

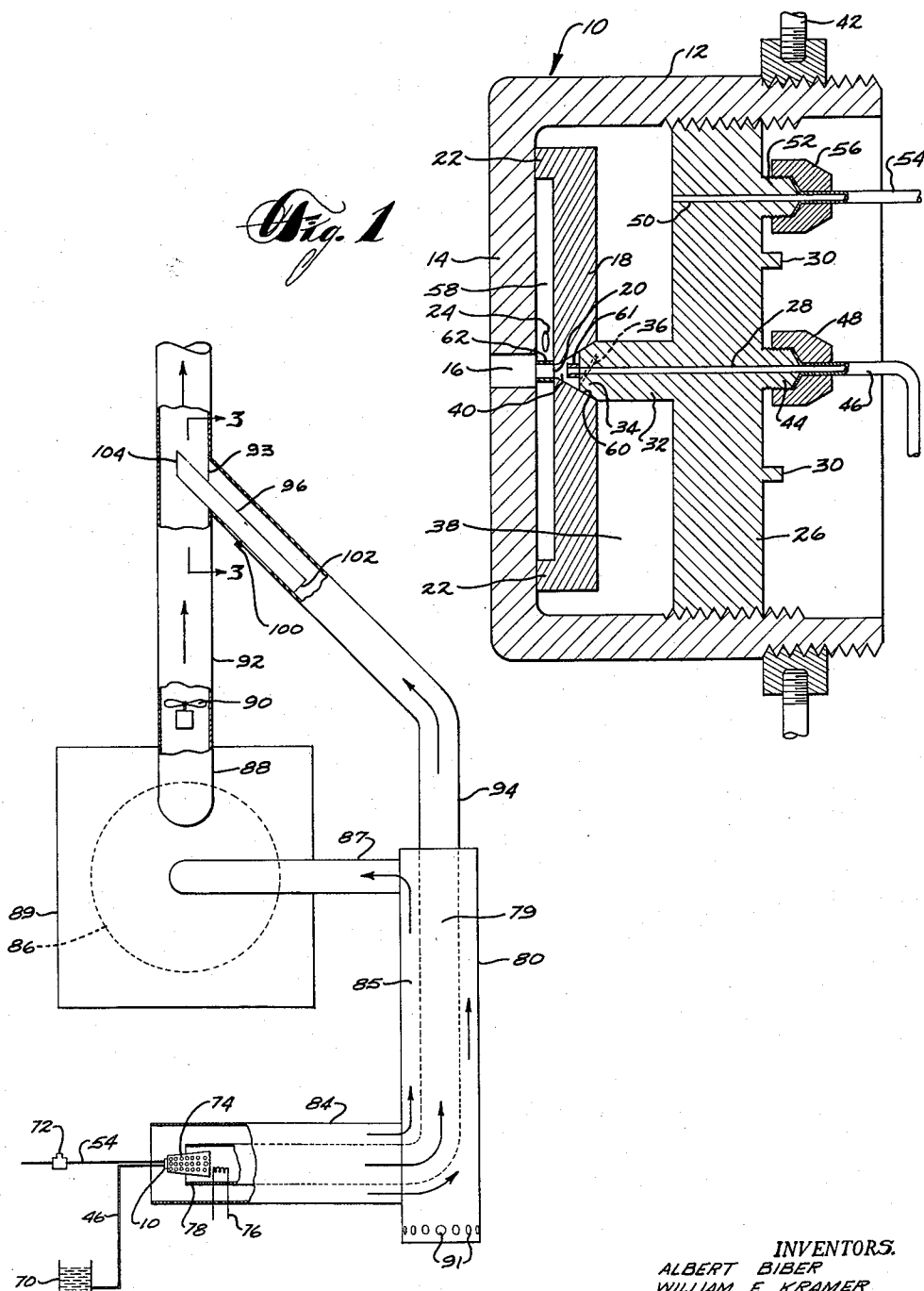
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A. BIBER ET AL
AIR HEATING APPARATUS

