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C. SPEARMAN

PROCESS OF ORE SEPARATION

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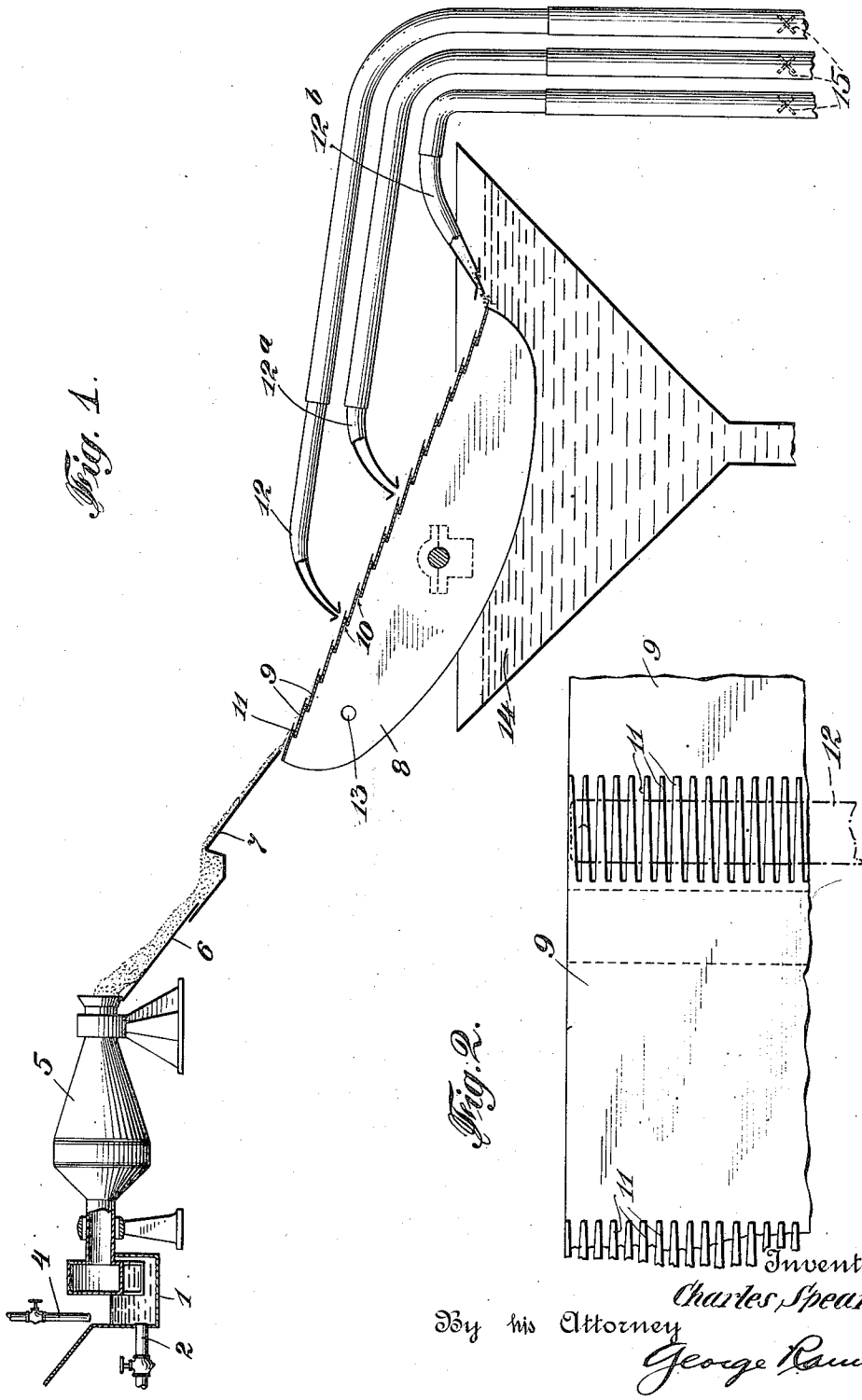


Fig. 1.

