March 15, 1938. A. MACCHI 2,111,432

FUEL BURNING APPARATUS AND AIR INLET DEVICE THEREFOR

Filed Jan. 16, 1935

Fig. 1.

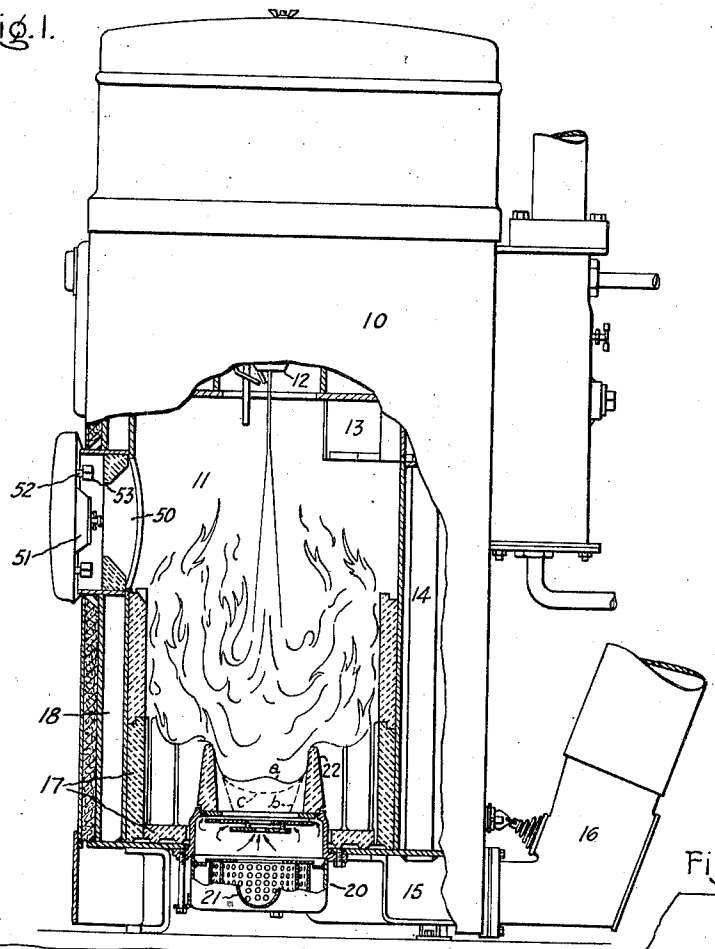



Fig. 2.

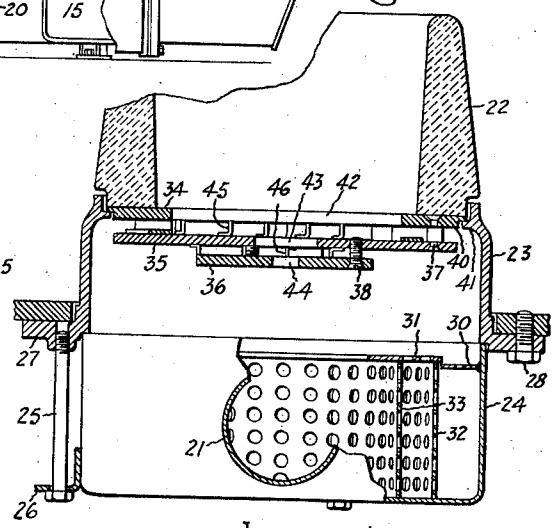
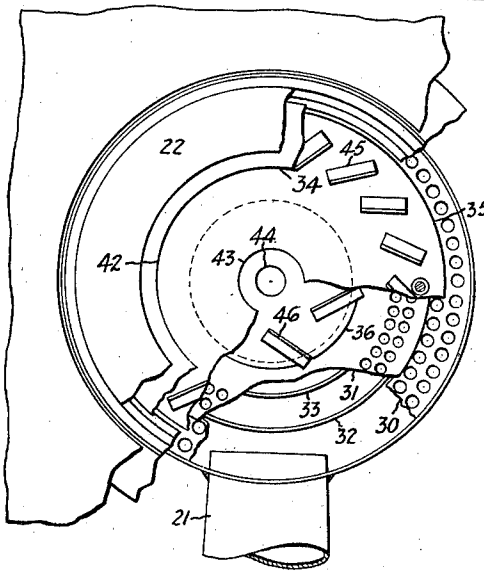



Fig. 3.




