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2 Sheets-Sheet 1

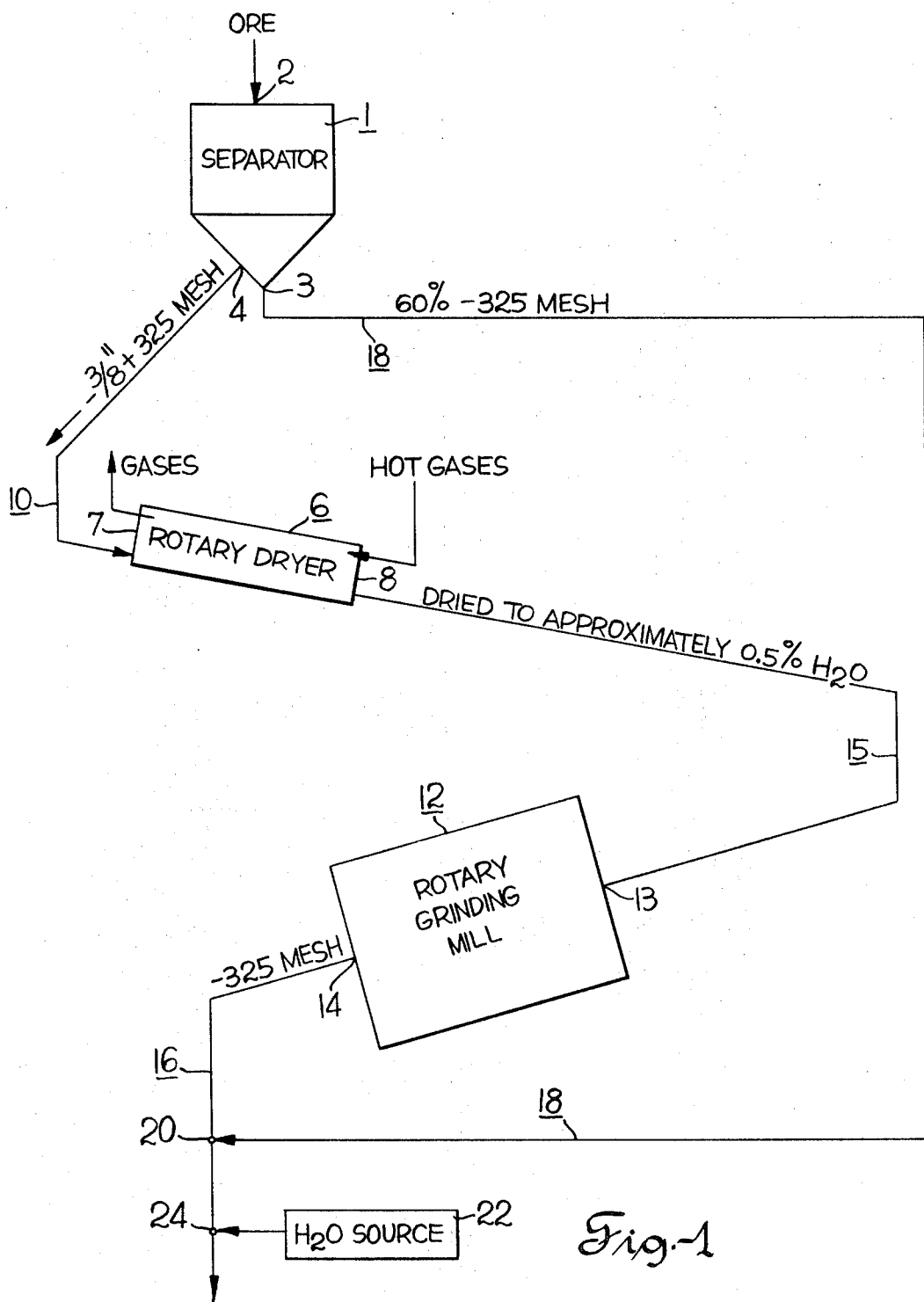


Fig. 1

