May 22, 1951 J. W. AYERS 2,554,450

FIRE-AVOIDING GRINDING AND CLASSIFYING SYSTEM AND PROCESS

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Fig. 1.

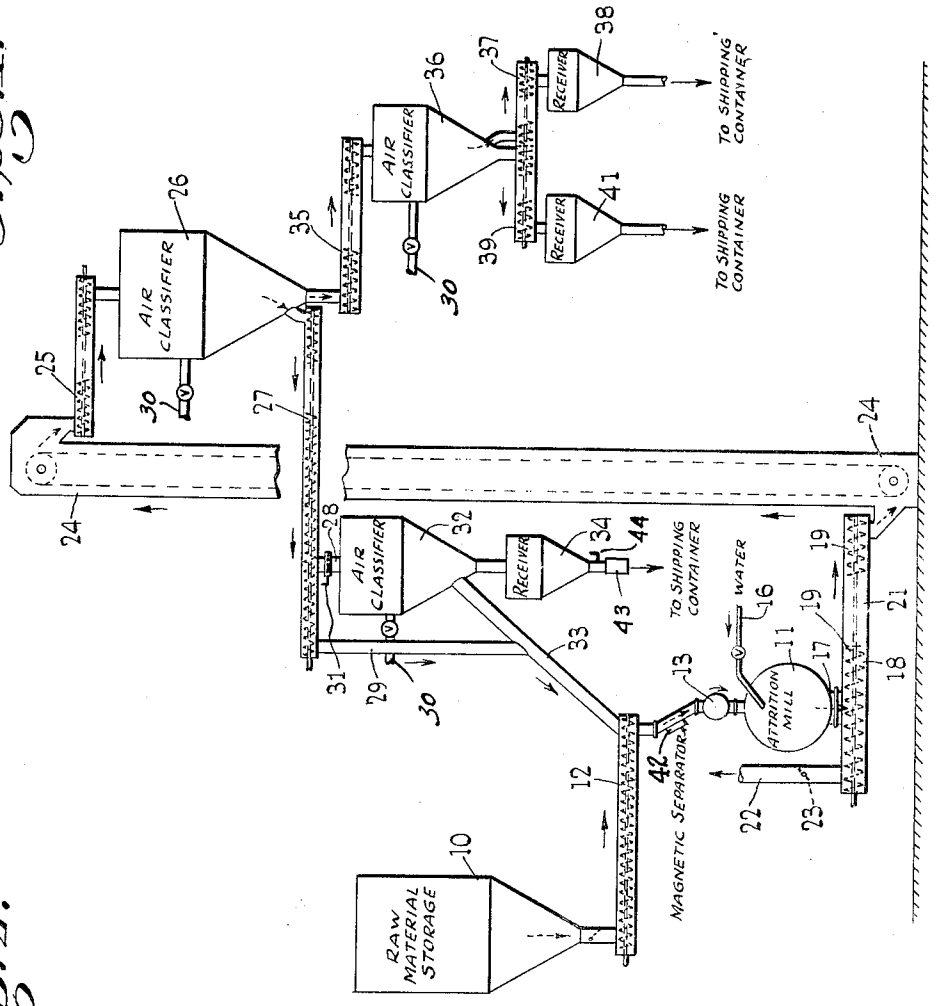
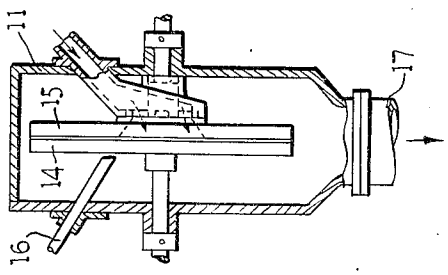


Fig. 2.



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FIRE-AVOIDING GRINDING AND CLASSIFYING SYSTEM AND PROCESS

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15 Claims. (Cl. 241—17)

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This invention relates to process and apparatus for the grinding and classifying of combustible materials and more particularly to the production of finely ground combustible material by a process including grading as to particle size in a centrifugal air separator system wherein danger of fires, explosions or deterioration due to oxidation of the ground material during the classification and as well during the grinding and the conveying thereof is avoided.