Inventor:
Aldo Macchi
by Harry E. Dunham
His Attorney.

Patented Mar. 15, 1938 2,111,432

# UNITED STATES PATENT OFFICE

2,111,432

## FUEL BURNING APPARATUS AND AIR INLET DEVICE THEREFOR

Aldo Macchi, Schenectady, N. Y., assignor to General Electric Company, a corporation of New York

Application January 16, 1935, Serial No. 2,009

10 Claims. (Cl. 158—4)

This invention relates to fuel burning apparatus and particularly to improvements in furnaces of the type disclosed as part of the subject matter of my Patent No. 2,022,512, issued November 26, 1935, and assigned to the assignee of the present invention, whereby improved combustion and flame stabilization are secured.

In the operation of the fuel burning apparatus disclosed in the patent above referred to, a stream of fuel and air is directed into one end of the combustion chamber of a furnace to produce flame therein and a whirling stream of air is directed into the combustion chamber from the other end thereof and in opposition to the fuel stream to support combustion, spread the flame laterally in all directions and return the flame in a whirling mass symmetrically back upon itself along the sides of the combustion chamber.

It is a principal object of the present invention to provide an improved air supply device which, when employed in furnaces utilizing opposed fuel and air jets, will insure complete combustion of all particles of the fuel and will reduce flame flutter and combustion rumble to a minimum by more effective stabilization of the flame in the combustion chamber.

Another object of the invention is the provision of improvements in the construction of a combustion air inlet device whereby the deposit of unburned carbon particles on the surfaces of the device is rendered negligible.

As pointed out in my previously referred to patent, the stability of the flame is much greater when the fuel burning apparatus therein disclosed is so constructed and operated that the flame jet meets the air jet in close proximity to the mouth of the air discharge nozzle. It has been found desirable under some conditions to actually draw the flame into the interior of the nozzle and in effect anchor it there so that it is forced to whirl about the axis of the nozzle. This may be accomplished by a proper proportioning of the size of the nozzle and the velocity and angle at which the air enters thereinto so that a vortex is created within the nozzle. Under such conditions the air passes outwardly in the form of a whirling annular body adhering more or less closely to the walls of the nozzle passage, thus producing at the apex of the vortex, or at the base of the nozzle, a region in which there is insufficient air to support complete combustion of such fuel particles as reach the base of the nozzle. The unburned particles tend to form carbon deposits on the adjacent surfaces with the result that the air flow becomes impeded and eventually may be cut off entirely. A specific object of this invention is, therefore, the provision of an air inlet device having improved air baffling and directing means whereby the combustion of fluid fuel may be carried on with maximum efficiency in accordance with the general principles set forth in my previously referred to patent and whereby sufficient air is supplied at all points to produce complete combustion of the fuel particles and prevent impairment of the operation of the air inlet device by carbon deposits.

The detailed manner in which the present invention is carried out and the further advantages resulting therefrom will be set forth in the following description taken in conjunction with the accompanying drawing in which Fig. 1 is a side view of a vertical type oil burner furnace partially cut away to show the manner of mounting the improved air inlet device therein in opposed relation to the fuel delivery nozzle; Fig. 2 is an enlarged vertical cross section showing in detail the arrangement of the air distribution box, air discharge nozzle, baffle plates and guide vanes; and Fig. 3 is a partially cut away plan view showing more clearly the arrangement of the radially offset guide vanes.

