the furnace as well as poor combustion of the fuel. If the flame is located too close to the burner ring, again poor combustion. This same flame will also cause rapid deterioration of the burner ring, necessitating frequent replacement. The shape of the flame is dependent in part upon the type of path the secondary air is travelling as it enters the burner ring and in part upon the point with respect to the burner ring the primary air carrying the fuel is introduced to the secondary air. The position of the flame with respect to the burner ring is determined largely by the point of introduction of the primary air to the secondary air.

When pulverized, solid fuels are used, the primary air functions only as a fuel carrier. Only sufficient primary air is introduced to the burner as is necessary to efficiently transport the fuel from the pulverizer to the burner. Excessive air is not utilized in order to maintain a non-explosive fuel-air ratio. Where the proportion of air

to fuel is low the mixture is too rich to ignite or if ignited, to sustain combustion. Since fuels may vary it becomes necessary to adjust the quantity of primary air necessary to transport the fuel. This is particularly true where the fuel may vary from dry to wet. When the fuel is wet, additional air is necessary to transport the heavy fuel and, therefore a greater proportion of the combustion air is introduced through the primary air stream. Where, however, the fuel is very dry, the proportion of air entering by means of the primary air stream may be quite small. In fact, it may be so small that insufficient air is provided by the primary air stream together with the secondary air stream to insure ideal combustion conditions. When this is the case, the provision for a tertiary air stream becomes important because this permits introduction to the primary air stream, at the burner, sufficient additional air to make up the difference and thus at all times insure an ideal combustion mixture.

Considering first the normal operating conditions wherein only primary and secondary air is used, by means of the rod 68 the damper ring 70 is moved inwardly until it tightly engages the annular block 72. This shuts off the tertiary air supply. The primary air is introduced through the pipes 47.

It is an important feature of my burner that the primary air is introduced axially of the burner rather than tangentially. Heretofore, it has been common practice to introduce this fuel-air mixture tangentially, and perpendicularly to the axis of the burner. This results in appreciable velocity loss of the primary air whereby quantities of the fuel drop out and accumulate in the burner. Not only does this result in improper combustion and a general disruption of the efficiency of the furnace but it can result in the accumulation of fuels where they may ignite. These fuel accumulations sometimes produce fires and periodically cause serious explosions. By introducing the solid fuel axially of the burner there is no reduction in the velocity of the primary air and thus the fuel is not permitted to drop out of suspension. Therefore, all of the fuel is carried into the combustion chamber of the furnace and no dangerous accumulations occur within the burner itself.

By reason of the spiraling of the pipes 47, the primary air, as it is introduced to the burner, is given an initial clockwise rotation. The pipes 47 discharge the primary air with its fuel into the outer part of the throat piece 30. This mixture, rotating in a clockwise direction, then passes through the restricted passageway 33 between the inclined sides of the throat piece 30 and the end of the tertiary air duct 60. It is important that sufficient turbulence be created in the primary air stream at this point to assure a thorough mixing of the fuel throughout all portions of the primary air. To effect this mixing, the passageway 33 is adjusted to a size such that the particular volume of primary air passing through this passageway will be caused to accelerate as it passes the end of the tertiary air duct 60 and then enter a turbulent air pattern in the inward portion of the throat piece 30. This is done by axially adjusting the tertiary air duct 60 by means of the bolts 63. Thus, not only may the desired turbulence be created to effect mixing at the time the burner is installed, but this passageway 33 may be adjusted from time to time during the operation of the burner to accommodate varying volumes of primary air necessitated by the condition of the fuel being utilized. The movement of the tertiary air duct 60 axially of the burner does not affect the closure of the damper ring 70 since this entire structure moves bodily with it.

After the primary air leaves the throat piece 30 it travels through the extension 34 and adjacent the inward end of the extension 34 is again forced into a clockwise spiral path by the vanes 48. The exact point at which the primary air is acted upon by the vanes 48 may be determined by axial adjustment of the central tube 80.

