Dec. 10, 1957 F. W. YOUNG 2,815,826

AIR FILTRATION

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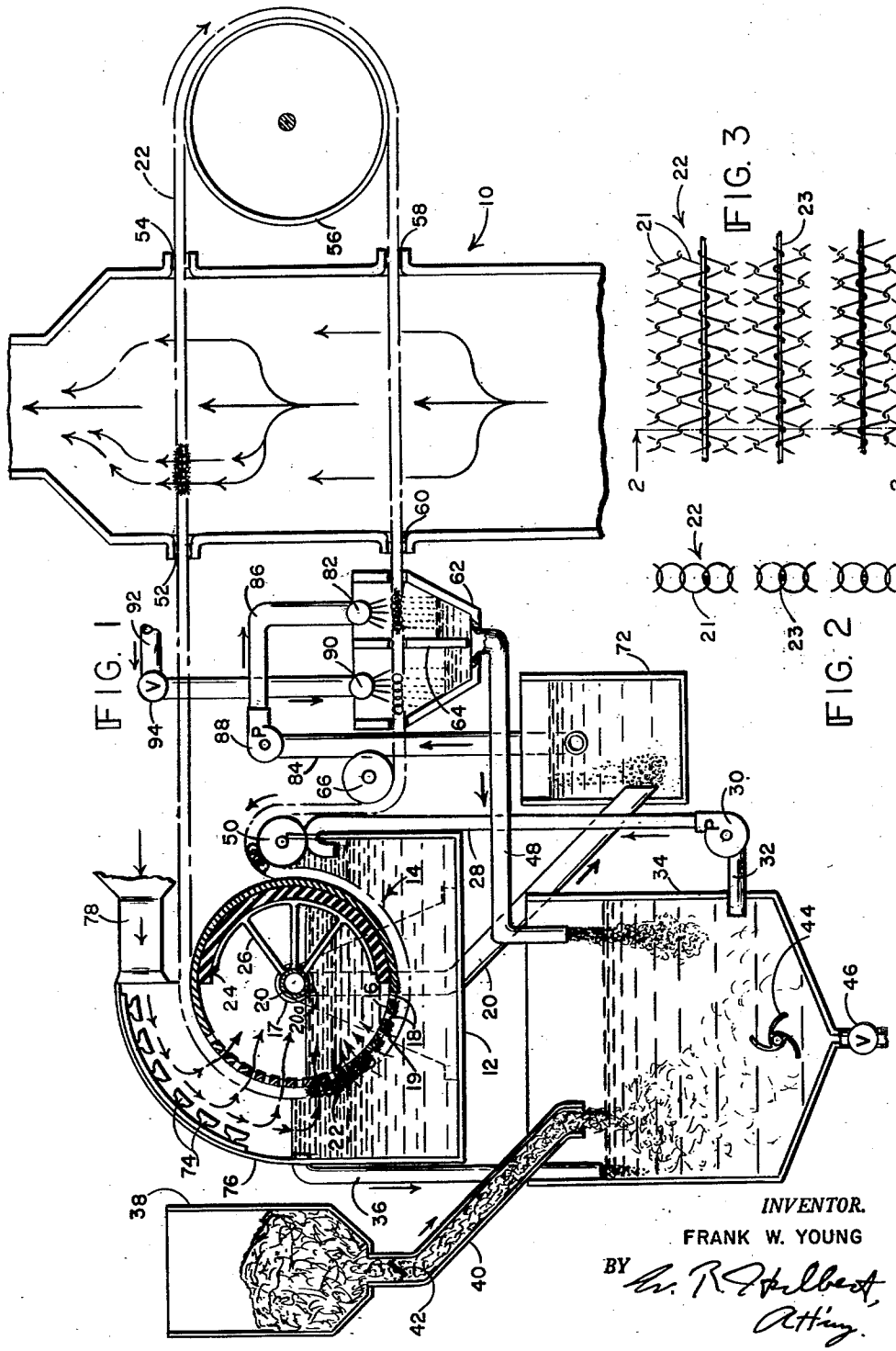


FIG. 1

FIG. 3

FIG. 2

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AIR FILTRATION

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This invention relates to cleaning of gases and more particularly relates to a novel method and apparatus for continuously and very efficiently separating entrained particles from a gaseous mixture passing through a conduit.

One object of the invention is to provide an improved method of and apparatus for separating particles from a traveling stream of gas.

