Sept. 22, 1925. 1,554,854

O. HUBMANN

PROCESS OF AND APPARATUS FOR DRYING COMBUSTIBLE MATERIAL BY MEANS OF FIRE GASES

Filed June 5, 1924. 3 Sheets-Sheet 1

Fig. 1.

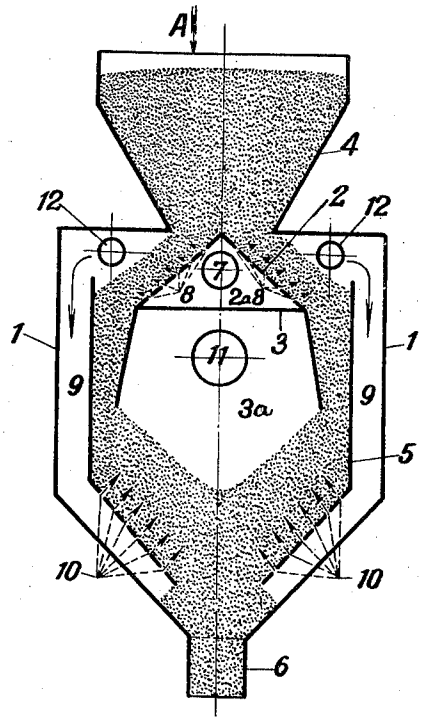
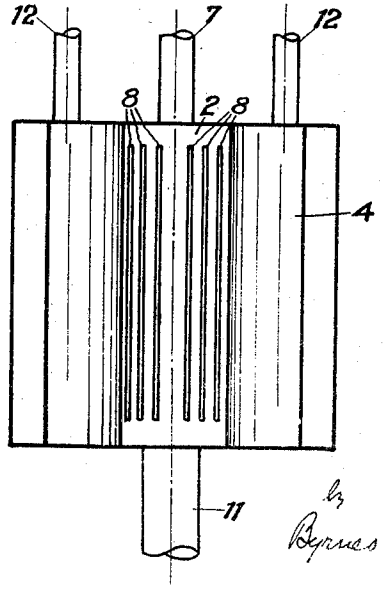



Fig. 5.




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Fig. 2.

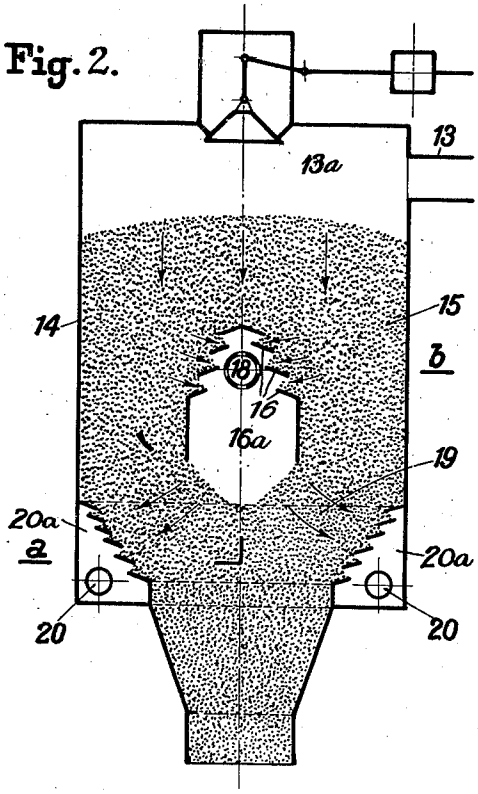
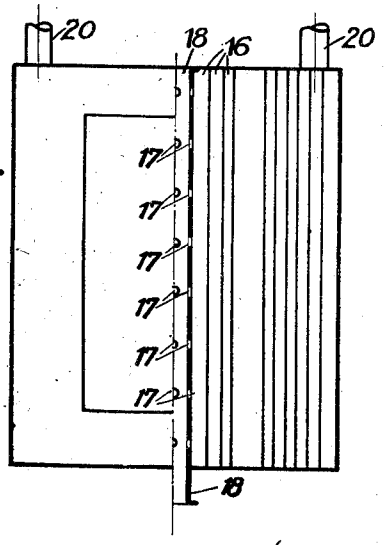



Fig. 6. (a-b)




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Fig.3.