The position at which the primary air is discharged

into the secondary air stream with respect to the burner ring 2 is made adjustable. By means of the bolts 32, the throat piece 30 may be moved axially of the secondary housing 7. The movement of the throat piece 30 moves with it the entire structure outwardly of the throat piece and all of the structure passing through the throat piece. Thus, the entire structure relating to the primary and tertiary airs may be moved inwardly or outwardly as required. The exact position at which satisfactory combustion will be produced is dependent upon a number of factors. One of these factors is the proportion of combustion air entering through the primary air lead with respect to the proportion of the combustion air entering through the secondary air lead. It will depend in part upon the velocity of the air as it enters the burner as well as the shape and size of the burner ring 2 and the size of the furnace with which the burner is to be used. The quality and type of fuel employed will also have an appreciable influence upon this matter. It is thus seen that it is essential to make the burner adjustable to meet each of these factors since each of them may vary from one installation to another and from time to time during the operation of the furnace.

The secondary air enters through the conduit 13. The tangential arrangement of the conduit 13 with respect to the secondary air chamber 8 causes the air to circulate within the secondary air chamber 8. Since the secondary air is forced in under pressure, it is forced to escape through the conical ring 14. The conical ring restricts the passage of the air thereby increasing its velocity and at the same time bringing it into contact with the vanes 15. The already circling air is forced into a precise spiral pattern by the vanes as it enters the burner ring 2. Since the point at which the secondary air is released from the conical ring 14 into the burner ring 2 is important in determining the length and shape of the flame produced in the furnace, the conical ring 14 is made adjustable axially of the burner. By adjustment of this conical ring, the flame may be extended further into the furnace or it may be withdrawn closer to the burner ring. The axial movement of the conical ring 14 also permits the ring to be moved in conjunction with the primary air lead whereby the two may be maintained in a particular relationship while both are moved inwardly or outwardly with respect to the combustion chamber of the furnace.

The quantity of secondary air passing through the conical ring 14 as well as the shape of the stream of air escaping into the burner ring 2 may be controlled by movement of the annulus 41. The further the annulus 41 is moved into the conical ring 14 the greater the restriction of the amount of air which may pass between the annulus and the conical ring 14. When the annulus 41 is moved to its maximum inward position, it serves as a damper substantially stopping all air which would otherwise pass through the conical ring 14 into the burner ring 2. Under these circumstances, some air will pass through the passage within the annulus 41 and in turn will be caused to spiral by the vanes 42 in this passage. The use of the annulus in its most inward position will result in a narrow ring of air entering the burner ring 2, which ring of air will be spiraling at a relatively high velocity due to the restriction of the passageway through the annulus. When the annulus is moved to a position where it does not completely block the passage of air through the conical ring 14 but merely severely restricts it, the resulting shape of the air stream will be a cone converging as it passes through the burner ring 2. Such a cone will impinge upon the primary air thereby creating an elongated narrow flame. This is desirable in certain installations.

Where the fuel is particularly dry or where a substantial portion of the kinetic energy of the primary air stream is absorbed in the pulverizer, it may become necessary to supplement the primary air with tertiary air in order to provide sufficient air for efficient combustion. To introduce tertiary air, the damper ring 70 is moved outwardly to permit the desired quantity of tertiary air to pass through the tertiary air tube 60. Before the tertiary air is introduced to the primary air in the throat piece 30 it is caused to enter a spiral path by means of the inclined fins 73. The precise shape of this spiral as it enters the primary air stream may be controlled by axial manipulation of the annular block 72 upon which the fins 73 are mounted. At the same time, the correct point for introduction of the tertiary air to the primary air stream may be determined by axial movement of the tertiary air duct 60.

The pipe 83 is used to introduce a liquid fuel primarily for lighting the burner. When the burner is to be lighted, one of the access ports 6 is opened to permit an igniting means to be introduced to the stream of liquid fuel, such as oil, being sprayed from the nozzle 84. In this case only secondary air is used. Once the oil stream has been ignited and the burner ring 2 has been sufficiently heated, primary air is introduced. When a self-supporting flame has been established dependent upon the solid fuel, the oil is shut off by means of the valve 86.

