Dec. 14, 1954 W. C. CAMPBELL 2,696,892

GAS HUMIDIFYING AND ELECTRICAL PRECIPITATION SYSTEM

Filed June 8, 1951 2 Sheets-Sheet 1

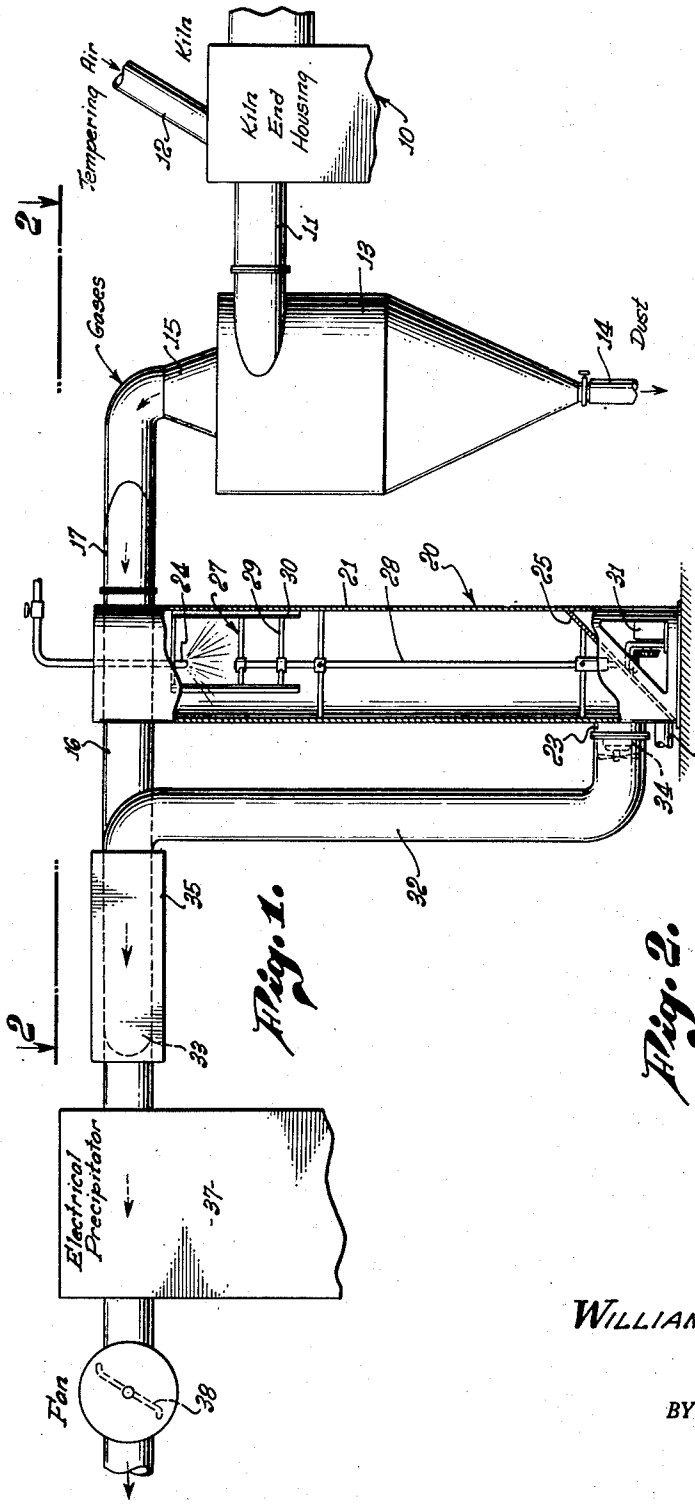


Fig. 1.

