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[33] **Japan**

[31] **42/63,241**

[56]

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[54] AIR SWIRLING VANES FOR BURNER 2 Claims, 8 Drawing Figs.

[52] U.S. Cl..... **239/402,**
239/399, 239/405, 239/424, 431/187

[51] Int. Cl..... **B05b 7/10**

[50] Field of Search..... 239/399,
405, 402, 424; 431/265, 187, 188, 9

ABSTRACT: The present invention provides an improved burner performance adapting air-swirling vane device comprising air blades fixedly supported and arranged in cone shape between an inner supporting ring and an outer supporting ring, and a restriction ring connected to the inner ring or integrally formed therewith in such a manner that the outlet area of air outgoing through the blades is smaller than the inlet area of air entering into the blades, whereby the widening of the air reversal zone behind the swirling is restricted to a necessary extent, the flame shape is held small, the stability of the holding flame is improved, the range of an oscillating burning is reduced, and an appropriate counter air flow velocity is reduced in the reversal zone for improving the combustion loading. Furthermore, if necessary, a plurality of small holes are formed along a circumference of substantially the middle of the inner ring integrally formed with the restriction ring or along a circumference of the inside diameter side of the restriction ring when this is connected to the inner ring to allow the flow of air to prevent carbon deposit from being accumulated on the vane device.