3,119,604

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2 Sheets-Sheet 1



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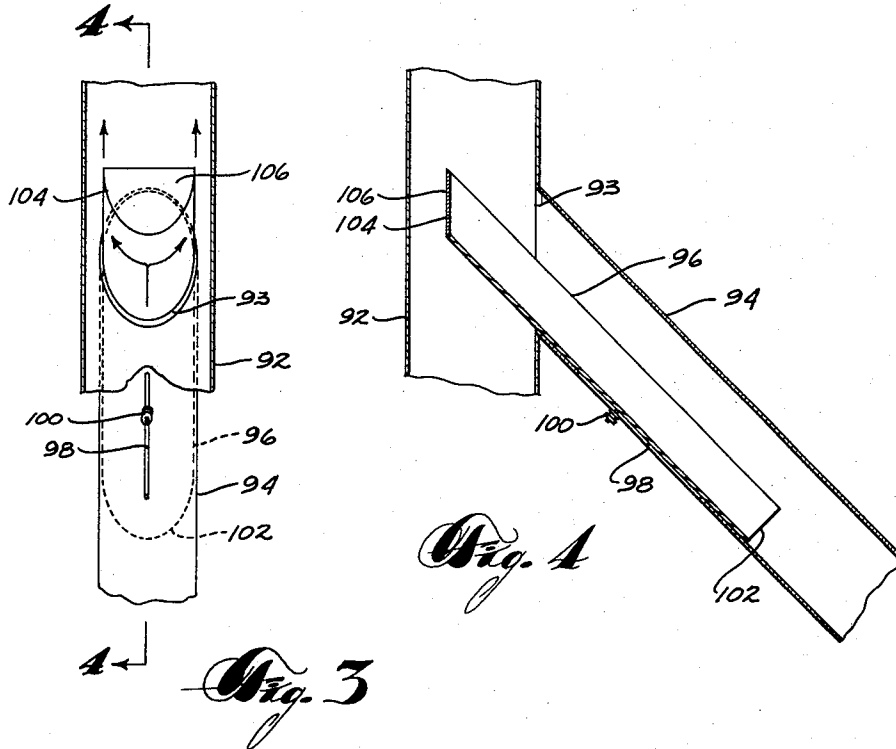
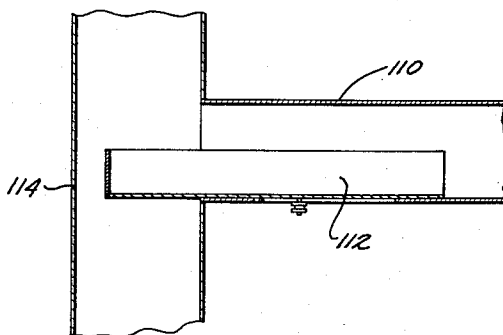


Fig. 5

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AIR HEATING APPARATUS

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8 Claims. (Cl. 263—33)

This invention relates to an improved aspirating apparatus having utility for indirect heating of a gas, such as air, and more particularly relates to an improved aspirating apparatus in combination with dryer apparatus utilizing indirect heating of the drying gas.

In conventional dryer apparatus employing the combustion of fuel for heat, such as domestic clothes dryers, the air utilized as a drying medium is generally heated directly by admixture with hot combustion gases from a burner to which gaseous fuel is charged. However, it is not advantageous to directly heat drying air when a burner is employed which utilizes liquid fuel oil. Liquid fuel fired burners produce atomized oil droplets which may deposit upon the material being dried and leave traces of oil or at least an odor of oil. Therefore, when firing a domestic clothes dryer burner nozzle with liquid fuel it is important that the drying air be indirectly heated in order to prevent combustion gases from entering the dryer.

When firing a domestic clothes dryer with a liquid fuel burning nozzle it is generally necessary that the type of nozzle employed be of an aspirating type which is adapted so that an aspirating gas, such as air, passing through the nozzle at a slightly super-atmospheric pressure aspirates into the nozzle oil existing under atmospheric pressure. A primary reason for utilizing an aspirating nozzle in domestic clothes drying equipment is that the heating load of such dryers is relatively small, requiring only about 0.15 to 0.50 gallon of fuel oil per hour. If it were desired to burn liquid fuel oil employing a nonaspirating burner nozzle at such low flow rates it would be necessary to utilize a nozzle having an oil discharge orifice which is so extremely restricted that nozzle plugging would occur due to unavoidable particles of dirt in the oil or due to coke formation within the nozzle during combustion. At such low flow rates nozzle plugging would be so frequent that maintenance problems would make the use of a nonaspirating oil burner nozzle prohibitive. In contrast, when an aspirating nozzle is utilized the nozzle discharge orifice and oil passageways within the nozzle can be extremely large in comparison since the oil is not pumped through the nozzle under pressure but rather is exposed to the nozzle under only atmospheric pressure and is drawn into the nozzle by means of an aspirational gas.

