March 11, 1958 B. LÖFGREN ET AL 2,826,397

SCRUBBERS

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FIG. 1.

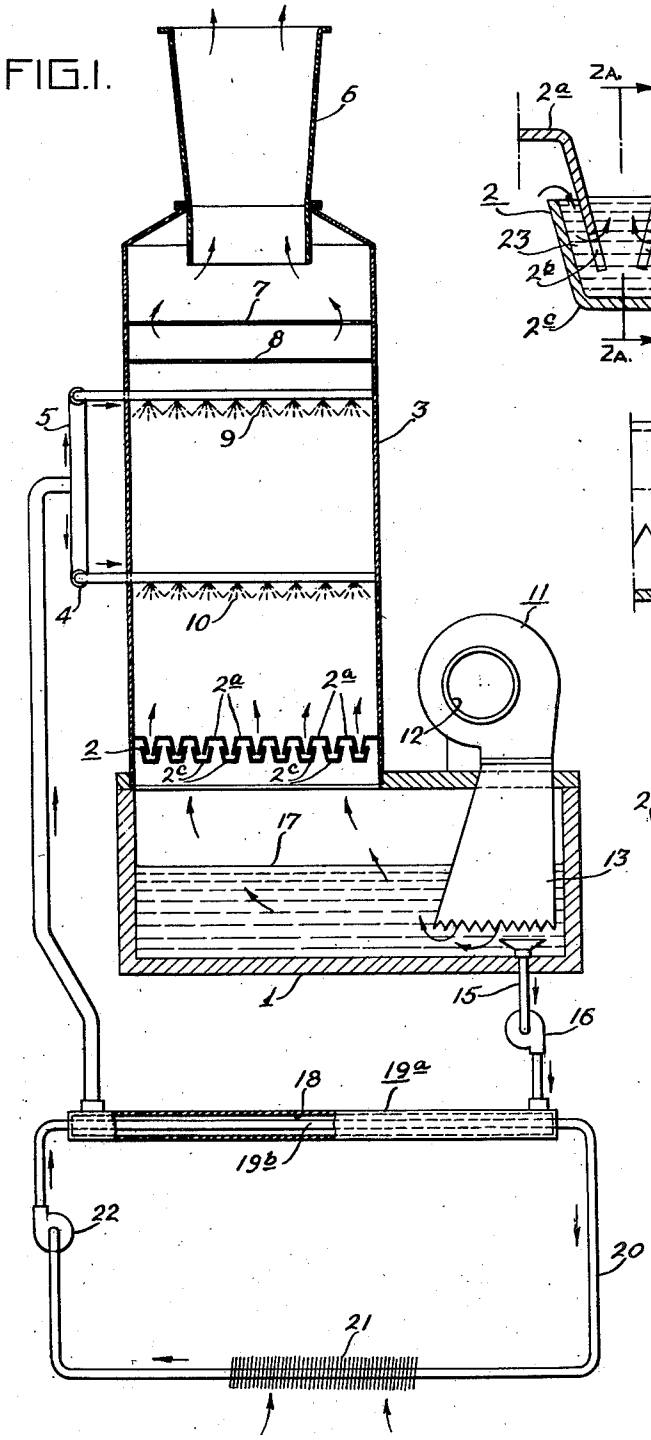


FIG. 2.

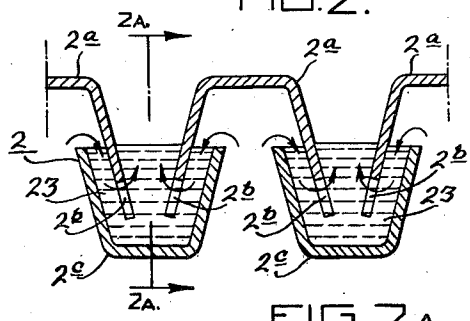


FIG. 2A.

