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Imatake et al.

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[54] **BURNER**

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[52] **U.S. Cl.** **431/353**, 431/182, 431/183, 239/404

[51] **Int. Cl.** **F23d 15/02**

[58] **Field of Search** 431/182, 183, 185, 431/350, 353; 239/404, 402

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[57] **ABSTRACT**

The present invention relates to a burner, in which burning air given the power of rotation and a fuel given the power of rotation are mixed and the resulting mixture is burnt, characterized in that a step part for mixing air and fuel and igniting the mixture is formed of a ceramic material to improve the effect of flame maintenance. In addition with the above mentioned description, according to the present invention, a burner, which is equipped with a straight air nozzle for supplying a linear air flow along the axial center of the burner and in which the ignition face is stabilized is provided.

5 Claims, 8 Drawing Figures

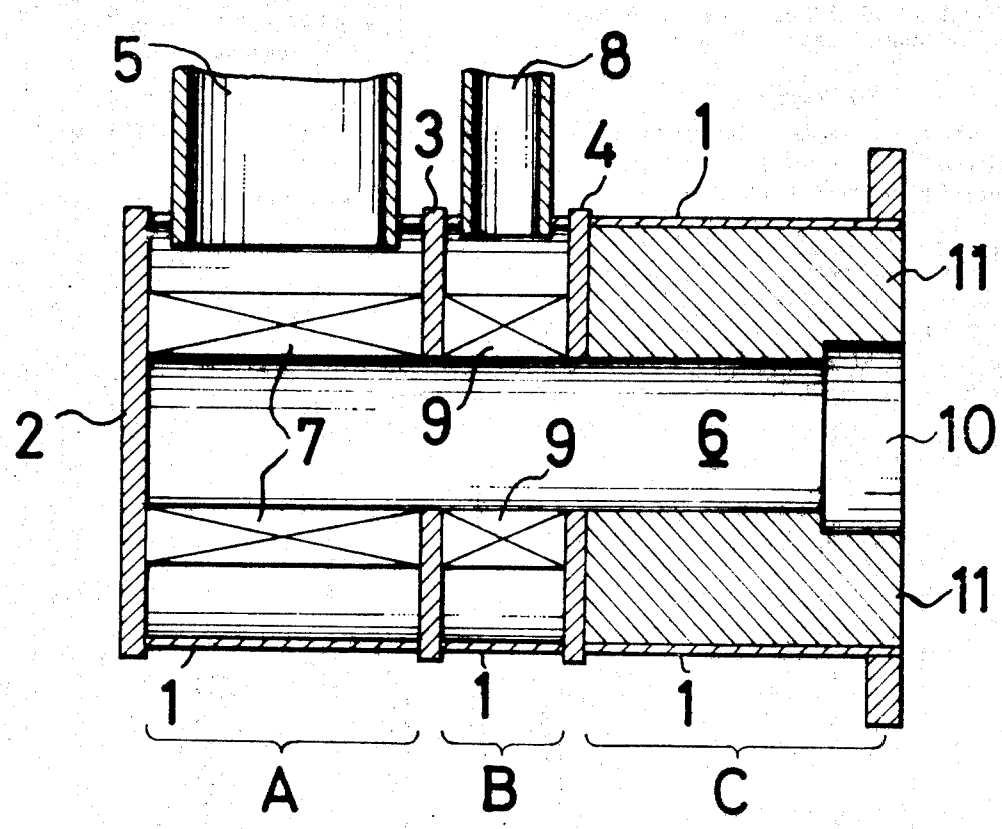


FIG. 1

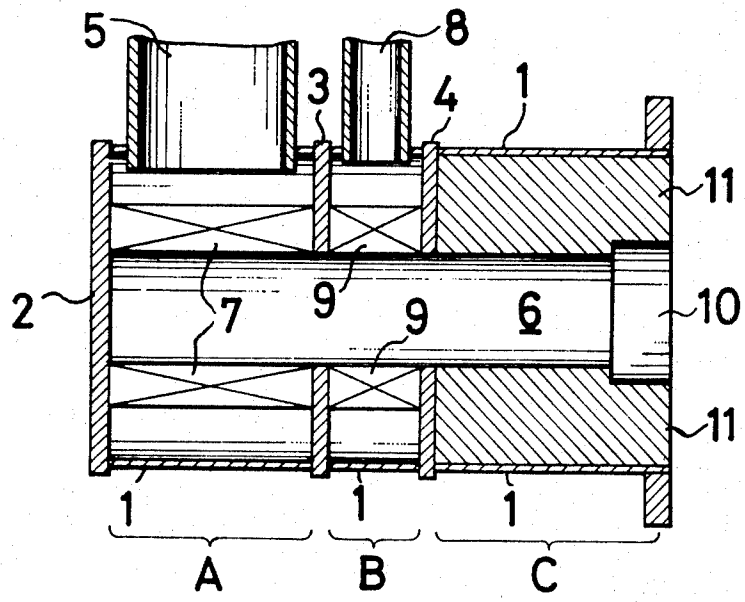
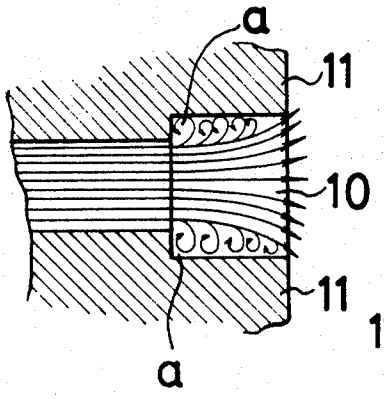


