UNITED STATES PATENT OFFICE.

ARTHUR J. MOXHAM, OF WILMINGTON, DELAWARE.

ORE-SEPARATING PROCESS.

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To all whom it may concern:

Be it known that I, ARTHUR J. MOXHAM, a subject of the King of Great Britain, residing at Wilmington, county of New Castle, and State of Delaware, have invented a new and useful Improvement in Ore-Separating Processes, of which the following is a full, clear, and exact description.

My invention relates to the well known process of separating solids of different specific gravity, and particularly the metallic and silicious constituents of iron ore, by means of a liquid of relatively high specific gravity and prefereably a liquid of a specific gravity above that of the lighter solid and below that of the heavier solid.

In separating the constituents of iron ore by means of a liquid which, for convenience, may be referred to as a liquid of mean specific gravity, the number of liquid solutions that are practically available is limited, and of those that are available all are quite expensive. It must also be understood that the mere fact that a liquid is of a specific gravity somewhere between the specific gravities of the two solids to be separated does not render it most advantageously available as a separating medium, where gravity alone, unassociated with agitation, is relied upon to effect the separation. On the contrary, the separating medium, to effect a proper separation, should not only have an intermediate specific gravity but should be of a specific gravity that will correspond closely to what is theoretically required. This is especially true in the separation of ore that is uncrushed or is not finely crushed. The reason for this will be obvious if it is borne in mind that the ideal product which it is desired to separate should be composed not of pure iron ore but of iron ore having a fairly defined proportion of silicious material—such product being most suitable for smelting.

The difficulty of selecting a suitable separating medium is further enhanced by the fact that different kinds of ore have different specific gravities. For this reason, a liquid separating medium that is available for one kind of ore is sometimes unavailable, or undesirable, for another kind of ore. For example, a fair specific gravity for a solution for calcined limonite or hematite iron ore is that of antimony bromid, 3.65. With many of the other ores, however, for example magnetitic iron ore, as also many of the lead, zinc, copper and other minerals, a solution with a higher specific gravity would be advantageous, while with uncalcined limonite a solution with specific gravity not over 3.40 is preferable. Further, it is necessary, in order to maintain the fluidity of certain separating media, to heat them to, and keep them at, an artificial temperature. For example, antimony bromid has to be kept at a temperature of approximately 100° C. and of course the ore must be maintained at a similar temperature. Of the solutions that can be used cold, it is a general rule that they are of lower specific gravity than those that can be used hot. At the present time it is believed that no solution of a specific gravity exceeding about 3.40 can be used at normal temperatures, say in the neighborhood of 30° C. until we come to the very high specific gravity liquid metals, such as mercury. Between these two extremes, there exists in the present state of our knowledge a gap that can only be filled by heated solutions.

The objects of my invention are, first, to render available for use as separating mediums a number of solutions that have heretofore been practically unavailable; second, to enable the use of certain of such solutions of relatively low specific gravity at ordinary temperatures; third, to enable certain of said solutions to be employed in the separation of different kinds of ore including the heavier, as well as the lighter ores.

To effect this object, my invention consists of so treating the ore, preliminarily to its immersion in a separating liquid of mean specific gravity, as to either reduce the specific gravity of the heavier portion of the material to be separated, or of both portions, heavier and lighter, of such material.

More specifically, my invention consists in reducing the specific gravity of the ore by coating it with a blanket liquid or other

material of a specific gravity substantially lower than that of the separating liquid. It is preferable that the portion which floats should also be reduced in specific gravity, but is not absolutely essential. In fact the floating portion might even be made heavier while the sinking portion is made lighter, so long as the increase in specific gravity of the lighter portion is not great enough to interfere with its floating. Such practice, while possible, is not recommended, however, as I find the greater the difference in the specific gravity of the separable ingredients, the more perfect the separation. It will be understood that such coating liquid should preferably be one that is not miscible with the heavier separating liquid and that is also a neutral liquid—that is, one that will not chemically react with the separating liquids. Preferably, though not necessarily, the coating liquid is also one that is of less specific gravity than the lighter of the two solid constituents. In fact, the lighter the coating liquid—assuming that a definite proportion of the same adheres to each of the solid constituents, the greater the reduction in the specific gravities of the coated solids.