When combustion gases are supplied directly to drying air enroute to a dryer for the purpose of heating this air a single circulatory system through the dryer for both heating gases and drying air is utilized. However, when combustion gases cannot be directly charged to the drying air stream it is necessary that a double circulatory system be employed, one for the drying air which goes through the dryer and the other for the combustion gases which must indirectly heat the air in a heat exchanger and bypass the dryer. The apparatus of this invention embodies an advantageous double circulatory system wherein the flow of drying air after discharge from the dryer is utilized to advantageously regulate the flow of both secondary air required for fuel combustion and the exhaust of combustion products.

This invention comprises forcing wet, drying air through a drying air conduit having a side opening, passing the combustion gases from the burner into a combustion gas conduit, exposing the combustion gases in the combustion

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gas conduit to said side opening in the drying air conduit, disposing longitudinally within said combustion gas conduit an elongated channel having an open top of a type as is formed by longitudinally splitting an elongated tube on a plane including its longitudinal axis to produce a channel whose brim lies on said plane and defines an open top in said channel, extending said channel through said side opening into said drying air conduit, orienting said channel rotationally with respect to its longitudinal axis so that the drying air traveling in said drying air conduit impinges only upon the outside of said channel and flows substantially tangentially past the brim of said channel defining the open top thereof, and adjusting the distance said channel projects into said drying air conduit whereby the discharge rate of combustion gases through said channel is regulated.

The flow of drying air tangentially past the brim defining the open top of the channel permits the drying air to create an evacuated zone above the channel. Combustion gases from the combustion gas conduit flow along the channel into this evacuated zone and are aspirated therefrom. Movement of drying air past the outside of the brim defining the open channel top in a direction which is tangential with respect to the channel top opening permits the drying air to exert a maximum aspirational effect. The apparatus as described advantageously avoids any component of movement of drying air transversely across the open channel top since such transverse air movement would tend to impede aspiration from the channel and possibly even produce a back pressure against the combustion gases.

Since the aspirational effect upon the aspirating channel of this invention is exerted only over the portion of the open top of the channel which extends into the drying air conduit, the rate of removal of combustion gases is regulated by adjusting the distance which the channel projects into the drying air conduit, said distance being increased if it is desired to increase the rate of removal of combustion gases and said distance being decreased if it is desired to decrease the rate of removal of combustion gases. For each flow rate of dryer air there exists an optimum distance for the channel to project into the drying air conduit. If the channel projects too great a distance into the drying air conduit aspiration there-through will be too great and not only will a large excess of air be supplied to the burner, thereby unnecessarily cooling the combustion gases, but also residence time of combustion gases in the heat exchanger will be concomitantly reduced, thereby causing poor heat transfer and high stack temperatures. On the other hand, if the channel projects too small a distance into the drying air duct the secondary air flow rate to the burner will be too small for complete combustion, causing the flame to become smoky, and the movement of the combustion gases in the heat exchanger will not be conducive to a high rate of heat exchange. It is seen that proper adjustment of the aspirating channel of this invention is critical to dryer operation.

The apparatus of this invention utilizes the flow of drying air for the adjustment of secondary air flow to the burner and removal of combustion gases from the burner. The apparatus is adapted to produce optimum burner operation and high heat transfer while employing separate ducts for drying air and combustion gases and with only the drying air duct being provided with a blower. In accordance with this invention, the flow of drying air regulates the flow rate of combustion gases with the drying air flow rate itself undergoing substantially no coincident regulation. These and other advantages of the invention will be apparent by reference to the accompanying drawings in which FIGURE 1 shows a preferred aspirating liquid fuel burning nozzle for use in a domestic clothes

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dryer, FIGURE 2 shows a diagrammatic view of a domestic clothes dryer fired with the liquid fuel aspirating nozzle of FIGURE 1 and having separate paths for the circulation of drying air and combustion gases, FIGURE 3 is a cross section view along the line 3—3 of FIGURE 2, FIGURE 4 is a cross section view along the line 4—4 of FIGURE 3, and FIGURE 5 is a fragmentary view of a modification of the clothes dryer of FIGURE 2.