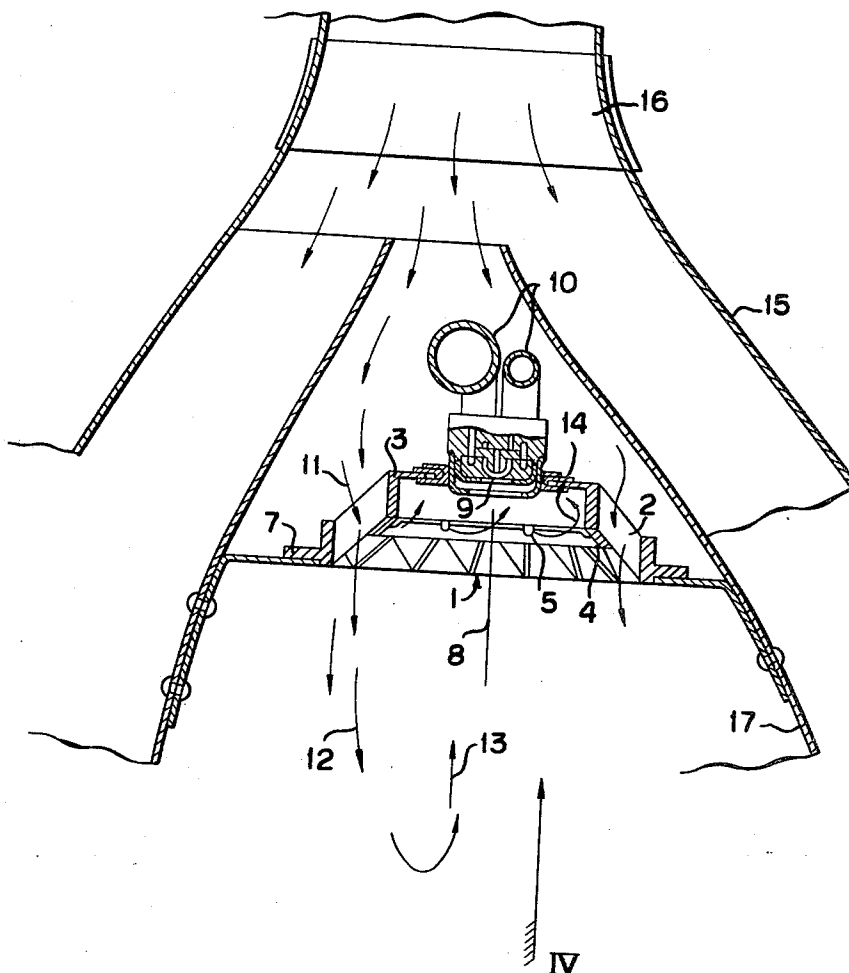


FIG. 1

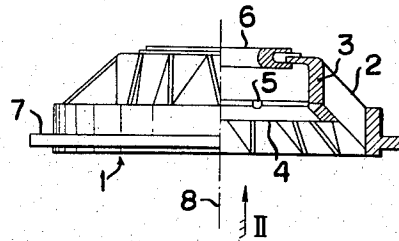


FIG. 3

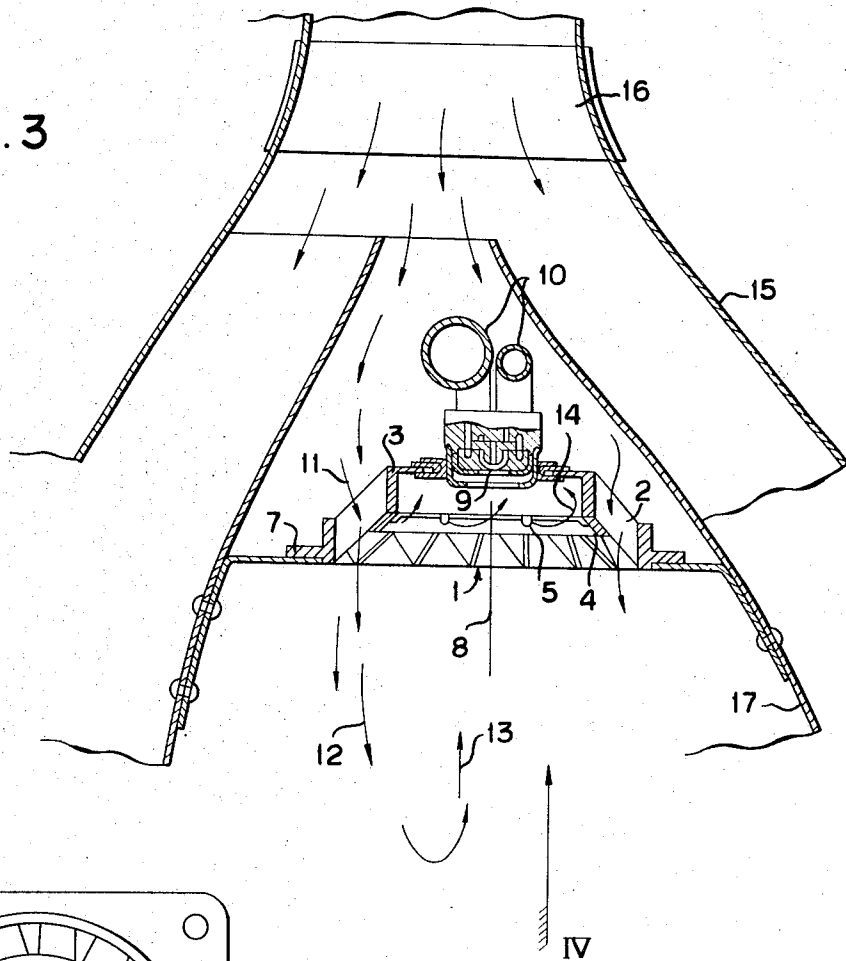


FIG. 2

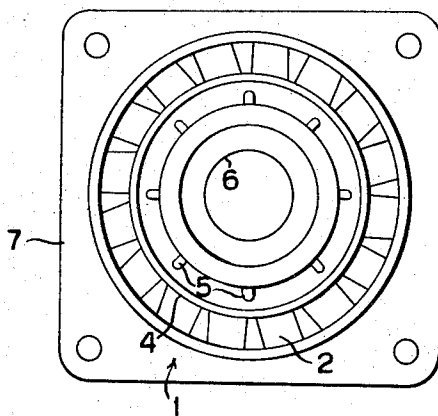


