July 19, 1949. B. J. PARMELE 2,476,507

CYCLONE BURNER

Filed Oct. 30, 1946

4 Sheets-Sheet 1

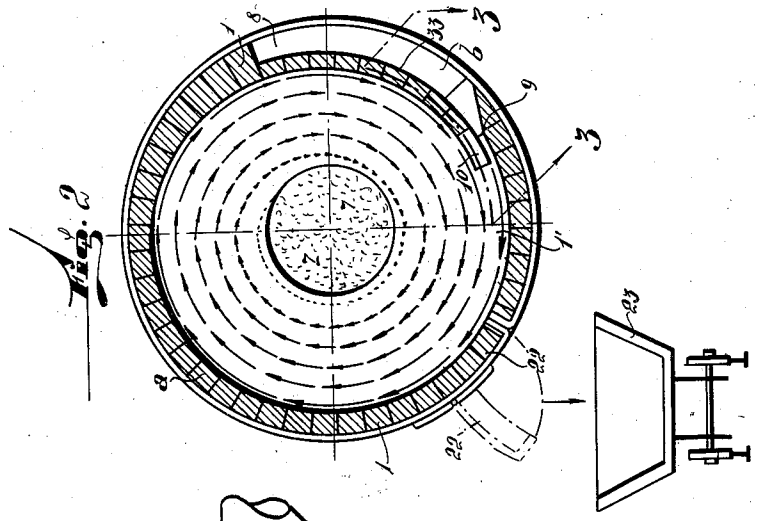

Fig. 2

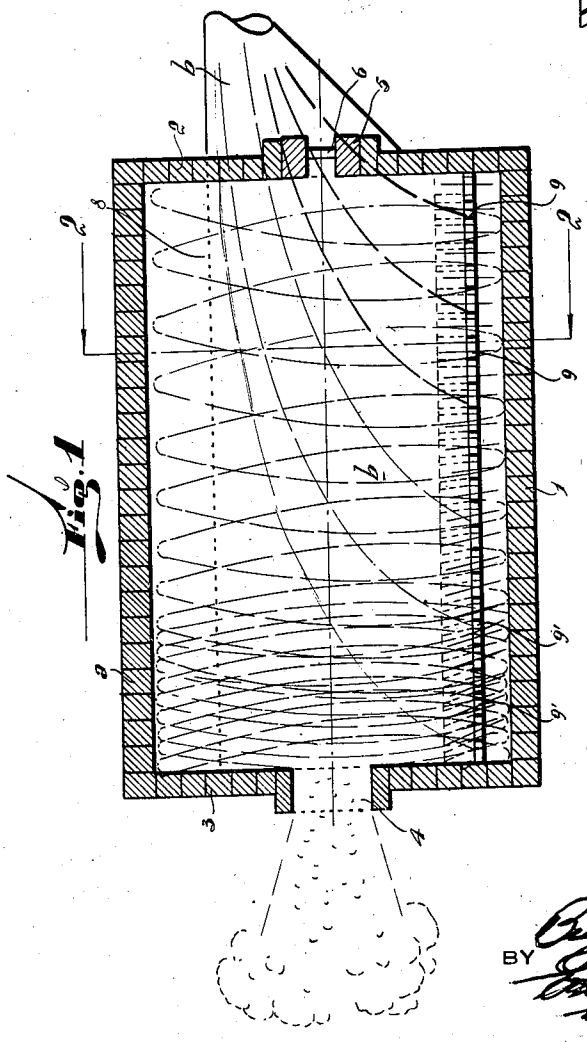

Fig. 1

INVENTOR

Benjamin J. Parmele

BY

ATTORNEYS

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Fig. 3

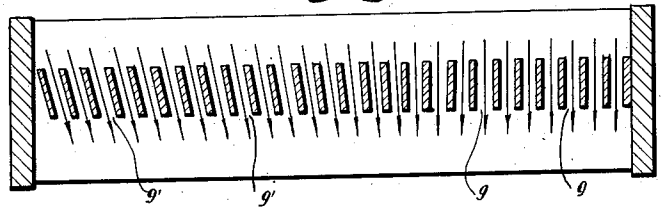