Fig. 2.

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CHARLES SPEARMAN, OF WESTMOUNT, QUEBEC, CANADA.

PROCESS OF ORE SEPARATION.

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To all whom it may concern:

Be it known that I, CHARLES SPEARMAN, a subject of the King of Great Britain, residing at Westmount, in the Province of Quebec, Dominion of Canada, have invented certain new and useful Improvements in Processes of Ore Separation, of which the following is a specification.

This invention relates generally to the separating, concentrating and purifying of ores and minerals, and pertains directly to a process which may be utilized for the separation of minerals, the separation of metals and metallics from their ores, the concentration of ores, the purification of concentrates, and like purposes.

As is recognized in the art, it is desired frequently to accomplish a selective separation of desired minerals from their ores, such separation being selective either as to the kind of mineral to be taken from ore containing a plurality of minerals, as to size or quality of the mineral content desired to be taken, as to the proportion and amount of mineral it is desired to withdraw, and as to divers and variable factors existing by virtue of the differences between different ores, variations in an ore, and other causes and conditions. For example, in the concentration and purification of graphite and molybdenite ores it frequently occurs that these minerals are found in association with mica, copper, wallastonite, calcite, or other minerals, which other minerals are useful for some purposes—and it may be desirable to recover them—or which other minerals may be usefully employed if left in association with the graphite or molybdenite, or which minerals it may be necessary to separate absolutely from the graphite or molybdenite in order to render the latter in proper condition for certain uses.

Likewise, due to variations in the richness of ores, or in variations in their refractory properties, variations in the nature, form and amount of matrix and gangue material as well as other variations in the nature and properties of the ore, it becomes desirable to vary the treatment in the process of separation or concentration in order to operate at the highest efficiency.

It is the purpose of my present invention to provide a process which admits of a selectively variable treatment of the ore such as to accommodate a wide diversity of conditions in the ore and enable always the highest recovery at the highest efficiency.

More specifically stated, an object of my invention is to provide a process by virtue of which selection may be made among the various mineral contents of ores for the recovery of a desired ore, or desired ores, either separately or in association.

Another object of my invention is to provide a method whereby an early differentiation and segregation of divers mineral contents of ore is accomplished.

Another object of my invention is to provide a process which permits of a variable treatment of ores to accomplish the recovery and selection of desired contents practically as soon as any segregation of the divers contents is accomplished, so that there will never be any overcrowding of the concentrate removing means, such as might result in loss in the tailings.

A further object of my invention is to provide a process whereby the operations of selection and extraction of a desired mineral content or contents may be carried on continuously and concomitantly with the operations of freeing, segregating and separating divers desired mineral contents of the ore from the undesired content.

A further object of my invention is to provide a process of separation whereby the classifying or assorting of the desired values as to purity, size, weight, specific gravity, or other characteristics, may be accomplished concomitantly with the separation of the values from the undesired content of the ore.

A further object of my invention is to provide a process whereby a very large volume of material may be handled in a very short time.

A further object of my invention is to provide a process which is continuous, whereby any and all desired values may be extracted from ores in a single handling of the material.

A further object of my invention is to provide an improved process for the recovery of graphite, molybdenite, and other minerals from graphite and molybdenite ores.

Other and further objects of my invention will be obvious or pointed out herein

and in the appended claims and illustrated in the accompanying drawings forming a part of this application.

I will describe my improved process as applied to ores such as graphite ore or molybdenite ore, and I will explain the process as practiced by an illustrative form of apparatus, but it will be understood that the process is designed for use on ores which are various both as to kind and form, and that it may be accomplished my means of apparatus different from that herein disclosed.