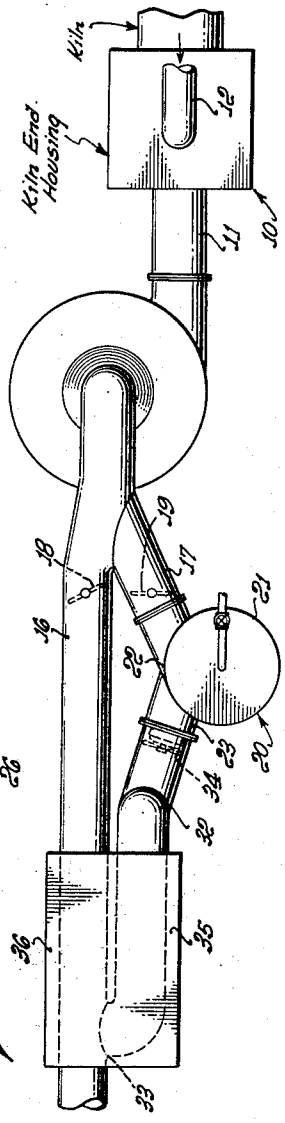


Fig. 2.

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GAS HUMIDIFYING AND ELECTRICAL PRECIPITATION SYSTEM

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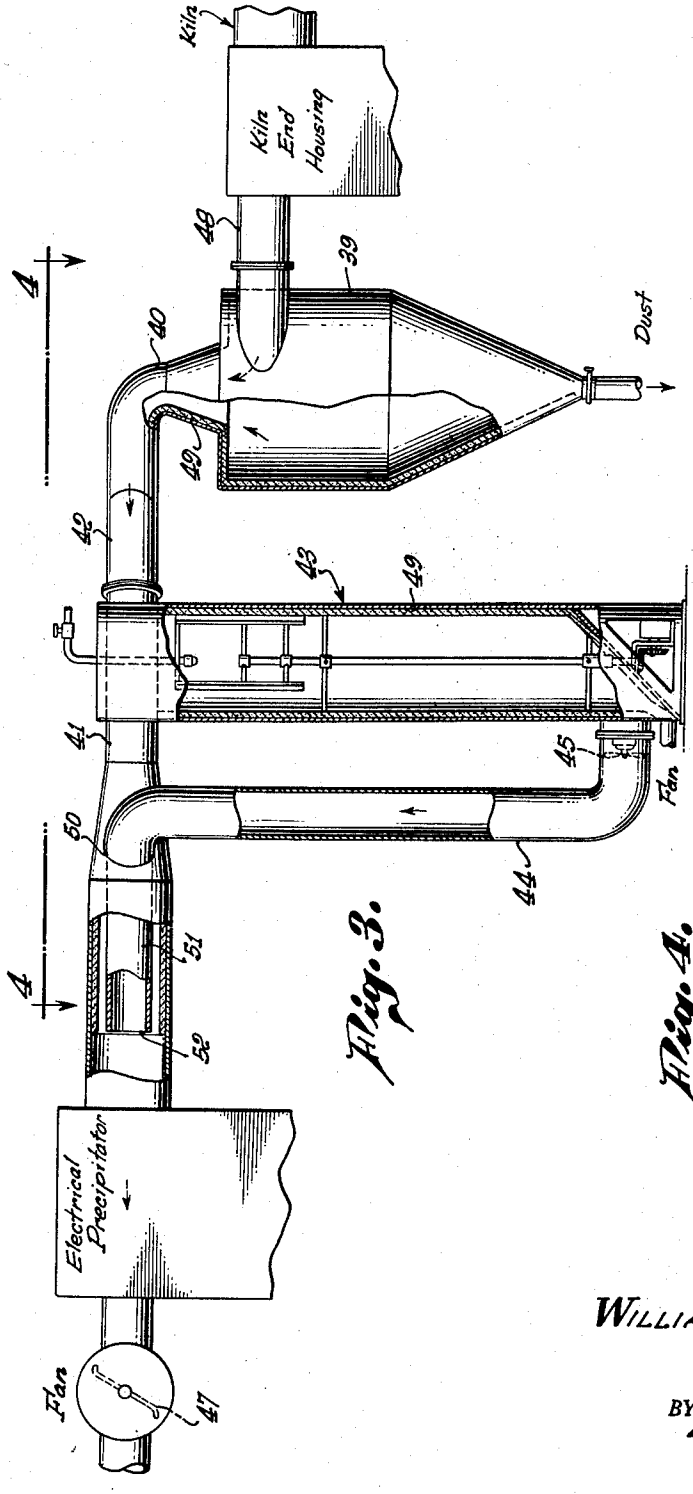


Fig. 3.