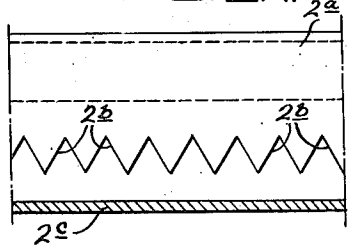
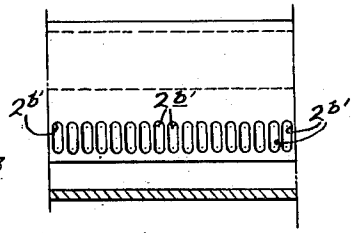


FIG. 2 B.



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SCRUBBERS

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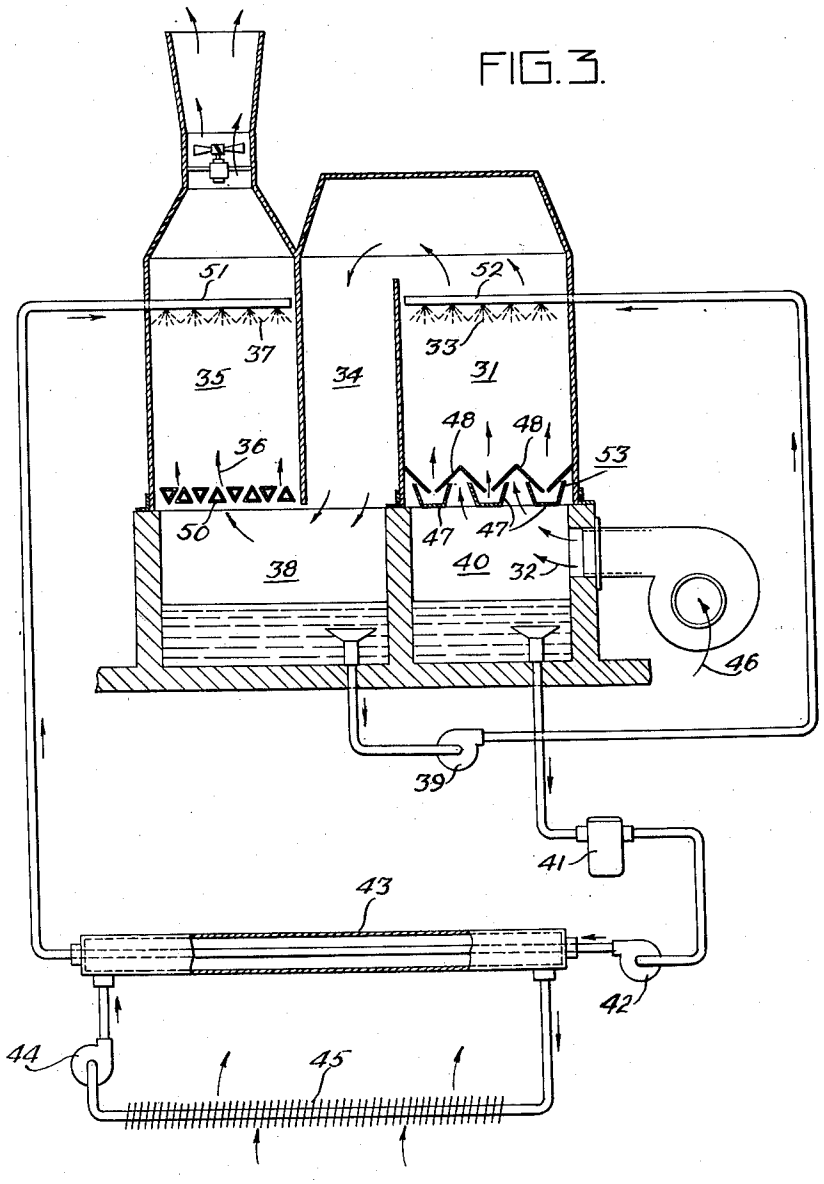
FIG. 3.