Referring to FIGURE 1, a longitudinal cross sectional view of a nozzle designated generally as 10 is shown having a tubular body portion 12 which is internally and externally threaded as shown. The forward end of body portion 12 terminates with a substantially flat integral enclosure 14 which is on a plane transverse to the axis of tubular body 12. Enclosure 14 has an axial central orifice opening 16. Orifice plate 18 immediately inside of and adjacent to enclosure 14 has an over-all diameter less than the internal diameter of tubular body 12 and has an axial orifice 20. Orifice 20 is the apex of an axial conical bore 60 as shown. The diameter of orifice opening 16 is larger than the diameter of orifice opening 20 and a cylindrical duct 62 extends from orifice 20 to partially obstruct the entrance to orifice 16. The forwardly protruding peripheral rim 22 of orifice plate 18 contains one or more borings 24 which open in a tangential manner into swirl chamber 58 which is formed by virtue of rim 22 setting apart the rearward surface of enclosure 14 and the forward surface of orifice plate 18.

A plug 26 having external threads and an axial bore 28 is equipped with two or more prongs 30 on its rear face so that it can be screwed into the interior of tubular body 12 and urge orifice plate 18 in sealing engagement against the inner surface of enclosure 14 so that orifice opening 20 is axially disposed. Plug 26 has a central forwardly projecting stud 32 terminating with a frusto-conical swirl stem 34 which holds orifice plate 18 in place by abutting firmly against the complementary internal surface of the base portion of conical bore 60 leaving unoccupied the apex of conical bore 60, the unoccupied apex of conical bore 60 constituting a swirl chamber 40. Swirl stem 34 is equipped with one or more peripheral slots 36 extending the length of the stem and providing passage between air chamber 38 and swirl chamber 40. Slots 36 are generally comparable in cross section and length with borings 24 so that the pressure drop through each is generally the same. In one example, slots .030 inch square are employed. Bore 28 which is coaxial with tubular body 12 constitutes a connecting passageway for the suction of oil from an oil reservoir on a lower level, not shown, into swirl chamber 40. Bore 28 is extended through a portion of the length of swirl chamber 40 by means of cylindrical tube 61. The internal diameter of cylindrical tube 61 is smaller than the diameter of orifice 20.

After the orifice plate 18 is secured in position by tightly screwing plug 26 into place as shown in FIGURE 1, the entire resulting nozzle assembly is secured into position for use by means of supporting rods 42 which rods can be secured at their opposite ends to the perforated tube 74, shown in FIGURE 2. After the nozzle is assembled and secured into place, an oil reservoir on a level lower than the nozzle is connected to the nozzle at externally threaded boss 44 extending rearwardly from the center of plug 26 and coaxial with oil passageway 28. Suitable flared tubing 46 extends from below the level of oil in the reservoir and is attached in sealing connection to boss 44 by means of nut 48. Passage of compressed air to chamber 38 is provided by passageway 50 through plug 26 terminating with rearwardly extending externally threaded boss 52 to which flared tubing 54 is attached in sealing connection by means of internally threaded nut 56.

In operating the nozzle shown in FIGURE 1 air under a pressure between about 2 and 10 pounds per square inch gauge, pressures in the upper portions of this range being employed when it is desired to aspirate greater

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quantities of fuel oil than are aspirated at air pressures in the lower portion of this range, is charged to air chamber 38 from which it passes through groove 36 and enters swirl chamber 40 substantially tangentially and swirls in swirl chamber 40. The swirling air draws oil from a reservoir which is on a lower level than the nozzle by suction through passageway 28 into swirl chamber 40 where a fuel-air mixture is formed which passes through orifice 20 and duct 62 to a second orifice 16. Tube 61 allows the air to assume an adequate swirling pattern prior to aspirating in oil and prevents air back pressure against the oil from the reservoir. Additional air from air chamber 38 passes through tangential inlet duct 24 to second swirl chamber 58 from which it swirls through orifice 16 where it increases in velocity and aspirates into itself the fuel-air mixture from duct 62 to form a new mixture in which the oil is more highly atomized and which is richer in air. The new mixture is discharged in a swirling pattern through orifice opening 16.

It has been found that cylindrical ducts 61 and 62, which project axially at least a portion of the distance into each swirl chamber, are essential to operation of the nozzle and in the absence of either or both of these ducts it was found that the air was unable to aspirate sufficient oil into itself to create a mixture of oil and air capable of sustaining combustion.

