United States Patent [19]

Cash

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[54] **ENTRAINMENT NOZZLE**

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[52] **U.S. Cl.** **239/562;** 239/289; 239/568; 55/264; 55/440; 55/DIG. 41; 98/58; 98/78

[51] **Int. Cl.²** **B05B 1/26;** B05B 1/32; B05B 7/00

[58] **Field of Search** ..... 181/46, 56, 60, 64, 51, 181/36 C, 64 A, 33 HD, 72, 33 HB; 239/428.5, 548, 562, 568, 289; 98/59, 58, 78, 79; 55/264, DIG. 41, 266, 440, 464

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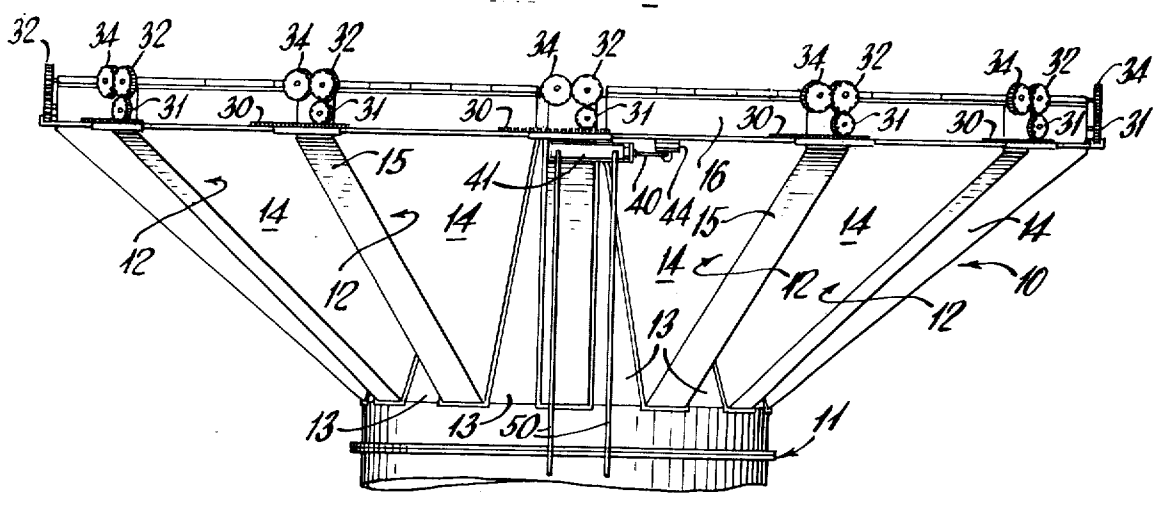
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Attorney, Agent, or Firm—Brooks Haidt Haffner & Delahunty

[57] **ABSTRACT**

A nozzle having a plurality of radially extending and upwardly diverging fingers provides narrow slots that divide a flow of hot gases and vapors into long, thin streams to increase the entrainment ratio of ambient air to hot gases in arrangements for eliminating visible air pollution by vapor condensation.