Referring to the drawing, 10 represents a boiler furnace having a combustion chamber 11 into which a stream of fuel, preferably mixed with sufficient air to support partial combustion, is discharged by means of a nozzle, the discharge end of which is represented at 12. Products of combustion are exhausted from the combustion chamber by means of exhaust chamber 13, fire tubes 14, flue pan 15 and flue pipe connections 16. The end of the combustion chamber opposite to the fuel delivery nozzle is lined with refractory material designated as 17 and the combustion chamber is surrounded by water space 18. The boiler furnace illustrated and in conjunction with which the present invention is herein described is of the type which is fully disclosed in United States Letters Patent No. 1,992,794 of H. S. Woodruff, issued February 26, 1935, and assigned to the assignee of the present invention. However, it is to be understood that the air inlet device of the present invention is not limited to application only with this type of furnace but on the contrary is suitable for utilization in any type of furnace in which it is desired to produce combustion by opposed fuel and air jets in a manner similar to that set forth in my previously referred to patent.

The air inlet device embodying the present invention is disposed in the end of the furnace

opposite to the nozzle 12 and in axial alinement therewith for supplying combustion air to the furnace combustion chamber in opposition to the fuel stream. This air inlet device includes an air distribution box 20 to which air is supplied by means of conduit 21 from any suitable source (not shown) and from which air is discharged through annular refractory nozzle 22. The air distribution box is made up of a ring-shaped member 23, which is adapted to protrude through openings in the end plate of the boiler furnace and the refractory lining 17 into the combustion chamber, and a cup-shaped member 24, the rim of which is adapted to engage the outer rim of the ring-shaped member. Members 23 and 24 are secured together by means of bolts 25 which pass through brackets 26 provided on the outer surface of the member 24 and engage the flange 27 provided on the outer rim of the member 23. The air box is mounted in place by means of bolts 28 which pass through the flange 27 and engage the end plate of the furnace. It is of course evident that the details of construction of the air box 20 and of the mounting thereof are susceptible to modification without departure from the true spirit and scope of the present invention and it is not intended that such details be considered as limiting the invention.

In the interior of the cup-shaped member 24 of the air box 20 are provided perforated baffle plates 30 and 31 and circular bustles 32 and 33 for producing an evenly distributed flow of air from the conduit 21 into the outer portion of the air box formed by the member 23 and thence outwardly through the nozzle 22. This general arrangement of baffle plates and bustles, which is disclosed in United States Letters Patent No. 1,983,386 of Peter L. Mikeska, issued December 4, 1934, and assigned to the assignee of the present invention, forms no part of the present invention and in fact would be rendered unnecessary were the air supplied to the air box along the axis thereof rather than at right angles to the axis.

At the inlet end of the nozzle 22 is placed a baffling device for very accurately controlling the flow of air from the box 20 through the nozzle passage. This baffling device comprises plates 34, 35, and 36 disposed in parallel relation to each other and in spaced apart planes transverse to the axis of the nozzle. Plates 34 and 35 are secured together by any suitable means, as for example, the bolt and spacing washers represented at 37, and plate 36 is secured to plate 35 by means of screws 38 or any other suitable means. It is preferable that the spacing between plates 34 and 35 be greater than that between plates 35 and 36 in order that the main body of combustion supporting air is discharged from the space between plates 34 and 35. Plate 34 is provided with a flange 40 for engaging a flange 41 provided on the rim of the ring-shaped member 23 in order to support the baffle plate in position in the mouth of the air box and also to provide for the mounting of the refractory nozzle 22 upon the plate 34. The plates 35 and 36 are of such size that their edges do not touch the walls of the box 20 and thus it is made possible for air to pass from the interior of the box around the edges of the plates and through the spaces between the plates. Centrally located in the baffle plate 34 is an opening 42 which is of slightly less diameter than the inlet end of the nozzle and which is in axial alinement with the nozzle passage. Openings 43 and 44 are provided in the plates 35 and 36 respectively in axial alinement with the opening 42, the opening 43 being of less diameter than the opening 42 and the opening 44 being of less diameter than the opening 43.