In my co-pending application Serial No. 683,768 filed July 15, 1946, I described and claimed a process for producing fine particle size powders and industrial flours wherein natural organic combustible material is ground in a hot operating grinding mill in a superatmospheric pressure of steam generated by vaporization of water in the mill, which vaporization serves not only to take up the excess heat generated by friction in the mill but also to provide steam in an unfailing amount which positively excludes oxygen from contact with the ground material. The process of the present invention, in its preferred embodiment, includes the process of the said application as its initial step. In its broader aspect the invention is independent of any specific procedure for grinding the combustible material so long as particles of considerable fineness of about 100 mesh or smaller are produced under conditions requiring exclusion of oxygen from the ground material until cooling has occurred.

Finely ground combustible material discharged from conventional grinding mills ordinarily requires classification to obtain products of more uniform size to meet specifications for the various industrial uses. A typical screen analysis of a finely divided combustible material produced by or utilized within the process of the invention is as follows:

Mesh Size	Particle Size in Microns	Per cent by Weight Through Screen
20	840	95.17
48	297	86.50
100	149	71.50
150	105	64.22
200	74	53.87
250	62	51.49
325	44	37.76

The classification of material of a small mesh, usually smaller than 100 mesh, may be more efficiently accomplished in centrifugal air separators than on screens. In the table below there are described typical air separators contemplated for the practice of the classification process of the present invention and their feed rates as applied to ground walnut shell flour of the size distribution described above.

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Size of Separator (Diameter)	Volumetric Capacity	Rate of Circulation within Separator	Pressure within Separator	Feed Rate in Lbs./Hr. to Separator
Feet	*Cu. ft.*	*C. f. m.*	*Inches of water*	
8	400	10,000	8	6,000–8,000
6	181	8,000	9	3,000–5,000
4	58	3,000	7	800–2,000

At the feed rates described in the above table the suspended dust concentrations in the separators are very high and are in the range of explosive dust mixtures. When explosions have occurred in equipment of this kind serious damage has resulted because of the large cubic capacity within the separators and the large quantity of dust contained therein. Since fine grinding operations ordinarily produce very hot material for classification in the separators, the separation and classification of the mill discharge is difficult and hazardous due to the danger of explosion of the hot dusts.

An object of the present invention is to provide a system for conveying and classifying finely divided combustible material to and in centrifugal air separators in which danger of fires, explosions or oxygen deterioration is avoided. It is also an object of the invention to provide a process for grinding and classifying natural organic or vegetable material wherein the said operations are economically carried out and wherein the heat of the grinding operation is employed to advantage in the subsequent conveying and classifying steps, all without the above mentioned dangers.

Broadly considered, the present invention may be said to involve an improved process of classifying finely divided combustible material in centrifugal air classifier systems wherein the ground material is conveyed and classified in an atmosphere of at least 85% relative humidity and such atmosphere is maintained at a temperature above its dew point. In a more limited embodiment, the process includes a grinding operation carried out under a superatmospheric pressure of steam wherein the hot ground material together with steam employed or generated in the mill are passed together through a centrifugal air classi-

fier system wherein the atmosphere is at a relative humidity of at least 85% and the temperature is maintained above the dew point as a result of heat developed in the grinding operation.

Experimentation has demonstrated that if the relative humidity of the atmosphere in the classifying system is maintained as high as the above-mentioned 85%, explosions will not occur regardless of the dust concentration in the atmosphere.

In a specific embodiment of the invention, English walnut shells in their normal air-dry condition containing 8 to 10% moisture were fed to a grinding mill and ground therein in accordance with the process disclosed in the hereinbefore mentioned co-pending application. The moisture content is generally reduced during the grinding operation to 2 to 4% and the hot dry ground product obtained hence is in substantially dry form and may contain from 2 to 10% moisture. By operating the mill at a temperature of approximately 275° F. not only were conditions desirable for the satisfactory grinding of the shells maintained but also enough heat was provided in the material discharged from the mill to maintain a temperature in the conveyors and separators, in which the mill discharge was classified, high enough to prevent the precipitation of moisture from the humid atmosphere. The steam present during the grinding operation and that present in the classifying system were maintained in proper thermal balance to keep the whole system under non-explosive conditions.