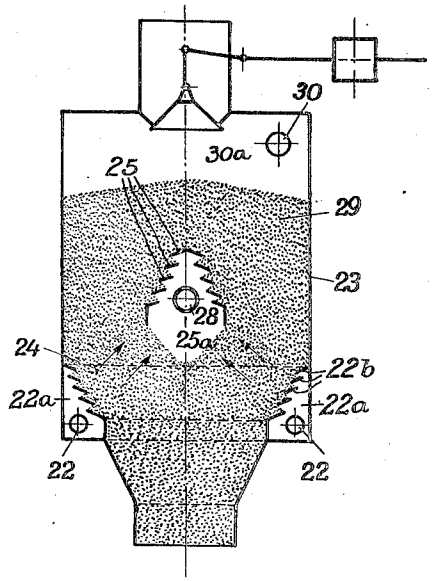
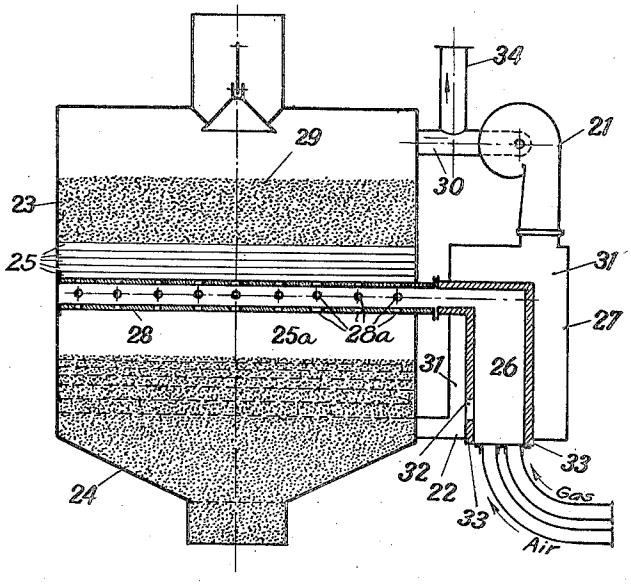



Fig.4.




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# UNITED STATES PATENT OFFICE.

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## PROCESS OF AND APPARATUS FOR DRYING COMBUSTIBLE MATERIAL BY MEANS OF FIRE GASES.

Application filed June 5, 1924. Serial No. 718,145.

*To all whom it may concern:*

Be it known that I, OTTO HUBMANN, a citizen of Germany, residing at Frankfort-on-Main, Gervinusstrasse 17, Germany, have invented certain new and useful Improvements in Processes of and Apparatus for Drying Combustible Material by Means of Fire Gases, of which the following is a specification.

This invention relates to a process of and apparatus for the drying of combustible material by means of fire gases.

In connection with shaft driers for directly drying combustible material by means of fire gases it has heretofore been necessary to carefully regulate the temperature of the drying gases to avoid gasification which sets in when the temperature rises above 300° C. and to avoid, in particular, combustion which according to experience often occurs in connection with fire gases of relatively high oxygen content.

It is the principal object of this invention to make it possible to use fire gases of high temperatures and of high oxygen content for directly drying combustible material in shaft driers or the like without the injurious results heretofore experienced.

The invention, the principles upon which it is based and the material advantages derived therefrom may be readily understood from the specification in connection with the accompanying drawings, in which:

Fig. 1 is a more or less schematic representation of a shaft drier embodying the invention;

Fig. 2 is a modification thereof; and

Figs. 3 and 4 are schematic end and side views showing another form.

Fig. 5 is a top plan of Fig. 1, and

Fig. 6 is a section on the plane *a*—*b* of Fig. 2.

Having reference to Figs. 1 and 5, the drying chamber 1 has at its top a hopper 4 and at its bottom an outlet 6.

