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GAS CLEANING METHOD

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Fig. 1.

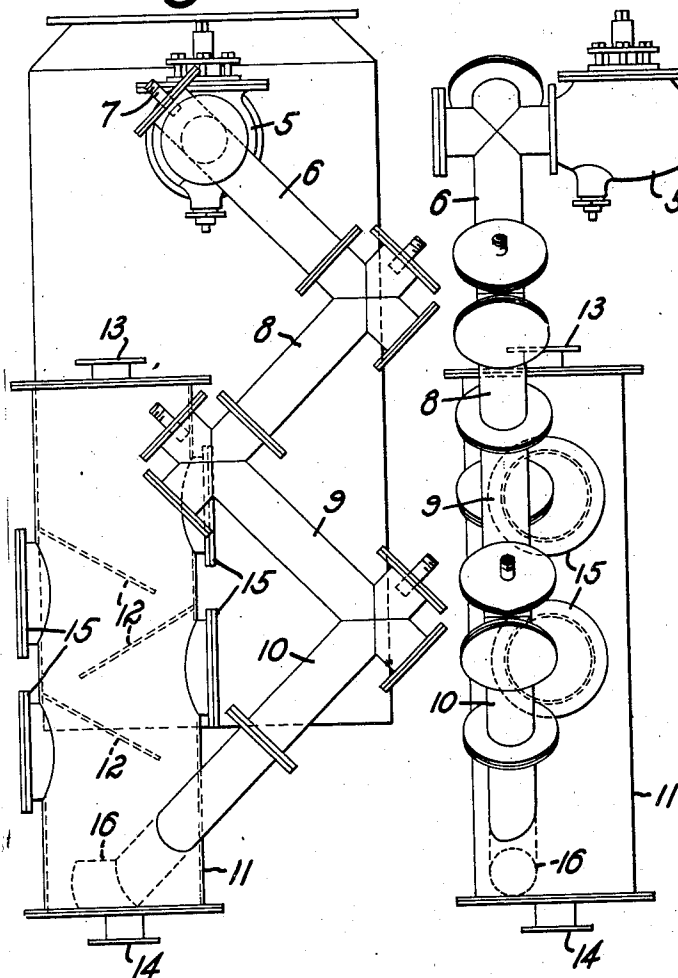


Fig. 2.

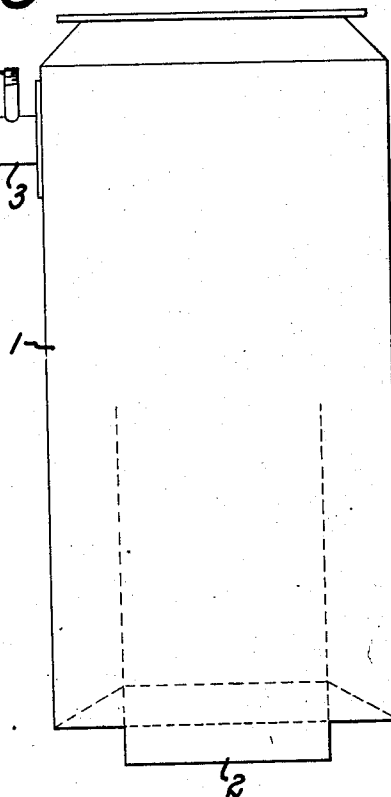
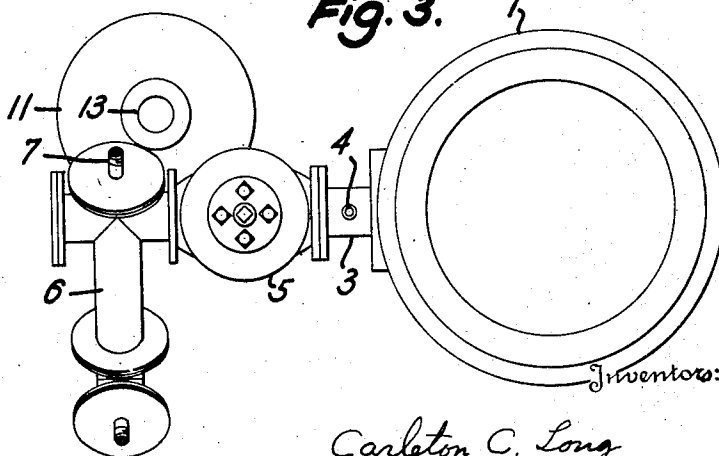


Fig. 3.