FIG. 8

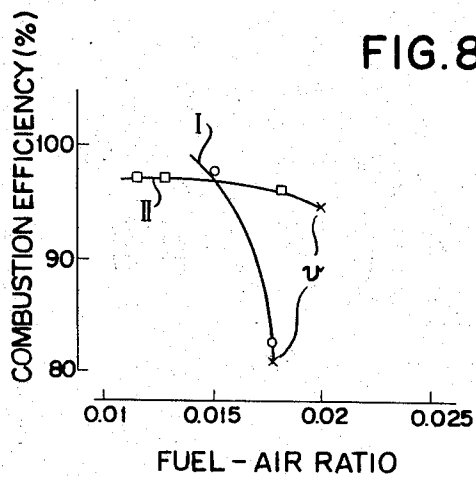


FIG. 7

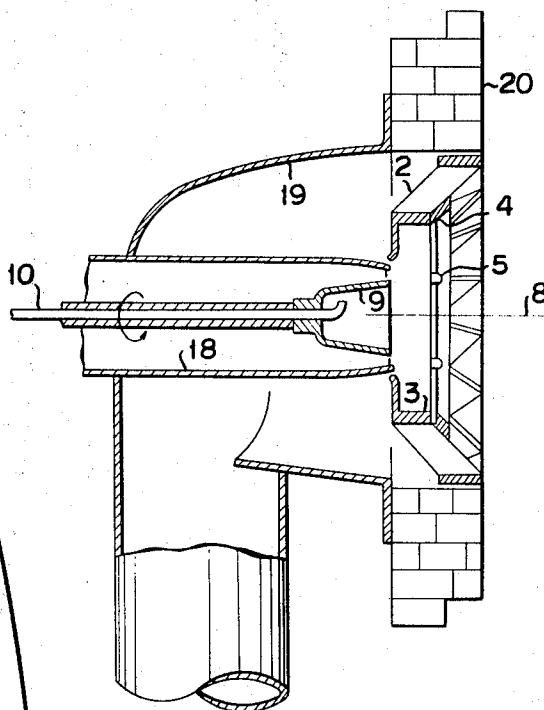


FIG. 4

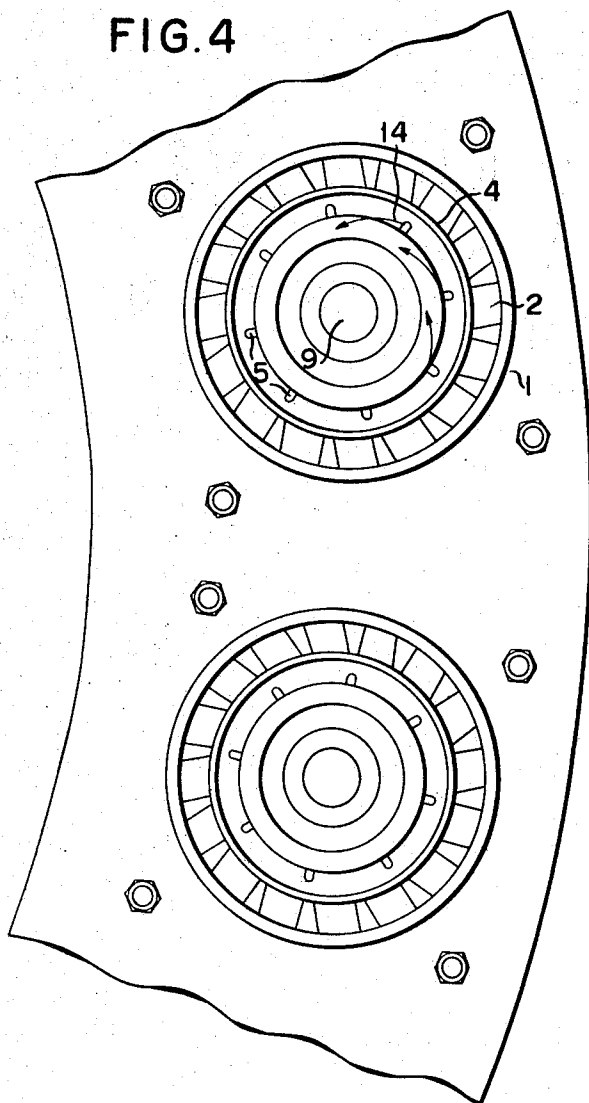


FIG. 5

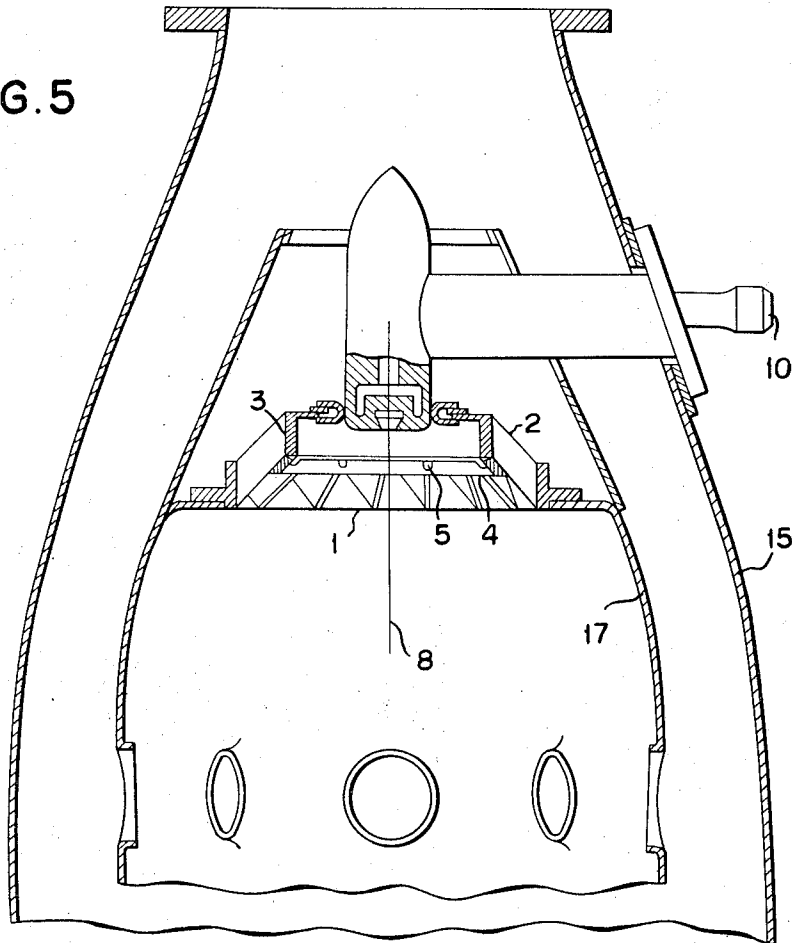
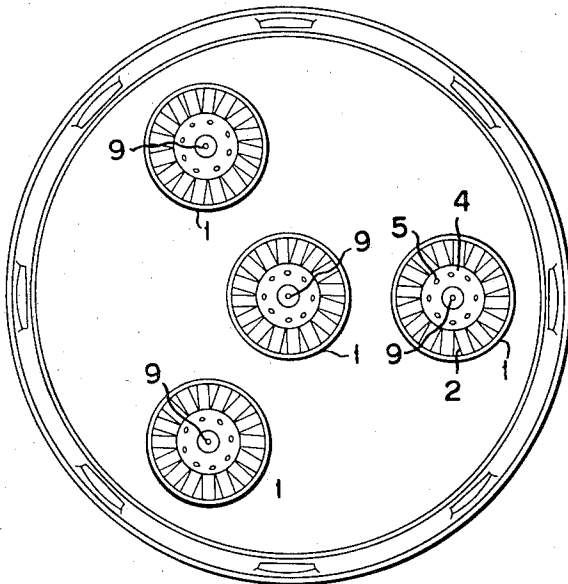


FIG. 6



AIR SWIRLING VANES FOR BURNER

This invention relates to burners and more particularly to air swirlers for use in burners or furnaces.

