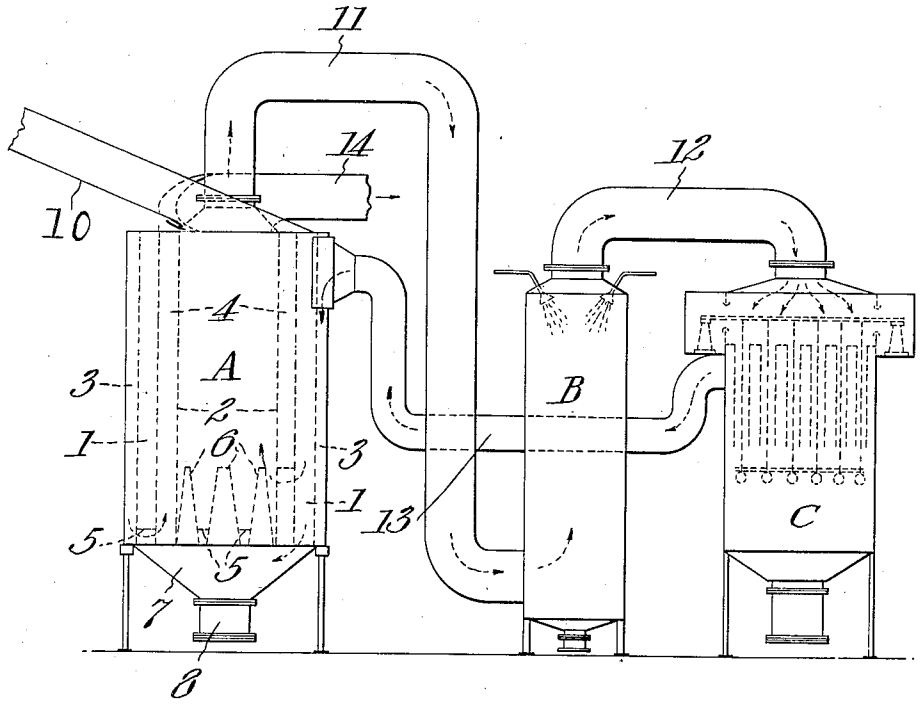
June 6, 1933. A. F. MESTON 1,912,381

COMBINED HEAT EXCHANGER AND DRY CLEANER

Filed March 26, 1930 2 Sheets-Sheet 1

Fig. 1.




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Fig. 2.

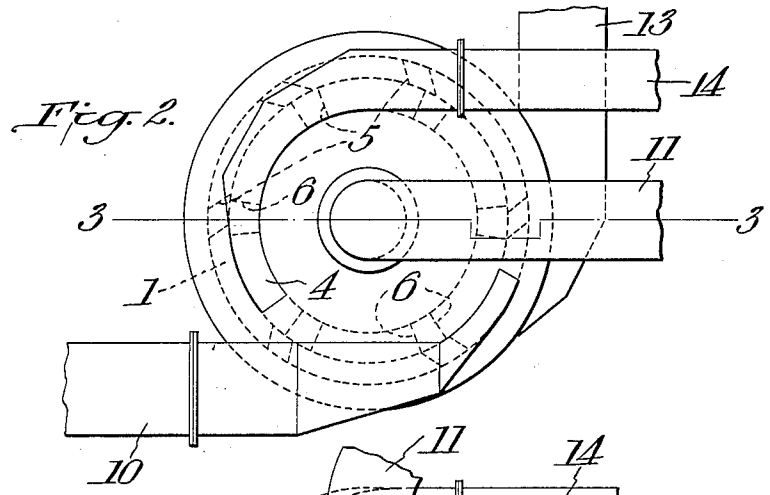
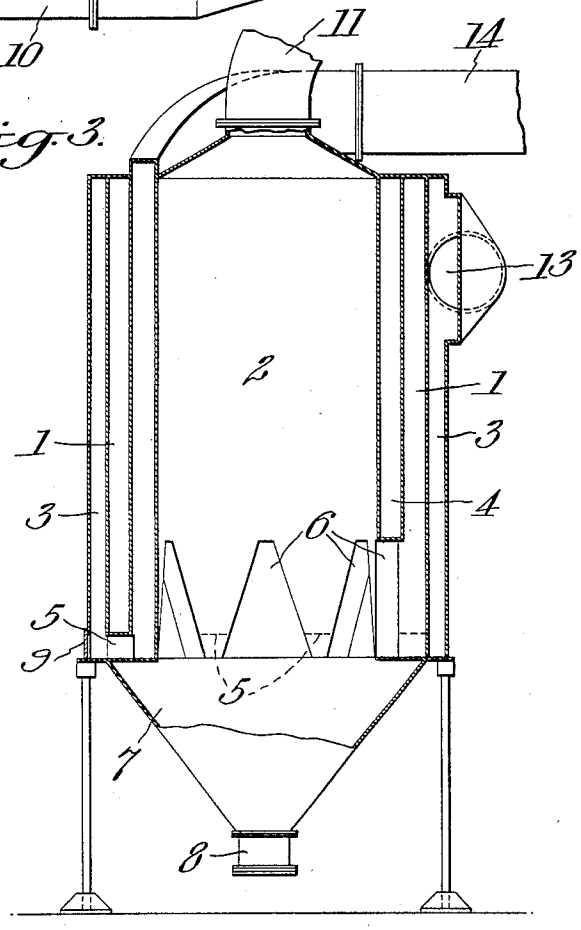