Fig. 3A

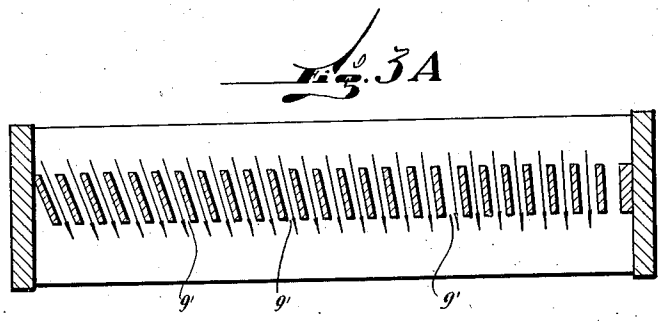
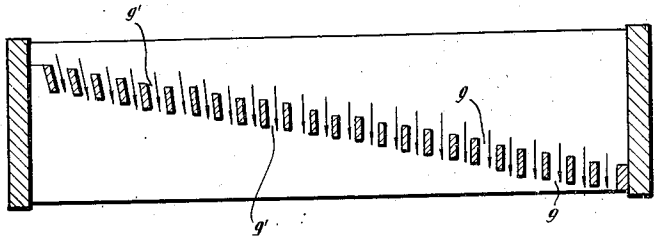


Fig. 4



INVENTOR
Benjamin J. Parmele
BY
Thurston & Mealey
his ATTORNEYS

July 19, 1949. B. J. PARMELE 2,476,507

CYCLONE BURNER

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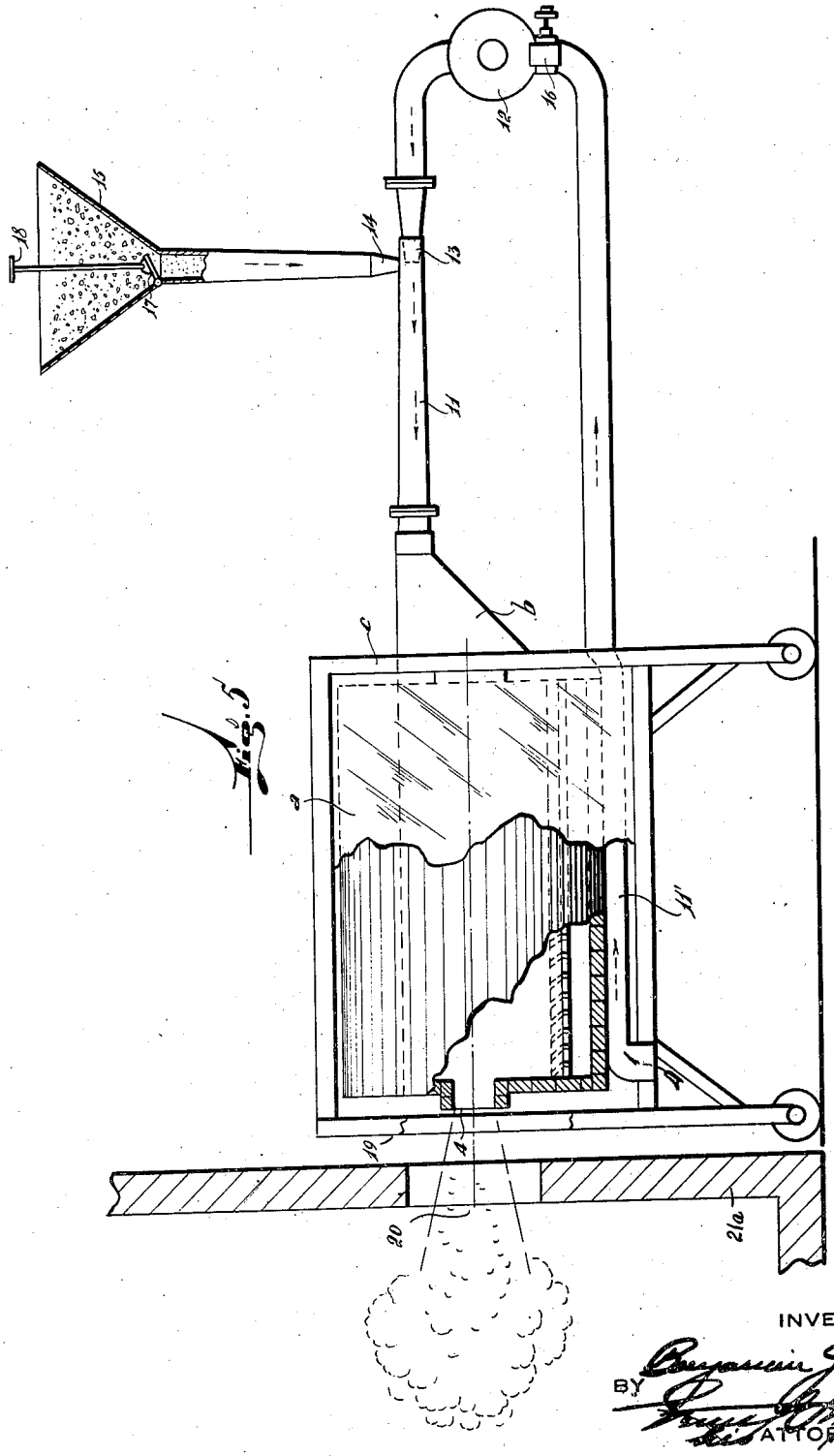