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GAS CLEANING METHOD

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6 Claims. (Cl. 75-88)

This invention relates to an improved method for removing dust from gas by first conditioning the gas with steam and then passing the gas through a system of tubes and water sprays so arranged as to condense the steam and create a large degree of turbulence in the gas stream, and finally separating the water from the cleaned gas.

The invention is particularly applicable to the removal of zinc dust or "blue powder" from the carbon monoxide gas produced as a by-product in the reduction by carbon of zinc oxide materials.

The removal of zinc fume or blue powder from the gases poses a particularly difficult problem well known to those versed in the art of continuous zinc smelting processes. In such a process zinc oxide materials, more or less intimately admixed with coke or other carbonaceous matter, are heated to a temperature sufficiently high to promote the ready reduction of zinc oxide to zinc metal vapor. Concomitantly formed is carbon monoxide gas from the carbon entering into the reaction. The zinc vapor and carbon monoxide are led away from the hot charge to a suitable condenser where a portion of the zinc vapor is condensed to liquid zinc metal. The condenser may be of the surface type wherein contact of the zinc vapor with a relatively cool surface brings about condensation of the zinc, or, the condenser may be of the internal type wherein contact of the zinc vapor with a mass of molten metal effectively condenses the zinc vapor to zinc metal. In either type, a certain portion of zinc vapor remains uncondensed, the minimum amount being a function of the temperature of the exit part of the condenser.

The higher the condenser temperature, the greater will be the portion of non-condensed zinc vapor. For example, with an entrance gas composition by volume of 45% zinc vapor and 55% carbon monoxide and other diatomic gases, this being representative of actual experience, a condenser temperature of 500° C. under an absolute pressure of 383 mm. Hg will permit a loss, as non-condensed zinc vapor, of about 0.75% of the zinc vapor entering the condenser. At the condenser temperature of 550° C. the minimum amount of zinc remaining uncondensed is 1.83% of the total zinc entering the condenser, while at 600° C. the loss is 6.38% of the total zinc.

Inasmuch as the zinc condenser temperatures are frequently of the order of 550-600° C.,

the amount of zinc vapor accompanying the condenser exit gases, while not great in comparison with the amount of molten metal recovered from the condenser, is of appreciable magnitude with reference to future handling and utilization of the condenser gas. In order that this gas be handled by vacuum pumps, for example, it must be substantially dirt-free.

The first step in cleaning the condenser exit gases is an abrupt cooling from temperatures approximating those in the condenser to a temperature not far removed from normal atmospheric or room temperature. In practice, this is accomplished effectively by passing the gas through a curtain of water sprays, followed by bubbling through water. Shock chilling of this type condenses all the zinc vapor to very fine zinc dust, or "blue powder" as it is frequently termed. A large portion of the blue powder is trapped by the water and washed away with it, from which it may be recovered by settling ponds or other suitable apparatus. A portion of the finest powder, however, escapes entrapment with the water and passes on with the gas stream.

In actual practice, observations extending over a period of years have shown that from 90 to 95 per cent of the zinc vapor accompanying the condenser exit gases is trapped or collected by passage through the aforementioned gas washer. In practical terms, this means that with a condenser handling 16 tons of zinc per day and operating at 570° C. at 332 mm. Hg absolute pressure, the amount of zinc vapor accompanying the condenser exit gases is 1280 pounds per day. If 93% (or 1190 pounds) of this zinc is removed by the washer, some 90 pounds of zinc per day passes on with the condenser gas. The volume of gas to be handled by the gas-cleaning apparatus is, at the temperature and pressure (vacuum) conditions obtaining in the apparatus, of the order of 500 cubic feet per minute. On this basis the dust load is 0.875 grain per cubic foot (2000 milligrams per cubic meter). At the pumping station after the gas has been returned to atmospheric pressure, the flow rate is about 200 cubic feet per minute, with a corresponding dust loading of 2.19 grains per cubic foot (5000 milligrams per cubic meter). This is entirely too large an amount of dirt to be handled by the pumping equipment and lines; in matter of fact, pipe line and pump valve obstructions have occurred even with dust loads less than a tenth of the above. Thorough and complete gas

cleaning is necessary before condenser gases can be handled in a practical and commercial manner.

