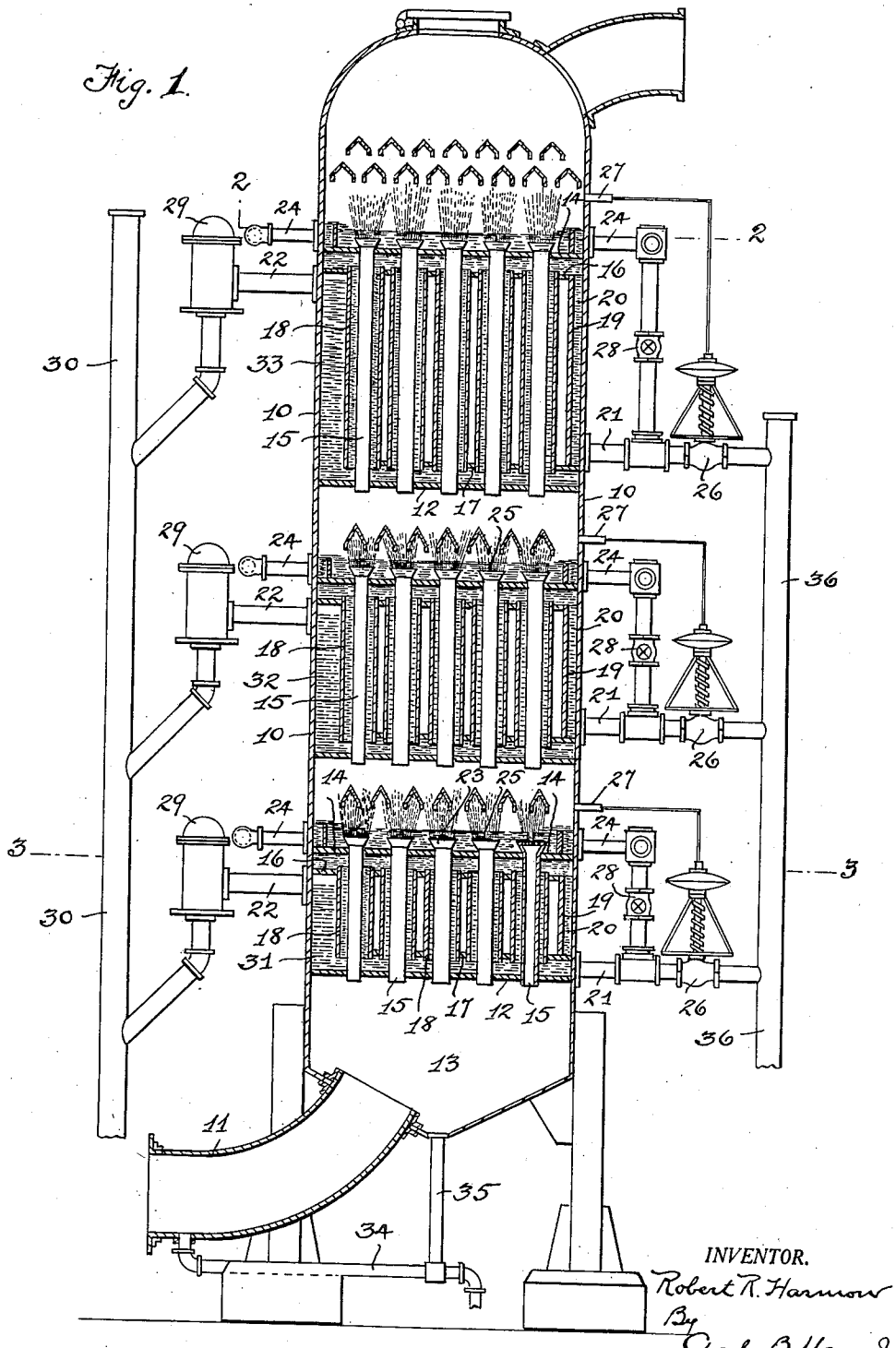
Sept. 27, 1932. R. R. HARMON 1,880,018

APPARATUS FOR CLEANING GASES

Filed Sept. 7, 1929 2 Sheets-Sheet 1

Fig. 1.



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Fig. 2.