Fig. 5

INVENTOR

BY

ATTORNEYS

July 19, 1949. B. J. PARMELE 2,476,507

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Fig. 7

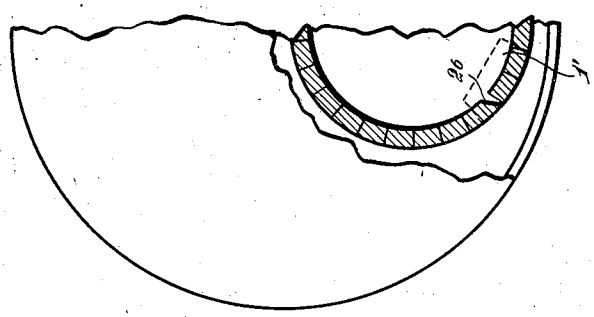
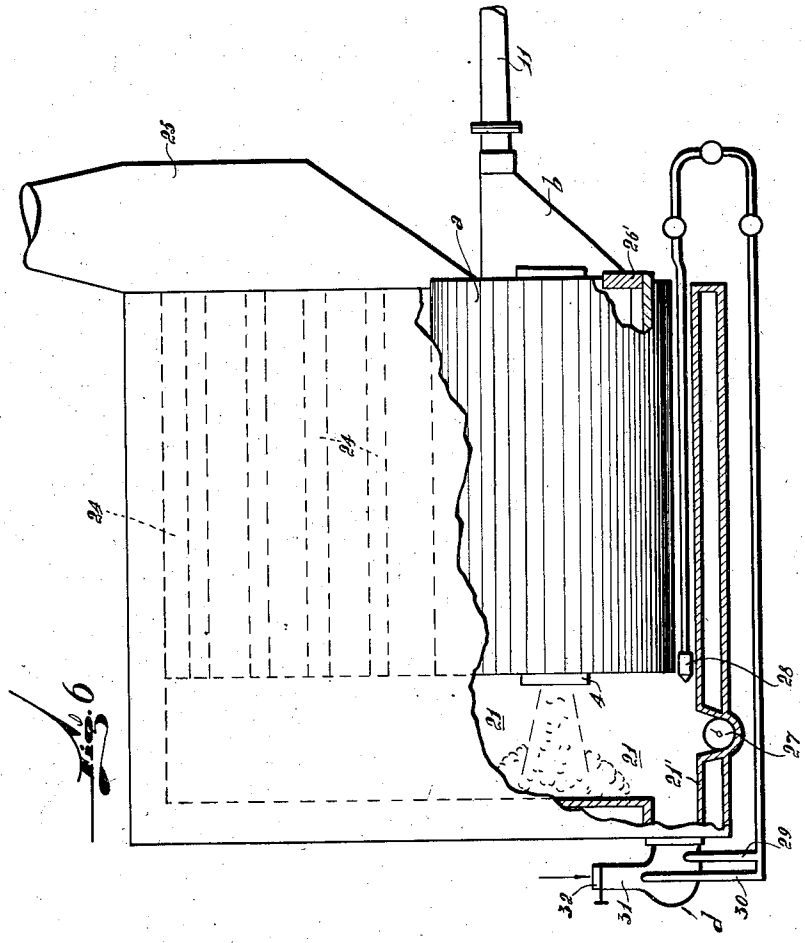


