

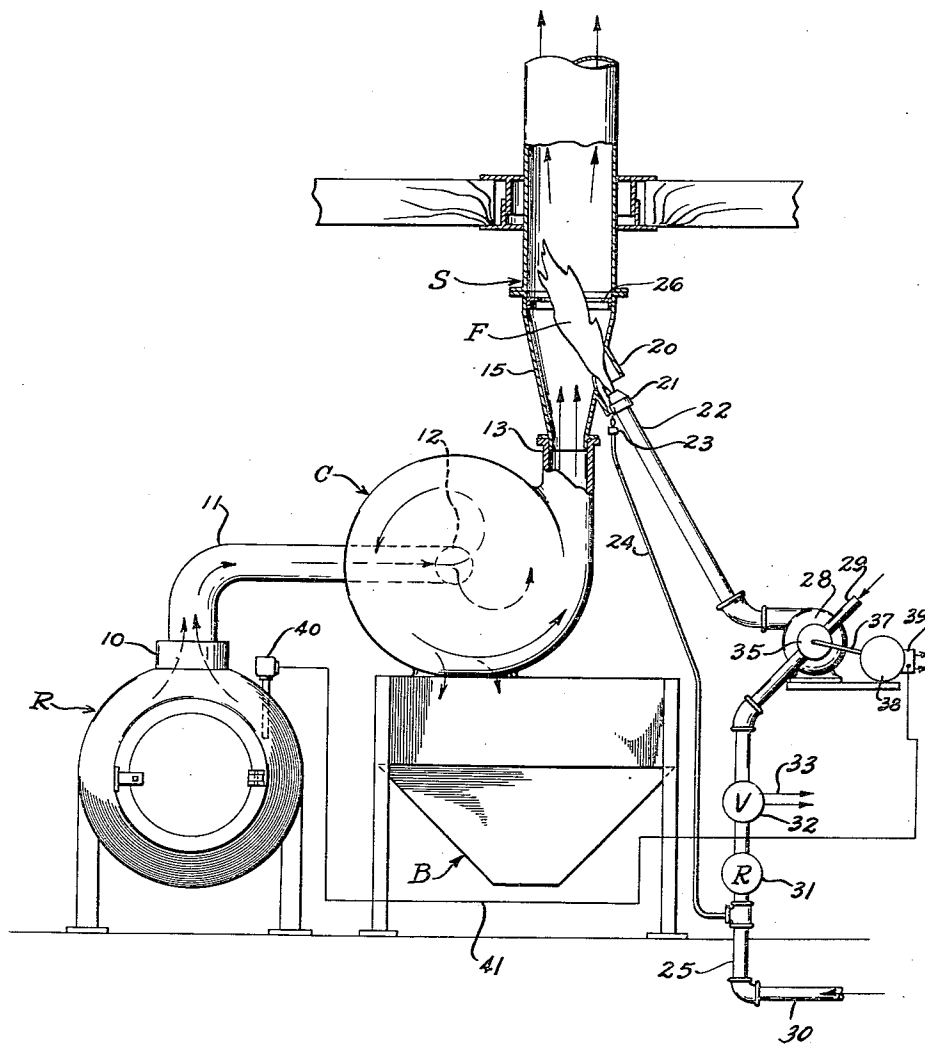
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METHOD AND APPARATUS FOR TREATING COFFEE ROASTER EXHAUST GAS

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## METHOD AND APPARATUS FOR TREATING COFFEE ROASTER EXHAUST GAS

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The present invention relates to an apparatus and method for reducing smoke and other substances in the exhaust gas streams arising from certain processes, particularly from coffee roasting processes.

In many industrial processes exhaust gases are evolved which are laden with smoke, vapor or entrained finely divided solids. Many means have been used to remove or reduce such constituents of the exhaust gas streams such as electrostatic precipitators, condensing systems, cyclone separators and other devices, either singly or in combination as systems of varying complexity. An example of such an industrial operation, to which the following description of this invention will be referred, is the process of roasting coffee. In this process the roaster exhaust gases may contain smoke, heavier solid material, such as chaff, of considerable range of subdivision, and vaporized waxes, greases or oils from the coffee beans. During the coffee roasting cycle large volumes of smoke with varying amounts of the other constituents are emitted to the atmosphere by the roaster stack or vent system. As a plant or public nuisance the smoke is of course objectionable, while the grease, wax or oil vapors give rise to a fire hazard, particularly when such materials are condensed in the vent ducts or stack. The present invention contemplates the interposition of a burner system between the roaster and the stack outlet whereby the smoke, waxes, greases, oils and some of the finely solid material at times present may be burned thereby to reduce or eliminate such substances in the exhaust stream vented to the atmosphere. Further, the accumulation of condensed wax, oils or greases in the vent stack is reduced or eliminated to obviate the fire hazard that otherwise might arise therefrom.