6 Claims, 9 Drawing Figures



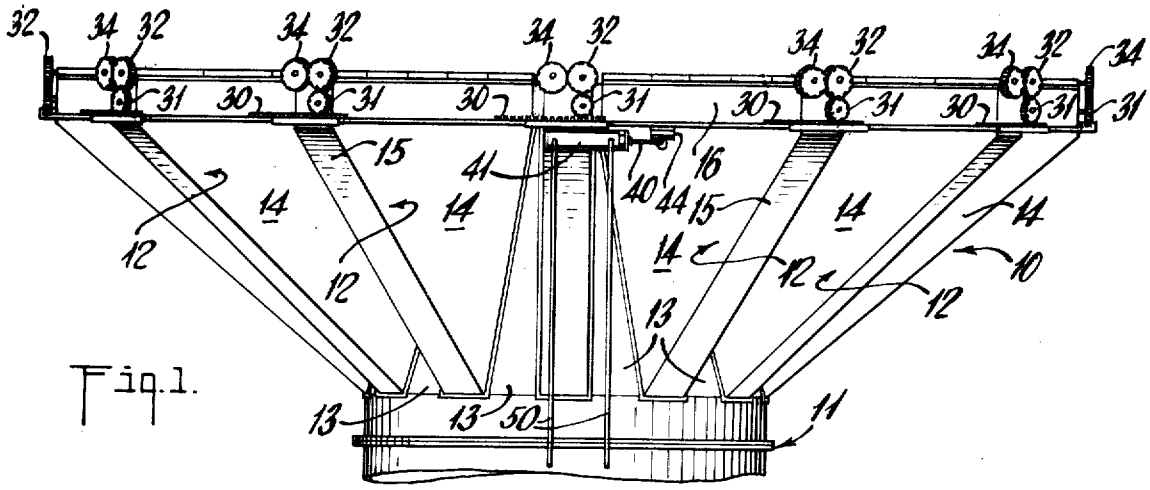


Fig. 1.