Fig. 6



INVENTOR
Benjamin J. Parmele
BY
Thomas H. Franklin
ATTORNEYS

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UNITED STATES PATENT OFFICE

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CYCLONE BURNER

Benjamin J. Parmele, Wilmington, N. C.

Application October 30, 1946, Serial No. 706,623

6 Claims. (Cl. 110—28)

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This invention refers to improvements in cyclone burners for various fuels, and more especially to combustion chambers of the type in which the fuel, carried by the air, is subjected to a thorough mixture with the said air prior to the discharge through the corresponding burner port.

The tangential or cyclonic internal combustion burner system is well known in various countries. However, in view of the fact that not all fuels are burned instantaneously, the resultant efficiency is rather low, since a portion of the particles of the substance to be burned describes a rotation cycle without being completely burned and leaves the burner chamber together with the burning gases, so that the utilization of the fuel must be considered as partial.

It is advisable to use a burner chamber the length and capacity of which are sufficient to provide for a longer helical rotation path, but as this expedient can be applied to a limited extent only in view of the increasing heat losses caused by an increase in the dimensions of the chamber, the problem still persists in all of its aspects.

Experimenting with various types of cyclone burners, I have come to the conclusion that since it is not possible to increase the capacity of the chamber in order to obtain a longer path of the fuel particles it is necessary to arrest the helical advance movement of the particles during their rotation caused by the air supply in which they are carried, so that in each section of the chamber the fuel particles describe a larger number of revolutions. This has been precisely obtained by means of the improvements according to this invention.

This invention comprises a particular arrangement of the fuel and compressed air supply port, due to which the mixture of fuel and air supplied to the chamber retards the normal helical progress towards the outlet, increasing the number of revolutions without affecting the progress of the same, i. e., the air and fuel injected into the burner chamber in a tangential and progressively slanting direction cause the unburned fuel particles to keep circulating until they are consumed and the gases and fly ash gain the central vortex and are ejected from the chamber.

For this purpose, the tangential entrance ports of the fuel and compressed air supply are constituted by a plurality of orifices which, being arranged in a row, extend from the rear wall of the burner chamber to the discharge or burner port thereof, with the essential characteristic that said orifices, adjacent to the discharge or

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front wall of the chamber, are slantingly arranged in a direction slightly opposite to the direction of discharge of the chamber. As a result the jets, formed of a mixture of air and fuel, which are injected into the burner chamber adjacent its discharge port, tend to arrest the advance movement of the helical revolution generated by the rotation in the chambers of the air streams from the other jets. Thus, the fuel particles are obliged to remain during longer periods in the burner chamber and, due to the longer trajectory imposed on them, their combustion is practically complete so that their utilization reaches a maximum.