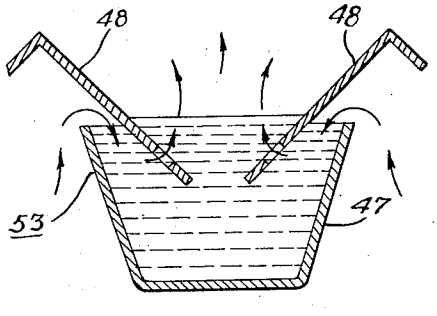


FIG. 4.

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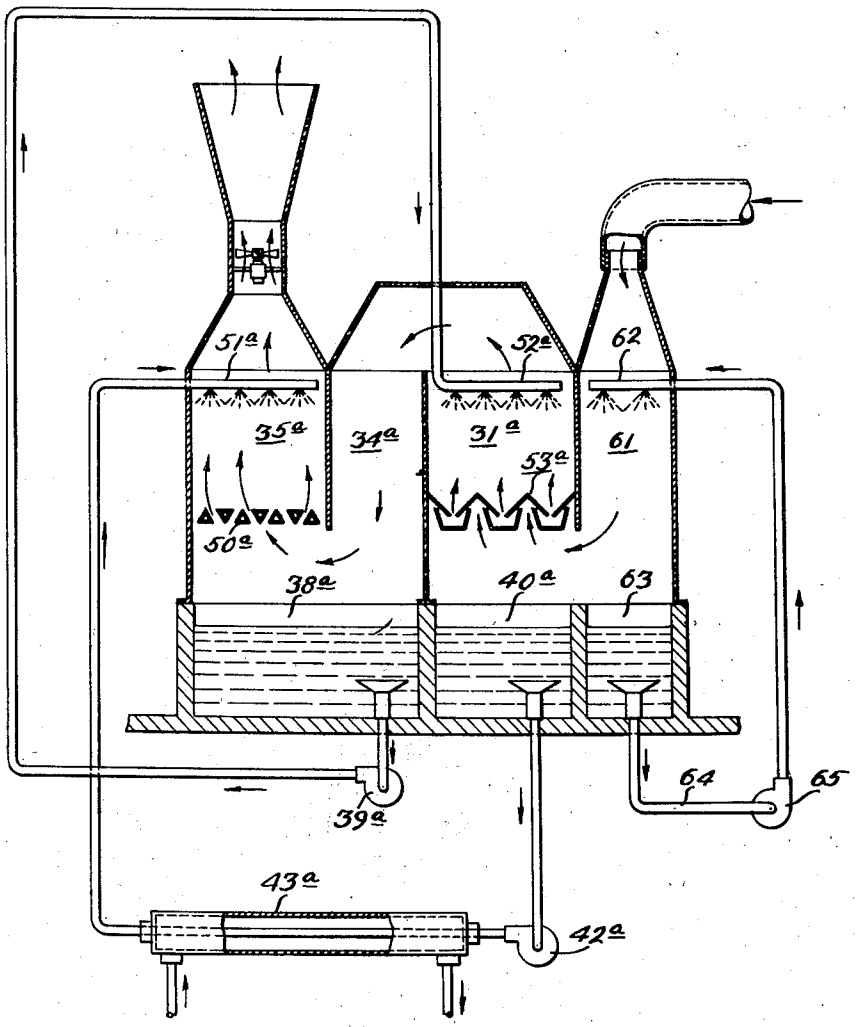
FIG. 5.



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2,826,397

SCRUBBERS

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4 Claims. (Cl. 261—11)

The present invention relates to improvements in scrubbers. Scrubbers are frequently used for recovering heat from the discharged ventilating medium, especially from the ventilating medium in driers for sheets of defibrated wood or the like. Such driers frequently work at such high temperatures that the discharged medium will be polluted by substances emanating from the sheets which substances normally are volatilizable at this high temperature.

