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METHOD OF ELECTROMAGNETICALLY SEPARATING ORES

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*Fig. 1.*

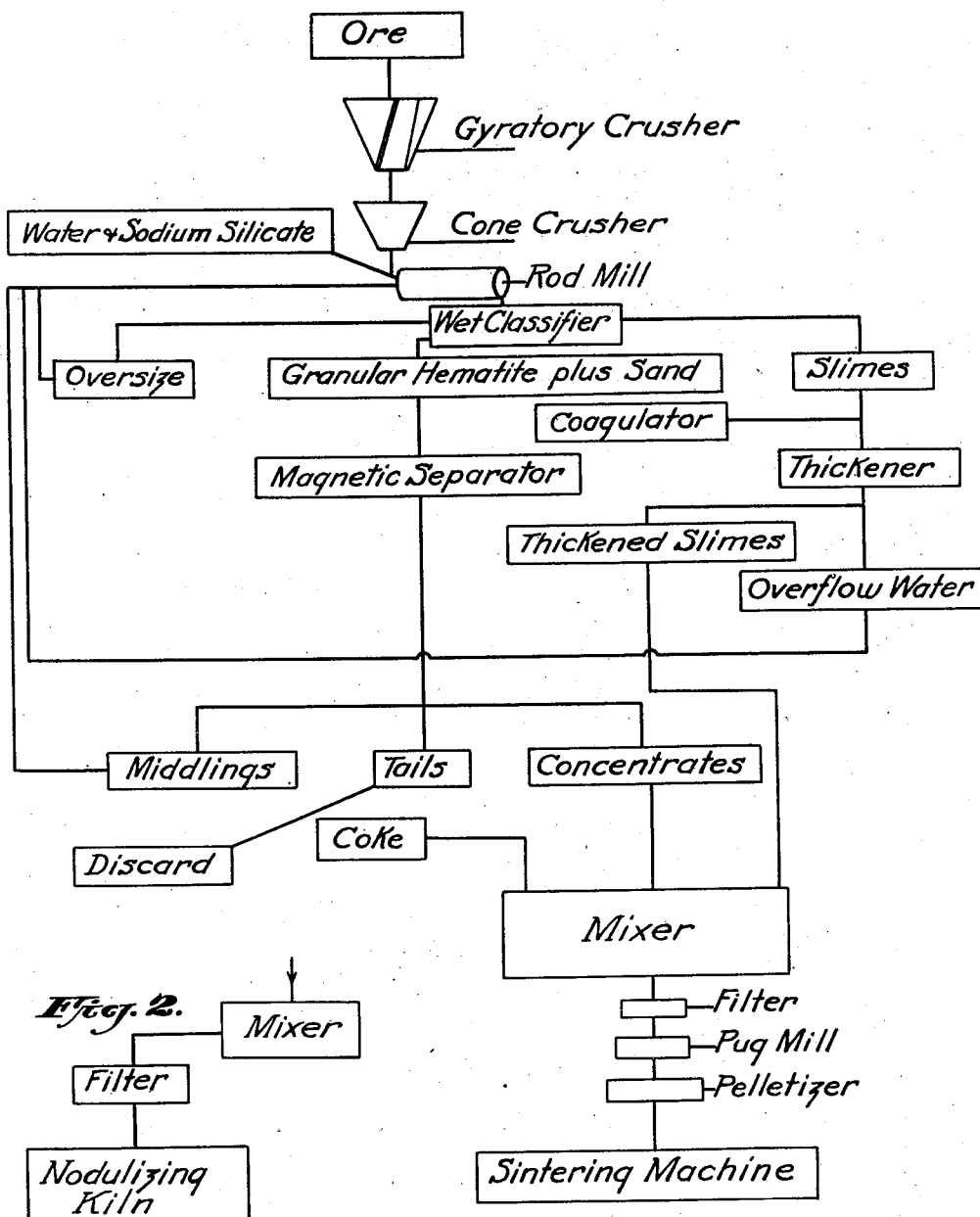
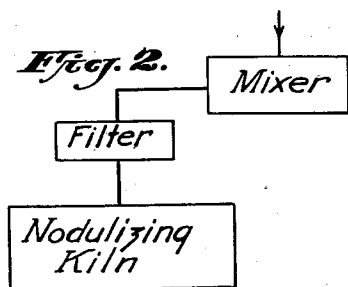