Apart from the objects mentioned hereinbefore, it is one of the main objects of the present invention to provide burner chambers which combine an effective operation with an efficiency which, from a practical standpoint, can be regarded as maximum.

A further object of the invention is to provide cyclone burners of minimum length and diameter in which, due to the interruption of the helical advance movement of the fuel particles carried by the air, it is possible to obtain a satisfactory combustion in the chambers of relatively reduced dimensions.

Another object of the present invention is to adequately distribute the fuel in the chamber by supplying the fuel to the same along the entire longitudinal extensions of the drum constituting the burner chamber.

A further object of the invention is to prepare the fuel in such a manner that the same is carbureted prior to the penetration into the chamber, so that the fuel reaches the chamber in a perfect condition for combustion.

Still another object of the present invention is to facilitate replacement of the feeder when worn out by constructing the feeder of metal and detachably mounting it on the burner.

Further objects and advantages of the invention will become apparent from the following detailed description thereof taken in connection with the accompanying drawings which illustrate some of the preferred embodiments of the burner, by way of example, only, and in which:

Figure 1 is a longitudinal sectional view of the chamber constituting the burner according to the invention.

Figure 2 is a transverse sectional view of the burner chamber taken along the line 2—2 of Figure 1.

Figure 3 is a horizontal sectional view of the

fuel and compressed air feeder taken along the line 3—3 of Figure 2.

Figure 3A is a sectional view similar to that of Figure 3 but illustrating a modification of the discharge orifices of the fuel and compressed air feeder.

Figure 4 is a sectional view similar to that of Figure 3 but illustrating a further modification of the discharge orifices of the fuel and compressed air feeder.

Figure 5 is a general lateral view of the improved burner according to the invention.

Figure 6 is a lateral view of the burner according to the invention applied to a marine boiler.

Figure 7 is a partial frontal view of a part of the burner illustrated in Figure 6.

In the figures, like or corresponding parts are designated with the same reference letters or numerals.

Referring to the drawings, *a* is the drum which constitutes the chamber, the lateral walls **1** of which are curved and practically of cylindrical shape. One end of said drum is closed by a rear wall **2** and the opposite end of the chamber comprises a front wall **3** which is provided with the corresponding discharge or burner port **4** through which the combustion gases pass into the fire box of the furnace.

Rear wall **2** is provided with a port having a detachable lid **5** provided with an observation window **6**. The lid is maintained in its closed position during the operation of the burner, but it can be easily opened in order to facilitate an inspection of the burner, and furthermore, to allow introduction of the starting fuel charge.

Similar to all burners of this type used in the United States of America, Sweden and other countries, the combustion chamber constituted by drum *a* is provided with a tangential port for the supply of fuel and compressed air, since due to this tangential supply port the fuel particles are caused to describe a helical rotational movement in order to be burned in the chamber and produce an igneous mass which is discharged through burner port **4** in the form of a flame jet, as can be seen in Figures 1 and 5.

On starting their rotational movement, the fuel particles tend to turn around against the interior surfaces of walls **1** but as the combustion progresses, said particles grow lighter and due to the decreased density describe revolutions of smaller diameter, as can be observed in Figure 2, until they penetrate into a central zone **7** where these fuel particles are totally consumed so that only the combustion gases, together with the impalpable volatile or fly ash particles, are discharged through burner port **4**.

This is the theory of the cyclone burners, but in practice not all of the fuel particles are burned prior to the discharge through burner port **4**, so that a part of the fuel is not utilized.

As already expressed hereinbefore, the disadvantages present in the known cyclone burners have been eliminated by means of the improvements according to the present invention, since the latter provides means to the effect that the injected air will control the advance movement of the helical trajectory of the fuel particles subjected to the combustion process.