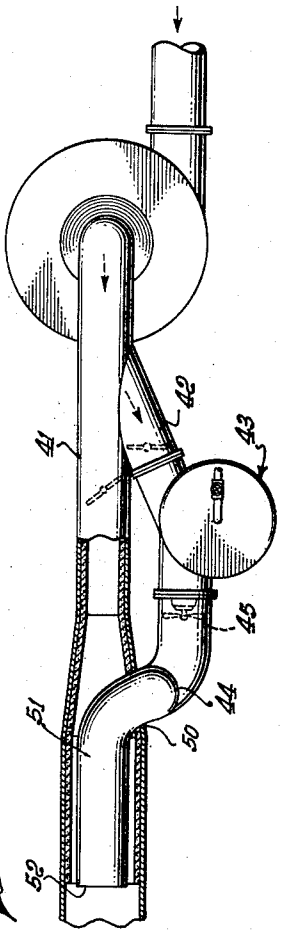


Fig. 4.

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United States Patent Office 2,696,892
Patented Dec. 14, 1954

2,696,892

GAS HUMIDIFYING AND ELECTRICAL PRECIPITATION SYSTEM

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Application June 8, 1951, Serial No. 230,654

3 Claims. (Cl. 183—7)

This invention relates to improved methods and apparatus for humidifying and removing contaminants from gases, and in certain of its aspects is particularly concerned with the treatment of discharge gases from a Portland cement clinkering kiln.

In many respects, the most desirable type of separator for removing contaminants from cement kiln gases is an electrical precipitator, typically of the well known Cottrell type. However, though such a precipitator has several very definite advantages for cleaning kiln gases, it also introduces certain problems, specifically in connection with the preparation of the gases for precipitation.

For one thing, an electrical precipitator can operate at top efficiency only if the gases fed to it are relatively humid, with the result that the hot and dry kiln gases from dry process cement plants must be humidified in some way before delivery to the precipitator. At the same time, though it is desirable to humidify the gases to a certain extent, it is also extremely important to avoid over-wetting the gases, especially to a degree such that entrained moisture forms hard-to-remove cement deposits from the cementitious dust particles being separated. To prevent the formation of such cement deposits, the gases passing through the precipitator should be free of any moisture in liquid form. Besides humidification, the hot and dry kiln gases usually require considerable cooling before delivery to a precipitator, in order to protect the precipitator against damage from excessive temperatures.

An important object of the present invention is to provide improved methods and apparatus for humidifying a stream of gases, typically in an electrical precipitation system, while at the same time assuring against overmoistening the gases, and providing for accurate regulation of their water vapor content. Specifically, this result is achieved by first dividing the gases into two separate streams, then humidifying only one of the separated streams, and finally reuniting the streams into a combined flow of air in which all moisture is vaporized. Such mixture of a humidified stream with a dry stream positively assures against excessive moisture in the combined flow, and renders possible very accurate but extremely simple control of the extent of humidification, by merely regulating the proportions of the two streams.

When the gases being handled are heated kiln gases, the invention contemplates not only the humidification of the gases, but also both their cooling to a temperature protecting the precipitator against damage, and their partial cleaning before delivery to the precipitator. As will appear, all three of these results, that is, humidification, cooling, and partial cleaning, may be achieved by merely directing into one of the two separated streams of gases a spray of relatively cool water.

To prevent the accumulation of cement deposits formed from a mixture of the water with the cementitious dust particles entrained in the gas, we preferably employ for introducing the water a mechanically cleaned cyclonic scrubber of the type shown in copending application Ser. No. 224,721, filed May 5, 1951, by Harry E. Kaiser et al. on Dust Separator, now abandoned. This scrubber acts to humidify, cool, and clean the gases, and at the same time is itself continuously mechanically cleaned by a special scraper assembly to assure against clogging of the device.

Best results are obtained if the moisture carried by the humidified stream is completely vaporized before remixture with the second stream. This is true because the second stream still carries large quantities of cementitious

particles, which would form hard-to-remove deposits with any moisture in the gases. To assure such complete vaporization of the moisture before remixture of the streams, we prefer to reheat the humidified stream to a temperature above its dew point while still separated from the second stream. Such reheating, and simultaneous cooling of the second stream, may be simply and effectively attained by merely directing the streams while still separated along proximate paths and in heat transferring relation, so that heat is transferred from one stream to the other. Certain particular features of the invention have to do with two preferred structural arrangements for so directing the separated streams along proximate paths.