It will be understood that a reduction in the specific gravities of the solids affected by the use of a coating will produce the same relative condition as if the specific gravity of the separating medium were increased. It will also be understood that the result will be to enable the employment as separating mediums, in most instances at ordinary temperatures, of a number of relatively light liquids that have heretofore not been deemed practically available.

It has been determined that if certain grades of ore are wet with a large excess of a suitable coating liquid and drained for a period of time varying from a few minutes to several hours, or even when mechanically treated, as, for example, by a centrifuge, it retains a considerable proportion of liquid. By reason solely of the surface attraction between the ore and the coating liquid, a proportion of this adherent coating liquid will remain in contact with the solids after their immersion in the separating liquid and after their removal therefrom following separation.

Having thus disclosed the essential feature of the invention, I will give several examples of specific ways in which the invention may be carried out, it being understood that the figures given are not intended to be absolutely precise, but are approximate and illustrative only, and that the particular coating liquid that will in practice be employed will have to be selected in view of the particular separating solution that is used, in view of the particular kind of ore that is to be subjected to the process, in view of the relative purity that it is desired that the separated iron constituent shall have, and in view of other conditions that may be presented in the particular separating process that may be employed.

The coating liquid that may be successfully employed to reduce the specific gravity of the ore or of the heavier portion thereof, will depend upon the nature of the separating liquid. For example, when using arsenic bromid as a separating medium, concentrated sulfuric or phosphoric acid may be used as a coating liquid; or if using acetylene bromid as a separating medium water can be used as a coating liquid.

Assume that a solution with a specific gravity of about 4.15 would give proper results in separating dry hematite ore with an average specific gravity of about 4.25. The nearest approach to a liquid of this density is, perhaps, antimony bromid, hereinbefore mentioned, which, when liquefied, has a specific gravity of about 3.65. Assume that the ore is preliminarily coated with a solution, for example, phosphoric acid, having a specific gravity of 1.7 and that the proportion of the same that adheres to the solid constituents during separation is ten per cent. The result will be to reduce the specific gravity of the ore to about 3.73 or say about .5 reduction. At the same time this will reduce the specific gravity of the silica from 2.66 to about 2.50. It will be understood that the practical effect of separating an iron ore having an average specific gravity of 3.73 in a solution with a specific gravity of 3.65 would be about the same as that of separating an iron ore having a specific gravity of 4.25 in a solution with a specific gravity of 4.15.

Assume that it is desired to employ a cold solution, such as acetylene bromid of a specific gravity of about 2.98, as a seperating medium for limonite ore of an average specific gravity of 3.65. Under ordinary conditions, unless the ore were crushed extremely fine, there would be a very poor separation. But with ordinary crushing, say to three-eighths or one-quarter inch mesh, and with a coating of water applied to the ore, very good results are obtained. The addition of water as a coating (assuming that about five per cent. of water will adhere thereto) will bring the specific gravity of the ore down to about 3.2 and of the silica to about 2.4 and the constituents consequently separate well in a solution of 2.98 specific gravity.

It is well known that there is much difference in the adhesion of most liquids to different solids. Iron ore is largely made up of oxid of iron and silica. Most solutions if directly applied will adhere to oxid of iron more tenaciously and in larger amount than to silica. I have discovered, however, that if water be applied in the form of a steam spray the amount retained

by the two is about the same, the difference in the surface attraction being practically overcome. Moreover, hydrofluoric acid and caustic soda tend to attack the silica while not attacking the iron and thereby also reduce if they do not entirely equalize the difference in surface attraction of the two. It is therefore possible to reduce the specific gravity of the heavier constituent (oxid of iron) more than of the lighter (silica) or to reduce them in relatively the same proportions, at will.