*Fig. 2.*



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METHOD OF ELECTROMAGNETICALLY  
SEPARATING ORES

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5 Claims. (Cl. 75-1)

This invention relates to ore treatment methods to obtain a separation between the metallic and non-metallic values contained in an ore. In a prior filed co-pending application, Serial No. 745,116, filed September 22, 1934, by E. E. Ellis and A. L. J. Queneau, there is disclosed and claimed an electro-magnetic separator device. In such an electro-magnetic separator device it is necessary for efficient separation to grind the ore to such a degree of fineness as will effect substantial separation between the magnetic and non-magnetic constituents of the ore.

In many ores, such as hematites, brown ores and the like, and in particular those ores known as oolitic ores, the grinding of the ores results in a relatively high percentage of "fines" of such small particle size that upon subsequent suspension in water they appear as colloidal suspensions or "slimes". These "slimes" are frequently, as in the case of oolitic ores, relatively high in metallic values and are not readily recovered by separation in the electro-magnetic separator, usually passing through the device practically unaffected by the electro-magnetic field and are lost in the liquid overflow from the various settling tanks.

One of the objects of the present invention is to provide a process of treating suspensions of ground ores for the effective removal therefrom of the slimes prior to passing the suspension through an electro-magnetic separator device, and for the recovery of the slimes and the return of the same to the metallic values separated by the electro-magnetic separator, and for the subsequent conditioning of the two products into a form adapted to be treated for the recovery of the metal content thereof by pyrometallurgical methods. Another object is to provide an improved ore treatment and recovery process. Another object is to provide an efficient ore treatment and recovery process for iron ores wherein the iron content is in such condition as compared to the gangue content as to require extremely fine grinding with resultant relatively large production of colloidal sized particles of the iron content. Other objects and advantages will be apparent as the invention is more fully disclosed.

In accordance with these objects, I have devised an improved process wherein the ore is first ground dry to a desired particle size, and then is ground wet to a desired final particle size found effective for any particular ore to obtain the necessary state of subdivision which is effective to obtain substantially complete separation

between magnetic and non-magnetic constituents therein, during which last grinding I incorporate within the ore-water mixture a sufficient amount of some dispersing agent such as sodium silicate. The resultant ground product then is passed through a suitable classifying device such as a wet mechanical screen or an hydraulic classifier wherein I separate out the oversize particles, and the slimes from the particles of the size desired for treatment in the electro-magnetic separator. The oversize particles are returned for further grinding as before; the correct size material is passed through the electro-magnetic separator device; and the slimes which pass out with the overflow water from the classifier are subjected to a treatment to recover the slime particles.

This treatment consists in passing the overflow water to a thickener with or without the addition of a coagulating agent such as lime, alum, etc. thereto, in which I obtain a thickened slime product which is relatively high in water content but which is exceedingly difficult to filter or otherwise remove the water content therefrom. To this thickened slime, however, I add finely ground carbonaceous material, such as coke, anthracite and the like, sized to pass a 6 or 8 mesh screen, and mix therewith the magnetically separated concentrates in such relative amounts as will produce a readily filterable product. This product then is subjected to a filtering operation to abstract sufficient water to permit treatment of the product in a nodulizing kiln or sintering machine to obtain an agglomerated material suitable for processing by pyrometallurgical methods.

This general process must be modified somewhat with respect to the specific ore to be treated. As a specific embodiment of the practice of the present invention but not as a limitation thereof, I will describe the same as it has been practiced in connection with the electro-magnetic separation of oolitic ores, more particularly siliceous oolitic iron ores. Oolitic iron ores are composed principally of grains of quartz (sand) which are held together by a network of cement composed of iron mineral. The iron mineral is relatively much softer than the sand.

In the crushing of these ores it is necessary to proceed in such manner as to break down the ore without crushing the individual sand grains but yet to free the grains from the iron mineral cement. The relatively soft iron mineral cement, however, thereby becomes to a large extent reduced to colloidal particle size

with the result that when the ore is suspended in water a large part of the values appear as slimes.

The crushing and grinding of this ore accordingly must be carried out in steps, and each step should be made by means of machines that will reduce the size of the ore treated in each machine while fracturing the minimum number of the individual sand grains. A sequence of crushing and grinding steps I have found suitable is as follows:—A large jaw or gyratory crusher to take the run-of-mine ore down to, say, 3 inches, then a cone crusher reducing the ore down to 1 inch, and finally a rod mill with peripheral discharge and operated with a light rod load,—the latter machine being operated in the usual wet way.