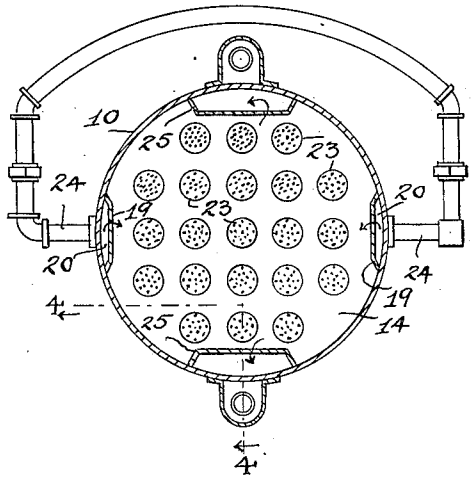


Fig. 3.

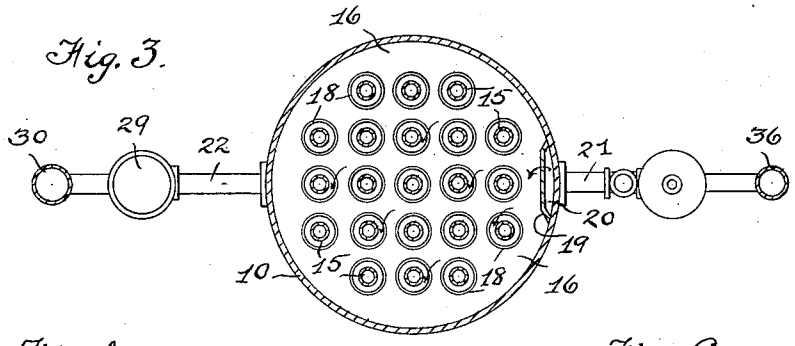


Fig. 4.

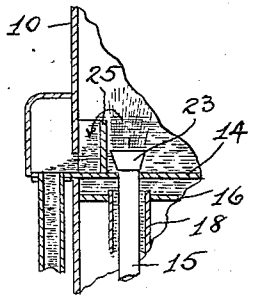


Fig. 5.

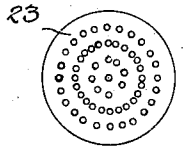
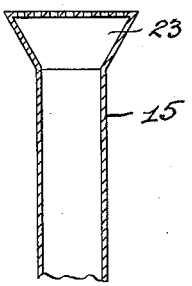


Fig. 6.



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UNITED STATES PATENT OFFICE

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APPARATUS FOR CLEANING GASES

Application filed September 7, 1929. Serial No. 390,902.

This invention relates to an improved apparatus for removing suspended solids and liquids from gases and vapors and has among its objects to provide improved means for effecting condensation of vapors about the suspended particles; to provide means for controlling the amount of and the rate which such vapor shall condense about such particles and to further provide improved means for ultimately removing all such bodies from the stream of gases and vapors, including the condensed vapors.

A further object is to provide an improved apparatus for effecting the removal of suspended solids and liquids from a gaseous stream in stages. By removing the coarser particles at one stage, then building up through condensation on the smaller particles to effect the growth of particles and their removal and thus by a plurality of stages of growth and removal effect removal of practically all suspended particles from the stream of gases.

The present apparatus has been especially designed for the cleaning of gases, such as those produced in the operation of blast furnaces, kilns, and boilers or such as are produced generally in chemical and metallurgical operations, and of rendering them ultimately free of suspended materials either for the purpose of making the gases themselves fit for further uses or to recover the value inherent in the suspended substances.

Heretofore, all the apparatus used to clean gases by wetting the suspended particles, have had as their principal aim, that intimacy of contact between the gas and washing liquid, which results in the hitting of the suspended particles with drops of the washing medium, or of actually "weighting the particles down", by condensing the vapor which hot gases normally carry, on the suspended particles.

Many experiments have indicated that, under ordinary circumstances, there is never enough vapor present in the hot gases to weight down the innumerable particles in suspension in the gases, and thereby cause the precipitation of all individually.

Simple calculations, also bearing out this statement, are based on the humidity of the gases, the number of particles in suspension per unit volume of gas and the mass of a particle necessary to cause its settling under the average velocities experienced in such work. It should be borne in mind also that the gases to be treated, due to their large volumes, must move at fairly high velocities in order to economize both size of apparatus and ground area, which of course precludes the removal by gravitational means of all save the very largest particles and droplets formed by condensation.

I have also discovered that if uninterrupted condensation of the vapor in the gas is allowed to take place on all the particles originally present in the gas, serious obstacles arise to prevent proper cleaning. One difficulty is, that due to the various kinds of particles in suspension at one time and the greater affinity of some of the particles over others for the condensible vapor, results in some receiving practically all of the vapor as it condenses, thus leaving a vast number suspended in the gas after the cleaning process has ended.