Fig. 3.




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Patented June 6, 1933

1,912,381

# UNITED STATES PATENT OFFICE

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## COMBINED HEAT EXCHANGER AND DRY CLEANER

Application filed March 26, 1930. Serial No. 439,161.

This invention relates to a heat exchanger for gases which is so constructed that it also functions as a gas cleaning means.

The general object of my invention is to provide apparatus for transferring heat from one stream of gases to another stream of gases while simultaneously removing suspended particles from at least one of the gas streams.

The particular object of my invention is to provide efficient and compact apparatus in which the same surfaces which confine and direct the stream of dirty gases in a manner conducive to dust removal are utilized for the conduction of heat.

A further object of my invention is to make possible the return of valuable sensible heat to gases after they have been cooled for cleaning at low temperature.

The invention is particularly valuable in the cleaning of blast furnace gases which are to be used as fuel in heating stoves and under boilers. These gases leave the top of the blast furnace at temperatures varying from 375° F. to 1100° F. depending upon the ore used and the practice followed in the operation of the furnace. The gases are very dirty. They carry in suspension large amounts of finely divided ore dust, fume particles, and pieces of coke and ore that are blown through the furnace charge by the blast. Before the gases can be used as fuel they must be cleaned. In practically all blast furnace installations the first step in gas cleaning is the use of a dry settler. The usual form of the settler is a round vertical shell which utilizes to some degree the centrifugal action of the cyclone dust catcher. Coke and ore particles and considerable dust is removed in this settler. In some installations, 50% or even more of the dirt, by weight, is removed in the settler. It provides, therefore, an important step in the cleaning of blast furnace gases, and should be retained in some form in any system directed toward the cleaning of such gases.

Because the fine particles are not removed in the dry settler, additional cleaning means are provided. The apparatus that follows the dry settler may also clean the gases while they are hot and dry or the apparatus may utilize water washing and clean the gases wet and at comparatively low temperatures. A common method of cleaning the gases is to pass them through spray towers, as is well known by those versed in the art; or the gases may be cooled and humidified and cleaned by electrical precipitation apparatus at low temperatures.

My invention can be used to special advantage in combination with cleaning methods and apparatus which treat the gases at relatively low temperatures,—for example, temperatures that are more than 200° F. below the temperature of the downcomer gases. If downcomer gases at 450° F. are wet washed and cooled to 100° F., it is apparent that a great deal of sensible heat goes out in the cooling and wash water. But if the washed gases can be raised 100 to 200° F. in temperature before they reach the burners, an appreciable amount of sensible heat will be recovered. And if the hot dirty gases can be cooled to an equal extent before they reach the washer, the gases can be made ready for cold wet cleaning with a small amount of cooling water.

A specific embodiment of my invention is shown for purposes of illustration in the accompanying drawings in which:

Fig. 1 represents a system for cleaning gases including a combination heat exchanger and dust catcher embodying the invention;

Fig. 2 is a plan of a form of the combination heat exchanger and dust catcher of the invention; and

Fig. 3 is an elevation in partial section of the form shown in Fig. 2.