Within the chamber 1 are disposed various casings prescribing a definite path for the material to be dried and definite conduits for the drying gases according to the principles of the invention. A deflector 2 having the shape of a roof extends between opposite walls of the chamber 1 and its crest is substantially centrally disposed relatively to the hopper so that the material flowing from the hopper is deflected in opposite directions. Partitions 5 extending parallel to the roof 2 from near the top wall of the chamber 1 to near the outlet 6 define in conjunction with the roof 2 passage-ways for the material and define in conjunction with the walls of the chamber from which they are spaced gas conduits 9. The bottom portions of the partitions are funnel-shaped to direct the material toward the outlet 6 and also the bottom portions of the chamber walls opposite the partitions 5 are preferably funnel-shaped as shown. The space within the roof is divided into two parts by a transverse partition 3, creating two separate gas spaces $2^a$ and $3^a$, respectively. In communication with the gas space $2^a$ is a pipe 7 through which the hot fire gases enter while a pipe 11 conducts gases out of the gas space $3^a$.

The upper portion of the roof 2, i. e. the portion above the partition 3, is perforated as indicated by the slits 8. Also the lower portions of the partitions 5 are perforated as indicated by the slits 10.

The operation is as follows:

The hot fire gases entering through pipe 7 into the gas space $2^a$ pass through the slits 8 or other suitable perforations into and through the material upon the roof, then flow over the upper edges of the partitions 5 downwardly through the conduits 9 and through the slits or other like apertures 10 upwardly through the descending material into the gas space $3^a$ from which they are drawn off through pipe 11.

By means of pipes 12 leading into the gas spaces above the upper edges of partitions 5 the heat of the gases coming out of the first drying zone may be replenished by the addition of hot gases before they pass through the second drying zone.

The hot fire gases are thus first brought into contact with the fresh relatively wet material where the danger of combustion is relatively small. The temperature may be the higher the greater the rate of movement of the material in its downward course. The cross-sectional area of the column of the material and its rate of movement may, of course, be adjusted to best suit the conditions desired. There is considerable room for making adjustments in this respect by the relative position of the roof 2, the parti-

tions 5 and the inlet opening through the hopper 4.

The temperature of the gas entering into the second drying zone, on the other hand, must be kept below the limit at which the partly dried material begins to volatilize. This condition is, of course, generally satisfied by cooling of the hot fire gases in passing through the first drying zone. By making the proper disposition in regard to the rate of movement, cross-section of material etc., as previously referred to, the conditions in the first zone may be so adjusted that the gases entering through slits 10 into the second drying zone have substantially the desired critical temperature. However, it is generally safer to adjust the conditions in the primary drying zone so that the gas issuing therefrom is slightly below the critical temperature and to bring the cooled gases up to the latter by admixing in proper proportion additional hot gases through pipes 12 or imparting additional heat in any other of the many well known ways. Regulation of the temperature of the gases passing into the second drying zone, in the manner and by the means suggested, is thus a relatively simple matter. It is, of course, unnecessary so far as the specific subject matter of the invention is concerned to refer to the availability of temperature indicators and translating mechanism for controlling temperature conditions.

The relation of parts, as indicated in Fig. 1 is such that assuming the material is fed into and discharged from the apparatus at substantially the same rate, the rate of movement is much slower in the lower part of the apparatus, i. e. in the second drying zone than in the upper part or the first drying zone.

The material in the second drying zone forms a much thicker layer to be penetrated by the gases. This is possible because of the fact that the material entering the second drying zone has been thoroughly preheated and the gradient of cooling of the gas is therefore decreased in proportion.

By dividing the drying process into two operations, as indicated, it is thus not only easily possible to reduce the danger of combustion, but the drying operations may be so balanced in the manner referred to as to obtain a most economical working condition.

The dust that may be carried along by the gases issuing from the first drying zone due to a relatively high velocity of the gases passing through the relatively thin layer of material is again reincorporated in the material leaving the second drying zone. This is facilitated by the abrupt changes of direction in the flow of the gas between the first and the second drying zone. The kinetic energy that the dust particles may have initially acquired is more or less destroyed by the deflections of the gas current so that a gravity separation in the conduit 9 prevents clogging of the slits 10. The dust drops to the bottom of conduit 9 and is discharged together with the material.

In the second drying zone is comparatively little tendency of dust formation since the temperature is lower and the velocity of the gases in passing through a larger area and a thicker layer is materially reduced.