Another similar and also serious objection to permitting the vapor to be condensed as above is that as the particles differ greatly in size, and as it is ordinarily easier to condense vapor on the largest particles than on the smallest, it follows that the particles which need the most vapor receive the least, and also that those which need the least, receive the most.

One object of this invention therefore, is; to provide suitable means and at the same time, economical means of condensing vapor on suspended particles, in the absence of liquid sprays, drops or jets.

Another object is; to provide means of controlling the quantity of vapor which will condense on the various grades and kinds of suspended particles, prior to their removal from the gases and vapors in any one stage.

A further object being; to provide means of interrupting the condensation of vapor and of removing the tiny droplets formed thereby, which contain the originally sus-

pended particles in stages and to secure an ultimately clean gas by such means.

With the above objects in view, the accompanying drawings illustrate a form of apparatus for carrying the invention into effect, wherein,—

Fig. 1 shows a vertical sectional elevation through the apparatus.

Fig. 2 illustrates a horizontal cross-sectional detail through the apparatus as viewed on the line 2—2 of Fig. 1.

Fig. 3 shows another cross-sectional detail through the apparatus as viewed on the line 3—3 of Fig. 1.

Fig. 4 illustrates a sectional detail on the line 4—4 of Fig. 2, and

Figs. 5 and 6 show top and sectional views respectively of one of the detached tube-heads.

In the drawings, the numeral 10 designates the shell of a vertical vessel through which the gas to be cleaned flows,—a nozzle or feed pipe 11 being provided at the lower end or base through which the gases are delivered to the interior of the vessel.

Above the feed pipe 11, I provide the shell with a horizontal header 12 which forms a lower receiving-chamber 13 in the shell between said header and the feed-pipe 11.

Another horizontal header 14 is provided in the shell and a series of vertical tubes 15, extend down through the header 14, and have their lower ends projecting through the lower header 12 so as to communicate with the receiving-chamber 13.

Between the headers 12 and 14, I provide two additional horizontal headers 16 and 17 and a series of tubes 18 extend vertically through these intermediate headers and each of said latter tubes 18 encircles one of the tubes 15.

It will thus be seen that the tubes 15 through which the gases pass upwardly in as many streams as there are tubes, are longer than the tubes 18 and pass through all four headers, while the said tubes 18 only extend through the intermediate headers 16 and 17.

At one side of the shell and between the headers 12 and 14, I provide a vertical partition 19 whose lower end is liquid-tight against the upper side of the header 17 but is spaced below the bottom of the header 16. This partition 19 forms a vertical chamber 20 so that water may be fed thereto through a pipe 21 which water will overflow the top edge of said partition and run over the upper side of the header 16 and then flow down through the tubes 18, in a direction reverse to that of the up-flowing gas in the tubes 15.

An overflow pipe 22 directly beneath the header 16, carries off the water that has circulated between the headers 12 and 14.

Above the header 14, the projecting upper end of each gas tube 15 carries a detachable head 23 each of which latter is provided with a series of fine ports or openings through which the gas passes and these heads are all kept submerged in water which is supplied by pipes 24 at diametrically-opposite sides of the shell and which is drained off at two other diametrically-opposite sides through partitions 25. The upper edges of these overflow partitions are located slightly above the tube-heads 23, so as to ensure that said heads will be kept submerged.

The force of the up-flowing gas will prevent the water from passing down through the tube-heads and the gas streams passing through the small perforations in the heads 23 and the water will again be sub-divided and broken up.

Attention is directed to the fact that the feed-water pipe 21 for the cooling water is controlled by a thermostatically-controlled valve 26,—the thermostat 27, being arranged in the side of the shell immediately above the tube-heads 23.

The thermostatic valve 26 will therefore determine the amount of water to be fed between the tube sheets and may also determine the amount of water to be delivered to the space above the header 14 and over the tube-heads, although I prefer to provide an additional valve 28 between the thermostatic valve 26 and the pipes 24 to separately regulate the flow of water over the tube-heads.

The overflow pipe 22 is connected to a trap 29 and the overflow water passes through said trap and empties into a manifold or conduit 30.

Up to this point, I have merely described the structures in the lower portion of the shell which carry on the first stage in the operation of cleaning the gases, and while the structures for carrying on the succeeding stages are of the same construction, they differ from the structure at the first stage only in that those of the second stage have increased areas in the length of tubes and height of compartments between headers and those of the third stage have increased areas over those of the second stage.