As stated, the entrance port for the mixture of fuel and air under pressure is constituted by a feeder *b* formed of a bell-shaped member terminating in a plurality of orifices **9** and **9'**. Said orifices **9** and **9'** of feeder *b* are arranged in rows under a step **10** provided in the interior surface

of wall **1**. This surface is nearly cylindrical but the cross-section thereof gradually and slightly decreases to form a spiral whose pitch determines the height of step **10**.

Orifices **9** and **9'** are directed in a tangential direction towards the interior wall surface of the chamber in a zone corresponding to the bottom thereof. Since the diameter of the interior surface of the wall gradually diminishes in order to form step **10**, the fuel carried in the air stream and supplied to the combustion chamber through orifices **9** and **9'**, follows the course of the spiral, so that, after completing the first revolution, the fuel particles penetrate into the general mass of the flame and do not interfere with the supply of additional fuel and air introduced into the chamber through the new orifices.

Orifices **9** and **9'** form a row which extends from the rear wall **2** of the chamber to the front wall **3** thereof, so that due to the width of the bell-shaped end **8** of the feeder, the pulverized fuel is distributed in an efficient manner. In effect, since bell-shaped end **8** of the fuel and air feeder is sufficiently high to project the fuel from a zone immediately adjacent to rear wall **2** to a zone located adjacent the front wall **3** of the chamber, the fuel particles are distributed according to their weight, since the heavier particles fall, as is logical, more rapidly than the lighter ones, so that each particle, in accordance with its weight, describes a parabola different from those described by the other particles of the fuel. This has been graphically illustrated in the drawing of Figure 1 which gives an idea of the range of parabolas described by the different particles of the pulverized fuel.

In view of the fact that the heavier particles describe a shorted parabola, these particles penetrate into the combustion chamber through the orifices **9** adjacent to rear wall **2**, so that these heavy particles start their rotational movement from said rear wall and, describing a helical trajectory, follow a path of maximum length towards front wall **3** of the chamber. The lighter particles penetrate into the combustion chamber through other orifices **9'** which are more remote from rear wall **2**, so that the fuel particles penetrate into the chamber according to a porportional order through points which correspond to the rational path of the igneous mass in the chamber.

Apart from the distribution characteristic provided by feeder *b*, the latter originates the automatic control for the advance movement of the cycle of trajectories. Said control or regulation results from the arrangement of orifices **9** which, in the portion designated by **9'**, form an angle which is slightly inclined in a direction opposite to that of the discharge of the combustion gases. The inclination of the orifices in a direction contrary to that of the discharge of the burner increases even more in the zone immediately adjacent to the front wall **3**, since, starting from the central zone, the inclination increases from a minimum to a maximum value as can be seen in the drawings of Figures 3, 3A and 4, wherein are shown three of the possible variations in arrangement of the orifices.

Due to the inclined arrangement of orifices **9'** the air which carries the fuel particles and penetrates into the chamber through the zone of the feeder comprising the inclined orifices directed slightly against the direction of discharge of the burner, applies a certain braking action to the advance movement of the helical

paths described by the fuel particles during the rotation of the igneous mass in the combustion chamber, since the particles in these helical paths have to advance against force components which tend to rotate along a receding path towards the rear wall 2 instead of advancing towards front wall 3 of the chamber. Consequently, the fuel particles instead of completing their helical cycle with the corresponding number of revolutions, in accordance with the velocity and volume of the air injected together with fuel, describe a larger number of revolutions in the neighborhood of front wall 3 and thus describe a longer path than usual and are simultaneously subjected to an increased turbulent motion. Consequently the particles penetrating into the combustion chamber adjacent to rear wall 2, as well as the fuel particles which penetrate into the combustion chamber through the orifices of the intermediate zone and the zone adjacent to the front wall 3 of the chamber, are enabled to be completely consumed and maximum utilization of the fuel is obtained.