To promote the dispersion of the fine hematite slimes produced in the rod mill, I add continuously a small percentage of some dispersing agent, usually an aqueous solution of a soluble silicate, such as sodium silicate, to the water entering the rod mill.

Issuing from the peripheral discharge openings of the rod mill is a water ore pulp consisting of the following:—the hematite slimes dispersed in the water content of the pulp, the granular hematite, the silica sand substantially freed from the cementing hematite, and finally the oversize ore. This pulp passes to a classifying device, either a wet mechanical screen of the desired size of apertures or a hydraulic classifier. In any case the action of the classifying device or devices is to make three products of the rod mill discharge:

- (1) A slime dispersed in the overflow.
- (2) A granular product of the size desired.
- (3) An oversize product.

The slime with the overflow water passes to a thickener, from which issue two products:

(1) The thickened slime composed in the main of finely comminuted hematite,—this is one of the finished products of the concentration process, and,

(2) The overflow clear water which returns or not, as desired, to the grinding circuit, i. e. it may be pumped back to the feed of the rod mill.

In the practice of my process I may elect to add a coagulating agent to the slime product entering the thickener, this in order to increase the rate of settling of the slime therein. The coagulating agent may be any one usually added to pulp circuits for such a purpose,—lime, alum, etc., or a combination of these.

The sized granular product composed of fine grained hematite and relatively large grains of sand pass to a wet magnetic separator of the type described in my above identified United States patent application Serial No. 745,116 filed September 22, 1934. The magnetic separator makes three products:—hematite concentrates, non-magnetic tailings composed of substantially iron-free sands, and a middling product. The hematite concentrate, a final product of concentration, is sent to the agglomerating plant; the non-magnetic tailings to the dump, and the middlings are returned to the grinding circuit for further processing, as is well understood by persons skilled in the art of ore dressing.

The oversized product from the classifying devices is returned to the rod mill for further grinding so as to become of the desired size for the above described process.

The final products thus consist of hematite slimes and hematite grains. Both of these mag-

netic concentrates are high grade, i. e. high in iron. They are, however, in too small a state of division to be acceptable for the iron blast furnace. They must be agglomerated into relatively large masses.

Owing to the very fine state of division of the slimes in their thickened state, as issuing from the thickener, they are much too high in water content (50% and over) for direct treatment in the agglomerating plants. It is thus necessary to further reduce the water content. This, in their thickened condition, is extremely difficult owing to their colloidal nature and specific gravity. In order to bring them to a physical condition suitable for commercial filtration I resort to the following step:—To the thickened slimes are added the following solid materials:

1. The granular hematite product: the magnetic concentrates.

2. The required weight of coke, of suitable size, to either sinter or nodulize the mixture: slimes plus concentrates.

I prefer to add the required amount of coke in a regulated and desired size, usually all through 6 or 8 mesh, or thereabouts. This is readily accomplished by passing the available coke (metallurgical coke or coke screenings) through a rod mill with peripheral discharge. The precise amount of carbonaceous material high in fixed carbon (coke, anthracite, etc.) coke being the usual material available so added may be varied widely without departure from my invention as one skilled in the art may perceive.

The mixture of thickened slimes, magnetic concentrates and sized carbonaceous material is sent to a suitable vacuum filter. This, preferably, is of the mechanical vacuum type, and so designed as to receive the feed on top of the rotating filtering medium. The granular magnetic concentrates, owing to their specific gravity and size, are precipitated through the feed to the bottom of the feed and adjacent to the filtering medium, thus forming a porous mass through which the excess water may readily pass without, however, allowing the finely divided hematite slimes to accompany it. The sized coke dispersed through the feed acts further as an aid to filtration in providing innumerable centers for the passage of the excess water.

The filter cake contains approximately, on the average, 25% water. In this condition the filter cake is suitable for processing through an agglomerating plant, nodulizing kiln or sintering machine. The sintering machine used is preferably of the mechanical type, with a moving grate passing over one or more wind boxes in which is created the necessary vacuum by means of fans. The filter cake is first sent through a repulper or pug mill in which it is broken up and fluffed up. From the repulper or pug mill the broken up filter cake passes to a pelletizer, from which issues individual pellets approximating 6 mesh in size. In this condition it forms an ideal feed for the sintering machine to which it is fed.