Described generally, my invention comprises a process in which ore, either before or after being suitably dressed or reduced to free the discrete particles of the desired values from the matrix, is permitted a moisture content of proper proportion to disable or impair the affinity of certain of its contents for a selected agglomerating agent. This preparatory establishment of moisture content of the ore is in the nature of a differentiating qualification which may totally disable the affinity of certain of the contents of the ore for the selected agglomerant, and impair to varying degrees the affinity of others of its contents therefor. In the illustrative process hereinafter described the specific disabling or differentiating agent utilized is water, but it is obvious that it may be varied by use of other agents selected in accordance with the affinitive characteristics or properties of the various contents of the ore.

Following the differentiation of divers contents of the ore by this agent, the ore is treated with an agglomerating agent which is immiscible or non-assimilating with the agent previously employed, and which agglomerating agent is selected with regard to the affinitive properties of the desired mineral content of the ore therefor. The result of the treatment of the ore to this point, therefore, will be the artificial differentiating of various contents of the ore by qualities tending to contribute or accomplish their segregation through influences producing stratification, and to endow the selected values with agglomerative capacity as a further distinction from the undesired contents. The ore with its contents thus differentiated may have a fluid consistency or may be treated to give it such, or it may be submitted to the further steps of the process in its comminuted form. The pulp or ore in this prepared form is then subjected to a working or agitating operation and moved progressively in the form of a sheet or shallow stream, preferably in a gradient or inclined direction, whereby the differentiated constituents of the ore are enabled to segregate in stratified relationship in conformity with their non-assimilating characteristics. During this operation discrete particles in the mass which have been endowed with the agglomerative capacity will be agglomerated at the surface of the progressively moving sheet where they will remain due to the flocculence, sponginess, size, or comparative specific gravity of unit volume of the agglomerate entities.

While the pulp, or sheet of reduced ore, is being subjected to the concomitant agitation and progressive movement, it is brought, by the latter, into operative association with a suitable selecting device which is effective to remove a desired content or desired contents of the ore. This the selecting apparatus is enabled to do by virtue of the stratification, segregation or agglomeration which has been effected within the moving mass of ore by the agitating and progressive movement thereof. Accordingly this selecting apparatus may be disposed at the point in the progressive course of the ore whereat stratification or segregation within the mass has reached the stage where one kind, size or quality of content may be mechanically selected from the other contents. Moreover, a plurality of such selecting devices may be employed, arranged in such relationship that they may select a desired content practically as rapidly as it is agglomerated or segregated in the progressively moving mass. Or, the disposal of a plurality of such selecting devices may be such as to enable one to withdraw one desired content, and another to withdraw another desired content which is separately stratified or segregated from other contents of the mass. Moreover, it is desirable that the selecting means be selectively variable with respect to the pulp stream or moving mass of ore.

As an illustrative example of the practice of the process, I will describe the process as applied to the separation or concentration of graphite from graphite ore, reference being had to the accompanying drawings in which Figure 1 represents diagrammatically one form of apparatus which may be utilized in the practice of the process, and Figure 2 represents diagrammatically a fragmentary top or plan view of a portion of the apparatus.

The moisture content of the ore to be treated having been ascertained, the ore is subjected, if necessary, to suitable operations to establish its moisture content at a proportion between 1 percentum and 12 percentum by weight, the specific proportion being determined by the amount necessary to wet or film the non-metallic content, or the undesired content, without leaving an excess of moisture in the ore such as might tend to film or to wet the metallic content, or the desired content, and thereby retard the subsequent artificial differentiation or agglomeration of the metallic content, as