TO AGGLOMERATING APPARATUS

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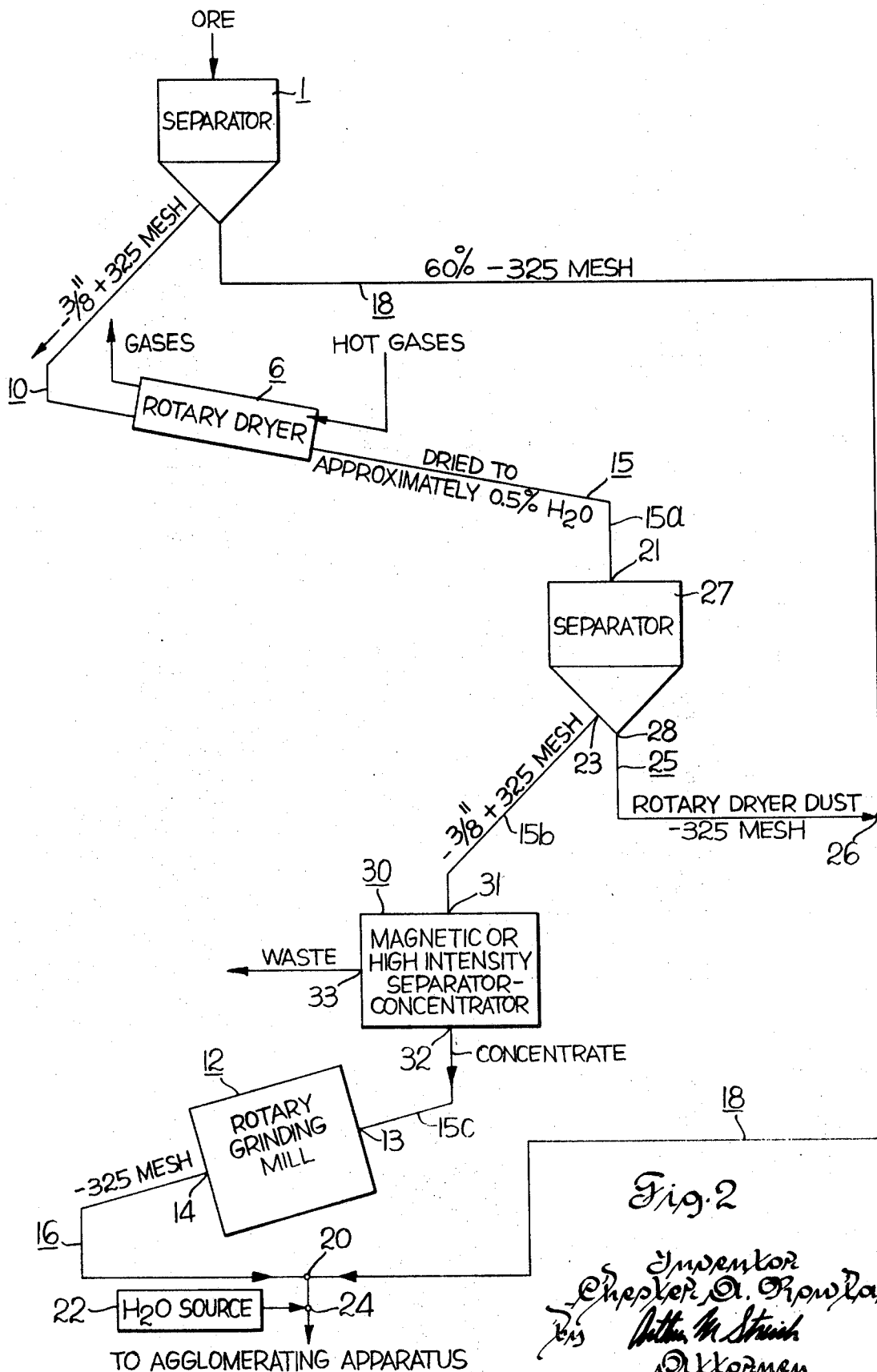