The object of the invention is the provision of a simple method and apparatus whereby combustible smokes and vapors may be reduced or eliminated from the exhaust gases of industrial operations. Another object of the invention is the provision of a burner device adapted for incorporation in exhaust ducts to eliminate by combustion combustible smoke, vapor or finely divided solid materials carried by the exhaust gas of industrial operations. Other objects and advantages of the invention will appear from the drawing and the following description.

In the drawings a system is shown whereby the exhaust from the coffee roaster oven R is treated by the apparatus and process of this invention before being emitted by the exhaust stack S to the free atmosphere. The exhaust from the roaster outlet 10 is conducted through the duct 11 to the inlet 12 of a blower type chaff collector C, the outlet 13 of which is connected by a burner assembly including an expanding or venturi conduit section 15 to the bottom of a vertical portion of a vent duct or stack S. The chaff collector C may be of the centrifugal blower type such as the "Rotoclone" separator, the inlet of which opens through the blower casing axially to the center of a rotary impeller which blows the exhaust stream to the

stack, the casing and impeller thereof being so arranged that heavier solid particles, accelerated to an interior casing wall, escape through openings in the interior surface of the casing into a circumferential collecting chamber which opens through a bottom outlet of the separator to the top of a closed separated chaff storage bin B. At intervals as required, the collected chaff may be withdrawn through a port in the bottom of the bin. By this means, in the exhaust stream leaving the outlet 13, the non-smoke solid material is substantially eliminated.

At the side of the conduit expansion section 15 a flame injection opening, surrounded exteriorly by the upwardly and obliquely directed burner nipple 20, is provided for introduction of a flame produced by the burner nozzle 21, the nozzle being supplied through mixed fuel conduit 22 with a suitable air-gas mixture. The nozzle 21 may be mounted to burner duct or conduit 15 by the nipple 20, the nipple being provided with an opening near the end of the nozzle tip for burner ignition by a pilot flame. Mounted adjacent to and below the opening of nipple 20 is an external pilot flame nozzle 23 supplied by the pilot line 24 with fuel gas from the main gas line 25. The shape of the burner conduit section 15, in tapering or expanding outwardly from the separator outlet permits and aids the injection of the burner flame into the exhaust gas stream, and prevents surges in the flow from extinguishing the burner flame.

The burner nozzle 21 and burner nipple 20 aligned therewith are disposed so that the flame F of the burner is directed obliquely across the center line of the stack and Venturi section and so that the flame attains the lower end of stack S. Preferably a baffle ring 26 is included in the burner assembly affixed to the interior circumference beyond the end of the expanding portion of conduit section 15. The dimensions and mutual disposition of the section 15, the baffle ring 26, flame injection shield nipple 20, burner nozzle 21 and normal operating flame size are best selected so that the ring will surround or embrace that portion of the normal burner flame which is of highest temperature range. Thus the exhaust stream delivered by the outlet of the blower type separator C encounters the burner flame before entering the lower end of the stack, thereby initiating burning of the combustible smoke, solids, and volatile constituents thereof. The provision of the baffle ring furthers the completeness of burning by inducing a local turbulence between the exhaust stream and the hot gases of the flame. A plurality of similar burners may of course be used in suitably spaced relation. Likewise liquid fuel burners may be used to provide a proper gas-air relation in the fuel stream delivered to the nozzle 21 and to maintain a proper flame disposition in the Venturi section, a gas-air mixing blower 28, such as a "Maxon" draws air from the air inlet 29 and gas from the line 25 through its gas inlet 30. Between gas supply line 25 and the blower inlet the fuel gas passes first through a pressure regulator 31 and a solenoid operated safety gas shut-off valve 32. The solenoid leads 33 are connected to the electrical lines providing power for the motor of blower 28 and the motor driven separating blower C. The solenoid valve is of the normally closed, spring urged type maintained in open position only when the solenoid thereof is energized. Hence, in the event of electrical power failure the valve 32 automatically closes in consequence of the deenergization of its solenoid thereby cutting off all fuel to the blower 28 and the burner nozzle 21. Also, as a safety measure, the pilot light fuel line 24 is connected to the line 25 on the main side of regulator R so that the pilot flame is maintained at all times. Associated with the fuel blower-mixer 28 is a ratio valve 35, through which air and gas are passed to the