Although the preferred embodiment of the invention relies only upon the heat generated by the friction in the mill for supplying the heat energy in the whole grinding and classifying system, heat may be supplied, in a less desirable embodiment, from some external source. It might be necessary in certain instances that the mill be run at a lower temperature than that which provides sufficient heat for the system and under such conditions, heat may be supplied to the system by feeding superheated steam to the separators or by externally heating the system thereby to keep the atmosphere therein above the dew point.

For accomplishing the results of the present invention the grinders, conveyers and separators must be provided with the necessary seals in order to prevent excess radiation loss, dust loss and loss of steam necessary to hold the relative humidity of the atmosphere in the separator at 85% or above. In any ordinary apparatus, the ground product, as it passes through conveyers, elevators, and separators loses heat and its temperature drops, but in the preferred process of the present invention, the initial temperature of the ground material and steam discharged therewith is sufficiently high to prevent precipitation of water anywhere in the classifying system. When the grinding mill is run at a temperature of 275° F., the separator temperature will be maintained in the neighborhood of 180° to 212° F.

In accordance with a still further embodiment of the present invention, a high feed rate to the separators is maintained by recirculating a substantial proportion of the ground material through the classification system. This recirculation step serves two important functions. The first is that such step permits the separators and also the mill to operate more efficiently and second that it returns to the separators a substantial amount of heat, thereby facilitating or permitting the maintenance of adequately high temperatures, that is above about 150° F., in the separators to avoid a cooling sufficient to permit the dew point or condensation to be reached. A small recirculating load does not have sufficient heat capacity to hold the temperatures of the separators above the dew point of the atmosphere therein because of radiation loss in the system and also the rate of production of the finished product is low, and therefore a large recirculating load ratio of at least 3 to 1 is employed in accordance with this embodiment. That is to say the recirculating load in the system is at least 3 times the weight of the finished product collected from it.

Radiation loss from the conveyers and separators may be lessened by the employment of insulation around the apparatus or around the entire system but the cost of installing such insulation and maintaining it is prohibitively high. The preferred embodiment of the present invention as hereinbefore described involving the hot grinding operation and preferably also a high recirculating load of material, is economical and more practical for maintaining sufficiently high temperatures.

In order that the invention may be more completely understood, a schematic drawing is included showing in Figure 1 a grinding, conveying and classifying system in which the present invention may be practiced. A vertical section of a suitable type grinding mill is shown in Figure 2.

With reference to the drawing, there is illustrated a feed storage hopper 10 for the raw material connected to a grinding mill 11 through a screw conveyer 12 and a rotary feed and seal valve 13. The mill 11 is of a conventional type having oppositely rotating grinding plates 14 and 15. Water serving to remove excess heat from the mill through vaporization and serving to provide a superatmosphere of steam is introduced into the mill through the valved conduit 16.

The mill is provided with an outlet 17 at its bottom for the ground material and is connected to a conveyer 18 having therein an interrupted screw 19 adapted to provide a plug seal of the ground material in the usual manner in the space 21 therebetween. In the feed end of the screw conveyer a vent pipe 22 having a regulatable valve or damper 23 is provided for maintaining a pressure of 1 to 3 pounds per square inch or more and for relieving any excess vapor pressure which may develop in the mill.

The conveyer 18, at its discharge end, is connected to an elevator 24 which at its top end connects to a plug seal conveyer 25 connected in turn at its discharge end to the primary air classifier 26.

The discharge opening on this air classifier 26 for the coarse material is connected to a plug seal conveyer 27 and to spouts 28 and 29. The spout 28 connects through a gate valve 31 to a secondary classifier 32. The spout 29 is connected with another spout 33 joined to the outlet for coarse material from the air classifier 32 and is also joined to the screw conveyer 12 leading to the grinding mill 11. The fine material classified in the classifier 32 passes to a receiver 34 from which it is discharged into shipping containers.