A series of L-shaped members 45 are mounted between plates 34 and 35 around the opening 42 to form air directing vanes and are arranged to impart a whirling motion, which is in a counter-clockwise direction when viewed from the discharge end of the nozzle (see Fig. 3), to the air passing between the plates 34 and 35 and outwardly into the nozzle passage. A similar series of vanes 46 are mounted between plates 35 and 36 around the opening 43, but these latter vanes are arranged to impart to the air passing between plates 35 and 36 and thence through opening 43 into the nozzle passage a whirling motion which is in a clockwise direction as viewed in Fig. 3 or, in other words, in a direction opposite to that of the whirling motion created by vanes 45.

The furnace 10 is provided with an inspection opening represented at 50 which is closed by means of a sealing cover member 51 held in place by bolts 52 which engage studs 53 provided on the rim of the opening. It is to be understood that the construction of the inspection opening and the cover therefor may be of any desired form but it is preferred that the shape and size of the openings be such that the baffle units formed by the plates 34, 35 and 36 and the vanes 45 and 46 may be removed therethrough for cleaning, repair or replacement.

In the operation of the furnace, an expanding stream of fuel and air is injected axially into the combustion chamber of the furnace by means of the nozzle 12 as represented in Fig. 1 of the drawing. Combustion is initiated by any suitable form of ignition means and it is preferable that the percentage of air in the stream be sufficient to support only partial combustion. Secondary combustion air is supplied to the box 20 through conduit 21 and passes through the perforations in the plates 30 and 31 and the perforations in the bustles 32 and 33 and flows in an evenly distributed mass into the body of the air box formed by the circular ring 23. The main portion of this air passes between the edges of the plate 35 and the wall of the member 23, through the space between the plates 34 and 35 and upwardly into the inlet end of the nozzle 22. Vanes 45 impart a whirling motion to this portion of the air which is in a counter-clockwise direction when viewed from the discharge end of the nozzle, and by reason of the centrifugal force thereby produced the air tends to form in an annular whirling body as it passes outwardly through the nozzle passage. A second and smaller portion of the air passes between the edges of the plate 36 and the wall of the member 23 and thence through the space between the plates 35 and 36 and upwardly through the opening 43. Vanes 46 impart a whirling motion to this last referred to portion of air in a clockwise direction when viewed from the discharge end of the nozzle. Thus in effect two annular whirling bodies of air are discharged into the inlet end of the nozzle, one within the other and whirling in opposite directions. A third portion of air is discharged upwardly into the inlet end of the nozzle along the axis thereof through the restricted opening 44 in the plate 36. If the method of combustion disclosed in my previously referred to patent is practiced, it is preferable, as stated, that the outer whirling body of air be of greater volume

than the inner whirling body and that the central axially discharged stream be of smaller volume than either of the whirling bodies. However, it is to be understood that, without departing from the present invention, it is possible to modify the construction of the air inlet device to produce such relations between the volumes of the three streams as may be most suitable under particular sets of conditions.