Another object of the invention is to provide such an improved method of and apparatus for gas cleaning in which the particles are filtered from the gas onto a traveling mat or web forming a filter medium which is passed across the path of travel of the gas.

Still another object of the invention is to provide such a method and apparatus in which the web or mat forming the filter medium is formed continuously from a bath containing a mixture of liquid and filter material and in which, after passage across the path of travel of the gases, the web is disintegrated into its components, these components washed and then returned to the original bath to be reused in the formation of the web.

Yet another object is to provide such a method and apparatus permitting the formation of the filtering web or mat from inert fibrous material which will be nonreactive with the components of the gaseous stream being cleaned.

In accordance with the invention I continuously form a web of fibers from a bath containing a mixture of filter material and liquid. This formation may most conveniently be carried out on the surface of a continuous rotary vacuum filter which may be of a conventional type. The web is formed by depositing the material in an endless open-work support or belt which passes around a portion of the periphery of the filter and then across the stream of gases to be cleaned and back to the filter drum. The filter material becomes matted and embedded in the belt to form the traveling web. The web after it is formed may be dried, if necessary, by a current of dry warm air or otherwise and then when it is led across the path of travel of the gaseous mixture to be cleaned, the gases will pass through it and the particles be captured and deposited on the filter material of which the web is composed. Preferably, I lead the web around a roll and return it in such a way that it passes twice through the gas duct, this being possible in view of the fact that the web is firmly matted in the supporting belt and does not merely rest on the surface thereof. Thereupon, I disintegrate the web and separate the dirt by washing the material from the supporting belt. The filter material is then returned to a make-up tank to which may be added additional material and fresh liquid as needed and the mixture returned to the original bath so that the material may be reused in again forming the web. The dirt collected forms a sludge which can be removed periodically or continuously from the bottom of the make-up tank, or otherwise.

The material of which the endless belt or support is composed and the particular material forming the filtering web are chosen so as to be nonreactive with chemicals which may be carried by the gaseous mixture. This is especially important if the gases to be cleaned are at high temperatures, of 1000° F., for example, such as in the stacks of blast furnaces and open hearth furnaces, or the like. In such installations I prefer to employ a stainless steel belt and I deposit on it as filter material fibers of rock wool, glass wool, slag wool, etc., the web and the chain belt being thoroughly dried before encountering the gaseous mixture to reduce any corrosive effect.

Still further objects, features and advantages of the invention will become apparent from the following detailed description of presently preferred apparatus for practicing the same, taken in conjunction with the accompanying drawings in which like parts are indicated by like numerals in the several views and in which:

Fig. 1 is a schematic representation of a complete installation for the cleaning of flue gases according to the invention;

Fig. 2 is a fragmentary cross-sectional view on line 2—2 of Fig. 3 showing the construction of one form of endless chain belt which may be employed in the system shown in Fig. 1; and

Fig. 3 is a plan view of the belt, illustrating the special arrangement which insures good tracking of the traveling belt.

As seen in the drawings, a duct, such as a flue or stack of a blast furnace or open hearth furnace, through which passes a stream of gases to be cleaned, is indicated generally by the numeral **10**. On one side of this duct **10** is mounted a tank **12** adapted to contain a bath comprising a liquid suspension of the material which has been selected as suitable to make up the filtering web. Mounted for rotation about a horizontal axis and partially submerged in the bath contained in the tank **12** is a continuous rotary vacuum filter drum indicated generally by the numeral **14**. Rotary drum vacuum filters are well-known (see, for example, U. S. Patent No. 2,352,303), and, therefore, I will not describe the construction and operation of the filter in detail, except to indicate certain advantageous arrangements which should be employed to obtain optimum results in accordance with the invention.

The rotary filter may comprise a cylindrical drum **16** which is perforated throughout by a series of ports **18** and carries a filter cloth **19** on its surface. Entering the drum, as through a trunnion **17** at one end thereof, is a filtrate pipe **20** which is preferably of reasonably large diameter since it also serves to evacuate air as well as liquid from the interior of the drum through openings **20***a*. Arranged to be carried on the surface of the drum **16** resting directly on the filter medium **19** is an endless chain belt **22** which, in the particular embodiment shown, may also serve as a drive for rotating the drum. As best seen in the fragmentary views of Figs. 2 and 3, this link or chain belt **22** is preferably made up of a series of sections of metallic links **21**, the sections being joined to each other by rods **23**. The links in adjacent sections alternate in being turned first right-hand and next left-hand, and the sections themselves may be, for example, conveniently about two feet in length each. By thus alternating the direction of the links from section to section, I insure that the belt will track properly on the rolls and drum.