The product of the sintering machine comprises sintered lumps of the iron particles and is in a good physical condition and of a good chemical composition for use in the blast furnace.

In case it is desired to use for an agglomerating device a nodulizing kiln instead of a sintering machine, the filter cake as issued from the mechanical vacuum filter is fed directly to the nodulizing kiln. The resulting nodules form also a product suitable for the blast furnace.

The above description of the present invention

should be read in connection with the accompanying drawing in which Fig. 1 represents a flow sheet diagram of the process of the present invention and Fig. 2 illustrates an optional modification of the same.

Having broadly and specifically described the present invention and given one specific embodiment of the practice of the same, it is apparent that the invention is adapted to wide modification without departing essentially from the same as may be defined in the following claims.

What I claim is:

1. The method of treating ores to recover the metal values contained therein, which comprises dry crushing the ore to relatively small sizes, wet grinding the ore to the desired final sizes effective to separate the metallic and non-metallic values from each other, during said wet grinding admixing therewith a dispersion reagent, classifying the wet ground ore to effect a segregation of oversized, sized and slimes, treating the sized particles in an electro-magnetic separator device to recover the desired magnetic particles therein, treating the slimes to recover a thickened slime product, mixing the thickened slime product with granular carbonaceous material and the recovered magnetic particles to obtain a filterable material, filtering the material, and agglomerating the filtered material to obtain masses thereof suitable for treatment by pyrometallurgical processes for the recovery of the metal values therein.

2. The method of treating ores to recover the metal values contained therein, which comprises dry crushing the ore to relatively small sizes, wet grinding the ore to the desired final sizes effective to separate the metallic and non-metallic values from each other during said wet grinding admixing therewith a dispersion reagent, classifying the wet ground ore to effect a segregation of oversized, sized and slimes, treating the sized particles in an electro-magnetic separator device to recover the desired magnetic particles therein, treating the slimes to recover a thickened slime product, mixing the thickened slime product with sized carbonaceous material and the recovered magnetic particles to obtain a filterable material, filtering the material, and pelletizing the filtered material and subjecting the pelletized material to agglomeration by sintering to obtain masses thereof suitable for treatment by pyrometallurgical processes for the recovery of the metal values therein.

3. In the electro-magnetic separation of mate-

rials suspended in a liquid, the method which comprises incorporating within the suspension a dispersing reagent, classifying the suspension to separate oversize and slimes therefrom, subjecting the classified particles of the suspension to electro-magnetic separation, treating the separated slimes to recover the same, mixing the said slimes and electro-magnetically separated material together with sized carbonaceous material to form a filterable material, filtering the same and treating the filtered material to agglomerate the same into larger masses.

4. The method of treating an ore to recover the metal values thereof which comprises grinding the ore to a particle size adapted for the separating electro-magnetically of the magnetic and non-magnetic constituents thereof, forming the ground ore into a suspension, incorporating therein a dispersing agent, classifying the suspension to eliminate oversize particles and slimes therefrom, subjecting the classified material to electro-magnetic concentration of magnetic from non-magnetic particles, recovering the slimes, mixing the slimes and the recovered magnetic particles together with sized carbonaceous material to form a filterable mixture, filtering the mixture to reduce the water content thereof and then subjecting the filtered mixture to an agglomeration process adapted to form aggregates suitable for treatment by pyrometallurgical methods for the recovery of the metal values contained therein.

5. The method of treating oolitic iron ores for the recovery of the iron content thereof which comprises dry crushing the ore to relatively small particle sizes, wet grinding the ore in the presence of a dispersing agent to obtain crushing of the iron cementing material without substantial crushing of the sand grains thereof, classifying the material to eliminate oversize particles and slimes therefrom, subjecting the classified material to electro-magnetic concentration of magnetic from non-magnetic particles, recovering the slimes, mixing the slimes and the recovered magnetic particles together with sized carbonaceous material to form a filterable mixture, filtering the mixture to reduce the water content thereof and then subjecting the filtered mixture to an agglomeration process adapted to form aggregates suitable for treatment by pyrometallurgical methods for the recovery of the metal values contained therein.

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