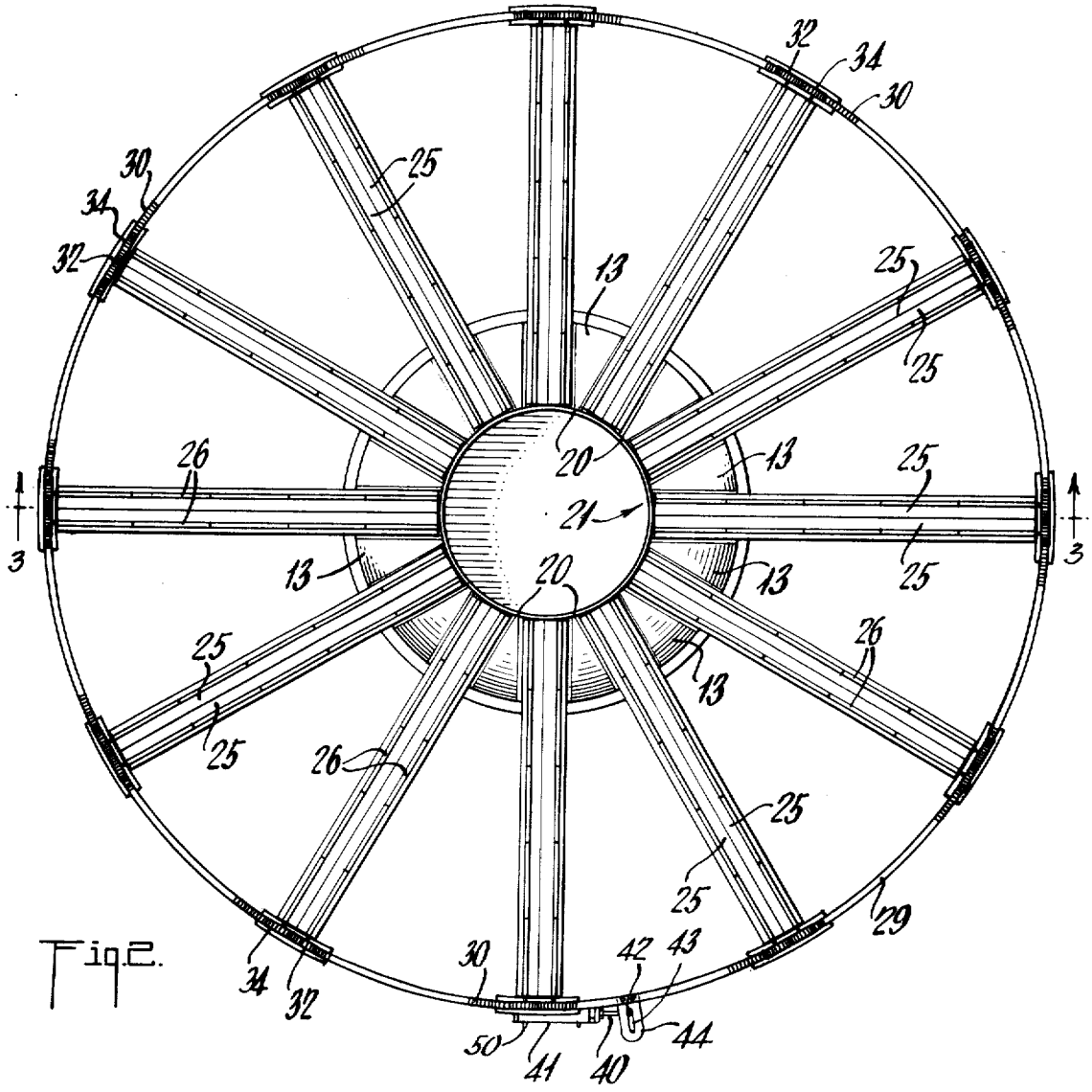


Fig. 2.

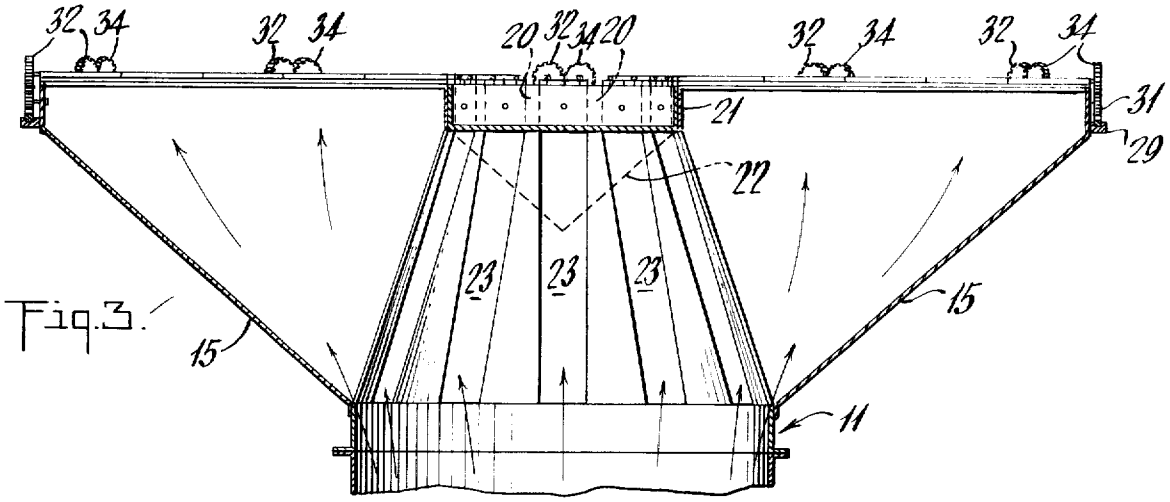


Fig.3.

Fig.4.

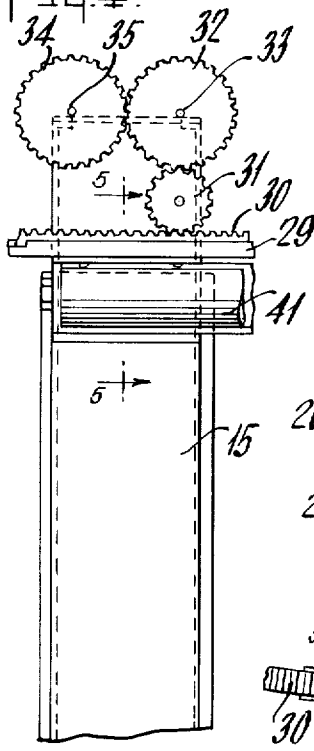


Fig.6.