FIG. 4

FIG. 2



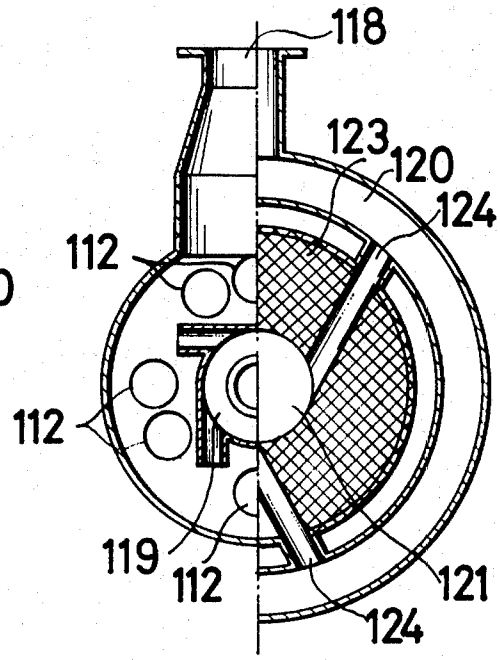


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FIG. 3

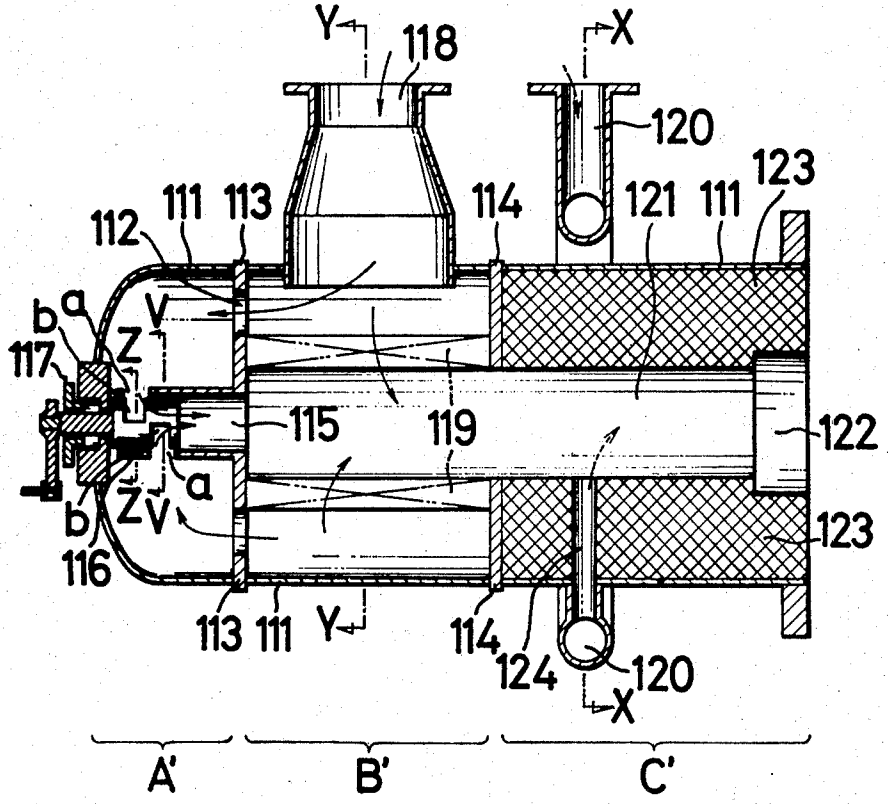

FIG. 5

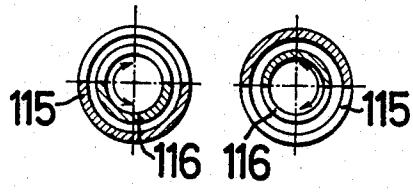

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FIG. 6

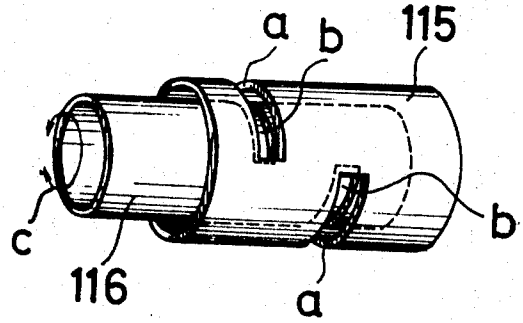


FIG. 7

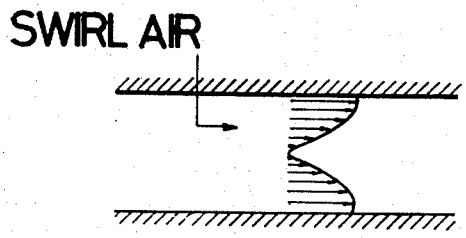
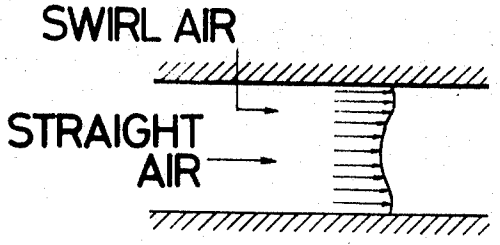


FIG. 8



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BURNER

The present invention relates to burner in which burning air given the power of rotation and a fuel given the power of rotation are mixed and the satisfactory combustion is carried out, and the object of the present invention is to provide a burner in which an air swirl part which gives the power of rotation to the burning air, a fuel swirl part which gives the power of rotation to the fuel, and a step part where the burning air and the fuel brown out of each of said swirl parts are mixed and ignited are arranged in turn from a terminal in a casing of the burner, and, in which said step part is formed of ceramic materials to improve the effect of flame maintenance so as to be applied to the combustion load of wide range.

Furthermore the present invention relates to the burner in which the ignition face can be always kept at the same position and the stable combustion is accomplished, even if the combustion load varies largely.

One example according to the present invention will be now illustrated with reference to the drawings.