The removal of zinc fume or blue powder from carbon monoxide gas presents problems not ordinarily encountered in gas-cleaning practice. Among the special difficulties posed are extreme fineness of particle size; hydrophobic nature of zinc metal particles; ready inflammability and explosive properties of zinc dust when exposed to moisture and air; inflammability and explosive properties of carbon monoxide when mixed with more than a small amount (4-5%) of oxygen; and tendency of any precipitated material to adhere tenaciously to surfaces in such a manner as to lead to rapid obstruction of the cleaning apparatus.

With the present invention, cleaning efficiencies of the order of 99% are obtained, and, moreover, this cleaning is obtained using a minimum amount of water. Inasmuch as the water used in dust removal devices often is passed to settling ponds, thickeners, or other separation devices wherein the solids may be recovered and the water recirculated, it is desirable to keep the amount of water used at a minimum so that not too great an investment will have to be made in settling basins or equivalent separating and recovery devices.

Furthermore, this invention permits a continuous gas-cleaning operation in contradistinction to older methods wherein certain cyclic operations are inherent due to necessity for bag shaking, filter cleaning, or the like. Finally, the practice of the present invention does not require as large a capital investment in cleaning equipment as formerly employed methods.

Typically the apparatus of the present invention includes a conduit comprising a series of tubes having one or more abrupt changes in direction. Gas to be cleaned is passed through the conduit. Steam or other suitable vapor is admitted to the gas stream at a convenient point in the conduit, preferably near the inlet end thereof. The gas then passes into the first eductor or tube of the series. A fine spray of water or other suitable liquid is introduced at the head or inlet end of the eductor. The tail of the eductor terminates in the side opening of the following eductor, the head of which likewise contains means for introducing fluid in spray form. In this manner as many eductors as necessary may be united to provide a gas conduit in which the gas stream is subjected to high velocity and vigorous turbulence by the liquid sprays and condensing vapor. The tail of the final eductor leads to a gas disengagement chamber where means are provided to separate the liquid from the gas, preferably by decreasing the linear gas velocity to a low value by making the chamber of relatively large cross-section. Suitably located baffles also assist in precipitating by impingement mechanically entrained liquid. The separated liquid flows either to waste, if the liquid or solids are not of value, or to settling ponds, thickeners, or other suitable separating devices if the liquid or solids or both have value sufficient to warrant their recovery. The clean gas, for example, carbon monoxide, is compressed and made available for such purposes as may be required.

The method of precipitating suspended particles from a stream of gas bearing the same in accordance with the principles of this invention includes introducing a condensible vapor, such as steam, into the gas stream, injecting a jet of

liquid, for example, water, into the gas stream to condense the vapor, to precipitate substantially all the suspended particles and to accelerate the flow of the gas stream, and separating the liquid from the gas, for example, by substantially reducing the velocity of the gas stream or by causing it to impinge upon a surface, or by combined action of the two.

A still further object of this invention is to provide a process for cleaning gases bearing extremely finely divided solid material.

The objects and advantages of the present invention will be apparent from the following description taken in connection with the accompanying drawing in which:

Fig. 1 is a front elevation of one form of apparatus embodying the principles of the invention;

Fig. 2 is a side elevation thereof; and

Fig. 3 is a plan view of the same.

A preliminary gas washer is indicated at 1. This gas washer is of conventional design known in the art. It preferably is a shock precipitator in which the gas from the zinc condensers is subjected to a shower of cold water and subsequently bubbled through water for the purpose of precipitating the major portion of its burden of solid material. The preliminary gas washer has an inlet 2 and an outlet 3 for drawing off the partially cleaned gas. The outlet 3 also comprises an inlet for the secondary stage of the cleaning device. In this inlet, steam is injected through pipe 4 and mingled with the gas. The valve 5 is provided to regulate the flow of gas through the apparatus. From this valve the gas passes to an eductor 6 which aids in circulating the gas through the system. A jet of water is injected into the eductor through pipe 7 for actuating the same. The purpose of this jet is not only to aid in increasing the turbulence of flow of the gas, but also to assist in condensing the steam which has been injected into the gas stream. Condensation of the steam and intimate mixture of the gas with the water jet serves to precipitate the finely divided solid material from the gas stream.