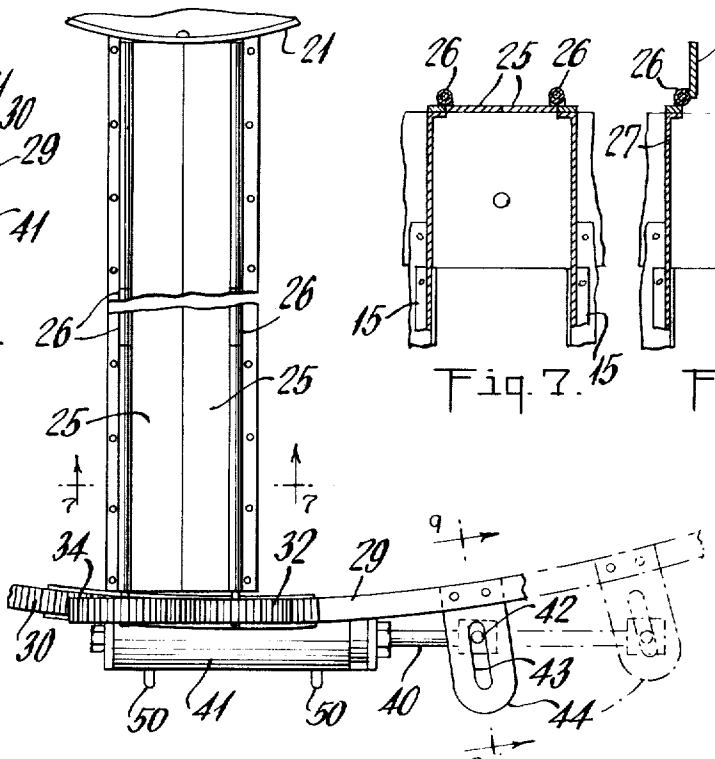


Fig.7.

Fig.8.

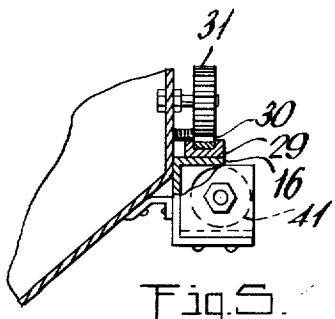


Fig.5.

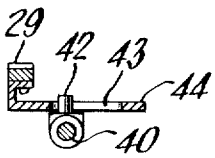


Fig.9.

ENTRAINMENT NOZZLE

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to elimination of visible air pollution by condensing vapors and thereby reducing the opacity of emissions from industrial and commercial processes. More particularly the invention relates to a nozzle for breaking a gaseous stream into long narrow walls to increase the entrainment of ambient air by the hot gases.

2. Description of the Prior Art

Various industrial and commercial processes emit effluents containing water vapor which, upon discharge into the atmosphere condenses to produce an opaque plume.

My prior U.S. Pat. No. 3,719,032, granted Mar. 6, 1973, describes an induction condenser comprising a plurality of registering low pressure venturis for minimizing such plumes by condensation of vapor through the mixing of induced cooler air with exhaust gases. The induction condensers described in my prior patent can be mounted directly above an outlet for exhaust gases with good results.

However, it has been found that the performance of vapor condensers can be improved by increasing the velocity of the gas stream entering the condensers. The present invention effects an improvement in the performance of the condensers disclosed in my said prior U.S. Pat. No. 3,719,032, and the disclosure of that prior patent is incorporated herein in its entirety by reference.

SUMMARY OF THE INVENTION

In accordance with the principles of my prior U.S. Pat. No. 3,719,032 the moisture content of gases discharged to the atmosphere can be reduced substantially by passing the gases through a low pressure venturi system. It has now been found that by the use of a nozzle arrangement to direct and channel the gas stream into such a venturi arrangement, the efficiency of the condensation process can be considerably increased, permitting the use of smaller venturi systems and reducing the overall height of the installation.

A hot gas and vapor stream leaving an outlet from an industrial or commercial process such as combustion, evaporation, drying or gas scrubbing contains water vapor. Such effluent gas streams have generally been expelled through stacks, but the present invention is applicable whether or not a stack is used.