The primary air classifier 26 is connected at its outlet for finely ground material to a plug seal conveyer 35 which at its discharge end is connected to a secondary air classifier 36. The outlet on the air classifier 36 for the coarser material is connected to a plug seal conveyer 37 in turn connected to the receiver 38. The outlet for the finest material from the said classifier is connected through a plug seal conveyer 39 to the receiver

41. From the receivers 38 and 41 the respective materials are introduced into shipping containers. For introducing additional steam to maintain the required temperature in the system, valved steam inlets 30 are provided on the classifiers.

From the foregoing description it will be noticed that the grinding mill 11 and the air classifiers 26 and 36 are surrounded by seals such that the hereinbefore described vapor pressures may be maintained and oxygen may be excluded. Air is excluded from the classifier 32 by means of seals created by the ground material in the conveyers 27 and 12, the feed valve 13 and in the outlet of the receiver 34 the latter being provided with a conventional sleeve or sock 43 attached to the spout 34 and adapted to hang over hook 44 when not discharging.

In any typical operation of the process of the present invention wherein the product described in the table set out herein is produced, the finest ground material withdrawn from the receiver 41 is of a size which will pass through a 325 mesh screen. The next larger cut is that obtained in the receiver 38, such material being that which is between about 200 and 325 mesh. The third and coarsest cut removed from the system is that obtained in the receiver 34 and such is of a size which will pass through a 100 mesh screen but not through a 200 mesh screen.

The ground material shown in the drawing as being returned through the spout 33 to the mill 11 may, in an alternative procedure, be separated from the system and, if so desired, further classified for sale as various large size cuts.

The hereinbefore described apparatus may be provided with any additionally desired valves and seals and with the usual magnetic separator to take out stray particles of metal. Such separator is shown diagrammatically at 42.

It should be understood that the present invention is not limited to the specific procedures, conditions and apparatus herein described but that it extends to all equivalents which will occur to those skilled in the art upon consideration of the scope of the claims appended hereto.

I claim:

1. In the classification of finely divided explosive dusts of combustible material in a centrifugal air separator system, the process of avoiding fires, explosions and oxygen deterioration which comprises, conveying and classifying the material in an atmosphere of at least 85% relative humidity and at a temperature above its dew point and returning at least ¾ of the ground material from the separator again through said separator whereby a high feed rate to the separator is maintained and the heat of the returned material serves to maintain the atsmosphere in the separator at a temperature above its dew point.

2. A grinding and classifying system for combustible materials all of the elements of which are enclosed and sealed for the exclusion of air, comprising in combination, a hot-operating, dry-grinding mill of a construction capable of grinding the material to particles of explosive dust size, sealed feeding and discharge means connected thereto for the materials, inlet means for introducing H_2O into the mill, a conduit connecting the mill with a classifier for transferring the ground material, a centrifugal air classifier connected to said conduit through a sealed feeding means, separate sealed discharge means for the fine and coarse cuts connected to said classifier, and a conduit connecting the discharge means for the coarse cut to the mill through a sealed feeding means.

3. In a grinding and classifying system for combustible materials the combination which comprises, an enclosed dry-grinding mill of a type adapted to operate at temperatures above 212° F. and to grind material to particles of explosive dust size, an enclosed centrifugal air classifier, sealed feeding means connected to the mill for introducing H_2O and the material to be ground, a sealed discharge means connected to the mill, an enclosed conduit connecting the mill to the classifier for transferring the ground discharge, sealed feeding means in said conduit for introducing the material into said classifier, a sealed discharge means connected to the classifier for the finer cut, a sealed discharge means connected to the classifier for the coarser cut, an enclosed conduit connecting said last mentioned discharge means with said mill through a sealed feeding means.