FIGURE 2 illustrates an advantageous domestic clothes dryer oil burning apparatus of the invention. In the apparatus of FIGURE 2, aspirating nozzle 10 is adapted so that the passage of pressurized air from an air compressor 72 to the nozzle through conduit 54 aspirates into the nozzle liquid fuel oil which is stored under atmospheric pressure in an oil reservoir 70 through conduit 46. Nozzle 10 is axially disposed within one end of a perforated tube 74 and discharges an air-oil spray to the other end thereof. An igniter 76 is disposed in the region of the perforated tube to ignite the nozzle spray. The nozzle and perforated tube combination is disposed partially within duct 78 coaxially therewith. Duct 78 is in communication with the hot interior zone means 79 of heat exchanger 80. Combustion gases from duct 78 pass through zone means 79 of the heat exchanger. Drying air inlet duct 84 surrounds burner duct 78 and the entrance of burner duct 78 is advantageously slightly recessed therein. Drying air enters zone means 85 of the heat exchanger through the annular space between ducts 84 and 78 under the influence of blower 90. Hot interior zone 79 is in heat exchange relationship with respect to the surrounding annular zone means 85 in the heat exchanger and the drying air is heated in transit there-through. The drying air also undergoes preheating in duct 84.

Heated air from heat exchanger 80 enters a rotary drum 86 inside dryer 89. Moisture laden air is withdrawn from rotary drum 86 through pipe 88 which leads to blower 90. Blower 90 discharges through a vertical pipe 92, which is a continuation of pipe 88. Blower 90 draws drying air from the atmosphere through the annular space between pipes 84 and 78, through annular zone means 85 of the heat exchanger, through pipe 87, dryer drum 86 and pipe 88, and blower 90 discharges wet air from rotary drum 86 through pipe 92. Additional drying air, if required, can enter the heat exchanger through openings 91.

Combustion gases from heat exchanger 80 are withdrawn through combustion gas pipe 94 which approaches drying air pipe 92 at an acute angle with respect to the upstream end thereof and which is connected into pipe 92 at an opening 93 in the side of pipe 92. Pipe 94 is somewhat smaller than pipe 92. At the intersection of pipe 94 and pipe 92 is disposed a longitudinally adjustable channel 96. Channel 96 can be formed from an elongated tube, preferably a cylindrical tube, by longitudinally splitting the tube on a plane including its longitudinal axis

to produce a channel whose rim lies on said plane and defines an open top in the channel. Channel 96 can be formed from a tube which is smaller than pipe 94 or which is substantially the same size as pipe 94, as shown. Pipe 94 approaches pipe 92 at an acute angle in order that flow of combustion gases from pipe 94 into pipe 92 will be as streamlined as possible and in order to provide a wider longitudinal adjustment range for channel 96 within drying air pipe 92, as compared to a right angle approach as illustrated in FIGURE 5.

As shown in FIGURES 3 and 4, the bottom of pipe 94 is provided with an elongated slot 98. A locking nut 100 is attached to a threaded stud which projects from and is secured to the bottom of channel 96 and which extends through slot 98. Upon loosening nut 100, the position of channel 96 can be longitudinally adjusted within pipe 94 and channel 96 can then be secured fixedly at any desired position by tightening nut 100. In this manner the degree of protrusion of channel 96 into exhaust pipe 92 can be adjusted. Slot 98 is covered by channel 96 no matter what the longitudinal position of the latter to prevent escape of gases therethrough.

The end 104 of channel 96 which protrudes into pipe 92 is preferably cut to extend parallel to the longitudinal axis of pipe 92 and is enclosed by means of plate 106. This configuration tends to reduce turbulence within pipe 92. The opposite end 102 of channel 96 is open in order to permit axial flow of combustion gases into channel 96. Channel 96 is rotationally oriented so that its concave interior surface faces in a downstream direction in pipe 92 and so that wet drying air flowing upwardly through pipe 92 impinges upon the convex exterior surface of channel 96 and passes upwardly along the sides of channel 96. At the upper rim of channel 96 air flow is tangential to the exterior channel surface, as indicated in FIGURE 3. Tangential flow past the outer rim of channel 96 in this manner induces the greatest possible aspirational effect at the channel. The wet drying air traveling upwardly through pipe 92 past channel 96 creates a vacuum above channel 96 which tends to withdraw combustion gases from pipe 94. The rate of withdrawal of combustion gases from pipe 94 is proportional to the extent of protrusion of channel 96 into pipe 92.