The nozzle of the present invention divides the ordinary cylindrical stream of gases and vapor into a number of long thin walls of flow. This is accomplished by deflection of the stream into radially extending fingers providing internal channels for upward flow. Preferably these thin walls of flow are fed into a condenser venturi as described in my aforementioned prior patent.

The flow of gases and vapour through the fingers of the nozzle is effectively controlled by vanes which can be selectively opened and closed for operation with varying rates of flow to be handled, thereby keeping the nozzle operation at the optimum design velocity for gas flow through the nozzle fingers.

The entrainment nozzle of the invention has a base for mounting on a stack or other discharge outlet for hot gases. Typically, for a cylindrical stack, this base is circular in plan. Mounted on the base, and extending upwardly and inwardly are a plurality of upwardly narrowing structural members defining elongated spaces therebetween through which hot gases can flow to the radially extending fingers of the nozzle. These fingers are formed by pairs of opposed generally triangular panels enclosing wedge-shaped spaces through which the hot gases flow as narrow walls of gas to exit through horizontal, radially extending slots at the top of the nozzle as rapidly ascending narrow walls of hot gas. The cartwheel-like arrangement is structurally sturdy and also permits automatic or manual control of the thickness of the ascending hot gas walls.

The regulation of the thickness of the hot gas walls is accomplished very effectively by movable vanes located at the upper slots of the fingers to open and close the slots. Preferably these vanes are mechanically interconnected for coordinated opening of all slots to the same extent.

By opening and closing the slot vanes variations in the rate of flow of hot gases into the nozzle are readily accommodated.

The entrainment capacity, that is, the amount of ambient lower temperature air that is drawn in and mixed with the hot gases in a condenser after the gases leave the nozzle, is a function of the velocity of the gases. The thin walls of gas, or course, contact a much larger amount of ambient air than would a single rising column of gas moving at lower velocity.

The extent to which the vanes are opened can be effectively controlled either manually or automatically to maintain the most efficient gas velocity and hence, the optimum entrainment ratio of ambient air to hot gases.

Automatic control can be made responsive to a pressure sensor located below the nozzle to widen the openings of the vanes when pressure increases and close the vanes to a suitable extent when even a minor pressure drop occurs.

As indicated the outflowing narrow walls of hot gases can be very effectively fed into a vapor condenser as disclosed in my prior U.S. Pat. No. 3,719,032; but some modification of that condenser or even a condenser of a different type could be employed with advantage with the entrainment nozzle of the present invention.

The construction and operation of the invention, as well as other features and advantages of the invention, will be more fully understood from the following detailed description of a preferred embodiment, especially when that description is read with attention to the accompanying drawing.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is an overall view in perspective of the nozzle of the invention.

FIG. 2 is a top plan view of the nozzle of FIG. 1.

FIG. 3 is a view in section of the nozzle of the invention, taken along line 3—3 of FIG. 2 and looking in the direction of the arrows.

FIG. 4 is a detail view of an arrangement for opening and closing slot vanes in accordance with the invention.

FIG. 5 is a detail view in section taken along line 5—5 of FIG. 4 and looking in the direction of the arrows with parts cut away to show hidden parts otherwise indicated by dashed lines.

FIG. 6 is a detail view from above of a slot vane arrangement and an actuating device with the open position of the device indicated by shadow lines.

FIG. 7 is a view in section taken along line 7—7 of FIG. 6 and looking in the direction of the arrows.

FIG. 8 is a view similar to that of FIG. 7 with the vanes fully open.

FIG. 9 is a detail view in section taken along the line 9—9 of FIG. 6 and looking in the direction of the arrows.

DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT

Reference is first made to FIG. 1 of the drawing showing the entrainment nozzle of the invention generally indicated by the reference numeral 10 in perspective from one side. The nozzle 10 is shown to have a base portion 11 adapted for mounting at an opening for the discharge of hot, steam or water vapor containing gases. Any suitable manner of sturdy attachment to an existing or adapted opening can be employed.