The arrangement in Fig. 2 is essentially similar to that in Fig. 1. The hot fire gases pass through pipe 13 into the gas space $13^a$ maintained above the charge in the chamber 14 and then penetrate the charge in downward direction. More or less in the center of the charge is a gas space $16^a$ created by deflector 16, the upper portion of which is perforated. The hot gases passing through the upper portion of the charge therefore following the path of least resistance flow into the gas space $16^a$.

On opposite sides in the lower part of the chamber 14 are gas spaces $20^a$ from which gas is withdrawn through pipes 20.

The gas in gas space $16^a$ thus flows through the columns of material in the lower part of the chamber to the gas spaces $20^a$.

The arrangement just described, like the arrangement in Fig. 1, has a first drying zone (15) and a second drying zone (19).

By means of an auxiliary pipe 18 leading into the gas space $16^a$ the temperature of the gases entering the second drying zone may be regulated in the manner previously described.

In order to effect a thorough mixing of the hot gases introduced through pipe 18 into the gas space $16^a$, with the cooled gases coming from the first drying zone, the pipe 18 may extend throughout the length of the gas space 16 and may be provided with a plurality of small openings 17, see Fig. 6 through which the gas may be forced at high velocity.

The apparatus shown in Figs. 3 and 4 is substantially the same as that in Fig. 2 and the arrangement disclosed differs only in the sense that the drying gas is passed through the charge in counter current relation while in Fig. 2 the current of gas is passed in the same direction as the material.

More or less centrally in the charge in chamber 23 is a gas space $25^a$ throughout the length of which extends a pipe 28 provided with small apertures $28^a$. The hot fire gases coming from the combustion chamber 26 enter the gas space $25^a$ through the apertures $28^a$ and then pass upwardly through the grate-like construction of the deflector 25 into and through the charge 29 above into the gas space $30^a$ from which they are withdrawn through pipe 30 by a blower 21 or the like and forced through a chamber 31

surrounding the combustion chamber 26 and pipes 22 into gas spaces $22^a$ corresponding to gas spaces $20^a$ in Fig. 2. From gas spaces $22^a$ the gases pass through the grate-like members $22^b$ into the second drying zone 24 and then penetrating the charge therein arrive in gas space $25^a$ where they mingle with the hot gas issuing from pipe 28 and in conjunction therewith pass through the first drying zone. The regenerating chamber 31 brings the cooled gas coming from the first zone into contact with the combustion chamber 26. By this disposition it serves as a heat insulator for the combustion chamber and the heat energy given off therefrom is utilized for reheating the gas cooled during its passage through the first drying zone.

A communication 32 between the combustion chamber and the regenerating chamber 31 may be used or adjusted to bring the temperature of the gas to the desired temperature before it enters the pipes 22, in case the heat exchange through the walls of the combustion chamber should not be sufficient.

When the apparatus just described is in normal working condition, the drying gas consists of water vapor and products of combustion. The volume of the gas stream maintained by the blower 21 is, of course, considerably greater than the volume of the gas stream generated in the combustion chamber. The excess gas which corresponds generally to the rate of gas production in the chamber 26 and the rate at which water is absorbed in the drying zones may be allowed to pass out of the circulating system at any suitable point, for instance through the pipe 34.

The high percentage of water vapor in the drying gas is particularly favorable for the drying operation inasmuch as it avoids physical disintegration of the material due to thermal action.

The apertures $28^a$ may be arranged in various ways, either to bring about thorough mixing or to more concentrate the hot gases in certain directions where a relatively greater drying action is required.

The circulating system shown in Fig. 4, including means for effecting heat regeneration and for carrying off the excess gas may be considered as generally typical also for the operation of the apparatus disclosed in Figs. 1 and 2 or other forms embodying the invention.

In the foregoing reference has been made to only two drying zones or two steps in the drying operation. It is understood that the principle disclosed can be applied to a larger number, although of course a practical limit is set by other considerations. Generally, such limit is reached when the increased working capacity and the increased degree of efficiency due to a multiplication of the drying steps or drying zones is offset by mechanical complexity and increased first cost.

Claims:

1. Process of drying combustible material, which consists in maintaining a column of material by adding fresh material thereto and discharging dried material therefrom, passing hot gases through a region of the column, imparting additional heat to gases issuing from the said region by admixing hot gases therewith and passing the resultant mixture of gases through another region of said column.