In recovering heat in driers working at a high temperature for the treatment of sheets of defibrated wood, there are great disadvantages caused by the impurities of the discharging ventilating medium. Said medium will often carry fibres and dust particles and furthermore resinous gases. When the discharging medium is cooled these impurities are precipitated on the cooling surfaces of the heat exchanger resulting in a decrease of the value of the heat transmission coefficient. Accordingly the heat recovery will be decreased. The resinous gases co-mingled with dust and fibrous particles are difficult to eliminate from the heat transmission surfaces. Said surfaces will be at least partly covered with dirt. During the operation of the scrubbers it has often been proved that ignition easily occurs in these impurities which results in a total destruction of the heat recovering plant. The ignition of the impurities can be caused by heat gases or sparks emanating from a fire within the drier. It is also possible that a self-ignition occurs in the accumulations of the resinous and the fibrous substances. In order to avoid this, it is known to spray water continuously or discontinuously over the heat transmitting surfaces. In operation of the conventional heat exchanging plants, however, they nevertheless often have been spoiled by fire, since the quantity of water has been maintained relatively small so as to reduce the heat loss in the medium to a predetermined quantity.

According to the invention the method for heat recovering by scrubbers is characterized by the fact that the ventilating medium discharged from the drier is passed through S-shaped passages by means of distributing devices in the form of water traps disposed in its path at least once during its passage through the scrubber and that circulating water (dirty used water) in a known manner is heated and that this water is conducted through a heat exchanger where the water is forced to transmit its heat to fresh water, said fresh water being intended for heating purposes, for instance for heating of ventilating air of a locality.

A modification of the method is characterized by that all or a part of the heated fresh water is drawn off and is replaced by cold fresh water which is added to the circulated fresh water. According to a convenient embodiment, at least so great a quantity of circulated dirty water is brought to pass through the scrubber that said quantity is able to cool the quantity of discharging ventilating medium down to about 150° C., even if said ventilating

medium has been heated very high for instance up to 1000° C. by fire.

According to the invention, the ventilating medium being discharged from the drier is thus led through a scrubber in which a great quantity of air is sprayed. The scrubber can be provided only with spray nozzles or can also be provided with contact surfaces. Said quantity of sprayed water is circulated. From this circulation only water of such a quantity is drawn off which corresponds to the quantity of gas condensed from the discharged ventilating medium. In such cases where many impurities are in the ventilating medium discharged from the drier it is preferred that fresh water be added to the quantity of water circulating in the scrubber in order to lower the concentration of dirt particles in the water. A very great quantity of circulating dirty water must be used in order to make sure that the discharged medium, for instance by a fire in the drier which raises the temperature of said medium, nevertheless can be cooled in the scrubber. The risk of any expansion by a fire is then eliminated. The expansion of flames is prevented by means of one or more S-shaped passages for the ventilating medium through the scrubber.

In heat exchangers of this type water is usually supplied by a number of spray nozzles in the upper part of a tower. The water is distributed in order to obtain a large contact surface for transmitting heat. The separate small drops of water may fall down through the tower in counter current direction to the medium. The medium is adapted to pass upwardly in the tower from the lower part thereof. The small drops of water contact each other when falling down through the tower resulting in a diminishing of the contact surface. The efficiency of the tower is therefore limited. A further increase of the height of the tower therefore does not result in any increase of the active contact surfaces. Prior apparatus is known in which water is sprayed from two or more levels in order to maintain an effective contact surface over the entire height of the tower. Such apparatus has the disadvantage that the difference of the temperature between the medium and the water is diminished. Furthermore, the contact surface is less efficient, i. e. the efficiency of a spray outlet disposed in the lower part of the tower will be less than that of a spray outlet disposed in the upper part of the tower owing to collisions between the drops.