Above the cylindrical base 11 the nozzle 10 is seen to have a plurality of equally arcuately spaced, radially extending wedge-like fingers 12. The fingers 12 extend upwardly and outwardly and are mutuallly separated by panels 13 which have an upwardly narrowing configuration from their points of attachment to the base 11. The panels 13 are slanted upwardly and inwardly.

Each of the fingers 12 has a pair of opposedly positioned, generally triangular, flat walls 14 joined at their lower edges by a generally rectangular bottom member 15 to form enclosed channels for the flow of hot gases.

A strong structural member, generally designated 16, extends in a circle around the widened upper perimeter of the nozzle, and is secured to the fingers 12 to support the fingers. This arrangement will be duscussed in detail hereinafter in connection with FIGS. 4–6.

FIGS. 2 and 3 illustrate the manner in which the gases discharged into the nozzle 10 are directed into and through the fingers 12 to form rapidly ascending narrow walls of flowing gas for effective vapor condensation above the nozzle. As shown in FIGS. 2 and 3, the panels 13 slant upwardly and inwardly from their points of connection to the base 11 to their narrow apex portions 20 which preferably are vertical and are joined to a structural ring 21 interconnecting the portions 20 of the several panels 13, which can be welded or otherwise attached to the ring 21. Mounted on the ring 21 and extending downwardly therefrom is a coaxially oriented diverter cone 22, shown in dashed lines in FIG. 3.

The arrows of FIG. 3 show the paths taken by the hot gases through the nozzle 10 and its fingers 12. As the gases enter through the base 11 they tend, because of the upwardly narrowing arrangement of panels 13, to pass through spaces 23 between adjacent panels 13 into the spaces enclosed between the sides 14 of the fingers 12. The diverter cone 22 aids in directing the flow of gases outwardly into the fingers 12 so that all of the flowing gases pass into the fingers 12.

It will be understood that the fluid dynamics of the streaming hot gases causes the gases to pass upwardly through the internal spaces provided within the fingers, so that if the fingers 12 are open at their tops the gas will emerge from the nozzle as a plurality of narrow walls of hot gases ascending in a spoke-like pattern.

As shown in FIG. 2 a pair of horizontally extending vanes 25 are provided at the upper end of each finger 12 for regulating the width of a slot between the vanes 25 through which the hot gases can pass as narrow walls. By regulation of the widths of the rectangular slots open between the pairs of vanes 25 a wide variation in discharge flow rates can be accomodated. These vanes 25 and their operation can be best understood from the detailed views of FIGS. 4–9.

As shown in FIGS. 7 and 8, the vanes 25 are preferably hingedly mounted for opening and closing movement with respect to the upper ends of the fingers 12 by means of piano hinges 26 securing the vanes 25 to the upper edges 27 of the side walls 15 of the fingers 12. FIG. 7 shows the vanes 25 in a completely closed position and FIG. 8 shows the fully open location of the vanes 25.

For actuation of the vanes 25 to an appropriate position, the arrangement of gears and a track shown in FIGS. 4–6 is highly effective. At the area of the outer end of each finger 12, an arcuate toothed rack 30 is provided on a rotatable ring 29 for arcuate movement with respect to the structural upper ring 16. A pinion gear 31 engaging the teeth of the track section 30 is mounted to also engage the teeth of a larger gear 32. The gear 32 is fixed to an axially extending rod 33 upon which a vane 25 is also fixedly secured. Accordingly, when the gear 31 rotates, the gear 32, by its rotation, turns the axial rod 33 and thereby moves the attached vane 25. By mounting the adjacent vane 25 on a gear 34 engaging the gear 32, an axial rod 35 fixed to the gear 34 can be caused to rotate in the opposite sense for movement of the other vane 25 of the pair of vanes.