The position of channel 96 within pipe 92 is adjusted until optimum burner operation is achieved. The position of the channel determines both the rate of removal of combustion gases from pipe 94 and the supply of secondary air to the burner 10. Concomitantly with withdrawal of combustion gases from pipe 94 air is drawn into burner duct 78. Since the opening of duct 78 is recessed within drying air inlet duct 84, the aspiration effect at channel 96 causes some of the air already in a state of motion within duct 84 to be diverted into duct 78 and serve as secondary burner air. The flame from the aspirating nozzle of FIGURE 1 has a thin elongated configuration and travels at a high axial velocity so that the secondary air entering duct 78 is in turn aspirated through the perforations in perforated tube 74 because of the flow of flame gases therein and is advantageously thoroughly admixed with the flame to improve combustion thereof. If channel 96 extends too far into pipe 92 not only will an excess of air be supplied to the burner beyond that required for complete combustion and thereby unnecessarily cool the combustion gases but also residence time in the heat exchanger will be concomitantly reduced thereby reducing heat transfer. On the other hand, if channel 96 extends too small a distance into pipe 92 although the residence time of the combustion gases in the heat exchanger will be high, the secondary air flow rate to the burner will be too small for complete combustion and the flame will become smoky. Therefore, for each rate of flow of drying air through the dryer a particular optimum setting for channel 96 exists. Adjustment of the setting of channel 96 may be required upon occasion,

for example, upon the dryer lint filter becoming excessively filled with lint.

FIGURE 5 shows a modification of the apparatus wherein a combustion gas pipe 110 containing a channel 112 enters a drying air pipe 114 at a right angle. However, it is noted that when the combustion gas pipe approaches the drying air exhaust pipe at an acute angle, as shown in FIGURE 2, results are superior because of the achievement of more streamlined flow and because the channel can extend a greater distance into the pipe transporting the aspirating gas, thereby permitting a much wider potential range of settings for the channel which in turn will permit much more precise adjustment of both burner and heat exchanger operation.

Various changes and modifications can be made without departing from the spirit of this invention and the scope thereof as defined in the following claims.

We claim:

1. An apparatus comprising a first conduit having a side opening, one end of said conduit being the upstream end and the other end being the downstream end, means for inducing flow in said first conduit from said upstream end to said downstream end, a second conduit joining said first conduit at said side opening at an acute angle with respect to the upstream end of said first conduit, an elongated channel having an open top and having a configuration as is formed by longitudinally splitting an elongated substantially cylindrical tube along its axis, said channel disposed longitudinally within said second conduit with a portion of said channel projecting into said first conduit, said channel disposed so that the portion of said open top projecting into said first conduit faces in a downstream direction in said first conduit, and means for adjusting the distance which said channel projects into said first conduit.

2. An apparatus comprising a first conduit having a side opening, one end of said first conduit being the upstream end and the other end being the downstream end, means for inducing flow in said first conduit from said upstream end to said downstream end, a second conduit joining said first conduit at said side opening at substantially a right angle, an elongated channel having an open top and having a configuration as is formed by longitudinally dividing an elongated substantially cylindrical tube along its longitudinal axis, said channel disposed longitudinally within said second conduit with a portion of said channel projecting into said first conduit, means for adjusting the distance which said channel projects into said first conduit, said channel disposed so that the portion of said open top of said channel projecting into said first conduit faces in a downstream direction in said first conduit.

3. An apparatus comprising a first conduit having an upstream end, a downstream end and a side opening, means for inducing flow through said first conduit from said upstream end to said downstream end, a second conduit joining said first conduit at said side opening, an elongated channel having an open top and having a configuration as is formed by longitudinally splitting an elongated substantially cylindrical tube along its axis, said channel disposed longitudinally within said second conduit with a portion of said channel projecting into said first conduit, said channel disposed so that the portion of said open top projecting into said first conduit faces in a downstream direction in said first conduit.

4. An apparatus comprising a first conduit having a side opening, one end of said conduit being the upstream end and the other end being the downstream end, means for inducing flow in said first conduit from said upstream end to said downstream end, a second conduit joining said first conduit at said side opening at an acute angle with respect to the upstream end of said first conduit, an elongated channel having an open top and having a configuration as is formed by longitudinally splitting an elongated substantially cylindrical tube along its axis, said channel

disposed longitudinally within said second conduit with a portion of said channel projecting into said first conduit, said channel disposed so that the portion of said open top projecting into said first conduit faces in a downstream direction in said first conduit.