It is therefore an object of the invention to eliminate the above mentioned drawbacks of prior known scrubbers. A scrubber in accordance with the invention is characterized by the fact that the space and the tank of the scrubber are divided by means of partitions in two or more treatment chambers adjacent to each other. The chambers are so joined that the gaseous medium can be led in S-shaped passages through the treatment chambers, the tank of the final treatment chamber being connected with the spraying device of a previous treatment chamber. The tank of the last mentioned chamber can be connected for instance by means of an indirect heat exchanger arranged outside the scrubber with the spraying device of the final chamber.

A modified embodiment is characterized by the fact that one or more of the treatment chambers are provided with means for distributing the medium and with water traps in the passage of the gaseous medium.

As a further modified embodiment, the chamber through which the gaseous medium first passes is provided with a closed passageway for the water serving only to clean the same.

It is thus a primary object of the invention that the scrubber is divided into two or more separate treatment chambers and the quantity of water intended to be heated

is led in series through the different chambers of the scrubber in a counter current direction to the gas. In the lower part of the first chamber reckoned in the flow direction of the gas there is arranged according to an embodiment of the invention a combined water trap and means for distributing the medium consisting of flutes combined with inverted generally U-shaped troughs, which extend downwardly a predetermined distance into the flutes thus forming S-shaped passages for the gaseous medium. Such a combined water trap and means for distributing the medium can also be arranged in the lower part of the other chambers.

The invention will now be more fully described in connection with the accompanying drawings showing different embodiments of a scrubber within the scope of the invention.

Fig. 1 shows diagrammatically a section of a scrubber.

Fig. 2 shows in a large scale the operation of the water traps shown in Fig. 1.

Fig. 2A is a local section on the line 2A—2A of Fig. 2;

Fig. 2B is a view similar to Fig. 2A of a modification within the scope of the present invention;

Fig. 3 shows a vertical section of a modified type of a scrubber.

Fig. 4 shows in a large scale the water traps shown in Fig. 3.

Fig. 5 shows another modification of a scrubber.

In Fig. 1, **1** stands for a tank which is connected by means of a pipe **15**, a pump **16** and a channel **18** of a heat exchanger **19***a* with a pipe **4**, **5** and spray nozzles **9**, **10** which discharge into a distributing means **2** in a scrubber **3**. The gaseous medium is blown into the tank **1** by means of a fan **11**, the inlet and outlet of which being designated **12** and **13**. The outlet of the fan opens into the tank below the level of the fluid **17**. As evident from the drawing, the area of the tank is much greater than that of the scrubber.

The edge of the outlet from the fan is serrated, toothed or perforated similar to the distributing means **2** as will be closer described in connection with the distributing means **2** in Figs. 2A and 2B. Such teeth of the edge are designated **2***b* in Fig. 2A. The perforation is designated **2***b'* in Fig. 2B. The designations **19***b*, **20**, **21** and **22** stand for different parts of the above mentioned heat exchanger. A conduit for the outlet of the gaseous medium from the scrubber is designated **6**. **7** and **8** designate prior known plate means for precipitating of water from the discharged medium. The slots of the plate **7** is located at a greater distance from the centre than what corresponds to the diameter of the outlet conduit **6**.

The operation of the means **2** for distributing the medium is shown in Fig. 2. Said means can consist of a number of flutes **2***c* in which there are inverted generally U-shaped troughs **2***a* extending downwardly partly into the fluid **23** (water). In Fig. 2 the operation of the downwardly extending edges of the trough is shown by the arrows. The edges can be either perforated as shown at **2***b'* in Fig. 2B or toothed as shown at **2***b* in Figs. 2 and 2A. A number of features can be attained by using the above mentioned arrangements. The accumulated impurities are collected in the fluid of the tank. In opposition to employing commonly used nets, there is no risk of clogging. The invention also prevents any chimney draft when the scrubber plant is out of operation or is being started. This to a great extent eliminates many violent fires when starting the driers.