FIG. 1 and FIG. 2 relates to one example of the burner according to the invention, in which the former is the longitudinal section, and the latter is the view showing the state of the flow of gas mixture in the step,

FIG. 3 to FIG. 8 shows other examples of burner according to the present invention, FIG. 3 is the longitudinal section, FIG. 4 is the view showing together the halves of the X—X section and of the Y—Y section in FIG. 3, FIG. 5 is the magnified view of the V—V section and the Z—Z section in FIG. 3, FIG. 6 is the oblique view of the apparatus for controlling the amount of straight air, and FIG. 7 and 8 are the views showing the speed distribution of air, in which FIG. 7 is the view of the speed distribution in the complete interception of straight air, and FIG. 8 is the view of the speed distribution in the appropriate control of straight air and swirl air.

The longitudinal section of the burner according to the present invention is shown in FIG. 1. The cover 2 is equipped at a terminal of the casing 1, and the inside of the casing 1 is divided into the air swirl part A, the fuel swirl part B, and the step part C from the cover 2 side to the direction of the axial center by the first dividing plate 3 and the second dividing plate 4. And said air swirl part A is constituted from an air-introducing pipe 5 for introducing the burning air and the first swirl vane 7 which serves to give the power of rotation to the introduced air and to blow said air into the mixing zone 6, said fuel swirl part B is constituted from a fuel-introducing pipe 8 and the second swirl vane 9 which serves to give the power of rotation to the fuel introduced from the introducing pipe 8 and to blow said fuel into the mixing zone 6, and said step part C is constituted from the mixing zone 6 and the ceramic material 11 which forms the step 10.

The state of working of the burner according to the present invention, constituted as above-mentioned as illustrated in the following. Burning air fed under a predetermined pressure from the exterior of the burner is introduced from the air-introducing pipe 5, let to pass through the first swirl vane 7 to be given the power of rotation, and then blown into the mixing zone. On the other hand a fuel is introduced from the fuel-introducing pipe 8, let to pass through the second swirl vane to be given the power of rotation, and then blown into the mixing zone 6. By this operation the fuel is mixed satisfactorily with the burning air to form a gas mixture. While the sectional area of the step 10 is large in comparison with that of the mixing zone 6, the gas mixture is diffused at the step 10 as shown in FIG. 2, an eddy flow is generated in a part of said gas mixture at the corner part *a* of the step 10, and this eddy flow acts as a flame maintaining part. Additionally the distance in which the burning air is passed to the mixing zone 6 is long in comparison with that in which the fuel gas is passed to the mixing zone 6 and the power of rotation of fuel in the mixing zone 6 is much remained in comparison with the power of rotation of burning air, so that most of the fuel flows along the wall of the mixing zone 6, the concentration of fuel in the gas mixture increases in the side near the wall even in the step 10, consequently the eddy flow in said corner part a is a gas mixture of higher fuel component. Because of this fact, the percentage of excess air at the flame maintaining part becomes about 1, even if the percentage of excess air is large. Additionally the step 10 is constituted from the ceramic material 11, it becomes red-hot by burning, so that the combustion speed is increased, and the effect of flame maintenance becomes still more reliable.

Additionally the present invention is not limited to said example, the structure of burner according to the present invention can be modified without departure from the scope there of and these modifications are also involved in the scope of the present invention.

The above described burner is equipped with the air swirl part which gives the power of rotation to the burning air, the fuel swirl part which gives the power of rotation to a fuel, and the step part where the burning air and fuel blown out of each of said swirl parts are mixed and ignited, in turn from a terminal in the casing of the burner, and is one in which said step part is formed of a ceramic material, the axial flow speed of the mixture of air and fuel can be increased to accomplish the stable combustion over the wide range of the percentage of excess air, and the combustion capacity can be made large, and which can be employed effectively as a burner for a heat accumulation type heat exchanger or a combustion furnace having a small burning chamber.