5. An apparatus comprising a first conduit having a side opening, one end of said first conduit being the upstream end and the other end being the downstream end, means for inducing flow in said first conduit from said upstream end to said downstream end, a second conduit joining said first conduit at said side opening at substantially a right angle, an elongated channel having an open top and having a configuration as is formed by longitudinally dividing an elongated substantially cylindrical tube along its longitudinal axis, said channel disposed longitudinally within said second conduit with a portion of said channel projecting into said first conduit, said channel disposed so that the portion of said open top of said channel projecting into said first conduit faces in a downstream direction in said first conduit.

6. An apparatus comprising first conduit means having an inlet end and a discharge end, the inlet end of said first conduit means being open to the atmosphere, a burner disposed coaxially within said first conduit means at said inlet end, a heat exchanger having a hotter zone means and a colder zone means, the hotter zone means connected in fluid flow relation intermediate the inlet end and discharge end of said first conduit means, second conduit means having an upstream end and a downstream end, said colder zone means connected in fluid flow relation intermediate the upstream end and downstream end of said second conduit means, means for inducing flow of atmospheric air through said second conduit means from said upstream end to said downstream end and through the colder zone means of the heat exchanger, said second conduit means having a side opening near its downstream end, the discharge end of said first conduit means joining said second conduit means at said side opening, an elongated channel having an open top and having a configuration as is formed by longitudinally dividing an elongated substantially cylindrical tube along its axis, said channel disposed longitudinally within said first conduit means with a portion of said channel projecting into said second conduit means, said channel disposed so that the portion of said open top projecting into said second conduit means faces in a downstream direction in said second conduit means.

7. An apparatus comprising first conduit means having an inlet end and a discharge end, the inlet end of said first conduit means being open to the atmosphere, a burner disposed coaxially within said first conduit means at the inlet end, a heat exchanger having a hotter zone means and a colder zone means, the hotter zone means connected in fluid flow relation intermediate the inlet end and discharge end of said first conduit means, second conduit means having an upstream end and a downstream end, said colder zone means connected in fluid flow relation intermediate the upstream end and downstream end of said second conduit means, means for inducing flow of atmospheric air through said second conduit means from said upstream end to said downstream end and through the colder zone means

of the heat exchanger, the inlet end of said first conduit means being coaxial with respect to and recessed within the upstream end of said second conduit means, said second conduit means having a side opening near its downstream end, the discharge end of said first conduit means joining said second conduit means at said side opening at an acute angle with respect to the upstream approach of said second conduit means to said side opening, an elongated channel having an open top and having a configuration as is formed by dividing in half an elongated substantially cylindrical tube along its axis, said channel disposed longitudinally within said first conduit means with a portion of said channel projecting into said second conduit means, said channel disposed so that the portion of said open top projecting into said second conduit means is concave in a downstream direction in said second conduit means, and adjustment means for adjusting the distance which said channel extends into said second conduit means.

8. An apparatus comprising first conduit means having an inlet end and a discharge end, the inlet end of said first conduit means being open to the atmosphere, a burner disposed coaxially within said first conduit means at said inlet end, a heat exchanger having a hotter zone means and a colder zone means, the hotter zone means connected in fluid flow relation intermediate the inlet end and discharge end of said first conduit means, second conduit means having an upstream end and a downstream end, said colder zone means connected in fluid flow relation intermediate the upstream end and downstream end of said second conduit means, means for inducing flow of atmospheric air through said second conduit means from said upstream end to said downstream end and through the colder zone means of the heat exchanger, the inlet end of said first conduit means being coaxial with respect to and recessed within the upstream end of said second conduit means, said second conduit means having a side opening near its downstream end, a drying chamber in series with said second conduit means between said heat exchanger and said side opening, the discharge end of said first conduit means joining said second conduit means at said side opening, and elongated channel having an open top and having a configuration as is formed by dividing in half an elongated substantially cylindrical tube along its axis, said channel disposed longitudinally within said first conduit means with a portion of said channel projecting into said second conduit means through said side opening, said channel disposed so that the portion of said open top projecting into said second conduit means faces in a downstream direction in said second conduit, and adjustment means for adjusting the distance which said channel extends into said second conduit means.

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