As a practical example of the invention a drier for porous plates of defibrated wood can be mentioned in which the discharge rate of the wet medium normally is 25,000 kg./h. and the temperature about 150° C. When a fire occurs in the drier, the temperature can momentarily increase to 1000° C. If the corresponding quantity of ventilating medium is to be cooled down to 100° C. it is necessary to eliminate a heat quantity of

$$25{,}000 \times (1{,}000 - 100) \times 0.25 = 5{,}625 \text{ Mcal./h.}$$

This quantity of heat is sufficient for a theoretical evaporation of about 10 tons of water. The quantity of water in the conventional plant must therefore have at least this value. Owing to practical difficulties it is however nearly impossible to distribute the water evenly over the area of the scrubber. The quantity of the circulating water must therefore be greater, at least twice as great as, and in certain cases even 5 to 10 times as great as the above-mentioned quantity of water of the plant in order to obtain the desired safety against fire.

The quantity of dirty water can in certain cases be greater than that necessary for preventing fire. This is because the quantity of heat which normally is transmitted to the dirty water is great.

The dirty water which is circulated in the above mentioned scrubber can normally not be used directly as water for the manufacture process, nor is such water suited for using in heating elements for preheating air. This is partly due to the earlier mentioned impurities of the water and partly because the water normally contains acetic acid, tannic acid, oxalic acid or similar substances which originate from the wood to be dried in the drier. According to the present invention the dirty water heats fresh clean water in separate heat exchangers. Such heated water can then be used either in the manufacturing process or can be circulated through the heating elements in which ventilating air intended for the factory is heated.

In Fig. 3 the inlet of the scrubber is designated **31**. In this the gas **32** of high temperature and water **33** of high temperature flow in counter current with respect to each other. From the part **31** of the scrubber the gaseous medium is passed through a channel **34** to another part of the scrubber **35** where after passing through distributing means **50** the partly cooled gaseous medium **36** will be in contact with cold water **37** from the nozzles **51**. The water which is partly heated in the last mentioned part **35** of the scrubber is accumulated in a tank **38** and is pumped by means of a pump **39** over to the nozzles **52** of the first mentioned part **31** of the scrubber where the circulated water will be more heated. The water which is heated in the part **31** of the scrubber passes through water-trap distributing means **53** and is collected in the tank **40** and is forced to pass a filtering means **41**. The water is then pumped by means of a pump **42** through a channel of a heat exchanger **43**. In this heat exchanger heat is transmitted indirectly to another quantity of water which by means of a pump **44** is forced through heating elements **45**. Said elements **45** are intended for indirectly heating air which for instance can be used as ventilating air for different spaces of the factory and also as ventilating air for driers. The arrow **46** stands for the incoming mixture of air and gaseous media from a drier. The mixture is forced to pass a water trap and/or means **53** for distributing medium on its way from the tank **40** before the mixture reaches the inlet part **31** of the scrubber. Such means **53** can consist of a number of flutes **47** combined with a plurality of inverted generally U-shaped troughs **48** partly extending into the flutes. This part of the scrubber is shown in a large scale in Fig. 4.

Fig. 5 shows a further modification of a scrubber having an inlet space **61** provided with only circulating water for the cleaning of the gaseous medium. The gaseous medium is then passed on to the main scrubber. which is similar to that shown in Fig. 3 and has corresponding reference characters followed by the character "*a*." In this way it is possible to eliminate the disadvantages which can occur in connection with the impurities. The water is recirculated in the space **61** by nozzles **62**, a collecting tank **63**, pipes **64**, and a pump **65**.

The supply water to the different parts of the scrubber is distributed by means of devices **9**, **10**, **51**, **52**, **51***a* and **52***a*. The distance between such devices and the water trap and/or means for distributing the medium,

which means are designated 2, 50, 53, 50*a*, and 53*a* in the lower part of the scrubber are adapted for getting a good result with respect to heating of the water. The distance should not be less than 1 to 1.5 m. and not greater than 2.5 m. for an optimum result. The distance is also dependent upon the velocity of the medium through the scrubber. The value of said velocity can vary between 1 and 3 m./sec. depending upon the density of the gaseous medium.