4. A grinding and classifying system for combustible materials, all of the elements of which are enclosed and sealed for the exclusion of air, comprising in combination, a hot-operating, dry-grinding mill of a construction capable of grinding the material to particles of explosive dust size, sealed feeding means connected thereto for the materials to be ground, inlet means for introducing H_2O into the mill, sealed discharge means connected to the mill for the materials and steam, a conduit connecting the discharge means with a classifier for transferring the ground material and water vapor, a centrifugal air classifier connected to said conduit through a sealed feeding means for said material and water vapor, sealed discharge means connected to said classifier for the finely ground material, a second sealed discharge means connected to said classifier for the coarser ground material and water vapor and conveying means connected to the second discharge means for transferring the coarse cut and water vapor to the mill through a sealed feeding means.

5. A grinding and classifying system for combustible materials, all of the elements of which are enclosed and sealed for the exclusion of air, comprising in combination, a hot-operating, dry-grinding mill of a construction capable of grinding the material to particles of explosive dust size, sealed feeding and discharge means connected thereto for said materials, inlet means for introducing H_2O into the mill, a conduit connecting the mill to a classifier for transferring the ground material and water vapor, a centrifugal air classifier connected to said conduit through a sealed feeding means, separate sealed discharge means connected to said classifier for the fine and coarse cuts respectively, a conduit connecting the discharge means for the coarse cut to a second centrifugal air classifier, separate discharge means for the fine and coarse cuts connected to said second classifier, and a conduit connecting the last mentioned discharge means to the mill through a sealed feeding means.

6. A grinding and classifying system for combustible materials, all of the elements of which are enclosed for the exclusion of air, comprising in combination, a hot-operating, dry-grinding mill, sealed feeding means connected to the mill for introducing H_2O and the material to be ground, sealed discharge means connected to the mill for the ground materials and steam, a conduit connecting said discharge means to a classifier for transferring the ground ma-

terial and water vapor, a centrifugal air classifier connected to said conduit through a sealed feeding means for said material and water vapor, sealed discharge means connected to said classifier for the fine cut of material, sealed discharge means connected to said classifier for the coarser cut and water vapor, a second centrifugal air classifier connected to said last mentioned discharge means, a discharge means connected to said second air classifier for the finer cut and a discharge conduit connecting said second classifier to said mill through a sealed feeding means for returning the coarser cut and water vapor to said mill.

7. The process of avoiding fires, explosions and oxygen deterioration in the grinding and classifying of combustible materials which comprises, grinding such material to particles of explosive dust size in a superatmospheric pressure of steam, passing the hot ground material together with the steam through a centrifugal air separator wherein the ground material is separated from the atmosphere therein, and maintaining the atmosphere in the centrifugal air separator at a relative humidity of at least 85% and at a temperature above the dew point of the atmosphere by means of the heat developed in the grinding operation supplemented by additional heat supplied to the separator.

8. The process of avoiding fires, explosions and oxygen deterioration in the grinding and classifying of combustible materials which comprises, grinding such material to particles of explosive dust size in a superatmospheric pressure of steam, passing the hot ground material together with the generated steam through a centrifugal separator wherein the ground material is separated from the atmosphere therein, and maintaining the atmosphere in the separator at a relative humidity of at least 85% and at a temperature above the dew point by means of the heat developed in the grinding operation supplemented by superheated steam fed into the separator.

9. In the classification of hot explosive dusts of combustible materials containing about 2 to 10% moisture in a centrifugal classifying system having sealed inlets and outlets thereto, the process of avoiding fires, explosions and oxygen deterioration which comprises continuously conveying and classifying the material in said system in a steam-containing atmosphere maintained at a relative humidity of at least 85%, and maintaining said atmosphere at a temperature above its dew point whereby air is positively excluded from said system.

10. The process of avoiding fires, explosions and oxygen deterioration in the grinding and classifying of combustible material which comprises, introducing such material into a mill in air-dry condition, grinding such material to a powder of explosive dust particle size in a superatmospheric pressure of steam, and passing the hot ground material together with the steam through a centrifugal classifier, and maintaining the atmosphere therein at a relative humidity of at least 35% and the temperature above the dew point by means of heat developed in the grinding operation, whereby there is obtained a ground powder containing no greater amount of moisture than that initially present in the material before grinding.