It is conventional to employ an air swirler, i.e. a rotor having air swirling vanes, for flowing the primary combustion air from around the fuel injector of the burner or burning device. Such air swirlers are applied to high combustion loading burning devices, and excellent effects can be obtained, and therefore such systems of combustion are in general use. The air revolving vanes form a zone of the revolving reverse air flow which is required for holding the flame stable on the downstream side, and at the same time for supplying the air for combustion, and this is an important role of the revolving vanes of the air swirler.

However, in most of the air swirlers now being used, the zone of the downstream flow is widened more than required, and even when a large amount of air is charged from the air swirling vanes, the counterflow within the zone of swirling air flow is slow, and the air flows away from the flame zone without being effectively used. When the amount of supplied fuel is increased, it often happens that fuel is excessively concentrated within the flame zone, and the stability of flame deteriorates.

The zone of swirling air flow is a portion where combustion loading (which is also called thermal loading) cannot be further increased, and if this portion is widened it becomes very difficult to increase the overall combustion loading.

On the other hand, there is another type of combustion system according to which the zone of swirling flow is not so much widened, but the shape of the zone of swirling air flow is not appropriate for conditions of high thermal loading so that the flame is easily separated and oscillating combustion is liable to be brought about, which is accounted to be the drawback of this system. Furthermore, carbon deposit is accumulated on the air swirling vanes which also causes a troublesome problem.

An object of the present invention is to improve the air swirler with the aim of improving the shape of the flame, stabilizing the flame and reduce any tendency to oscillating combustion.

Another object of the invention is to produce a relatively high counterflow of air within the swirling zone so as to improve the combustion loading.

A further object of the invention is to prevent or reduce carbon deposits from accumulating on the inside wall of the air swirler without deteriorating the burner efficiency.

According to the invention there is provided an air swirler for a burner comprising air swirling vanes of mixed flow type arranged with their tips offset downstream of the roots, an inner ring member supporting the roots, an outer ring member supporting the tips and a flow restriction ring connected to or integral with the inner ring and arranged to restrict the air outlet area of the swirler at the downstream end of the vanes to a dimension less than that of the air inlet area of the swirler at the upstream end of the vanes.

Preferably a plurality of small notches or holes are provided in spaced relation around a circumference of the restriction ring or the inner ring for preventing carbon deposit from being accumulated on the air swirling vanes. It is preferable to provide those notches or holes around the inside diameter side of the restriction ring, or in the neighborhood of the junction of the inner ring and restriction ring.

The invention also includes a burner incorporating an air swirler as described above.

Preferred embodiments of the invention are hereafter more particularly described with reference to the accompanying drawings, in which:

FIG. 1 is a front view in partial cross section of an embodiment of air swirler according to the present invention;

FIG. 2 is a plan view as observed in the direction shown by the arrow II in FIG. 1;

FIG. 3 is a cross section of an annular burner incorporating the embodiment of FIG. 1;

FIG. 4 is a plan view as observed in the direction shown by an arrow IV in FIG. 3;

FIG. 5 is a cross section of a can or tubular type burner in which the embodiment of FIG. 1 is incorporated;

FIG. 6 illustrates in plan view a multiburner of the can type equipped with the embodiment of FIG. 1 and observed from the downstream side;

FIG. 7 is a lateral cross section of a burner equipped with the said embodiment and applied to a boiler or heater; and

FIG. 8 is a graph showing characteristics of combustion efficiency (percent) versus fuel-air ratio obtained with the embodiment of FIG. 1.