It has been found that, in general, a single eductor is not sufficient to completely precipitate all of the solid burden from the gas. Accordingly, in the apparatus shown, four eductors have been provided, each one actuated by a jet of water and each drawing on the preceding eductor. A larger or smaller number of eductors may be used in series as required. In the drawing, eductor 8 is arranged at right angles to eductor 6 and eductor 9 is positioned at right angles to eductor 8 to form a zig-zag conduit. Water jets are placed at each bend of the conduit. It has been found that four eductors in series, as illustrated, are sufficient for most purposes.

From the last eductor 10, the gas is forced into a chamber 11 for the removal of substantially all the water. The chamber is provided with suitable baffles 12, and is considerably larger in cross-section than the eductors so that the gas velocity is substantially reduced therein. The stream of gas is diverted by the baffles so that the condensed water vapor is largely removed by setting and impingement. The cleaned gas issues from the chamber 11 through pipe 13 and may be used or discarded as desired.

An outlet 14 is situated in the bottom of the chamber for the removal of water bearing precipitated particles. This slurry preferably is passed to settling basins where the solids are re-

moved. The water may be recirculated through the apparatus.

Clean-out holes 15 are provided in the side of the chamber to give ready access to the interior thereof for cleaning purposes. In actual practice experience shows that the baffles are substantially self-cleaning, and the clean-out doors are opened only on unusual and rare occasions.

Preferably the zig-zag arrangement of eductors is positioned so that the water jets are directed generally downwardly to allow the conduit to drain readily. However, it is not essential to so position the eductors, and any other, suitable arrangement may be used.

Conduit 16, which carries the gas from the final eductor to the chamber 11, preferably extends through the wall of the chamber as shown and is offset to the axis of the chamber to impart a rotary movement to the gas in the chamber. This rotary movement results in considerable turbulence in the body of gas in the chamber and increases the efficiency thereof, due to the greater opportunity for impingement of drops of water against interior surfaces.

Although the conduits shown are of uniform cross-section, an alternative construction may be desirable in some situations. In this construction the eductors are fashioned in the form of Venturi tubes. By this construction better utilization of the velocity head of the water stream in assisting the gas flow may be realized. However, this type of construction is somewhat more expensive than simple pipes, hence the latter are preferred for those situations where the gas is drawn through the apparatus by large capacity vacuum pumps, as in the zinc furnace example cited above. For low vacuum or pressure applications, the Venturi shape eductor may in some situations be more economical.

In operation, gas, for example, from zinc condensers enters the preliminary gas washer at 2 where it is relieved of a large portion of its blue powder. The partially cleaned gas then passes through pipe 3 where steam is injected into it. Thereafter it is drawn through the series of eductors where substantially all the residual blue powder is removed. From the eductors, the gas and liquid pass to the baffle chamber 11 for the separation of the liquid and gas. The cleaned gas issues through pipe 13, while the liquid containing the removed solids is drained off through pipe 14.

The gas-cleaning efficiency of the device for very fine dusts is remarkable. With 0.22 micron diameter zinc dust gas clearances of over 99% have been obtained in practice even when treating gases the initial dust contents of which are already low.

The operation of the present invention is characterized by substantially complete removal of even the very fine dust. The exact reason for the unusually superior performance of this gas-cleaning device is not exactly understood. Without wishing to limit ourselves to this theory, it is supposed that the dust particles serve as condensation nuclei for the steam condensed by the water sprays. By this action the dust particle is trapped in a water droplet of much larger volume and mass than the dust particle itself. By virtue of the enhanced mass and volume, the particle and its surrounding droplet are easily washed down by the water sprays. While this mechanism undoubtedly occurs, it is not believed that it accounts entirely for the highly effective dust removal obtained. It is probable that the high

degree of turbulence and impingement action in combination with the water droplets and condensing steam, together with a possible flocculating action of the steam on the dust, are responsible for the efficacious removal of solid particles from the gas. It is also probable that a wall action is involved and that an advantageous feature of the invention is the high ratio of wall area to gas volume provided by the invention. It is believed, from experimental observations on eductors of different diameters, that the mean path or average distance that the particles must travel before contacting a surface (wall) is an important consideration in relation to dust removal efficiency. It has been found that decrease in gas velocity can be compensated for in part by decrease in diameter of the conduit or eductor. Variation of diameter of the eductor influences the dust removing ability more than variation in length of the eductor.