2. Process of drying combustible material, which consists in maintaining a column of material by adding fresh material thereto and discharging dried material therefrom, maintaining a stream of hot gases, passing said gases through a region of the column, then passing at least part of the gases issuing from the said region through the next region of the column and returning at least part of the gases issuing from the last region to the said stream of hot gases.

3. Process of drying combustible material, which consists in maintaining a column of material by adding fresh material thereto and discharging dried material therefrom, maintaining a stream of hot gases, passing said gases through a region of the column, then imparting additional heat to at least part of the gases issuing from said region, passing the same in the same manner through the next regions of the column and returning at least part of the gases issuing from the last region to the said stream of hot gases.

4. Apparatus for drying material comprising means for maintaining a column of material including means for adding fresh material and removing dry material, means for passing a stream of gases through a plurality of regions of the material, and means for imparting heat to said stream of gases comprising means for admixing hot gases therewith at points intermediate said regions.

5. Apparatus as defined in claim 4 comprising also means for returning at least part of the gases issuing from one of said drying regions to said stream of gases.

6. Process of drying solid combustible material which consists in establishing a moving column thereof, maintaining said column by feeding fresh material thereto and withdrawing dried material therefrom, passing a stream of gases through said column, and imparting heat to said gases by admixing hot gases therewith within said column.

7. Process of drying solid combustible material which consists in establishing a moving column thereof, maintaining said column by feeding fresh material thereto and withdrawing dried material therefrom,

passing a stream of gases into, through and out of said column, imparting heat to said gases within said column, and returning at least a portion of the gases issuing from said column to the stream of gases entering said column.

8. Process of drying solid combustible material which consists in establishing a moving column thereof, maintaining said column by feeding fresh material thereto and withdrawing dried material therefrom, passing a stream of hot gases into, through and out of said column, delivering hot gases from a generator thereof into said stream of gases within said column, bringing a portion at least of the stream of gases issuing from said column into heat transfer relation to said generator, and delivering the resulting gases into the stream of gases passing into said column.

9. Apparatus for drying solid combustible material comprising means for maintaining a moving column of material to be dried, said means including a chamber and means for supplying fresh material thereto and means for withdrawing dried material therefrom, means for passing a stream of gases through said chamber, and means within said chamber for introducing hot gases into said stream of gases.

10. Apparatus for drying solid material as defined in claim 9 in which said means for imparting heat comprises means for maintaining an open gas space within said chamber, and a gas supply conduit opening into said space.

11. Apparatus for drying solid combustible material comprising means for maintaining a moving column of material to be dried, said means comprising a chamber and means for supplying fresh material thereto and means for withdrawing dried material therefrom, means for passing a stream of gases into, through and out of said chamber, means for imparting heat to said gases comprising means for maintaining an open gas space within said chamber, a generator for hot gases, and means for delivering gases therefrom into said open gas space, and means for returning at least part of the gases issuing from said chamber to the stream of gases entering said chamber.

12. Apparatus for drying solid combustible material as defined in claim 11 in which said means for returning at least a part of the gases issuing from the chamber to the stream of gases entering the chamber includes a jacket surrounding said hot gas generator.

13. Process of drying combustible material, which consists in maintaining a column of material by adding fresh material thereto and discharging dried material therefrom, passing heated gases through a portion of the column, returning a portion of said gases to another portion of the column, and permitting the returned gases to mingle within the column with the heated gases supplied thereto.

14. Process of drying combustible material, which consists in maintaining a column of material by adding fresh material thereto and discharging dried material therefrom, passing heated gases through a portion of the column containing relatively wet material, returning a portion of said gases to another portion of the column containing relatively dry material, and permitting the returned gases to mingle within the column with the heated gases supplied thereto.

15. Apparatus for drying solid material comprising a hollow shaft and means for maintaining a moving column of material therein, means for maintaining an open gas space within said column, said gas space dividing said column into two zones, means for delivering hot gases from a combustion chamber into said gas space, means for passing a stream of gases through one of said zones said gas space and the other of said zones successively, and means for returning at least a portion of the gases issuing from said other of said zones into said stream of gases including a jacket surrounding said combustion chamber.

In testimony whereof I affix my signature.

OTTO HUBMANN.