hereinafter described. This establishment of the critical moisture content of the ore will be made by the addition of water, in the event the original moisture content of the ore is below the proportions specified, or by drying to the proper amount, in the event its moisture content exceeds the critical proportion. Also, the ore is dressed, or reduced to a suitable mesh, to free the discrete particles of the desired metal or metallic content from the matrix material, and from any other cleavably associated undesired mineral. This dressing of the ore may be accomplished concomitantly with the establishment of the critical moisture content, or may be effected either before or after the treatment for moisture. Obviously, if the original moisture content of the ore is within the proper critical proportions, no artificial treatment for moisture will be necessary. However, the establishment of the moisture content between the critical proportions specified is an important factor in the practice of the process. The ore thus treated is then subjected to a treatment by some selected agglomerating agent which is non-assimilating with the agent employed to film the undesired content, and which agglomerating agent in the case of graphite may be a non-assimilating oil such as kerosene. The proportion of agglomerant utilized must be such as to supply the discrete particles of the desired content with characterizing films without leaving an excess such as would tend to adhere to any of the undesired content which might be dry and would take on an oil film. In the case of graphite ore this proportion would be about 5 to 10 pounds of kerosene to one ton of ore of average graphite carbon content said 8 to 10%. This agglomerating agent is selected with reference to the preferential affinities of the desired contents as distinguished from the disabled, reduced or inhibited affinities of the contents which have been filmed or characterized by the moisture content. If it is desired to make selection of a plurality of different minerals from the ore, an agglomerating agent or agents may be utilized which will differentially film the different desired minerals or film them to different degrees. Artificial differentiation between different desired contents may be obtained also by regulating the proportion to the ore of the characterizing agents employed, the order in which the different characterizing agents are applied to the ore, and in other ways for the purpose of separate stratification or separate agglomeration of the different values.

This treatment by the agglomerating agent may be accomplished by reducing the ore in the presence of the differentiating agent or by discharging the previously reduced and prepared ore into a suitable mixer 1 into which water may be fed by the pipe 2, and kerosene by the pipe 4, the differences in the specific gravity of the two liquids maintaining the kerosene on top of the water so that the comminuted ore as charged into the box, comes into contact with the kerosene first and subsequently with the water. The use of the water at this stage of the process is to fully provide a medium for the reduction of the comminuted ore to a pulp of fluid consistency, and to provide an environment in which the differentiated contents of the ore will be enabled to adjust themselves in accordance with their specific gravities or in accordance with the artificial characteristics with which they have been endowed by the treatments just described. The mixing of the liquids with the ore may be accomplished in a suitable mixing apparatus 5, which, in the event the ore has not been previously reduced to its final mesh, may perform also the function of reducing the ore, referred to above. In this case the apparatus 5 would comprise a suitable mill, such as a ball mill, into which the ore is fed along with the water and the oil, and reduced in the presence of the water and oil, the mixing and differential filming taking place concomitantly with the freeing of the metallic content in the grinding process. From this it may be discharged by means of a suitable launder 6 on to a suitable distributing device 7. The distributing device is effective to distribute the pulp in the form of a shallow sheet or stream upon a separating device 8. This separating device in the form illustrated includes a plurality of pulp supporting stages 9 arranged in gradient relationship so that the pulp will move or flow from one on to another in its progressive movement along the device. During this progressive movement of the pulp it may be subjected to manipulation in suitable fashion to work the mass and permit its constituent particles to adjust themselves in accord with conditions contributing to stratification and agglomeration. This working or agitation of the mass may be accomplished by the injection of air or other fluid into it through apertures in the stages 9 or the apertures 9^a 10 adjacent thereto, or as a resultant of its progressive movement relative to separating or straining devices in the nature of apertured members or gratings 11 arranged at the terminations of different stages so that they lie in the path of the moving pulp. In the progressive movement of the pulp relative to these devices its smaller and heavier and more fluid portions will fall through the slots or openings, while its larger and lighter portions which are those that have been agglomerated into formative structures of a flocculent nature, or entities of increased

size, will be retained for a period by the separating members. This tends to produce an actual physical separation of agglomerated values from the unagglomerated contents, assisting in the segregation of the desired values at the surface of the pulp stream, and further contributing to the progress of stratification within the mass.