Feeder *b* is connected to a duct 11 provided with a blower 12 designated to impart to the air the velocity which is required for the supply and turbulence in the chamber constituted by drum *a*. Duct 11 comprises a Venturi tube 13 towards which is directed the discharge duct 14 of a hopper 15 which contains the pulverized fuel. Due to suction action of the Venturi tube the coal or other fuel particles are drawn into duct or pipe 11 where they are thoroughly mixed with the air, and thus are subjected to a sort of carburetion in order to be properly conditioned on penetrating into the combustion chamber.

The fuel supply may be controlled either by varying the velocity of the motor which drives blower 12 or by means of a valve 16 which constitutes the air intake of blower 12. Furthermore, the system is provided with another means for directly controlling the fuel supply, since between hopper 15 and discharge port 14 thereof there is provided a valve 17 which is governed by means of a handle 18.

In the embodiment shown in Figure 5, a portion of branch 11' of duct 11 is in contact with the walls of the chamber or drum *a*, so the air sucked in by blower 12 is previously heated in order to obtain a still better carburetion when the heated air mixes with the pulverized fuel after having passed through Venturi tube 13.

In the embodiment illustrated in Figure 5 drum *a* is mounted on a trestle *c* provided with a casing 19. The cyclone burner mounted on trestle *c* is arranged in front of the opening 20, which corresponds to the entrance port of fire box 21*a*, and the burner port 4, which constitutes the discharge opening of the combustion chamber or drum *a*, is directed toward the entrance port of the furnace.

In the embodiment of the invention shown in Figure 2, the lateral wall 1 is provided with a hinged lid 22 arranged beyond zone 1' against which impinges the air stream which injects the fuel coming from feeder *b*, i. e., lid 22, which extends along the entire length of chamber *a*, is located at a point where the clinker accumulates. Accordingly, the chamber may be periodically cleaned in a substantially simple manner, since once the lid 22 is carried to a position indicated by means of the dotted lines in Figure 2, the accumulated clinker falls into a wagonette 23 or other container which is arranged below trestle *c*.

In the embodiments of the invention illustrated in Figures 6 and 7, the burner according to the invention is incorporated into the structure of the boiler which may be of the "Scotch Marine", "Lancashire" or any other similar type comprising a fire box 21 and heater tubes 24 in communication with a chimney 25. In this case, beyond the zone 1', towards which the air with the admixed fuel is directed, there is provided a channel 26 slantingly arranged toward a discharge port for the liquid clinker mounted in rear wall 2. This discharge port may be constituted by a detachable cover 26'.

The bottom 21' of fire box 21 includes a helical transporter 27 for the discharge of the ashes. Should the capacity of this transporter not be sufficient for this purpose, bottom 21' is provided with a blower 28 which is designed to or may be operated as an extractor or ejector to remove excess ashes.

The rear part of fire box 21 is provided with an elbow-shaped duct *d* in which there are mounted two blowers 29 and 30, of which the former is mounted in the lower part of elbow *d* while blower 30 is mounted adjacently to the discharge opening of duct *d*. Blowers 29 and 30 constitute an ejector which is designed to remove the ashes accumulating on the bottom 21' of fire box 21, and said ashes are discharged through valve or port 32.

In any of its applications, the drum which constitutes the combustion chamber *a* is provided with a removable feeder *b*. This feeder is made of metal and terminates in a recess 33 formed in lateral wall 1 of the combustion chamber in which it is removably seated, enabling it to be replaced as necessary.

Summing up, the present invention refers to improvements in cyclone burners which comprise a chamber *a* formed by a laterally curved wall 1, a rear wall 2 and a front wall 3 provided with a discharge or burner port 4. The entrance or supply ports of the chamber are constituted by orifices 9 and 9' which, being arranged in a row in the lateral wall 1 of the chamber, form a line which extends from the rear wall to the front wall of the chamber, so that the fuel is distributed in accordance with the weight of the particles.

The fuel supply orifices, at least in the vicinity of the burner port in the front wall of the chamber, are inclined in a direction slightly against the direction of discharge of the combustion chamber.