The vanes 25 of all of the fingers 12 can be opened or closed simultaneously by means of the arrangement illustrated in FIGS. 4–6 and 9, wherein a piston 40 is shown mounted for reciprocating motion in a cylinder to drive the rack sections 30 with their circular supporting ring 29 through a rotational displacement around the ring 16 sufficient to open the vanes to the appropriate orientation. The piston 40 has an upstanding pin 42 at its free end and the pin rides in a slot of a radially extending member 44 bolted or otherwise secured to the rotatable ring 29. In the position shown in solid lines in FIG. 6, the vanes 25 are completely closed, but when the piston 40 is projected to its extended position, shown in shadow lines, the toothed rack sections 30 will have been moved some degrees around the nozzle, causing the gears 31, 32 and 34 to move the vanes on their axes 33 and 35 to an open position as shown in FIG. 8.

FIG. 1 shows the cylinder 41 with downwardly extending lines 50, which can suitably be hydraulic lines extending to a motor and control of known type for actuation of the piston 40 by remote control.

Alternatively, the nozzle could be manually controlled by suitable crank means or the like.

In the embodiment of the invention illustrated, there are 12 fingers 12 extending outwardly at 30° spacings. This illustrative example can be considered typical of the application of the nozzle according to the invention when high volume rates of discharge of hot gases are to be entrained and subsequently condensed.

As a more specific example, the arrangement of a 12-fingered nozzle 10 illustrated can advantageously have the following dimensions in a typical application. The base 11 could have a diameter of 54 inches, and each finger 12 could be 54 inches wide from the ring 21 to the ring 16. The bottom panels 15 of the several fingers 12 can be on an angle of 45° with the horizontal and the whole nozzle will then be about 4 feet in height. Suit-

ably, the walls **14** of the fingers **12** can be spaced 6 inches apart, and taking into account the hinges **26**, the fully opened position of the vanes shown in FIG. **8** would provide a rectangular slot for the exit of hot gases 54 inches long by 4 inches wide. The diameter of the ring **21** would then be about 30 inches.

The foregoing example, and the embodiment shown in the drawing, are intended only as illustrative. In a smaller scale application, there can be fewer of the equally arcuately spaced fingers **12**, since the volume of gases to be handled would be much smaller. Eight fingers, or six, or four, could be adequate, depending on the application. In other respects an arrangement with fewer fingers **12** would be similar to the embodiment described.

In some applications, a fan might be employed to force gases upward through the nozzle, but in most installations, a fan will not be needed or desirable.

The main structural members of the nozzle **10** can suitably be of metal such as steel or of fiber glass, but in installations where corrosive gases are present, stainless steel is the material of choice.

Various modifications, substitutions of material, and diverse applications of the nozzle of the invention will suggest themselves to those acquainted with the art. Such changes are considered to be within the spirit and scope of the invention.

what is claimed is:

1. An entrainment nozzle for breaking up a column of hot gases into a plurality of ascending narrow walls of gases comprising means for dividing said column of gases into separate streams and diverting each of said streams to and through a corresponding one of a plurality of horizontal slots extending radially from the original direction of flow of said column, a pair of opposed vanes mounted for pivotal movement between a horizontal closed position and a vertical open position for regulating the widths of said slots to accomodate varying rates of gas flow, each said vane being pivotally mounted on an axial rod, which rod is connected to rack and pinion means for actuation of the vane between a horizontal and a vertical orientation upon movement of the rack with respect to the pinion.

2. The nozzle of claim **1** wherein said slots are defined by a plurality of arcuately spaced radially extending fingers having internal spaces and top openings.

3. The nozzle of claim **2** wherein the fingers are equally arcuately spaced and wherein a cylindrical base upon which said fingers are mounted serves to admit hot gases to the nozzle.

4. The nozzle of claim **2** wherein said diverting means includes inwardly and upwardly extending panels arranged between adjacent ones of said fingers and a conical member with its apex pointing downwardly with respect to said gas stream to divert the gases into the internal spaces of said fingers.

5. The nozzle of claim **2** wherein each of said fingers has a pair of parallel, opposed generally triangular side walls defining a wedge-shaped space therebetween.

6. The nozzle of claim **1** wherein there are at least three of said slots, and said slots are equally arcuately spaced.

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