Another examples of the present invention will be here illustrated with the drawings of FIG. 3 and the rests. And yet the example described in the following has the next properties in addition to the properties of the above-described example. That is, the burner is eliminated the defects that if the power of rotation of the burning air, which is mixed with the fuel gas and given the power of rotation, is too strong, (in the following description the burning air with the power of rotation is called swirl air, while the burning air without the power of rotation is called straight air), the flame returns to the direction of the fuel injecting part, and the back fire phenomenon is offered to cause an explosion, on the contrary if said power of rotation is too weak, the flame rushes out forward, so becomes unstable and in danger of going out, and is one in which the ignition face can be always kept at the same position over the wide range of combustion variation and over all range of the percentage of excess air to the respective bombustion capacities to extend extremely the range of stable combustion.

FIG. 3 to FIG. 6 are illustrated in the following. The body of the gas burner 111 is in the shape of a cylinder

which is open at one terminal and closed at the other terminal. In the inside of the cylindrical gas burner body **111** the first dividing plate **113** and the second deviding plate **114**, the said plate **113** has the straight air introducing port **112**, are provided at the predetermined positions. The inside of the gas burner body **111** is divided into the straight air controlling part A', the swirl air blowing —in part B', and the fuel gas blowing —in part C'. And said straight air controlling part A' is constituted from the straight air nozzle **115** provided with the notch hole *a*, the control nozzle **116** provided with the notch hole *b*, and the rotation mechanism **117** which rotates the control nozzle **116**. Said swirl air blowing —in part B' is constituted from the air taking—in pipe **118** and the swirl vane **119** which gives the power of rotation to air. And said fuel gas blowing—in part C' is constituted from the fuel gas taking—in ring pipe **120** which is provided around the body **111**, the mixing zone **121** where air and fuel gas are mixed, the ceramic material **123** composed of the step **122** which is provided at the tip of the mixing zone **121**, and the fuel gas nozzle **124** which is arranged from said fuel gas taking—in ring pipe **120** to said mixing zone **121** through said ceramic material. Additionally said swirl vane **119** and said fuel gas nozzle **124** is, as shown in FIG. **4**, provided to the tangent direction of said mixing zOne **121** so as to rotate the introduced fuel. And the notch holes *a* and *b* are, as shown in FIG. **6**, provided around said straight air nozzle **115** and the control nozzle **116**, and if the control nozzle **116** is rotated as the arrow C, the sizes of the notch holes can be changed apparently. The real arrow shows the progressing direction of air, and the dotted arrow shows the progressing direction of the fuel gas in FIG. **3** and FIG. **4**.

The state of working of the example constituted as above-mentioned is shown in the following.