In operable association with the pulp stream, and in such relationship that the progressive movement of the pulp brings it into the effective zone of operation thereof, are one or more selecting devices 12, 12[a], and 12[b]. These selecting devices may be in the nature of suction nozzles disposed in association with the separating device 11 as illustrated by the dot and dash line in Figure 2. These selecting devices, furthermore, may be adjustable so that they may be selectively positioned with respect to the pulp stream. In the illustrated device the selecting apparatus 12[b] is associated with the surface of a suitable flotation body 14 on which the device 8 is supported and on to which the pulp is launched from the device 8. Suction may be induced in the devices 12, 12[a], and 12[b] in a suitable fashion such as by means of exhaust fans 15, or by siphonic action.

The arrangement and operation of the selecting devices 12, 12[a], and 12[b] is such that they will select from the mass of the progressively moving pulp a desired content or contents which have been separated, segregated or stratified in accordance with their differentiated characteristics. For example; the selecting device 12 may be disposed to lift from the surface of the pulp stream the graphite values which have been agglomerated and segregated at the surface of the pulp stream up to that stage of the process; the selecting device 12[a] may be arranged to take off the additional graphite values which have been agglomerated and moved to the surface of the pulp stream by the further manipulation and movement of the pulp during its progress from the zone of operation of the selecting device 12; and the selective device 12[b] may be arranged to gather from the surface of the flotation body the graphite values remaining in the pulp after the effectiveness of the separating device 12[a] on the progressing pulp has been exhausted, said remaining values having been separated out of the mass by surface tension separation on the flotation body 14.

This process may be utilized advantageously for the recovery of a desired mineral in different grades of purity. For example, the adjustment of the selecting devices may be such that the selecting device 12 would take from the pulp the values which were first agglomerated, or those containing none of, or the least amount of, foreign material. This result would accrue from the fact that the discrete particles containing none or the smallest amount of foreign material would be carrying the greater amount of agglomerating film, and hence would have the greatest capacity and earliest developed tendency to segregate and agglomerate. Discrete particles containing in addition to the desired value a certain proportion of foreign material would be endowed with the capacity for agglomeration by virtue of the film carried by the portion consisting of the desired mineral, but their specific gravity would be greater and their tendency and capacity for agglomeration less than these properties of the homogeneous particles, due to the water filmed or filled portions of the composite particles. As a result, the composite particles would be segregated and agglomerated more slowly than would the homogeneous particles, by virtue of which they would not be taken off by the selecting device 12 but would be taken off by the selecting device 12[a]. A third class of particles containing a larger proportion of the foreign or undesired material, but a certain proportion of the desired mineral, by virtue of the presence of the latter, would be endowed with properties permitting their separation from the pulp by the surface tension process, and hence would be selected by the device 12[b]. The portion of the pulp unaffected by the non-assimilating agent would, of course, be discharged as tailings through the flotation body. In this fashion the selected mineral would be assorted into grades according to purity.

In the event the desired metallic content of the ore is such that it can be most efficiently and effectively segregated or gathered by a frothing process, the agent utilized, in addition to having the qualities for artificially differentiating the desired metallics from the undesired contents, would have the further quality of contributing to the frothing of the mixture consequent upon its manipulation upon the separating device and the injection of air through the pulp stream as above descibed. There are many of such differentiating and frothing agents known in the art. The manipulation and aerating of the pulp to form the froth and segregate therein the desired metallics is accomplished during the progressive movement of the pulp upon the separating device. Due to the fact that the pulp, while being subject to this manipulation, is in the form of a very shallow stream or ribbon, it will be seen that opportunity will be given for the rapid segregation out of the mass of the desired metallic content, due to the fact that the progressively moving and undulating shallow stream of pulp offers a minimum impedance to the action of the froth forming agent in picking up and

transporting to the surface the metallic particles. Moreover, by the manipulation of the pulp in this fashion the froth is easily formed, due to the fact that in order to thoroughly work the material it is not necessary to subject it to violent agitation as in the case of large bodies of pulp. As in the case of the use of the non-frothing oil as above described, the progressively moving stream of pulp carries the froth and the values collected thereby to the selecting devices, the arrangement and adjustment of which may be such as to withdraw the froth and its carried values practically as soon as they are segregated at the surface of the pulp stream.