The invention produces the following advantages:

(1) Large efficient contact surface between the heat exchanging media.

(2) Mainly a counter current arrangement with respect to the heat exchanging.

(3) A rather low height of the heat exchanging apparatus.

(4) A water trap for preventing flames or a fire to pass through the apparatus.

(5) Such impurities, for instance fibres and resinous substances, which originate from the heat source will be washed out and precipitated.

What we claim is:

1. The method of eliminating the risk of fire while recovering by a scrubber heat from a hot flowing ventilating medium containing flammable volatile gases from a dryer comprising the steps of spraying water into the upper portion of the scrubber chamber over the entire cross-sectional area thereof at a rate of flow relative to the flow of the ventilating medium to be able to cool the medium to a temperature of 150° C. from a temperature of at least 1000° C., collecting said water at an intermediate point in the scrubber to form a water trap, affording discharge of the water from the trap to constitute the water trap a bath of circulating water, discharging and distributing the hot ventilating medium into the bath of circulating water in the water trap over the entire cross-sectional area of the scrubber chamber and into the spray of water in the upper portion of the scrubber for direct heat exchange with the circulating water and the spray to cool the ventilating medium and heat the circulating water, conducting the water heated by said ventilating medium to a separate heat exchanger and utilizing said water as a secondary heat exchange medium for heating fresh water, and using said heated fresh water for heating purposes.

2. In a scrubber for eliminating the risk of fire while recovering heat from a warm gaseous medium containing flammable volatile gases, a vertically disposed treatment chamber having two treatment sections adjacent each other, each section having spray means for non-flammable liquid mounted adjacent the top thereof, a tank at the bottom of said chamber for collecting the liquid discharged from said spray means and distributing means for distributing said medium over the full cross-sectional area of the section, at least one of said means comprising a plurality of cooperating V-shaped and inverted V-shaped troughs forming a non-flammable liquid trap

below the spray means in said section across the full cross-sectional area of the section to prevent travel of fire through said chamber, means for directing the gaseous medium upwardly successively through said second and first sections in an S-like path, whereby the medium is cooled by said liquid and heats the latter, means effecting cyclic flow of the liquid from the tank of the first section through the spray means of the second section, and from the tank of the second section through the spray means of the first section, to thereby afford circulation of the liquid countercurrent to the gaseous medium, and indirect heat exchange means separate from said chamber to receive the heated liquid from the tank of the second section to remove and recover the heat removed from the gaseous medium prior to the ejection of the liquid through the spray means of the first section.

3. An apparatus according to claim 2 including a third treatment section having a tank and non-flammable liquid spray means therein, means to direct the gaseous medium through the third, then the second, and finally the first treatment section, and means directly connecting the tank of the third section to the non-flammable liquid spray means of said section, in order to use the circulating non-flammable liquid in said third section only for cleaning the gaseous medium.

4. The method of eliminating the risk of fire in scrubbers for recovering heat from a hot flowing ventilating medium containing flammable volatile gases from a dryer comprising the steps of spraying water into the upper portion of the scrubber chamber over the entire cross-sectional area thereof at a continuous rate of flow relative to the flow of the ventilating medium to cool the medium at least down to a temperature of 150° C. from a temperature caused by a fire and as high as 1,000° C. by deliberately overrating the quantity of said spray water, collecting said water at an intermediate point in the scrubber to form a plurality of water traps, affording discharge of the water from the traps to constitute baths of circulating water, discharging and distributing the hot ventilating medium over the entire cross-sectional area of the scrubber chamber by passing the medium through said plurality of water traps and forcing the medium to continue into the spray of water in the upper portion of the scrubber for direct heat exchange with the circulating water and the spray to cool the ventilating medium and heat the circulating water.

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