Fig. 2

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3,606,173

DRY GRINDING SYSTEM FOR PREPARING IRON ORE FOR AN AGGLOMERATING PROCESS

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10 Claims

ABSTRACT OF THE DISCLOSURE

A dry grinding system is disclosed for preparing iron ore for a process in which the ore is formed into water-bound agglomerates and then dried and heat hardened to provide agglomerates with sufficient degradation resistance to withstand handling and shipment. The system includes a separator for receiving about minus 3/8 inch iron ore particles which may be at ambient temperature and dividing it into a fraction containing fines and dust of about minus 325 mesh and a fraction of plus 325 mesh and minus 3/8 inch material. The system also includes a rotary dryer and conveying means that deliver the plus 325 mesh-minus 3/8 inch fraction of material from the separator to the dryer where such material is dried to a moisture content of about 0.5%. A dry operating grinding mill is provided and a second conveying means delivers the ore from the dryer to the mill where such material is reduced to about minus 325 mesh and discharged into a third conveying means for delivery to agglomerating apparatus. A fourth conveying means is connected to separator to receive the dust and fines fraction and bypass the dryer and mill, and discharge such material into the third conveying means to mix with and cool the discharge from the mill to reduce a tendency of the mill discharge to steam and evaporate water therefrom when water is added thereto for making the water-bound agglomerates. The second conveying means may include in series flow relation a second separator followed by a concentrator with the concentrator separating iron values from tailings which are discharged from the second conveying means. The second separator removes dust and fines generated in the dryer and has an outlet for such material connected to a fifth conveying means, discharging such fines and dust from the second separator directly into the fourth and mill bypassing conveying means for later remixing in the third conveying means with concentrate discharged from the mill.

BACKGROUND OF THE INVENTION

Field of the invention

This invention relates to the preparation of mineral ore for forming into water-bound agglomerates for processes such as are disclosed in U.S. Pats. 2,750,272; 2,925,336; 3,313,534; and 3,396,952. In particular this invention relates to a dry grinding system for the preparation of iron ore which may also include the concentration of the iron values in such iron ore.

Description of the prior art

Wet grinding systems specifically tailored for iron ore agglomeration processes are disclosed in patents such as U.S. 2,965,316 and U.S. 3,397,844. Dry grinding systems are disclosed in patents such as U.S. 3,078,048 and U.S. 3,078,050.

Although wet grinding systems have been applied successfully to the preparation of iron ore for pelletizing processes, wet grinding cannot always be used because some iron ores when ground wet produce a pulp which

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cannot be filtered to a moisture content low enough to be rolled into balls, in balling drums such as shown in U.S. Pat. 1,994,718. Dry grinding systems known to the prior art have a disadvantage, when applied to iron ore pelletizing systems, resulting from the fact that in dry grinding the material is heated to temperature in the range of 180 to 250 degrees Fahrenheit and sometimes higher. Controlled prewetting of such hot and dry material is required in order that such material can be balled. At such temperatures prewetting before the balling drum and the water drops utilized too for balls in the balling drum, causes steaming and water evaporation thus making it difficult to control the moisture content of finely ground material to be balled. In a balling system operating with hot material from a dry grinding mill, it has been considered in the past to be necessary that either additional wetting be provided to cool the material, or an indirect cooler be provided. Adding more water may make the ore too wet for good balling and an indirect cooler requires large volumes of water which may be a severe disadvantage where water supplies are limited. Accordingly, it is such problem to which the present invention is directed and it is the primary object of the invention to provide a new and improved dry grinding system for preparing an iron ore or concentrate for balling that will minimize steaming and water evaporation when the finely ground material is wetted for balling.