A number of other solutions, now more or less impracticable for use as separating mediums, may be successfully and practically used, and most of them at ordinary temperatures, if the specific gravity of the ore is reduced as hereinbefore described. As examples of such cold solutions, may be mentioned bromoform, acetylene bromid, and many of the tungsten solutions, which have specific gravities ranging between 2.90 and 3.20.

In carrying out my process it will be understood that the ore can be preliminarily wet in any way, as by running the blanket liquid over the ore and allowing it to drain off for the necessary length of time or by passing the ore through a body of the blanket liquid, and when necessary afterward treating by centrifuge or otherwise until the remaining coating is reduced to the exact amount necessary. After the ore is coated, the separating process is carried out by means of any well known apparatus, the only essential steps being that the coated ore shall be placed in a separating tank, in a solution of the proper specific gravity, and that the solids that float and those that sink shall be removed separately by any known mechanical means. After the solids are separated, the adherent coating liquid may be removed, if necessary, for example, by evaporation with heat, or mechanically by means of a centrifugal wringer, or otherwise. A better result is achieved if using a heavier separating medium together with a minimum reduction of the specific gravity of the material to be separated, than if using a lighter separating medium and an excessive reduction of the specific gravity of the material to be separated. Moreover, in either event, the amount of coating material must be an exact and predetermined amount. The addition of an excessive or irregular amount of even so light a coating material as water is not permissible.

While the percentage of coating material that it is advisable to add varies with different coating materials and also with different separating liquids and with different ores, and therefore no definite percentage exists that would be applicable to all conditions, still it is important that with a given coating liquid, a given separating liquid and a given ore to be separated, the percentage of coating liquid that it is useful and at the same time practicable to employ must be not only fixed and determined within narrow limits but must be uniformly and equally distributed throughout the mass. The addition of an uncertain amount of water, or other coating material, or its irregular distribution throughout the mass, will be disadvantageous and sometimes fatal. Therefore the method of adding the coating liquid becomes of importance, and while I do not wish to limit my process to any particular way of adding the coating liquid the ways hereinbefore mentioned are preferred, namely, thoroughly wetting a given amount of solids with the coating liquid and draining for the proper length of time; or vaporizing the coating liquid and applying it in the form of a spray, or bringing the excess down to a specific amount by mechanical means such as a centrifuge. Merely allowing the ore to be caried by water flowing over a separating medium, which has been done heretofore simply for the purpose of carrying off the lighter solid constituents, would be ineffective in that the ore would probably carry with it such an excess of water as to make it impossible to use a very heavy liquid as a separating medium, and the irregularity of the distribution of the coating would be such as to not merely reduce the specific gravities of the different constituents, but to reduce their specific gravities in such an irregular and uncertain manner as to obstruct, rather than facilitate, the desired separation.

I have principally described the use of a coating medium lighter than either of the ingredients to be separated, but it should be pointed out that a coating material lighter than the heavier ingredient, even though it is heavier than the lighter ingredient, can be used within certain limits, as I have found that a difference as small as .10% or 1/10 between the specific gravity of the ingredients and the separating liquid will suffice to effect a good separation. It is generally practicable and always advantageous, however, to increase rather than decrease the difference between the specific gravity of the ingredients by the addition of a lighter coating liquid than either, or at least to reduce both as nearly in the same proportion as possible, rather than to bring this difference in specific gravity closer together; hence my preference is for the addition of a coating material lighter than either of the ingredients.

Having now fully described my invention, what I claim and desire to protect by Letters Patent is:

1. In the process of separating solid constituents of different specific gravities, first treating the solids by coating them with a

definite percentage of material adapted to reduce the specific gravity of each of the solid constituents to a predetermined degree, and then immersing them in a liquid separating medium.