11. The process of avoiding fires, explosions and oxygen deterioration in the grinding and classifying of combustible material which comprises, introducing such material into a mill in air-dry condition, grinding such material to a powder of explosive dust particle size in a superatmospheric pressure of steam, and passing the hot ground material together with the steam through a centrifugal classifier, and maintaining the atmosphere therein at a relative humidity of at least 85% and the temperature above the dew point by means of heat developed in the grinding operation, whereby there is obtained a ground powder containing no greater amount of moisture than that initially present in the material before grinding, and generating steam in said mill in an amount sufficient to maintain the herein specified humidity and temperature in the atmosphere in the said centrifugal classifier.

12. The process of avoiding fires, explosions and oxygen deterioration in the grinding and classifying of combustible material which comprises, introducing such material into a mill in air-dry condition, grinding such material to a powder of explosive dust particle size in a superatmospheric pressure of steam, and passing the hot ground material together with the steam through a centrifugal classifier, and maintaining the atmosphere therein at a relative humidity of at least 85% and the temperature above the dew point by means of heat developed in the grinding operation, whereby there is obtained a ground powder containing no greater amount of moisture than that initially present in the material before grinding, and venting off a portion of the steam provided in said mill during its passage from the mill to the centrifugal classifier.

13. The process of avoiding fires, explosions and oxygen deterioration in the grinding and classifying of combustible material which comprises, introducing such material into a mill in air-dry condition, grinding such material to a powder of explosive dust particle size in a superatmospheric pressure of steam, and passing the hot ground material together with the steam through a centrifugal classifier, and maintaining the atmosphere therein at a relative humidity of at least 35% and the temperature above the dew point by means of heat developed in the grinding operation, whereby there is obtained a ground powder containing no greater amount of moisture than that initially present in the material before grinding, and generating the steam employed by the mill by vaporizing the same by means of the heat developed in the grinding operation.

14. In the grinding and classification of finely divided explosive dusts of combustible material in a mill and centrifugal separator and classifier system, the process of avoiding fires, explosions and oxygen deterioration which comprises grinding such material to a powder of explosive dust particle size in a superatmospheric pressure of steam, passing the hot ground material together with the steam through a centrifugal separator and classifier system wherein the ground material is classified in and separated from the atmosphere therein in an atmosphere of at least 85% relative humidity and at a temperature above its dew point and returning at least three-fourths of the ground material from the separator and classifier system again through said mill and thence through said separator and classifier system whereby a high feed rate to this system is maintained and the heat of the returned material serves to retain the at-

mosphere in the system at a temperature above its dew point.

15. In the grinding and classification of finely divided explosive dusts of combustible material in a mill and centrifugal separator and classifier system, the process of avoiding fires, explosions and oxygen deterioration which comprises grinding such material to a powder of explosive dust particle size in a superatmospheric pressure of steam, passing the hot ground material together with the steam through a centrifugal separator and classifier system wherein the ground material is classified into a coarse fraction and a fine fraction and separated from the atmosphere therein, conveying the said fine fraction through a second separator-classifier system wherein a second fine and coarse fraction is made and separated therefrom, returning at least three-fourths of the coarse ground material again through said mill and thence through said separator and classifier systems whereby a high feed rate to the systems is maintained and the heat of the returned material serves to maintain the atmosphere in the systems at a temperature above its dew point, and conveying, classifying and separating the material throughout said systems in an atmosphere of at least 85% relative humidity and at a temperature above its dew point.

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REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
448,516	Gardner	Mar. 17, 1891
479,188	Krestner	July 19, 1892
1,367,895	Schouten	Feb. 8, 1921
1,385,674	Fraser	July 26, 1921
1,406,938	Cunningham	Feb. 14, 1922
1,478,205	Davis	Dec. 18, 1923
1,708,123	Day	April 9, 1929
1,795,603	Hussey	Mar. 10, 1931
2,008,892	Asplund	July 23, 1935
2,062,064	Knox	Nov. 24, 1936
2,100,691	Foster	Nov. 30, 1937