blower inlet, and which is adapted to maintain a selected fixed ratio of air to gas mixed in the blower and to regulate the fuel delivery to nozzle 21. The ratio valve 35 is linked by a control shaft 37 or other means to a motor 38 whereby the ratio valve setting may be changed to give a new fuel ratio or delivery rate of air-gas mixture upon suitable actuation of the motor. The operation of the motor 38 is controlled by switch 39 in the lead connections thereof controlling the extent of and direction of rotation of the motor. A thermally responsive element 40 in the roaster controls the operation of switch 39 as indicated by the generalized control line 41, linking the element 40 and the motor operating switch 39. Since the precise form of the control of motor 38 is not the subject per se of this invention, the control system is not shown in the drawings in detail. However, the element 40 may include thermally actuated upper and lower limit switches electrically connected with switch 39 to cause a rotation of the motor in one or other direction as the roaster temperature reaches one or the other temperature limit for which it is set. Accordingly, as the motor 38 is actuated at either one of these temperatures, the ratio valve 37 will be changed from one to the other of two selected settings to control the flame F.

Although the burner nozzle 21 might be located within the burner duct 15, since no auxiliary air supply is required with the blower C in operation, the use of the nipple-burner nozzle described has certain important advantages. The burner may be readily observed so that any burner failure is immediately apparent. The arrangement also permits the use of the simple and safe external pilot, while the pilot flame opening between burner nozzle and nipple reduces the hazard of reverse flame propagation into the nozzle under certain operating conditions.

In a typical roaster installation about 1000 cubic feet per minute of smoke laden exhaust gases were produced by the roaster with heavy smoke beginning at a roaster temperature of about 250°. These gases were exhausted from the roaster by a blower C through a burner section expanding in about a 16 inch length from a 9 inch throat diameter to a diameter of 15 inches—the diameter of the exhaust duct or stack S—with a 15 inch baffle ring having a 12 inch opening secured in the outlet end of the burner section. Suitable operation was obtained by the use of a neutral flame with about 100 cubic feet per minute of natural gas-air mixture, 10% by volume in fuel gas, injected through a nipple with 3 inch opening and axis disposed at about 30° to the axis of the burner conduit. Due to the venturi action at the place where the flame was introduced, no difficulty was encountered in the maintenance of proper flame injection. The exhaust gas which left the roaster at about 250° F. was at about 200° F. upon reaching the burner. With the temperature increase in the roaster during the roasting cycle to 430° F. final temperature, which raised the exhaust stream entering the burner to about 400° F., the amounts of smoke, volatilized wax and oil increased in the exhaust gas. By operation of the thermostatic control, the ratio valve setting was changed during the increase of the roaster temperature at the point where heavy smoke evolved to increase the temperature of the burner flame F to handle the increased amount of combustible materials in the roaster exhaust for the remainder of the roaster cycle. With drop in the roaster oven temperature during emptying and refilling with a new batch, the thermostat control reset the control valve to produce a lower temperature flame for the beginning of the next roaster cycle. Thus the gas consumption was reduced for that portion of the cycle when less smoke and other combustibles would be evolved.

I claim:

1. An apparatus for the removal of combustible constituents in an exhaust gas stream being vented from a coffee roaster oven through an exhaust duct to the atmos-

phere, comprising in combination chaff separating means and a burner duct assembly through which successively said exhaust stream is passed to said exhaust duct; said separating means having an inlet for the oven exhaust stream, a separated chaff outlet, and an exhaust stream outlet; said burner duct assembly including a conduit with an inlet end connected to the exhaust stream outlet of said separating means and an outlet end connected to said exhaust duct, said conduit having a portion expanding from a narrowed throat cross-section toward said outlet end, a nipple opening through said expanding portion interiorly to said conduit, said nipple being directed obliquely inward toward said outlet end, and a burner nozzle mounted to said conduit in alignment with said nipple for injecting a flame into said conduit.