In practice, an assembly in series of four eductors of 4-inch pipe, 25 inches in length, has been found to effectively de-dust zinc condenser gas at a flow rate of 500 cubic feet per minute. The steam consumption is 0.2 pound per minute; the water consumption (4 sprays) is 6 gallons per minute. Devices of this type have replaced scrub towers consuming upward of 150 gallons of water per minute.

A remarkable feature of the performance of the cleaner is that high cleaning efficiencies are realized even though the gas is not heavily laden with dust. In other words, not only the relative cleaning, but the absolute cleaning as well is satisfactory. By the introduction of the invention described herein to commercial use in zinc production, significant savings, both directly in reduced operating and maintenance costs, and indirectly through accompanying improvements in uniformity and stabilization of operations, have been realized.

It is possible to operate the gas cleaner without introduction of a condensable vapor. Even without the use of steam, considerable cleaning is realized. But the use of a condensable vapor in conjunction with the liquid stream and associated apparatus results in a higher order of dust removal.

We claim:

1. A method for removing blue powder from zinc condenser gases which comprises passing a stream of the gas in contact with a liquid to cool the same and to precipitate a portion of the blue powder from the gas, introducing a condensable vapor into the gas stream, injecting a jet of liquid into the gas stream concurrently therewith to condense the vapor, to precipitate substantially all residual blue powder and to increase the turbulence of flow of the gas stream, and separating the liquid from the gas.

2. A method for removing blue powder from zinc condenser gases which comprises passing a stream of the gas in contact with a curtain of liquid to cool the same and to precipitate a portion of the blue powder from the gas, introducing a condensable vapor into the gas stream, injecting a jet of liquid into the gas stream concurrently therewith to condense the vapor, to precipitate substantially all residual blue powder and to increase the turbulence of flow of the gas stream, thereafter decreasing the velocity of the gas to a value sufficiently low to permit substantially all entrained liquid particles to settle from the gas, and separating the liquid from the gas.

3. A method for removing blue powder from

zinc condenser gases which comprises passing a stream of the gas in contact with a curtain of liquid to cool the same and to precipitate a portion of the blue powder from the gas, introducing a condensable vapor into the gas stream, injecting a jet of liquid into the gas stream concurrently therewith to condense the vapor, to precipitate substantially all residual blue powder and to increase the turbulence of flow of the gas stream, thereafter causing said stream of gas to impinge upon a surface to remove substantially all entrained moisture from the gas, and separating the liquid from the gas.

4. A method for removing blue powder from zinc condenser gases which comprises passing a stream of the gas in contact with a curtain of water to cool the same and to precipitate a portion of the blue powder from the gas, introducing steam into the gas stream, injecting a jet of water into the gas stream concurrently therewith to condense the steam, to precipitate substantially all residual blue powder and to increase the turbulence of flow of the gas stream, and separating the water from the gas.

5. A method for removing suspended particles from a gas which comprises passing a stream of the gas in contact with a liquid to cool the same and to precipitate a portion of the suspended particles from the gas, introducing a condensable vapor into the gas stream, injecting a jet of liquid into the gas stream concurrently therewith to condense the vapor, to precipitate substantially all residual suspended particles and to increase the turbulence of flow of the gas stream, and separating the liquid from the gas.

6. A method for removing suspended particles from a gas which comprises passing a stream of the gas in contact with a curtain of water to cool the same and to precipitate a portion of the suspended particles from the gas, introducing steam into the gas stream, injecting a jet of water into the gas stream concurrently therewith to condense the steam, to precipitate substantially all residual suspended particles and to increase the turbulence of flow of the gas stream, and separating the water from the gas.

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