

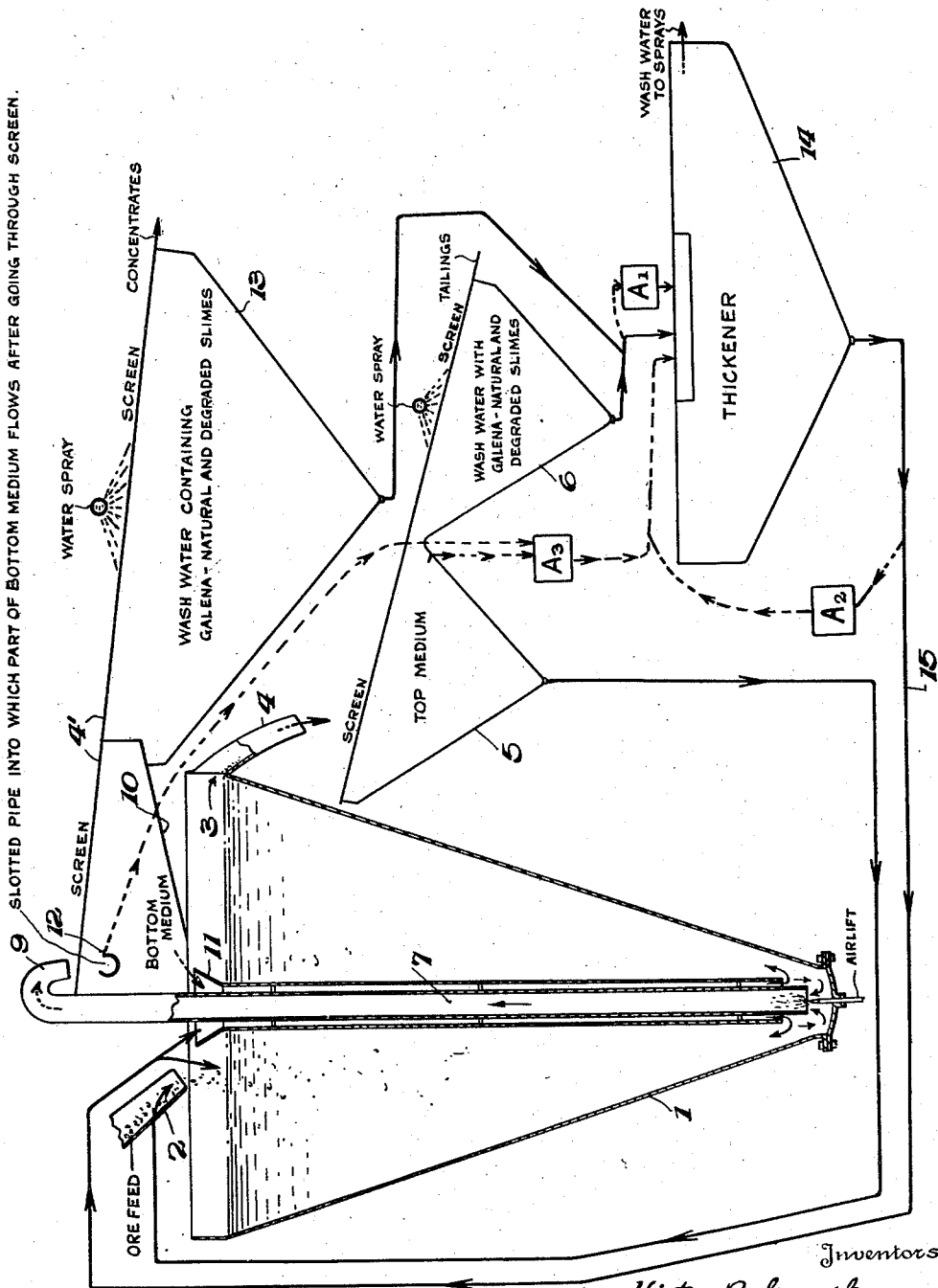
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PROCESS OF SEPARATING FRAGMENTARY MATERIALS

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PROCESS OF SEPARATING FRAGMENTARY MATERIALS

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This invention relates to processes for separating fragmentary materials of different specific gravities in a liquid medium whose specific gravity increases from the top downward, and has for its object to provide a process of this class whereby the materials may be separated with a high degree of accuracy and at a minimum cost, and which is capable of adjustment to efficiently separate from each other the particles of various ores or other substances subjected to treatment.

It has been proposed heretofore to provide a liquid separating medium of increasing specific gravity from the top downward by introducing into a body of water a plurality of finely divided solids of differing specific gravities, the proportions of water and the different solids being such as to provide a liquid medium in which the lighter particles to be separated will rise and the heavier particles will sink therein. At the initiation of the separating operation the specific gravity of the medium is adjusted with relation to the specific gravities of the materials to be separated, but owing to a variety of causes great difficulty has been experienced in maintaining the required specific gravity of the medium. Among these causes may be noted the following: lighter medium is removed from the top of the main body of the medium together with the lighter separated material and heavy medium is removed from the bottom together with the heavier separated material. Moreover, the materials to be separated are generally fed into the main body of the medium in a wet condition and even though they have been pre-washed, they are frequently accompanied by slimes and other fine bodies of solids and water.

One of the objects of the present invention is to provide a method of separating fragmentary materials of different specific gravities in a separating medium while maintaining in such medium at all times specific gravities required for accurate separation of the materials. Further objects will appear as the description of the invention proceeds.

In the practice of the present invention a suitable self-supporting or self-sustaining medium is placed in a container or tank preferably of inverted cone shape, the specific gravity of the medium at the top of the tank being less than that of the material to be separated out, the specific gravity decreasing from the bottom upward.