SUMMARY OF THE PRESENT INVENTION

According to a preferred embodiment of the present invention, a dry grinding system for preparing iron ore for a process in which the ore is formed into water-bound balls, includes a separator for receiving minus 3/8 inch iron ore particles, fines and dust, which may be at ambient temperature, and dividing it into a fraction containing fines and dust of about minus 325 mesh, and a fraction of plus 325 mesh and minus 3/8 inch material. The system also includes a rotary dryer and conveying means that deliver the plus 325 mesh-minus 3/8 inch fraction of material from the separator to the dryer where such material is dried to a moisture content of about 0.5%. A dry operating grinding mill is provided and a second conveying means delivers the ore from the dryer to the mill where such material is reduced to about minus 325 mesh and discharged into a third conveying means for delivery to agglomerating apparatus. A fourth conveying means is connected to separator to receive the dust and fines fraction and bypass the dryer and mill, and discharge such material into the third conveying means to mix with and cool the discharge from the mill, to minimize a tendency of the mill discharge to steam and evaporate water therefrom when water is added for balling. In another embodiment of the present invention the second conveying means includes, in series flow relation, a second separator followed by a concentrator. The concentrator in this arrangement separates iron values from tailings which are discharged from the second conveying means. The second separator removes dust and fines generated in the dryer and the second separator has an outlet for such material connected to a fifth conveying means which discharges such fines and dust from the second separator directly into the fourth and mill bypassing conveying means, for later remixing in the third conveying means with concentrate discharged from the mill.

Other features and objects of the invention that have present invention shown in the accompanying drawing.

BRIEF DESCRIPTION OF THE DRAWING

been attained will appear from the more detailed description to follow with reference to embodiments of the FIG. 1 of the accompanying drawing shows diagram-

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matically a dry grinding system for preparing mineral ore for balling, according to the present invention; and

FIG. 2 shows diagrammatically a second embodiment of the present invention, which includes concentration of the mineral ore to be prepared for balling by dry grinding.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to FIG. 1, in this embodiment of the present invention a primary separator 1 is preferably an air operated particle size classifying separator, which may be of the type disclosed in U.S. Pat. 3,219,185. The separator 1 has a material inlet 2, a first outlet 3 for dust and fines and a second outlet 4 for particles larger than dust and fines.

A dryer 6 is utilized which may be a rotary tubular dryer such as disclosed in U.S. Pat. 1,883,722. Such a dryer is inclined downwardly from a material feed end 7 toward a material discharge end 8. Hot gases used to dry material within such a dryer, are admitted to the dryer at the material discharge end 8 and such gases are discharged from the dryer at the material inlet end 7 as indicated by arrows. A first conveying means 10 is connected on a first end thereof to the second and particle discharging outlet 4 of the separator 1, and a second end of conveying means 10 is connected to the material inlet 7 of the rotary dryer 6 for delivering particles larger than fines and dust from separator 1 to dryer 6.

A dry operating grinding mill 12 is utilized which may be a rotating cylindrical multicompartment mill, such as shown in U.S. Pat. 1,591,941 to R. C. Newhouse, and having a material feed end 13 and a material discharge end 14. A second conveying means 15 is connected on a first end thereof to the material discharge end 8 of the rotary dryer 6, and a second end of the second conveying means 15 is connected to the material inlet end 13 of mill 12 for delivering the dried particles from dryer 6 to mill 12. A third conveying means 16 is connected to the material discharge end 14 of mill 12 for carrying ground particles away from mill 12.

A fourth conveying means 18 in this system is connected on a first end thereof to the dust and fines discharging outlet 3 of separator 1 and this conveying means bypasses both dryer 6 and mill 12, and is connected on a second end thereof to the third conveying means 16 at a connection indicated by reference number 20. At the connection 20 the mixture of fines and dust from separator 1 is mixed with the ground material from mill 12. A source of water 22 is provided for prewetting the mixture of ground material and dust and fines, before such mixture is agglomerated, as by being rolled into balls. The water source 22 is connected to the conveying means 16 at a connection 24 which is on a side of connection 20 opposite the mill 12.