The above and other features and objects of the present invention will be better understood from the following detailed description of the typical embodiments illustrated in the accompanying drawings, in which:

Fig. 1 is a side partially schematic representation of a first system for removing contaminants from cement kiln discharge gases;

Fig. 2 is a plan view of the system shown in Fig. 1 and taken on line 2—2 of that figure;

Fig. 3 is a side partially schematic view of a second kiln gas treatment system; and

Fig. 4 is a plan view taken on line 4—4 of Fig. 3.

In the form of the invention shown in Figs. 1 and 2, I have represented at **10** the kiln end housing of a Portland cement clinkering kiln, from which the kiln gases flow into a discharge duct **11**. The gases as they reach the kiln end housing are of very high temperature, considerably in excess of 1000 degrees F., and contain contaminants including entrained siliceous or mineral dust particles together with alkali metal compound fume. In this first form of the invention the hot gases are cooled to a temperature below 1000 degrees as they leave the discharge end of the kiln, by the introduction of atmospheric tempering air into the end housing **10** through air inlet line **12**.

From duct **11**, the tempered gases are directed tangentially into a conventional cyclone separator shell **13**, within which the gases spiral circularly in a manner centrifugally separating some of the dust particles from the gases. The separated dust falls downwardly within shell **13** for discharge through bottom outlet **14**, while the partially cleaned gases pass upwardly from the center of the shell and into duct **15**. This duct divides into two branch lines **16** and **17**, to divide the gas flow into two separate streams, the relative flow rates of the two streams being controllable by a pair of dampers **18** and **19** within the two branch lines **16** and **17** respectively.

The gas stream from branch line **17** is directed into a mechanically cleaned cyclonic gas scrubber **20**, within which this portion of the gas is humidified, cooled, and further cleaned. This scrubber has been disclosed more specifically, and claimed, in aforesaid copending application. As seen in Fig. 1, this scrubber includes a vertically extending cylindrical shell **21**, within which the gases spiral downwardly from an upper tangential inlet to a lower tangential outlet **23**. Such spiraling movement of the gas centrifugally separates out some of the entrained dust particles. The separation of these particles and of some of the fumes carried by the gases is enhanced by a spray of relatively cool water spreading outwardly from spray head **24** against the shell wall. The mud or slurry formed by moistening of the dust particles forms along the inner surface of shell **21**, to fall downwardly onto an inclined bottom wall **25**, by which it is directed into discharge line **26**.

By reason of the cementitious nature of the dust particles separated from the gases, the dust and water mixture has a tendency to accumulate in excessive amount on the shell wall, and there is consequently provided a scraper mechanism **27** for mechanically removing this material from the wall. This assembly includes a vertically extending drive shaft **28**, carrying arms **29** on which are mounted a plurality of scraper blades **30**, which engage and clean the shell wall. Shaft **28** is continuously rotated by a motor **31** beneath bottom wall **25**, to continuously move scraper blades **30** along the inner surface of the shell wall.

The humidified, cooled and relatively clean gas from scrubber **20** flows from the scrubber discharge **23** into

duct 32, which leads into line 16 at 33 to reunite the two separated streams of gas. The gas flow through scrubber 20 and duct 32 may be mechanically produced by a fan 34 within the duct, the gases being sufficiently cool at this point, as a result of the cooling effect of the scrubber, to prevent overheating of the fan.

As the gases flow into duct 32, they are preferably saturated with moisture most of which has been vaporized by sensible heat of the gases. In order to prevent any liquid moisture carried by this stream of gases from mixing with the dust particles in line 16 and forming a cementitious slurry as the two separated streams are brought together, the gases within duct 32 are heated to a temperature above their dew point prior to the reuniting of the streams.

Such heating of the gases is very simply effected by providing duct 32 with a portion 35 extending alongside and in such proximity to line 16 that the cooled gases within duct 32 are raised in temperature by heat from the gases in line 16. To maximize the heat transference between these two lines, their adjacent portions may be enclosed within a single tubular outer jacket 36, preferably formed of heat insulating material.