FIGS. 1 and 2 show in complete view an embodiment of air swirler indicated at 1. This comprises air swirling vanes 2, which swirl the flow of air in the axial direction 8 of the vanes, an inner supporting ring 3 for the vanes 2, a flow restriction or control ring 4 for adjusting the width of the air swirling zone, small notches or holes 5 for preventing the accumulation of carbon deposit on the inner supporting ring 3 and the restriction ring 4, a seat 6 for the fuel injector, and a flanged outer ring 7 supporting the outer tips of the vanes 2 and providing a mounting for the assembly.

In FIG. 3, there is shown a burner comprising a casing 15, and outlet guide vanes 16 of a compressor. A flame tube liner 17 is inserted into the casing 16, within which the combustion occurs. The core type air swirler 1 is provided on the flame tube liner 17, and in the central portion thereof the fuel injector 9 is provided and supplied with fuel from pipe 10.

In the embodiment of the invention, mixed flow type vanes 2 are arranged in a cone shape, i.e. with the tips forward of the roots and the sides of the vanes defining parallel frustocones. The air flowing through the vanes has a radial flow component towards the central axis 8 of the rotor as shown by an arrow 11 in FIG. 3. When such vanes are arranged on a plane parallel to the plane of flange, i.e. with tips and roots aligned, the air swirling zone is found to be widened too much, leading to deterioration of the flame shape and the flame stability and the combustion efficiency. It has also been proposed to arrange the vanes on a plane sloping at an angle to the plane of the flange. Such an arrangement of the vanes has advantages over vanes arranged in a plane parallel to the flange plane, but it is not sufficient for the purpose. For overcoming this defect, in accordance with the present invention, the restriction ring 4 is provided on the side of the inside diameter of the inner ring 3 for supporting the vanes 2 on its downstream side so that the air outlet area of the swirler will be smaller than the inlet area. By this arrangement it has been observed that the air flow passing through the vanes is not widened and passes along the path shown by arrows 11 and 12, and in the vicinity of the central axis 8 a counterflow shown by an arrow 13 is produced. Thus, when the line defined by arrows 11 and 12 is revolved about the central axis 8 the generated surface, substantially defines the outside outline of the air swirling zone.

In this embodiment, the inner ring 3 and the restriction or controlling ring 4 are connected by, for example, soldering or riveting or the like. However, the inner ring 3 and the restriction ring 4 may be formed integrally by for example, casting, or the inner ring 3 itself can be widened toward the end.

In case of a can type burner device having a single injector shown in FIG. 5, it is not necessary to take into consideration the mutual interference of the adjacent air swirlers, but in the case of a can type burner device of multiburner system shown in FIG. 6 or annular type burner device shown in FIG. 3 or FIG. 4, it is necessary to take into consideration some mutual interference, and the air swirling vanes of this invention have the effect of reducing the mutual interference.

FIG. 7 is an embodiment in which this invention is applied to the burner of a boiler, and 18 is a primary air pipe for atomizing the fuel, 19 is a secondary air duct for supplying the air for combustion, and 20 is the wall of the furnace. The adjustment of the width of the flame and the length thereof is carried out by changing the size of the controlling ring 4.

In order to prevent the accumulation of carbon deposit on the surface of the internal diameter sidewall of the air swirler 1, including the surfaces of the internal walls of the inner supporting ring 3, the restriction or controlling ring 4, and the fuel injector seat 6, a number of small notches or holes 5 are provided on the internal diameter side of the restriction ring 4. When the inner ring and the restriction ring are integrally formed on the inner ring itself is widened toward the end, a number of small holes or notches are provided in spaced circumferential relationship around a substantially middle portion of the inner ring so that a small amount of air having a swirling flow component is introduced through these notches or holes. It is preferable to determine the shape and position of the holes so that the air flowing through these holes shall have a sufficient swirling component along the inside wall of the air swirling vanes. According to this embodiment, the air swirls as shown by an arrow 14 in FIG. 3 along the wall of the inside diameter side of the vanes to form thereon the air layer to prevent the fuel from contacting with the wall to prevent the accumulation of the carbon deposit. The air which has entered through the small notches or the small holes 5 is supplied to the neighborhood of the center of the swirler 1 where the concentration of the fuel is liable to become excessive within the air swirling zone, so that even when the flow rate of fuel is increased, the air fuel mixture, which is close to the stoichiometric ratio, is supplied to the outer periphery of the restriction ring 4 which acts effectively in holding the flame stable.