Referring now to the system disclosed in FIG. 2, this embodiment of the present invention is similar to FIG. 1 but differs therefrom in the nature of the conveying means 15. With regard to the system of FIG. 1, the conveying means 10, 15, 16 and 18 may most easily be provided by such as conveyor belts, bucket elevators or pneumatic conveying devices, all of which are well known in this art and capable of being utilized in various combinations as necessary to transport a material from one station to another. In the system of FIG. 2 the same devices may be used for the conveying means 10, 16 and 18, but the second conveying means 15 is intended to include in addition thereto such other apparatus as will now be described. The system shows in FIG. 2, and in particular the second conveying means 15, includes a second separator 27, which may be of the same type as the separator 1, for separating dust and fines generated in dryer 6 from larger particles. Like separator 1, the separator 27 has an inlet 21, a first outlet 28 for dust and fines. The separator 27 from its material inlet 21 to

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the outlet 23 is part of the second conveying means 15 while outlet 28 of separator 27 operates to eject fines and dust from the second conveying means 15. A fifth conveying means 25 is connected on a first end thereof to the outlet 28 and on a second end thereof to the fourth conveying means 18 at a connection labeled 26. Thus dust and fines generated in dryer 6 is removed from conveying means 15 and added to the fines and dust from separator 1 for later mixing with the discharge from mill 12 at connection 20.

The second conveying means 15 in the embodiment of FIG. 2 also includes a concentrator 30, which as indicated on the drawing may be a magnetic or a high intensity separator-concentrator. Such machines are well known to those skilled in this art and a discussion of such machines may be found in Section 13 of the Handbook Of Mineral Dressing by Arthur F. Taggart, copyright 1945, published John Wiley & Sons, Inc., New York and Chapman & Hall Limited, London. In the aforesaid publication dry magnetic separators, for iron ores such as magnetite, are described in Section 13 pages 15-17, and high intensity machines for iron ores that are weakly magnetic such as hematites, are described in Section 13, pages 18-19. A separator-concentrator of either of the foregoing types would include a material inlet 31, a concentrate outlet 32 and a waste outlet 33 for tailings. In this embodiment then, the second conveying means 15 includes a conveyor 15a from dryer 6 to separator 27, separator 27 itself from its inlet 21 to its outlet 23, a conveyor 15b from the outlet 23 of separator 27 to the separator-concentrator 30, concentrator 30 itself from its inlet 31 to its outlet 32, and a conveyor 15c from concentrator 30 to mill 12.

The operation of the described systems to perform the method of the present invention shall now be described. A method of preparing an iron ore for wetting and water-bound agglomeration with the apparatus of FIG. 1 or FIG. 2 may begin with an oxidic iron ore containing particles in a size range which is plus 325 mesh— $\frac{3}{8}$ inch, and fines and dust of which about 60% will pass through 325 mesh. (All references to mesh sizes are intended to mean those sometimes referred to by those skilled in this art as Tyler mesh sizes.) Such feed material delivered to the separator 1 is subjected to the step of separating and discharging from outlet 4 the larger particles, i.e., plus 325 mesh—minus $\frac{3}{8}$ inch, from the smaller fines and dust size material. The particles discharged from the outlet 4 are then transported by the first conveying means 10 to the material inlet end 7 of the rotary dryer 6. Hot gases entering the material discharge end 8 of dryer 6 and passing therethrough and out the material inlet end 7, remove moisture from the material preferably to the degree that the material discharged from dryer 6 has been dried to a moisture content of approximately 0.5%. The particles discharged from the discharge end 8 of dryer 6 are then transported by the second conveying means 15, according to FIG. 1, directly to the feed end 13 of mill 12, while according to FIG. 2 the dried material passes to a second conveying means including conveyor 15a, dust and fines separator 27, conveyor 15b, separator-concentrator 30, and conveyor 15c before arriving at the material feed end 13 of mill 12. The particles of material passing through mill 12 are ground dry in mill 12 to pass 325 mesh. The dry grinding of these particles to such smaller size particles will generate considerable heat raising the temperature of the material to within the range of 180 to 250 degrees Fahrenheit or higher. Such temperatures are sufficient to cause considerable steaming when the material is wetted at the location 24. The water is added from source 22 at location 24 in order to bring moisture content back up to the range of 6-12% as required to make good water-bound balls in a balling drum constructed and operated as disclosed in U.S. Pat. 1,994,718. Steaming and evaporation of water from the material makes it difficult to control the moisture content of the material fed to

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agglomerating devices such as the aforesaid balling drums. However, the dust and fines that have bypassed the grinding mill 12 are delivered by the fourth conveying means 18 to the third conveying means 16 at the location 20 upstream of the water input at 24. This results in the mixing of the cooler material with the hot material from the mill 12 and cooling such material before it is wetted at 24. Steaming and evaporation has therefore been reduced and minimized by the present invention and the control of the moisture content in the material to be balled has been facilitated.