Approximately fifty percent of the drum surface is sealed off against air leakage and filtration by an internal shoe **24** mounted on spokes **26** which may be supported on the pipe **20** or axle of the drum, or in any suitable manner. The tank **12** is supplied with the suspension of filter material through a supply pipe **28** which is connected to the output of a pump **30**, the input side **32** of which

communicates with the make-up tank **34**. The liquid level of the bath contained in the tank **12** is maintained constant by an overflow pipe **36** which conducts any overflow suspension back into the make-up tank **34**.

Fresh filter material such as suitable fibers, as needed, are supplied to the tank **34** from a hopper **38** through a conduit **40**, the flow being controlled by a valve or damper **42** so that the mixture in the tank **34** will have the proper consistency. The fibers are uniformly distributed in the liquid by the action of an impeller **44**. The tank **34** has an outlet **46** and a liquid inlet **48** for purposes which are hereinafter more completely explained.

The spiral wire belt **22** is led onto the periphery of the drum **16** over a guide roll **50** just before the drum surface submerges in the bath on downside. The belt then passes through the bath, re-emerges from the same, after becoming matted with the filter material which forms a web, as hereinafter explained, and is led off the drum at a point approximately 270° from the point of beginning. The belt and web then pass through an opening **52** in the duct or flue **10**, across the path of travel of the gases, as indicated by arrows, and out another opening **54**. The belt and web then pass around a roll **56**, which may be driven by any suitable means, reverses its direction and passes back across the stack **10** through openings **58** and **60**. After leaving the opening **60**, the belt passes through a casing **62** which is divided by an internal partition **64** into two chambers, for washing purposes, as hereinafter explained, thence about a guide roll **66** to the point of beginning.

The outlet pipe **20** serves to exhaust air and filtered liquid which rises above the open end of the pipe **20** from the interior of the drum **16**. This pipe operates as a barometric leg to draw air and liquid and discharge into another tank **72**, the lower end of the pipe **20** being below the liquid level of the tank **72**. A pressure differential is thus created which forces liquid and air from the exterior of the drum **16** through the belt **22**, filter cloth **19** and ports **18** on the ascending side of the drum, thus building up a mat or cake of filter material in the open-work belt.

Arranged through an arc of approximately 90° opposite the surface of the drum **16** on the up side thereof, I provide optionally a bank of infra-red heating lamps **74**. This portion of the surface of the drum is enclosed, at least in part, by a hood **76** thus forming a drying chamber for the web which is formed on the endless belt. Discharging into this drying chamber is the outlet of an air heater **78** through which air is drawn by the pressure differential above mentioned. These fibers will quickly form a mat or web entangled with and firmly held by the links of the chain. I have found in general, that the thickness of the web or pad will be determined by the thickness of the chain belt in which it is deposited. Furthermore, the stock may be very free-flowing and even during the relatively small arc wherein filtration occurs will build up into a web of required thickness very rapidly. Even with stock having a consistency of about .1% to about .25%, with a belt speed of about one inch per minute a web two inches thick may be easily produced. With such consistencies and at such speed, the filtrate will pass through the belt, filter cloth and filter drum at about 1,000 gallons per minute. This means that the pipe **20** must have a diameter such as to produce and handle such a great flow. For example, a pipe of the diameter of twelve inches arranged so that there is a reasonable head between the liquid level within the filter drum **16** and that in the tank **72** will be found entirely suitable to induce and carry a flow of this magnitude as well as to suck air through the heater and into the drum in desired volume.

The web formed in this manner will then, after emergence from the bath, be rapidly and thoroughly dried by the action of the hot air provided by the heater **78**, the drying action being accelerated by radiant heat from the lamps **74**, if desired. The thoroughly dried web then passes through the opening **52**, across the flue **10**, around the drive roll **56**, again through the flue, passing in through the opening **58** and out through the opening **60** to the first washing in the tank **62**. The web being deposited in and reinforced by the links of the belt **22** will undergo this reversal without injury. The first wash is provided by a sprayer **82** fed with filtrate liquid from the tank **72** by means of pipes **84** and **86** and pump **88**. Liquid discharged by the sprayer **82** will largely disintegrate the fibrous web, causing the fibers and the entrained particles, picked up thereby during passage through the stack, to drop to the bottom of the tank **62** from whence they will drain to the make-up tank **34**. The chain and any remaining entangled fibers then pass through an opening in the partition **64** to be washed again by a spray **90** of clean fresh liquid supplied from a main **92** and controlled by a valve **94**. This second washing serves completely to clean the chain belt so that it will be ready for the redeposit therein of the fibrous web when it again passes through the bath in the tank **12**.