2. A method for removal of combustible constituents from the exhaust gas stream of a coffee roaster oven comprising the steps of centrifugally separating entrained solid particles from the exhaust gas stream, thereafter burning combustibles in the gas stream by subjecting the exhaust gas stream while in flow through a discharge conduit to the action of flame injected into the conduit and controlling the flame action in relation to the prevailing temperature of the oven thereby to increase the burner flame upon increased content of combustibles in the exhaust stream attending increased oven temperature.

3. A burner apparatus for removing combustible constituents from the exhaust gas stream of a coffee roaster oven adapted to incorporation in an exhaust duct from the oven to the atmosphere, comprising a conduit section having a portion expanding in cross-section for insertion in said duct with the largest cross-section extending in the discharge direction of the conduit, a nipple on the wall of said conduit section with one end opening thereto, the axis of said nipple being directed obliquely inwardly toward the direction of expanding cross-section, a burner nozzle mounted to said conduit section adjacent to and in substantial alignment with said nipple for injecting flame into said conduit section, and a pilot flame burner nozzle mounted exteriorly to said conduit section adjacent to the outer end of said nipple.

4. A burner apparatus for removing combustible constituents from the exhaust gas stream of a coffee roaster oven adapted to incorporation in an exhaust duct from the oven to the atmosphere, comprising a conduit section having a portion expanding in cross-section for insertion in said duct with the largest cross-section extending in the discharge direction of the conduit, burner nozzle means for producing a flame in said conduit section, the axis of said nozzle being directed obliquely inwardly toward the direction of expanding cross-section, means supplying fuel to said nozzle means, and means controlling the fuel delivery in response to the temperature of said oven.

5. The method of removing combustible constituents from the exhaust vapors of a coffee roaster oven, comprising the steps of separating entrained solid particles from the exhaust vapors immediately upon escape of the vapors from the roaster oven while simultaneously imparting movement to the vapors through a roaster exhaust conduit, expanding the vapors while flowing through the conduit and subjecting the expanded vapors to the action of a flame injected into the expanded vapors for burning combustibles therein while maintaining a continuous flow thereof and controlling the flame intensity on the expanded vapors in relation to the temperature prevailing within the roaster oven thereby to increase the burner flame upon increased content of combustibles in the exhaust stream attending increased oven temperature.

6. A burner apparatus for removing combustible constituents from the exhaust gas stream in an exhaust duct leading from a coffee roaster oven to the atmosphere, comprising a conduit section having an inlet adapted for communication with said duct and an outlet, said section having a portion expanding in cross-section from inlet to

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outlet thereof, a nipple on the wall of said section between said inlet and said outlet, said nipple being inclined to the axis of said section and extending toward the outlet of said section, and a burner nozzle positioned adjacent said nipple and substantially aligned with said nipple for injecting flame into said conduit section.

7. A burner apparatus for removing combustible constituents from the exhaust gas stream in an exhaust duct leading from a coffee roaster oven to the atmosphere, comprising a conduit section having an inlet adapted for communication with said duct and an outlet, said section having a portion expanding in cross-section from inlet to outlet thereof, a baffle ring circumferentially received in said section adjacent the outlet of said section, a nipple on the wall of said portion between said inlet and said outlet, said nipple having one end opening into said portion, the axis of said nipple being inclined to the axis of said section and extending through said baffle ring toward the outlet of said section, and a burner nozzle positioned adjacent said nipple and substantially aligned with said nipple for injecting flame into said conduit section toward said baffle ring.

8. A burner apparatus for removing combustible constituents from the exhaust gas stream from a coffee roaster oven including in combination, a coffee roaster having an exhaust gas outlet conduit, a generally vertically disposed

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conduit section communicating with said exhaust conduit, said conduit section having an inlet for receiving exhaust gases from the exhaust conduit and an outlet for exhausting gases to the atmosphere, said section having a portion expanding in cross-section from the inlet thereof to the outlet thereof, and means for injecting a flame into the interior of said portion along an axis extending generally toward the outlet of said section.

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