It will be appreciated that modifications of the disclosed embodiments of my invention are possible without departing from the spirit of the invention or the scope of the claims.

Having thus described my invention what I claim as new and desire to secure by Letters Patent is:

1. Improvements in cyclone burners for various fuels, of the type comprising a drum-shaped chamber having a closed rear wall, a front wall provided with a burner port located opposite to said rear wall, and a curved lateral wall provided with tangential fuel and compressed air entrance ports, said entrance ports being constituted by a plurality of orifices which, being arranged in a row in said lateral wall, form a line extending from said rear wall to said front wall of the chamber, and said orifices, at least adjacent to the burner port of the chamber, being slantingly arranged in a direction slightly opposite to the direction of discharge of the chamber.

2. Improvements in cyclone burners for various

fuels, of the type comprising a drum-shaped chamber having a closed rear wall, a frontal wall located opposite to said rear wall and provided with a discharge or burner port, and a plurality of tangential fuel and compressed air entrance ports arranged in the curved lateral wall of said chamber, said entrance ports being constituted by a plurality of orifices, which extend in a row extending from said rear wall to said front wall of the chamber and which, in the vicinity of said burner port, are slantingly directed in a direction slightly opposite to the direction of discharge of the chamber, the inclination of said orifices gradually decreasing towards said rear wall of the chamber.

3. Improvements in cyclone burners for various fuels, of the type comprising a drum-shaped chamber having a closed rear wall, a front wall located opposite to said rear wall and provided with a burner port, and a plurality of tangential fuel and compressed air entrance ports arranged in the curved lateral wall of said chamber, said ports being constituted by a plurality of orifices arranged in a row extending from said rear wall to said front wall of the chamber and which are slantingly directed in a direction slightly opposite to the direction of the discharge of the chamber solely in the vicinity of the said front wall.

4. Improvements in cyclone burners for various fuels, of the type comprising a drum-shaped chamber having a closed rear wall, a front wall provided with a discharge or burner port, and a plurality of tangential fuel and compressed air entrance ports arranged in the curved lateral wall of said chamber, said entrance ports being constituted by a plurality of orifices arranged in a row extending between said rear and front walls of the chamber and which, at least adjacent to said front wall, are slantingly directed in a direction slightly opposite to the direction of discharge of the chamber, said orifices forming part of a feeder comprising a bell-shaped discharge end which, starting from an air and fuel mixer tube, gradually widens to extend from said rear wall to said front wall of the chamber.

5. Improvements in cyclone burners for various fuels of the type comprising a drum-shaped chamber having a closed rear wall, a front wall provided with a discharge or burner port, and a plurality of tangential fuel and compressed air supply ports arranged in the curved lateral wall of the chamber, said entrance ports terminating in the lower portion of a step provided in the interior surface of said lateral wall and being constituted by a plurality of orifices arranged in a row extending from said rear wall to said front wall of the chamber and which, at least in the vicinity of the said front wall, are slantingly directed in a direction slightly opposite to the direction of discharge of the chamber.

6. Improvements in cyclone burners for various fuels, of the type comprising a drum-shaped chamber having a closed rear wall, a front wall provided with a discharge or burner port, and a plurality of tangential fuel and compressed air entrance ports arranged in the curved lateral wall of the chamber, said entrance ports being constituted by a plurality of orifices arranged in a row extending from said rear wall to said front wall and which, at least adjacent to the said front wall, are slantingly directed in a direction slightly opposite to the direction of discharge of the chamber, said orifices forming part of the bell-shaped discharge end of a tubular feeder which includes an air blower and a fuel ejector, to obtain an efficient carburetion and distribution of the fuel with an automatic control of the helical advance movement of the fuel and air stream within said burner chamber.

BENJAMIN J. PARMELE.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,618,808	Burg	Feb. 22, 1927
1,969,371	Hawley	Aug. 7, 1934
2,395,103	Clausen et al.	Feb. 19, 1946