As a result of the cooperative action of the three streams of air, the low pressure region, which is produced in the center of the nozzle by the whirling of the outer body of air, is in effect moved toward the discharge end of the nozzle. The solid line *a* in Fig. 1 diagrammatically represents in cross section the approximate configuration of the surface of contact between the downwardly directed fuel and air stream and the upwardly directed air stream. If only vanes 45 and baffle plate 35 were employed without the opening 43, the cross section of the surface of contact between the opposed streams would be of the approximate form shown by the dotted line *b* in Fig. 1. In this latter case it will be evident that there would exist at the base of a nozzle a region wherein there would be insufficient air to support complete combustion of all fuel particles injected into the nozzle and unburned carbon particles would collect on the center surface of the plate 36. As previously pointed out, it has been found desirable to draw the flame downwardly into the nozzle to a certain extent, and hence it is necessary to provide means to prevent the above referred to deposit of carbon. The introduction by means of opening 43 and vanes 46 of an auxiliary whirling body of air of smaller volume than that introduced through vanes 45 tends to produce a surface of contact between the opposed fuel and air streams which may be represented approximately in cross section by the dotted line *c*. Although the desired results may be obtained to a degree by having the auxiliary body of air whirl in the same direction as the main body of air, it is preferable to have the two bodies of air whirl in opposite directions since increased turbulence is thereby produced at the base of the nozzle to insure more complete mixing of the air with the fuel particles. In either case, there may still be some tendency for carbon to deposit on the center surface of the plate 36. This is prevented by the provision of the restricted opening 44 in the plate 36 through which a jet of air is discharged along the axis of the nozzle, thereby producing the surface of contact represented approximately by the line *a* and insuring a sufficient supply of air at the base of the nozzle for complete burning of all fuel particles.

It will be evident from an understanding of the present invention that the air inlet device forming the subject matter thereof will function in the same manner and with the same advantageous results in cooperation with a nozzle discharging an opposed stream of either finely divided solid fuel, finely divided liquid fuel or gas, and also that it may be employed in any type of furnace which is adaptable for the production of combustion in a manner similar to that set forth in my previously referred to application, whether the fuel and air streams be injected into the furnace combustion chamber along vertical or along horizontal axes.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. In a fuel burning apparatus including means providing a combustion chamber and means for directing into said chamber from one end thereof a stream of combustible mixture, a combustion air supply device comprising a nozzle arranged with its outlet in position to discharge air into the other end of said chamber in axial alignment with and in opposition to such stream of combustible mixture, means for projecting a stream of air into the inlet of said nozzle along the axis thereof and means for projecting an annular whirling body of air into the inlet of said nozzle around said axial stream of air.

2. In a fuel burning apparatus including means providing a combustion chamber and means for directing into said chamber a stream of combustible mixture, a combustion air supply device comprising a nozzle arranged with its outlet in position to be in alignment with such stream of combustible mixture for discharging air in opposition to the stream of combustible mixture, means for projecting an annular whirling body of air into the inlet of said nozzle and means for projecting a stream of air into the inlet of the nozzle along the axis of said whirling body of air.

3. In a fuel burning apparatus including means providing a combustion chamber and means for directing into said chamber a stream of combustible mixture, a combustion air supply device comprising a nozzle arranged with its outlet in position to be in alignment with such stream of combustible mixture for discharging air in opposition to the stream of combustible mixture, means for projecting into the inlet of said nozzle a quantity of air in a column along the axis of the nozzle, means for projecting into the inlet of said nozzle a relatively larger quantity of air in a whirling annular body around said axial column of air, and means for projecting into the inlet of said nozzle a still larger quantity of air in an annular body whirling around said first body of air in the opposite direction from the direction of whirl of said first body of air.

4. In a fuel burning apparatus having means providing a combustion chamber, a combustion air supply device including in combination an air box having a discharge nozzle arranged with its outlet in position to discharge air into said chamber, a baffle plate disposed at the inlet end of said nozzle and having an aperture in axial alignment with the nozzle, a second baffle plate disposed within said box in parallel spaced relation to said first baffle plate with the edges thereof in spaced relation to the walls of said box and having an aperture in axial alignment with said nozzle and of smaller size than the aperture in said first plate, a series of vanes disposed between said plates around the aperture in said first plate and arranged to impart a whirling motion to air passing between the plates, a third baffle plate disposed within said box in parallel spaced relation to said second plate with the edges thereof in spaced relation to the walls of said box and having an aperture in axial alignment with said nozzle and of smaller size than the aperture in said second plate, and a series of vanes disposed between said second and third plates around the aperture in said second plate and arranged to impart a whirling motion in the opposite direction with respect to said first whirling motion to air passing between said second and third plates, the aperture in said third plate providing for the discharge of a column of air along the axis of the nozzle and into the inlet thereof.