A system which utilizes the savings in heat and cooling water made possible by my invention is shown in Fig. 1. The combined heat exchanger and dust catcher which comprises my invention is shown at A connected by gas conducting flues to water tower B and electrical precipitator C. The hot, dirty, or so-called "raw" gas comes down from the top of the blast furnace in pipe 10, enters and passes down space 1, turns at the bottom of the space and rises in space 2, leaves the exchanger through pipe 11, enters near the bot-

tom of wash tower B, leaves the wash tower through pipe 12 and enters the electrical precipitator C. The gases return from electrical precipitator C by pipe 13, enter the concentric passage 3 of exchanger A, pass to the bottom of passage 3, enter passage 4 and rise to the top of this passage to leave the exchanger by pipe 14.

In apparatus A, the heavy dust is removed from the gases and the gases are partially cooled as they pass over surfaces which are exposed on the other side to cooler gases. When these partially cooled and partially cleaned gases enter the spray chamber B, they are further cooled, partially washed, and supersaturated with moisture. The electrical precipitator throws out the entrained moisture and suspended dust or mud in the gases which come over in pipe 12. This is a downdraft precipitator and so it is easy for the sludge that is thrown out near the top of the pipes to slide down and push down all precipitated dirt with it into the sump. The clean, cool, saturated gases return to the heat exchanger through pipe 13 and are heated in passing through 3 and 4 where they are in heat exchange relationship with the hotter gases passing in 1 and 2.

This combination of apparatus uses all the equipment in a very efficient manner. The exchanger A receives the gases at a velocity which is well adapted for the removal of the heavy particles. The particles are removed hot and dry and can be taken from the bottom of the hopper 7 in the same manner that they are removed from any dry dust settler. This same high velocity gives as efficient heat exchange as sturdy and easily cleaned apparatus of this general character can provide. The temperature of the gases is reduced in the heat exchanger to a temperature which makes humidification in tower B easily attained without excess of water. Automatic means (not shown) can be provided which will regulate the amount of water in accordance with the temperature and humidity required in the gases. There is no need for water washing in this tower because the precipitator follows it and it can be made to cool and humidify as intended without the use of vanes or moving parts or any of the other means which are provided to make water washing more efficient but which set up a great resistance to the flow of gases or require a great deal of power. The precipitator receives gases that are cool and of small volume, which permits this apparatus to be of minimum size. The gases come to the precipitator moist and preferably supersaturated. Such gases are usually of proper conductivity for cleaning by the well known electrical method described in the patent to Cottrell, No. 895,729. The dust thrown out is moist and conducting, which is also a favorable condition for electrical precipitation. By carrying over a sufficient amount of moisture as a mist, or by spraying this needed moisture into the top header of the precipitator and precipitator this moisture with the dust, the precipitator is made self-cleaning as described in the patent to Meston, No. 1,329,844.

The temperature of the gases leaving the precipitator is purposely low,— 90°–110° F. The gases leave saturated with moisture, and, as cold gases require much less moisture for saturation than do hot gases, it is possible to reduce the moisture content of the gases by passing them through the electrical precipitator which throws out all the moisture not required for saturation (or 100% relative humidity) at the low temperature.

The coefficients for gas-steel-gas heat transfer apparatus are low and large surfaces are required to transfer the heat available in the hot dirty gases to the cold clean gases. The amount of heat transferred per hour per square foot of surface depends upon the velocity of the gases past the surfaces and the temperature difference between the hot and cold gases. The higher the velocity of the gases (until a very high velocity is reached) the greater the heat transfer, but the power required to move the gases goes up rapidly with increasing velocity and it soon becomes uneconomical to further increase the gas velocity past the heat conducting surfaces in order to obtain the transfer of additional heat. I have found that a velocity of from 30 to 70 feet per second covers the economical range for heat transfer in this type of exchanger and that in this range of velocities there is obtained the proper centrifugal action which is necessary to get a removal of the gas by cyclonic effect.