2. In the process of separating solid constituents of different specific gravities in a heavy liquid, first treating the solids to reduce the specific gravity of each of the solid constituents to the extent required to cause the separating liquid to have the desired specific gravity relative to the specific gravity of each of the solid constituents, and then effecting the separation of the solid constituents in such separating liquid.

3. In the process of separating solid constituents of different specific gravities in a heavy liquid, first treating the solids to reduce the specific gravity of each of the solid constituents to the extent required to cause the separating liquid to have a specific gravity of the desired mean between the respective specific gravities of the heavier and lighter solid constituents, and then effecting the separation of the solid constituents in such separating liquid.

4. In the process of separating constituents of different specific gravities in a liquid, first intimately associating with the separate particles constituting both solid constituents other material of lower specific gravity than that of the heavier solid constituent, and adding such material in such proportion as to cause the separating liquid to have the desired specific gravity relative to the specific gravity of each of the solid constituents, and then effecting the separation of the solid constituents in such separating liquid.

5. In the process of separating constituents of different specific gravities in a liquid, first intimately associating with the separate particles constituting both solid constituents other material of lower specific gravity than that of the heavier solid constituent and lower than that of the separating liquid, and adding such material in such proportion as to cause the separating liquid to have the desired specific gravity relative to the specific gravity of each of the solid constituents, and then effecting the separation of the solid constituents in such separating liquid.

6. In the process of separating solid constituents of different specific gravities in a heavy liquid, first intimately associating with the separate particles constituting both solid constituents other material of lower specific gravity than that of either of the solid constituents and lower than that of the separating liquid, and adding such material in such proportion as to cause the separating liquid to have the desired specific gravity relative to the specific gravity of each of the solid constituents, and then effecting the separation of the solid constituents in such separating liquid.

7. In the process of separating solid constituents of different specific gravities in a heavy liquid, first coating the separate particles constituting both solid ingredients with a liquid of lower specific gravity than that of either of the solid constituents and lower than that of the separating liquid, and adding such coating liquid in such proportion as to cause the separating liquid to have the desired specific gravity relative to the specific gravity of each of the solid constituents, and then effecting the separation of the solid constituents in such separating liquid.

8. In the process of separating solid constituents of different specific gravities in a liquid separating medium, first coating each of the solid constituents with a liquid of lower specific gravity than that of the liquid separating medium, then immersing the coated solids in such liquid separating medium having a specific gravity between the specific gravities of the two coated constituents, and then separately removing the solid constituents that float and those that sink.

9. In the process of separating solid constituents of different specific gravities, first coating both solid constituents in a liquid heavier than water but lighter than that of the heavier solid constituent, and then effecting the separation of the solid constituents in a liquid separating medium.

10. In the process of separating solid constituents of different specific gravities, first coating both solid constituents in a liquid heavier than water but lighter than that of the heavier solid constituent, and then effecting the separation of the solid constituents in a liquid separating medium, of a specific gravity greater than that of the coating liquid.

11. In the process of separating solid constituents of different specific gravities, first coating the solids in a liquid heavier than water but lighter than that of either of the solid constituents to reduce the specific gravities of each of the solid constituents, and then effecting the separation of the solid constituents in a liquid separating medium of a specific gravity greater than that of the coating liquid.

12. In the process of separating solid constituents of different specific gravities, first coating both solid constituents in a liquid heavier than water but lighter than that of the heavier solid constituent, and then effecting the separation of the solid constituents in a liquid separating medium of a specific gravity between the specific gravities of the coated constituents.

13. In the process of separating solid constituents of different specific gravities, first coating the solids in a liquid heavier than

water but lighter than that of either of the solid constituents to reduce the specific gravities of each of the solid constituents, and then effecting a separation of the solid constituents in a liquid of a specific gravity between the specific gravities of the coated constituents.

In testimony of which invention, I have hereunto set my hand, at Wilmington, Del., on this 26th day of March, 1912.

ARTHUR J. MOXHAM.

Witnesses:
C. E. SPENCE,
THOMAS BURN.