The relative rates of flow through line 16 and the scrubber circuit are so controlled that the stream beyond point 33 is humidified just properly for most efficient operation of the electrical precipitator 37. This stream is then passed through the precipitator, within which virtually all remaining contaminants are removed, and the gases then discharged to the atmosphere. A fan 38 at the discharge side of the precipitator may serve as the main gas moving element of the disclosed system.

Figs. 3 and 4 illustrate a variational form of the invention similar in many respects to the Fig. 1 arrangement, and including a cyclonic separator 39 into which the kiln gases are first passed, an outlet duct 40 leading from separator 39 and dividing into two branches 41 and 42, a mechanically cleaned cyclonic scrubber 43 through which a stream of gases from branch line 42 is directed, a duct 44 through which the cooled, humidified and partially cleaned gases from the scrubber are displaced by fan 45 back into the second stream of gases within branch line 41, an electrical precipitator through which the combined streams are then passed, and a fan 47 at the discharge side of the precipitator for creating the main draft of gases through the system.

One difference between the two forms of the invention is that in the second form no atmospheric air is introduced in the system to temper the heated kiln gases. This arrangement has the advantage of reducing the quantity of gases which must be handled, and therefore reducing the sizes of the various units of equipment. To protect the apparatus against the consequently higher temperatures of the gases up to the point of introduction of the cooling water, the kiln discharge line 48, separator 39, duct 40 and its two branches 16 and 17, and scrubber 43 are preferably all lined with a suitable refractory material 49.

A further difference between the Figs. 3 and 4 form of the invention and the first form resides in the manner in which the two separated streams are directed along proximate paths in heat transferring relation to raise the temperature of the humidified stream by heat from the second stream. Specifically, in Figs. 3 and 4, the discharge line 44 from scrubber 43 extends directly into branch line 41 at 50, and then has a portion 51 extending axially along the center of line 41 in annularly spaced relation to its refractory side wall, and ultimately discharging at 52 into the stream of gases within line 41. During their passage through portion 51 of line 50, the humidified and cooled gases are raised in temperature to above their dew point, with the result that all moisture is vaporized prior to the reuniting of the two streams.

In all respects except those specifically discussed above, the system of Figs. 3 and 4 is constructed and functions

in substantially the same manner as the first described system.

In both forms of the invention, the division of the gases into two streams not only enables extremely accurate humidity control, but also has the advantage of permitting 100% humidification of the gases in the mechanically cleaned scrubber. Such complete saturation in the scrubber has been found highly desirable for avoiding plugging problems that could not be overcome by the scraper, as for instance in the scrubber outlet duct 32 or 44.

I claim:

1. The method of removing dust and fume contaminants from high temperature gases from a Portland cement clinkering kiln that includes dividing said flow into two separate streams, passing one of said streams through a mechanically cleaned water spray type scrubber to cool, add water to, and remove some of the contaminants from said gases, vaporizing a portion of said water solely by sensible heat contained in the gases before their separating into two streams, raising the temperature of said one stream above its dew point by directing the streams while still separated along proximate paths in heat transferring relation to heat said one stream from the other, then reuniting the gas of said separated streams into a humidified, cooled and partially cleaned combined stream, and passing said combined stream through an electrical precipitator to remove further contaminants therefrom.

2. Apparatus for removing dust and fume contaminants from a flow of heated gas comprising means for dividing said flow into two separate streams, a shell through which one of said separated streams is directed, means for spraying water into the gas within said shell to remove some of the contaminants therefrom and cool and humidify the gas, a mechanical scraper in the shell acting to clean the separated contaminants from the wall thereof, conduit means then directing said streams together into a combined stream, and an electrical precipitator into which said combined stream flows from said conduit means and operating to remove contaminants therefrom.

3. Apparatus for removing dust and fume contaminants from a flow of heated gases from a Portland cement clinkering kiln comprising a discharge duct leading from said kiln and dividing into two branches to divide the flow into two separate streams, a scrubber shell through which one of said streams is directed, means for spraying water into the gas within said shell to remove some of the contaminants therefrom and cool and humidify the gas, a mechanical scraper in the shell acting to clean the separated contaminants from the wall thereof, conduit means then directing said streams together into a combined stream, and an electrical precipitator into which said combined stream flows from said conduit means and operating to remove contaminants therefrom.

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