The amount of surface, provided by steel plates, which it is economical to use in a heat exchanger, also reaches an economical limit. This is true from the standpoint of cost of the steel structure and also from the standpoint of space required. The present invention was conceived with the above considerations in mind. The apparatus can occupy the same space now occupied by the usual dry settler. The shell of a settler as now installed may be used as the outer shell of the combined heat exchanger and dust catcher which comprises my invention.

One embodiment of the invention is shown in Figs. 2 and 3, in which 10 is the pipe from the top of the blast furnace through which the hot dirty or raw gas enters the exchanger. The exchanger is made up of four cylindrical shells and in between the shells there are annular spaces for the flow of gases. The hot gases entering through 10 are projected in a downward direction into space 1, go down through this space with a helical path which sets up an appreciable centrifugal force and throws the heavy suspended particles to the outer surface of the path. Near the bottom

of the passageway are communicating openings 6 which let the gas flow from space 1 into space 2. These communicating passages are tapered and are formed in such a way that they pass through space 3 but do not communicate with space 3. Only a small part of the gas goes through the upper part of the passages and enters 2, but as the gases in space 1 go farther down the space, the velocity becomes less, the passageways become wider, and more and more gas goes through the passageways into space 2. Finally at the bottom of space 1 the remaining gases go into a conical space 7 and there complete the turn in a suitable vortex and ascend passage 2. It is essential in this type of apparatus that the gases be allowed to slow down and assume a peculiar motion while making the turn; otherwise eddy currents start up which mix the dust, which has been sliding down the outer surface of the chamber, with the upturning gases and again carry the dust along with the gases. In this apparatus the space in the cone with the combined areas of passages 6 at the bottom of space 1, is so great that the velocity, as the gas turns and goes from 1 to 2, is under four feet a second. The removed material finds its way into hopper 7 from which it is removed by a special gas-tight gate 8.

The partially cleaned gases leave the exchanger through pipe 11 at the top of the apparatus. Cool gases returning from the secondary cleaning apparatus enter the exchanger through pipe 13 which communicates with space 3. The gases are liberated tangent to the annular passage 3 and find a helical path down around space 4 to the bottom of the space. Here are a number of passageways 5 leading from space 3 under, but not communicating with, space 1 and into space 4. The gases ascend in space 4 and leave the apparatus through pipe 14. The scouring action of the gases as they pass over the surfaces keeps the surfaces clean. However, if at any time an examination has to be made or the surfaces are to be cleaned, the gases can be by-passed from pipe 10 to pipe 11 and from pipe 13 to pipe 14 (through pipes and valves not shown), the apparatus can be blown free from combustion gases with steam or air and the apparatus entered for inspection. The spaces used for the passage of gases are made wide enough to permit the entry of a man, not less than 15 inches wide and preferably between 18 and 24 inches. At the time of such an inspection the walls can be brushed clean or blown down with a hose. The apparatus is then sealed up, the air blown out with steam, and the gases again admitted and allowed to flow through as before.

Cleanout holes 9 are opposite the passages 5 and any solid material that might collect in the passages 3 and 4 can be removed through these holes.

When the gases are received at very high temperature, the pipe 10 and the first passage in the exchanger 1 can be brick lined. The apparatus as shown has the hot gases in an inner space so that the radiation losses to the outside air will not be as great as if these hot gases were in the outer shell. In fact, the cold gases coming from the secondary cleaning apparatus are purposely put in the outside shell so that the lagging required for heat insulation will be a minimum. This arrangement is not necessarily the one to be followed in the construction of the apparatus, but is the arrangement recommended because I have found it minimizes the heat losses in the apparatus.

Apparatus embodying my invention may be constructed according to various designs. The cyclone type dust catcher in a cylindrical shell has been used to illustrate the invention because of its suitability to the important field of conditioning blast furnace gases, but I do not limit myself to a construction using cyclonic action. Any construction utilizing centrifugal force as a means of throwing out the dust particles can be used. Nor do I limit myself to the reheating of the previously cooled gas. Different gases can be heated or cooled in apparatus embodying my invention and more than two gas streams can be simultaneously passed through apparatus of the general character described.

I claim:

1. Apparatus for cleaning gases comprising a plurality of concentric heat-conducting cylindrical walls providing a plurality of concentric chambers, a plurality of conduits serially connecting the lower ends of alternate chambers to form at least two non-communicating gas passages in heat interchange relationship and separate flue connections for the passage of gas connected with the upper end of each of said passages.