The treatment of the ore in this fashion, and the removal of the values and the froth, in which they are collected and by which they are supported, almost immediately the froth is formed on the progressively moving stream, obviates the necessity of violent agitation as it renders it unnecessary to maintain a large quantity of froth to support the load of mineral for an appreciable length of time or to sustain it until it is scraped off the surface, or to contribute and maintain the buoyancy necessary to float it upon the surface of the flotation body for a material length of time, as is necessary in cases where the froth is rafted or floated off, or scraped or skimmed from the flotation liquid. This treatment is especially commendable in the separation of the brittle ores such as those containing copper, zinc and lead sulphides.

Having thus described my invention, what I claim is:

1. The process of ore separation which includes treating the ore to endow divers contents thereof with different characteristics tending to produce segregation and agglomeration of a desired content, working the slightly moistened ore thus treated to agglomerate and bring to the surface further of the desired constituents, moving the said slightly moistened ore progressively in the form of a long, freely flowing sheet, and removing the desired particles from the surface of the sheet at successive stages in the course of the progress thereof.

2. The process of ore concentration, which includes the reduction of the ore to discrete particles of a desired size, the treatment of the particles with an agglomerating agent having preferential affinity for a desired mineral content of the ore, working the slightly moistened ore so treated to contribute to the cumulative agglomeration of the capacitated particles, causing the agglomerated particles to move as an unbroken freely flowing stream mass, and removing by suction the agglomerated particles from the mass according to the rapidity of their agglomeration during the working thereof.

3. The process of ore concentration, which includes the reduction of the ore to discrete particles of a desired size, the treatment of the particles with an agglomerating agent having preferential affinity for a desired mineral content of the ore, treating the slightly moistened ore so treated to contribute to the cumulative agglomeration of the capacitated particles, moving the slightly moistened ore progressively as a long, freely flowing stream, and removing by suction the agglomerated particles from the stream at successive stages of the progress of the stream in classes according to the rapidity of agglomeration.

4. The process of ore concentration which includes the reduction of the ore to discrete particles of a desired size, the treatment of the particles with an agglomerating agent having preferential affinity for a desired mineral content of the ore, moving the slightly moistened ore so treated progressively as a long, flat, freely flowing stream, manipulating the said slightly moistened ore in the course of such movement to contribute to the cumulative agglomeration of the desired constituents, removing the agglomerated particles from the stream in classes according to the rapidity of the process of agglomeration, and the working of the pulp to agglomerate and bring to the surface further of the desired constituents intermediate the removals.

5. The process of concentrating ores, which includes the reduction of the ore to discrete particles of a desired size, the treatment of the reduced ore with an agglomerating agent having a preferential affinity for a desired content of the ore, advancing the slightly moistened ore as a long, flat, freely flowing stream by gradient stages, manipulating the slightly moistened ore to contribute to the progress of agglomeration during the advance, withdrawing the agglomerated particles at particular stages during the advancing of the ore, and working of the pulp to agglomerate and bring to the surface further of the desired constituents intermediate the particular removals.

6. The process of concentrating ores, which includes the reduction of the ore to discrete particles of desired size, the treatment of the reduced ore with an agglomerating agent having a preferential affinity for a desired content of the ore, advancing the slightly moistened ore as a long, flat, freely flowing stream by gradient stages, manipulating the slightly moistened ore to contribute to the progress of the agglomeration during the advance, withdrawing the agglomerated particles at successive stages during the advancing of the ore, and discharging the undesired content at the end of the stream.

7. The process of ore concentration, which includes the reduction of the ore to discrete

particles of a desired size, the treatment of the particles with an agent effective to differentially characterize the different mineral contents of the ore, manipulating in the form of a long, flat, freely flowing sheet the slightly moistened ore so treated to contribute to the cumulative stratification of different mineral contents thereof in different strata in accordance with the characteristics contributed by the differentiating agent, and removing by suction the particles forming the surface stratum in classes according to the rapidity of their stratification.

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