I have found that a suitable filtering web may be formed very rapidly using a free filtering suspension of fibers in liquid. It is for this reason I preferably seal off a substantial portion of the submerged area of the filter drum to prevent the web from becoming too thick prior to emergence from the bath. The consistency of the fibrous mixture used, the speed of travel of the belt **22**, the amount of heat and air required for drying, etc., may all be adjusted by engineers skilled in the art to meet the requirements of any particular installation. Where the gases to be cleaned do not contain corrosive chemicals, and very high temperatures are not involved, the step of completely drying the web prior to use in cleaning the gas may be unnecessary or, indeed, undesirable, for a moist web may in some cases clean the gas more effectively. Dirt particles captured by the web from the gaseous vehicle and washed off by the sprays into the tank **62** pass with the fibers through the pipe **48** back into the make-up tank **34**. This tank is preferably provided with a bottom having sloping sides so that the dirt will collect in the form of a sludge in the very bottom of the tank. This sludge may be cleaned out periodically by opening the valve **46**. It is evident that these particles may be separated in any other suitable manner.

The particular filter material employed will, of course, be chosen with reference to the conditions of operation, including the chemical composition, temperature, and other characteristics of the gas to be cleaned. For blast and open-hearth furnace gases, a mineral slag wool has been found suitable. Other inert materials may also be used for hot gases, including rock wool, glass wool, etc. These materials when formed into a filtering pad or web on the spiral wire belt will be found to remove substantially 100 percent of the dirt from the flue gas, and this is an important accomplishment in an industry where pollution of the atmosphere is such a serious problem. When operating on gases which contain appreciable quantities of sulfur, or other chemicals capable of forming corrosive solutions with water, it is essential that the fibers and belt be completely dry before the web is advanced through the flue to prevent formation with the moisture of corrosive compounds, such as sulfuric acid, which would attack the steel wire belt. For these purposes the drying system must be made completely adequate and engineers skilled in the art will have no difficulty in establishing the requisite characteristics for a particular installation.

It will be evident also that the liquid levels in the various tanks may be controlled by suitable float valves or otherwise, and that various automatic control devices well known in the art of filtration may be utilized to make the practice of the invention as nearly fully atuomatic as may be.

It is clear that the invention may be practiced utilizing other components and structures than those specifically

herein disclosed and described, that the nature of the construction materials and filter materials may be varied to meet the requirements of particular installations, and that other modifications, adaptations and rearrangements, nevertheless within the scope of the invention, will occur to those skilled in the art. Therefore, the invention is not limited to the specific arrangements and details of the preferred embodiment illustrated in the drawings and herein described, but only by the scope of the appended claims.

I claim:

1. The method of continuously separating particles from a gaseous vehicle which comprises firmly matting a relatively thick fibrous web of filter material in a traveling open-work carrying medium moving through an endless path by forcing liquid carrying such material through said medium as the latter passes through a bath in a portion of said path, passing the web thus formed and said medium through another portion of said path in at least one direction across a stream of gas carrying the particles to be separated so as to filter out said particles, washing both said material and the entrained particles from said medium as the latter passes through still a third portion of said path, and thereafter returning the clean medium to the point of beginning for reuse.

2. The method as claimed in claim 1 which includes the steps of separating said material from said particles after both have been washed from said medium and returning the separated clean material to the bath to be used again in the practice of said method.

3. The method as claimed in claim 2 which includes the step of drying the web prior to passing the same through said stream.

4. Apparatus for continuously separating particles from a gaseous vehicle moving as a stream through a conduit, which comprises the combination with said conduit of an endless gas and liquid permeable belt, supporting and driving means for moving said belt through a predetermined closed path during at least one portion of which it passes across said conduit, and during another portion of which in advance of said first-named portion it passes through a bath adapted to contain a mixture of liquid and fibers, and during a third portion of which it passes through a washing zone, means for forcing liquid through said belt while passing through said bath to embed a relatively thick and durable mat of said fibers therein, means arranged in said washing zone for washing said fibers and any particles deposited thereon from said belt after the latter has passed across said conduit, and means for thereafter separating said particles from said fibers and returning the latter to said bath.

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