5. In a fuel burning apparatus including means

providing a combustion chamber, a combustion air supply device including in combination an air box having an end plate provided with an aperture communicating with said chamber, a pair of baffle plates disposed within said box in parallel spaced relation to each other and to said end plate with the edges of the baffle plates in spaced relation to the side walls of said box, said baffle plates having apertures in axial alignment with the aperture in said end plate, the aperture in the outermost one of said baffle plates being smaller than the aperture in said end plate and the aperture in the innermost one of said baffle plates being smaller than the aperture in said outermost baffle plate, a series of vanes disposed between said outermost baffle plate and said end plate around the aperture in the end plate and a second series of vanes disposed between said outermost and said innermost baffle plates around the aperture in the outermost baffle plate, said first and said second series of vanes being arranged to impart whirling motion to air passing between said outermost baffle plate and said end plate and between said outermost baffle plate and said innermost baffle plate, respectively.

6. In a fuel burning apparatus having means providing a combustion chamber, a combustion air supply device including in combination an air box having a discharge opening at one end thereof communicating with said chamber, a plurality of baffle plates disposed within the box in parallel relation to the plane of said opening and in spaced relation to each other with the edges thereof in spaced relation to the sides of said box, said plates having apertures in axial alignment with said opening, and a series of vanes disposed between adjacent ones of said plates and arranged to impart whirling motion to air passing between the plates.

7. In a fuel burning apparatus having means providing a combustion chamber, a combustion air supply device including in combination an air box having a discharge nozzle arranged with its outlet in position to discharge air into said chamber, an apertured baffle plate disposed within said box in a plane normal to the axis of said nozzle and in spaced relation to the inlet end of the nozzle with the edges thereof in spaced relation to the walls of said box, a second baffle plate disposed within said box in parallel spaced relation to said first baffle plate with the edges thereof in spaced relation to the walls of said box and having an aperture of smaller size than the aperture in said first baffle plate, a series of vanes mounted on the outer side of said first plate around the aperture therein and arranged for imparting a whirling motion to air passing over the plate and thence into the inlet of the nozzle and a second series of vanes mounted between said first and second plates around the aperture in said first plate and arranged for imparting a reverse whirling motion to air passing between the plates and thence through the aperture in said first plate.

8. In a fuel burning apparatus, the combination with means providing a combustion chamber and means for directing into said chamber a stream of combustible mixture, of means for projecting a stream of air into said chamber in substantial alignment with and in opposition to such stream of combustible mixture and means for projecting into said chamber an annular whirling body of air around said stream of air.

9. In a fuel burning apparatus including means providing a combustion chamber, a combustion air supply device including in combination an air box having an end plate provided with an aperture communicating with said chamber, a baffle plate disposed within said box in parallel spaced relation to said end plate, a second baffle plate disposed within said box in parallel spaced relation to said first baffle plate, the edges of both of said baffle plates being in spaced relation to the side walls of said box and both of said plates having apertures in axial alignment with the aperture in said end plate, means for imparting whirling motion to air passing between said end plate and said first baffle plate and means for imparting whirling motion to air passing between said first baffle plate and said second baffle plate which last mentioned whirling motion is in the opposite direction to that of said first whirling motion.

10. A baffling device for controlling the flow of air through a combustion air discharge opening into a combustion chamber of a fuel burning apparatus, said device comprising a first baffle plate having an aperture therein, a second baffle plate secured in parallel spaced relation to said first plate and having an aperture in alinement with and of smaller size than the aperture in said first plate, a third baffle plate secured in parallel spaced relation to said second baffle plate and having an aperture in alinement with and of smaller size than the aperture in said second plate, and a plurality of vanes secured between said first and second plates and between said second and third plates around the apertures therein and arranged to impart whirling motion to air passing between said plates.

ALDO MACCHI.