As the structures employed at the several stages of cleaning and removal are alike, a description of the one is deemed sufficient for the others.

In the present instance, I have elected to show three stages of cleaning and removal of suspended particles in the gas stream, to wit; the mechanism at 31; that at 32 and that at 33, all of which are alike in construction but vary in area, and each stage having a separate thermostatically controlled water supply.

Pipes 34 and 35 at the base of the shell serve as drains for carrying off any drip or condensate that may otherwise collect in the inlet gas conduit or feed-pipe 11 or in the bottom of the shell.

The operation of the apparatus is as follows:

Gas previously saturated with water vapor and containing finely divided and suspended particles of various substances, such as dust or fume or metallurgical smoke, enters chamber 13 at the base of the shell below the tubes and devices of the first cleaning and removal stage 31.

Here the gas is divided into streams by passing up through the series of tubes. As these streams of gas pass the upper ends of these tubes, they are forced to escape through the numerous perforations in the tube-heads 23 which sub-divide it to a far greater degree than the tubes and following this sub-division, the gas is forced to pass through a body of water in which the tube-heads are submerged.

Cold water is supplied above and between the headers from a manifold 36 to pipes 21 and 24, flowing through thermostatically controlled valves 26. The flow of this water being thereafter divided into two streams; one to pipe 21 and the other to pipe 24. The flow through pipe 24 may be controlled by an ordinary valve. The water which passes through pipe 21 flows upward into the compartment between the headers 14 and 16 and onto the header 16 from which it then passes down through the tubes 18 and around the gas-tubes 15. Flow of the water is therefore downwardly and counter-current to the direction of flow of the gas around the tubular members 15, in order to effect the proper cooling of the latter. Overflow is by way of pipe 22 into the discharge line 30.

Water entering from pipes 24 flows into the compartment above the header 14 from two directions, thence passing around and over the tube heads 23 and out at the diametrically opposed discharge partitions, weirs or dam sheets 25.

The gas passing through the perforated tube-heads 23, as previously stated, is forced to bubble through the water overflowing these members, and at such a violent rate as to preclude any of the water from passing downward through the perforations therein. By placing the tube-heads 23 above the header 14, any surging of the water which might occur in flowing around these members would not appreciably disturb the head of water above the perforations, and a uniform bubbling action will therefore occur, over the entire surfaces composing the tube-heads. This bubbling action is a very desirable feature.

Causing the gas to pass through such a battery of tubes 15, thence through a flared perforated tube-head, the latter placed at a distance above the header 14 and insuring that a liquid level be maintained so as to cause a definite head of liquid to be retained above such tube heads, is a distinctive feature of the apparatus and one that is very desirable in the workings of the apparatus and process.

It will be noted that the tubular members 15 and headers are placed in a plurality of cleaning and removal stages and that the succeeding series are of greater length than those preceding. This is another desirable feature of the apparatus as it provides for adequate cooling in each stage and further, that the gas may be subjected to a greater degree of cooling in each successive stage with an equal quantity of circulating water as a cooling medium, if desired.

It is further to be noted that the thermo-controlled valves 26 determine the total quantities of cooling water that enter the separate stages through pipes 21 and 24, and that the quantity of water entering any single stage through the line 21 may be controlled separately by a valve placed for the purpose in pipe 24. I wish to stress the significance and advantage of such an arrangement and the reasons for keeping these two streams apart.

Bearing in mind the reason for cooling the gas indirectly, i. e. in the absence of sprays, drops or jets, in order to conserve all condensible vapor, it will be apparent that the most effective and economical means has been thereby eliminated. Since we must use surface cooling, it is necessary to use surface condensers as herein shown. However, it is possible to cool the gas by passing it through the tube heads submerged in the body of water without seriously affecting the economics of the process in so far as the loss of vapor is concerned. By cooling in this fashion, I am able to economize vastly the surface condenser equipment required. Now, inasmuch as the cooling process must be repeatedly interrupted to permit removal of the droplets formed in the condensation stages, and since to do this, water must be kept overflowing the tube heads, I propose to control this water by a valve in the main supply line, and by throttling this valve or by opening it wide, prevent any cooling of the gas in its passage through the submerging water, or, cause maximum cooling to take place there as may be desired.

It will be readily grasped that by such a combination, I have embodied the two means of cooling of the gas in the same apparatus, so that either means may be employed in operation,—the one or the other means to be determined by the conditions of operations and by other factors encountered.