It will be recognized that my burner provides a unit which is not only simple to install and adjust for optimum combustion but a unit which may be readily and easily cleaned and repaired. Any part of the unit may be reached without extensive disassembly. The burner may be taken apart section by section or it may be taken apart by removal of a few large sub-assemblies whereby the particular part to be cleaned or repaired is quickly made accessible. When desired the entire burner may be removed as a unit. At the same time, my burner provides a compact unit designed for burning fuels under a forced draft, in which the quantum of air to fuel may be quickly, precisely and easily regulated and in which the introduction of air into the furnace is confined to those streams subject to complete regulation. The burner does not admit of numerous air leaks which frequently cause inefficient combustion and lack of combustion control in conventional burners. It is further seen that my burner may be precisely constructed and this precision can be carried over into the burner after it has been installed because it is unnecessary to make any structural changes in the burner since all adjustments necessary for efficient operation are permitted by the original, factory built structure.

When the furnace is to be used to burn liquid fuels, the liquid fuel may be introduced through the burner as it is initially constructed for solid fuels by use of the pipe 83 and the nozzle 84. When a liquid fuel is thus used the tertiary air duct 60 may be moved inwardly until a seal is effected between the chamfered inward edge 62 of this duct and the walls of the central passageway of the throat piece 30. At the same time, the damper ring 70 is moved inwardly to effectively shut off the tertiary air. Valves in the air supply system for the burner and external of the burner, adapted for rapid operation, may be used for shutting off the primary and tertiary air in lieu of disturbing the adjustments for solid fuels. The liquid fuel is then burned with only the secondary air stream operating. The inward movement of the tertiary air duct 60 will cause the nozzle 84 to move inwardly with respect to the burner ring 2. This may be compensated by moving the central tube 80 together with the pipe 83 outwardly with respect to this tube. The required adjustments for proper combustion may be effected by manipulation of the conical ring 14 and of the annulus 41.

When gaseous fuels are burned, it is possible to use my burner without modification of the structure. The gaseous fuel is introduced through the same tubes 47 as are used for a pulverized, solid fuel. In this case, the tertiary air is shut off and the gaseous fuel caused to spiral and enter the burner ring where the combustion

mixture will be formed to fire the furnace at the desired point in the burner ring. Since all of the various parts of my furnace are adjustable, the exact point of ignition of this mixture may be closely regulated to position it correctly with respect to the burner ring.

Numerous modifications of my invention may be made without departing from the principle thereof.

I claim:

1. In a burner assembly, the combination including: a housing having therein a secondary air chamber; a primary air conduit concentrically mounted to said secondary air chamber, a portion of said primary air conduit extending through said secondary air chamber; a tertiary air conduit concentrically mounted to said primary air conduit and adapted to discharge into said primary air conduit; said primary air conduit being axially adjustable with respect to said housing; a conical ring mounted in the discharge end of said housing for movement axially of said housing; a plurality of inclined vanes mounted within said conical ring; a conical annulus slidably mounted on said primary air conduit and movable into said conical ring; the greater external diameter of said annulus being substantially equal to the lesser internal diameter of said conical ring; an air passage between said annulus and said primary air conduit; a plurality of inclined vanes mounted in said air passage.

2. In a burner assembly, the combination including: a housing having therein a secondary air chamber; a primary air conduit concentrically mounted to said secondary air chamber, a portion of said primary air conduit extending through said secondary air chamber; a tertiary air conduit concentrically mounted to said primary air conduit and adapted to discharge into said primary air conduit; said tertiary air conduit being axially adjustable with respect to said primary air conduit; said primary air conduit being axially adjustable with respect to said housing; a conical ring mounted in the discharge end of said housing for movement axially of said housing; a plurality of inclined vanes mounted within said conical ring; a conical annulus slidably mounted on said primary air conduit and movable into said conical ring; the greater external diameter of said annulus being substantially equal to the lesser internal diameter of said conical ring; an air passage between said annulus and said primary air conduit; a plurality of inclined vanes mounted in said air passage; a plurality of inclined vanes mounted in said tertiary air conduit for reciprocating movement axially of said tertiary air conduit; a plurality of inclined vanes mounted in said primary air conduit adjacent the discharge end thereof for reciprocating movement axially of said primary air conduit.

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469,254	France	May 15, 1914
323,578	Great Britain	June 13, 1929
363,396	Great Britain	Dec. 11, 1931