From the foregoing detailed description of the present invention, it has been shown how the objects of the invention have been attained in a preferred manner. However, modifications and equivalents of the disclosed concepts such as readily occur to those skilled in the art are intended to be included within the scope of this invention.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A dry grinding system comprising:

a primary particle size classifying material separator having a first outlet for dust and fines and a second outlet for particles larger than dust and fines;

a dryer having a material inlet and a material outlet;

a first conveying means connecting the second outlet of the separator to the material inlet of the rotary dryer for delivering the larger particles to the dryer;

a dry operating grinding mill having a material inlet and a material outlet;

a second conveying means connecting the dryer outlet to the mill inlet for delivering dried particles from the dryer to the mill;

a third conveying means connected to the mill outlet for discharging material therefrom; and

a fourth conveying means connected on a first end thereof to the dust and fines outlet of the primary separator and bypassing said dryer and mill to a connection on a second end thereof to the third conveying means, to deliver the dust and fines from the primary separator to the third conveying means to mix with and cool discharge from the dry grinding mill.

2. A grinding system according to claim 1 in which said primary separator is an air classifying material separator, said dryer is a tubular rotary dryer, and said mill is a rotary cylindrical shell grinding mill.

3. A grinding system according to claim 1 for preparing iron ore for agglomeration and in which the second conveying means includes a concentrator for separating iron values from tailings, and means discharging said tailings from said iron values delivered by the second conveying means to the mill.

4. A grinding system according to claim 3 in which the second conveying means also includes a secondary particle size classifying material separator preceding the concentrator in series flow relation, said second separator having an outlet for dust and fines generated in the dryer, and a fifth conveying means connecting the dust and fines outlet of the secondary separator to the fourth and mill by-

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passing conveying means, for mixing with ground concentrate in the third conveying means.

5. A grinding system according to claim 1 for preparing material for water-bound agglomeration and in which means are provided for adding water to the cooled mixture in the third conveying means, said water adding means being connected to the third conveying means on a side of the connection between the fourth and third conveying means, opposite the mill.

6. A method of preparing, for wetting and water-bound agglomeration, a material containing particles in a size range of about plus 325 mesh—minus $\frac{3}{8}$ inch and fines and dust of which about 60% will pass through a 325 mesh screen, the method comprising the steps of:

separating said particles from said fines and dust;

drying said separated particles to a moisture content below 1%;

dry grinding the dried particles to a size at least as small as said fines and dust; and

mixing the fines and dust separated from the particles prior to drying and grinding, with the dried and ground particles to cool the dried and ground particles and thus provide a material prepared for wetting and water-bound agglomeration with a minimum of steaming and evaporation of water added to prepare for agglomeration.

7. A method according to claim 6 comprising the additional step of wetting, preliminary to agglomeration, the cooled mixture of ground particles and the fines and dust separated from the particle prior to drying, by adding to said mixture water in such amounts as provides said mixture a moisture content of from 6 to 12%.

8. A method according to claim 6 in which said particles are dried to a moisture content of about 0.5%.

9. A method according to claim 6 for preparing iron ore for wetting and water-bound agglomeration in which after said separated particles have been dried, such particles are concentrated by separating iron values from tailings and the tailings are excluded from the dry grinding step.

10. A method according to claim 8 in which after the separated particles have been dried but before such particles are concentrated, fines and dust generated during drying are separated from the dried particles, and such fines and dust are mixed with the fines and dust separated from the particles before the particles are dried.

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