It is therefore to be understood that with the present apparatus controlled cooling takes place with the proper apportionment of the vapor in the saturated gas, among the residual number of suspended particles, to form droplets about these particles and effect their removal from the gas in successive stages.

At each stage of operation, the tubular structures are alike except that they differ only in their respective lengths or in the total exposed surface in each series of tubes.

As the gas passes up through the tubes, cooling liquid circulates around the tubes to effect cooling of the gas passing therethrough.

By utilizing a plurality of separate cooling stages of increased cooling capacity, together with the features of separate thermostatic control of the cooling liquid supplied to each stage, I am able to cause the proper degree of cooling in each stage, reversing the natural order of cooling in the apparatus when desired, and can therefore apportion the vapor to be condensed, among the various grades of suspended particles in either equal or varying amounts, as in an ascending or descending progression, to suit the needs of any individual set of conditions.

Furthermore, by passing the gas through the body of liquid overflowing the perforated tube-heads, I am able to readily remove the droplets formed during the cooling and condensation of the vapor in the preceding cooling stage, and I thereby prevent the continued growth of such particle-centered droplets. Thus, I cause the vapor to condense on the suspended particles solely, to cause their proper growth in the cooling stages, and remove the dust-centered or fume-centered droplets as the gas is filtered through the body of liquid in which the tube-heads are submerged.

Having described my invention, I claim,—

1. An apparatus for cleaning gas having a plurality of separately-arranged tubular means one in advance of another for separately and successively dividing the gas into streams and condensing out vapor in the gas streams on suspended particles therein and forming particle-centered droplets, means between each set of tubular means for liquid-filtering the gas to remove particle-centered droplets formed in the preceding condensing operation and means for thermostatically controlling the condensing operation at each of the tubular means independently of the others.

2. An apparatus for cleaning gas having a plurality of separate condensing means one in advance of another for condensing vapor in the gas on suspended particles therein and forming particle-centered droplets, means between each two condenser means for liquid-filtering the gas to remove particle-centered droplets developed in the preceding condenser and separate means for thermostatically controlling the cooling liquid to each condensing means.

3. An apparatus for cleaning gas having a vessel with means arranged therein for successively condensing vapors in the gas about suspended particles and forming particle-centered droplets, means for filtering out the particle-centered droplets as they are developed and means actuated by variations of temperature in the vessel adjacent each condensing means for controlling the operation of each condenser.

4. An apparatus for cleaning gases in stages having a plurality of separate condensing means one in advance of another to condense successively in stages vapors from the gases about suspended particles therein and form particle-centered droplets in each condenser, means for independently controlling the quantity of vapor condensed in each stage and means for filtering out particle-centered droplets from the gases formed therein in one stage prior to the passage of the gas to the next succeeding stage.

5. An apparatus for cleaning gases in stages having a plurality of separate condensing means one in advance of another to condense successively vapors from the gases about suspended particles therein and form particle-centered droplets in each condenser, means for independently controlling the fall in temperature of the gases to condense therefrom at least equal quantities of vapor in each condensing stage and means for filtering out particle-centered droplets from the gases formed therein in one stage prior to the passage of the gas to the next succeeding stage.

6. An apparatus for cleaning gases in stages having a plurality of separate condensing means one in advance of another to condense successively vapors from the gases about suspended particles therein and form particle-centered droplets in each condenser, means for independently controlling the flow of cooling medium at the condensers to regulate the quantity of condensate in each condenser and means for filtering out particle-centered droplets from the gases formed therein in one condenser prior to the passage of the gas to the next condenser.

7. An apparatus for cleaning gas comprising a vertical shell having an inlet at the bottom for gas to be cleaned and an outlet near the top, plural sets of headers in said shell, each set of headers comprising lower and upper headers and a pair of intermediate headers between said lower and upper headers, vertical tubes extending all the way from the upper side of the uppermost header down through the intermediate headers and also through the lowermost header each of said tubes having perforated heads on their upper ends above the upper header and forming passages for the up-flowing gas, tubes extending vertically through the two intermediate headers of each set and open at the top and bottom said latter tubes encircling the intermediate portions of the longer set of first named tubes, means for circulating water through the intermediate tubes between the upper and lower header and about the longer

tubes, and means for maintaining a moving body of water across the upper header of each set of headers said bodies of moving water flowing over the perforated heads on said tubes and carrying off intercepted particles from the gas between the sets of headers.

In testimony whereof I affix my signature.

ROBERT R. HARMON.