The air fed from the exterior under a predetermined pressure flows into the air blowing—in part B' from the air taking—in pipe **118**, most of the air is given the power of rotation by passing through the swirl vane **119** to became the swirl air, and then is blown into the mixing zone **121**. While a part of the air flowing in from the air taking—in pipe **118** flows into the straight air control part A' through the straight air introducing port **112** of the first dividing plate **113**, and it is blown out from the inside of the straight air nozzle **115** in the mixing zone **121** through the notch hole *a* of the straight air nozzle **115** and the notch hole *b* of the control nozzle **116**. On the other hand the fuel gas is given the power of rotation by passing through the fuel gas nozzle **124** from the fuel gas taking—in ring pipe **120**, and blown into the mixing zone **121**. By this fact the fuel gas is mixed with the swirl air and the straight air. And the stable combustion at the position of the step **122** is accomplished by controlling the amount of the straight air. The amount of said straight air is controlled by rotating the rotation mechanism **117** and shifting the relative positions of the notch hole *b* of the control nozzle **116** and the notch hole *a* of the straight air nozzle **115** to change the apparent size of the notch holes. Now if the straight air is cut off completely and the swirl air with the strong power of rotation is flown in the mixing zone **121**, the air flow becomes a strong eddy flow and its tangent speed increases to the axial center. Accordingly based upon the eddy theory and the Bernoulli's theorem the axial flow speed of air decreases if the tangent speed of air increases, and these speed distributions are offered as shown in FIG. **7**. When combustion is carried out under such air flows, the flame is feasible to return to the axial center part to cause the back fire phenomenon because the axial flow speed near the axial center is late (and the distribution of static pressure is in the shape shown in FIG. **6**). Additionally as the pressure in the gas burner body **11** is risen by this back fire phenomenon, the flowing-in amount of the fuel gas becomes little, the combustion becomes discontinuous and becomes very unstable combustion state. And if the flowing-in amount of the straight air is increased (that is, if the axial flow speed of the straight air is fast) and if the combustion is carried out under the condition of the weak power of rotation in the swirl air, the flame gushes out of the step **122** to cause the blowing-out phenomenon. Based upon the above description if the amount of the straight air is controlled by rotating the rotation mechanism **117**, the axial flow speed of the straight air and the power of rotation of the swirl air can be fixed at the suitable values, the speed distribution as shown in FIG. **8** is obtained, and the stable combustion can be carried out with keeping the ignition face at the position of the step **122** all the time. According to this example the control amount of the straight air is suitable within the range of 0–30 percent of the amount of air flowing into the air taking-in pipe **118**. By controlling the amount of the straight air in this range the ignition face can be maintained at the position of the step **122** to accomplish the stable combustion, if the combustion capacity is changed in the range of 100–20 percent over all zone off the percentage of excess air. Additionally in this example if the control amount of the straight air is increased, the amount of the swirl air is decreased, while the swirl air is increased if the amount of the straight air is decreased, so that the absolute taking-in amount of air may be always constant, this mentions that the stable combustion can be kept with the constant mixing ratio of air and fuel, and the combustion capacity can be changed without variation of the temperature of the burning gas fixed at some valve.

The burner according to the second example, in which burning air is given the power of rotation to be mixed with the fuel, is equipped with the step part formed of a ceramic material, the straight air nozzle for supplying the linear air flow along the axial center of the burner and the control apparatus for controlling the amount of the air introduced to the straight air nozzle, and this burner can be employed effectively as a burner for a heat accumulation type heat exchanger or a combustion furnace having a small burning chamber, because it is one which can be applied to the extensive combustion load and in which the ignition face can be always kept at the same position to accomplish the stable combustion.

Additionally the present invention is not limited to the above-mentioned example, that is, the gas burner, but can be applied to burner burning other fuel, and the arrangement thereof can be modified without the departure from the scope thereof, and these modifications are also involved in the scope of the present invention.

What is claimed is:

1. A burner comprising a housing, a central passage in said housing, air inlet means on said housing for introducing a supply of air into said central passage, said air inlet means imparting a rotary motion to the air in-

troduced into said central passage, fuel inlet means on said housing for introducing fuel into said central passage, said fuel inlet means being located axially downstream of said air inlet means, said fuel inlet means imparting a rotary motion to the fuel introduced into said central passage, said central passage having a portion defining an air and fuel mixing zone located axially downstream of said fuel inlet means, and means at the longitudinal downstream end of said central passage defining a concentric step formed by an increase in diameter of said central passage, said rotary moving air moving axially along said central passage to mix with said rotary moving fuel whereby the rotary moving air and fuel move axially into and through said mixing zone before exiting past said concentric step where upon the mixture is burned.

2. A burner according to claim **1** wherein said means defining said concentric step is made of ceramic material.

3. A burner according to claim **1** further comprising control means on said burner housing located upstream of said air inlet means for introducing a supply of air directed linearly along the axial central portion of said central passage.

4. A burner according to claim **3** wherein a partition is provided between said air inlet means and said control means, and passages in said partition disposed radially outwardly of said central passage for directing air from said air inlet means to said control means.

5. A burner according to claim **4** wherein said control means comprises an inner tube concentrically disposed within an outer tube, said inner tube and outer tube having openings on the cylindrical walls thereof, and means for effecting relative rotation between said inner and outer tubes to adjust the alignment between said openings in said inner and outer tubes and thereby control the amount of linearly directed air introduced into said central passage.

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