2. Apparatus for cleaning gases comprising a plurality of concentric heat-conducting cylindrical walls providing a plurality of concentric chambers, a plurality of conduits serially connecting the lower ends of alternate chambers to form at least two non-communicating gas passages in heat interchange relationship, means defining a conical dust collecting chamber communicating with the lower portion of one of said gas passages, and separate flue connections for the passage of gas connected with the upper end of each of said passages.

3. Apparatus for cleaning gases comprising a plurality of concentric heat-conducting cylindrical walls providing a plurality of concentric chambers, a plurality of conduits connecting the lower ends of alternate chambers to form at least two non-communicating gas passages in heat interchange relation-

ship, and means for tangentially admitting gas into each of said passages.

4. A method of conditioning hot gas containing suspended particles which comprises passing the hot gas as a confined stream through a dust arrester of the cyclone type and simultaneously removing heat from said hot gas by passing a continuous stream of colder gas in heat interchange relationship consecutively over first one and then the other of the boundaries of said stream of hot gas.

5. A method of conditioning hot gas containing suspended particles which comprises directing the hot gas in a confined vortical stream in heat exchange relationship with a continuous stream of cold gas passing consecutively over the inner and outer boundaries of said vortical stream of hot gas.

6. Apparatus for the exchange of heat between two streams of gas comprising a plurality of heat-conductive walls defining four concentric chambers, connected at their lower ends so as to cause one gas stream to flow serially through two alternate chambers and the other gas stream to flow serially through the other two alternate chambers in a continuous spiral path.

7. Apparatus for the exchange of heat between two streams of gas comprising a plurality of heat-conductive walls defining four concentric chambers, connected at their lower ends so as to cause one gas stream to flow serially through two alternate chambers and the other gas stream to flow serially through the other two alternate chambers, the connecting means between the chambers through which the hotter gas flows comprising a dust hopper, and the connecting means between the chambers through which the colder gas flows comprising a plurality of conduits at the lower ends of said chamber.

8. Apparatus for cleaning gases comprising four concentric cylindrical heat-conducting walls defining a central chamber and three annular chambers concentrically surrounding said central chamber, end members closing said chambers at the top and bottom thereof, a conduit connected to the upper end of the outermost of said annular chambers, a plurality of conduits connecting the lower end of said outermost annular chamber with the lower end of the innermost of said annular chambers, and a conduit connected to the upper end of said innermost annular chamber whereby said outermost and innermost annular chambers form an interconnected passage for gases, a conduit connected to the upper end of the intermediate annular chamber, a plurality of conduits connecting the lower end of said intermediate annular chamber with the lower end of the central chamber, and a conduit connected to the upper end of said central chamber, whereby said intermediate annular chamber and said central chamber form a further interconnected passage for gas in heat transfer relation to the first-defined passage for gases.

9. Apparatus for cleaning gases comprising four concentric cylindrical heat-conducting walls defining a central chamber and three annular chambers concentrically surrounding said central chamber, end members closing said chambers at the top and bottom thereof, the end member closing the bottom of the central chamber defining a conical dust collecting chamber, a conduit connected to the upper end of the outermost of said annular chambers, a plurality of conduits connecting the lower end of said outermost annular chamber with the lower end of the innermost of said annular chambers, and a conduit connected to the upper end of said innermost annular chamber, whereby said outermost and innermost annular chambers form an interconnected passage for gases, a conduit connected to the upper end of the intermediate annular chamber, a plurality of conduits connecting the lower end of said intermediate annular chamber with the lower end of the central chamber, and a conduit connected to the upper end of said central chamber, whereby said intermediate annular chamber and said central chamber form a further interconnected passage for gas in heat transfer relation to the first-defined passage for gases.

10. A method of conditioning hot gas containing suspended particles which comprises passing the hot gas as a confined stream through a dust arrester of the cyclone type and simultaneously removing heat from said hot gas by passing a continuous stream of colder gas with a velocity of from 30 to 70 feet per second in heat interchange relationship consecutively over first one and then the other of the boundaries of said stream of hot gas.

In testimony whereof, I affix my signature.

ARCHIBALD F. MESTON.