Thus the characteristics of the swirler of the present invention reside in its simple structure, and with only the minor alteration involved, an amelioration of the overall combustion efficiency of a burner can be obtained.

In accordance with experiments in which the improvement of the stability of holding flame attributable to the attachment of the controlling ring 4 onto the air swirler 1 was checked in regard to the overall combustion efficiency, it was found that when the ratio of fuel and air flow rate by weight (hereinafter this ratio is cited as fuel-air ratio), is increased, a greater effect can be obtained.

The results of the experiments relating to an annular type high loading combustor are shown in FIG. 8. The abscissa of FIG. 8 shows the fuel-air ratio from the stand point of the overall fuel-air ratio, and the ordinate shows the combustion efficiency by percentage.

In FIG. 8, curve I shows the case when the restriction ring is not provided, curve II shows the case when the restriction ring of this invention is provided. As is apparent from the curve I, the efficiency is abruptly dropped as the fuel-air ratio increases, however, according to curve II, the efficiency is held substantially constant even when the fuel-air ratio is increased. The points in curves I and II shown by V show the limits at which oscillating combustion occurred, respectively, and in case of curve II, such oscillation occurs at a higher fuel-air ratio compared to the case of curve I, which means that the present invention is superior to the conventional device in preventing oscillations combustion. Furthermore, although

not shown in FIG. 8, it has been found that the length of the flame was kept shorter.

In regard to the results of the experiments about the accumulation of carbon deposit, when there are a number of small notches 5, only the surface on the side of the external diameter of the controlling ring 4 becomes somewhat blackened, and no carbon deposits adhere on other portions. When there is no notch 5 on the controlling ring 4, the accumulation of carbon deposit is observed sometimes on the surface of the internal diameter sidewall of the inner and restriction rings, but, depending on the specific property of the fuel, it is not always necessary to provide small notches or holes 5.

The advantages of the invention may be summarized as follows:

1. The mutual interference of the air swirling vanes 2 can be prevented and at the same time, the form of the air swirling and reversal zone is retained in the best form by restricting the width of the air swirling zone generated downstream of the air swirler 1 so that the width of the air swirling zone cannot become more than required.
2. An improved velocity of the counterflow 13 is produced within the air swirling zone with the result that flame stability is improved, reducing oscillating combustion, and increasing the combustion loading.
3. The accumulation of carbon deposit on the surface of the internal sidewall of the air swirler is prevented in the preferred case.

The above given advantages are increased in view of the fact that the combustion improvement can be maintained at high combustion loading, and when compared with a conventional burner device, the burner of this invention has a greatly improved overall efficiency.

As examples of burners in which the air swirler of the invention may be employed, there may be mentioned burners used in gas turbine engines for aircraft, gas turbine engines for electric generators, ships, and locomotive engines, and burners used for boilers, both domestic and commercial, and various other kinds of heaters or furnaces.

We claim:

1. An air swirler for a burner comprising air swirling vanes of mixed flow type arranged with their tips offset downstream of the roots, an inner ring member supporting the roots, an outer ring member supporting the tips, the inner ring and the outer ring being substantially parallel with the axial direction of the swirler so as to flow the air axially, the positions of the inner ring being offset from the position of the outer ring in the axial direction upstream of the roots, and a flow restriction ring connected to the inner ring and arranged to restrict the air outlet area of the swirler at the downstream end of the vanes to a dimension less than that of the air inlet area of the swirler at the upstream end of the vanes.

2. An air swirler as claimed in claim 1, in which a plurality of small openings are provided at a circumference in the neighborhood of the junction between the inner ring and the flow restriction ring.