This medium is formed by mixing in water a finely divided heavy solid or solids of a spe-

cific gravity not less than 7.0, such as galena or galena concentrates or finely divided metals, either alone or in association with a metallic mineral such as magnetite, in proper proportions with natural slimes (which sometimes contain magnetite) of the ores or other materials to be separated. These natural slimes may be and generally are accompanied by other finely divided solids of high or low specific gravity.

Specific gravity.—In a solid plus water mixture, there is a definite mathematical relation between the average sp. gr. of the solids, the percentage of the solids, and the resulting sp. gr. of the suspension, expressed by the following formula:

$$\frac{1}{d} = \frac{P}{S} + 1 - P$$

d = specific gravity of pulp
 S = specific gravity of dry solids
 P = percent solids

Thus in a galena plus slimes mixture having an average sp. gr. of 5.9 it will require 72.2% of the solids to produce a medium of 2.50 sp. gr. at the top. This mathematical relationship is independent of the grain size of the solids.

Grain size.—The self-supporting powers of a suspension medium are related to the size of solid grains in said medium. The finer the grains, the greater is the self-supporting power. However, fluidity is increased by coarser grains. Therefore, the ideal self-supporting medium is one in which there is a maximum amount of grains of a size contributing to self-support, and a maximum percentage of coarse grains for liquidity. In a medium of 2.5 top sp. gr., the maximum grain size of galena which can be supported, is approximately 150 mesh. In a medium of a higher top specific gravity, larger galena grains may be supported. It has been found that 2.80 top sp. gr., 100 mesh grains will not settle out, under operation conditions with a minimum of agitation.

Most common non-metallic slimes such as clay and calcite, exhibit a greater tendency to form fine slimes than does galena. They are also lighter and more buoyant. Galena is heavy, breaks into granular particles, and in a pure state must be ground very fine to form a self-supporting medium.

We have discovered that by separating out a portion of the fine non-metallic slimes of a given ore to provide the supporting qualities, and adding thereto a proper amount of the relatively coarser grains of ground galena, for example,

to supply liquidity, an ideal medium is the result.

On account of the low cost of the natural slimes in the ore, it is obvious that the most economical medium will be one in which there is a maximum of such slimes. More of such natural slimes may be used when the sp. gr. of the separation is low than when it is high. The measure of this mixture is usually made in terms of metal in the mixture. Thus when galena is used it is in terms of lead in the mixture. Pure galena is 86.6% lead. At 2.50 top sp. gr. of medium it is possible to use solids of 55% lead and get good results.

It is essential in the present invention that the heavier solid or solids of the medium have a specific gravity of not less than 7.0. In the majority of the ores treated by a process of this character, the sp. gr. of the gangue minerals to be separated out have a specific gravity of at least 2.5, and in order that such gangue minerals may be caused to rise in the separating medium, it is essential that the medium at its upper portion should have a specific gravity of not less than 2.5. The use of the heavier solid of a sp. gr. of not less than 7.0 is essential to provide a medium having a top sp. gr. of 2.5 if the proper liquidity of such medium is to be preserved.

It is also essential in the practice of the present invention that the separating medium be one which when brought to rest will remain liquid throughout its entire depth for several hours, with the specific gravity thereof increasing from the top downward, and such a medium is herein referred to as a self-supporting or self-sustaining medium. When the solids in such a self-supporting medium may tend to very slowly settle when the liquid is at rest, the settlement is in the nature of a movement of the solids from the upper portion of the container downward with a resultant increase of the proportion of solids in the lower parts of the medium and a consequent increase in the density thereof. However, even under these conditions the bottom of the medium is not in the form of an impervious layer but will permit bodies of higher sp. gr. to pass therethrough.

There is a force in a liquid suspension, supporting grains which would ordinarily sink, that is not entirely understood. It is probably the same force or combination of forces found in colloidal solutions. This may include an electrical force of attraction or repulsion. Whatever the force may be, the effects thereof are uniform and are of importance in the self-supported or self-sustaining medium of the present invention.

While after several days settling of such a medium, the lower layers of the medium may be too thick to have any value as a separating medium, nevertheless if apparatus employed in the practice of the process is shut down for a few minutes, a few hours or even a day, said self-sustaining medium can readily be set in motion again by liquid handling means, such as stirring devices, pumps, air lifts and the like, and the medium than be restored to proper condition.

Thus it will be apparent that one of the advantages of such a self-supporting medium is that there is no clogging of tanks, pipes, pumps or accessories during normal shut-down periods, such as would be caused by solidified non-liquid layers of the settled particles of the medium.

Moreover, when in operation, the gentlest of stirring will resist settlement and preserve the

proper fluidic conditions indefinitely with a high differential between the top and bottom sp. gr. of the medium, and the stirring may be utilized to aid in maintaining the required differential between the top and bottom of the medium.

When ores to be separated are fed into a separating medium they are accompanied by a variety of slimes some of which have no metallic values, and some of which have more or less metallic value, and in addition to this certain slimes are produced by the degrading action of the ore itself during the process. These slimes produced by the degrading action of the ore during the process may be of either of the two classes mentioned above. If all of these slimes were permitted to remain in the medium during the process the result would be an accumulation of such slimes which would eventually so increase the percentage thereof as to destroy the required specific gravity and liquidity of the self-sustaining medium.

Having determined the proper composition of the self-sustaining medium by test, experiment or otherwise, for the ore under treatment, it is of imperative importance that this composition be maintained approximately constant. It will be recognized from the above that the composition of the self-sustaining medium is determined by the proportions of slimes of differing grain size and specific gravity and of the water employed.

By the present invention steps are taken to withdraw from some point in the system an amount of medium for purification sufficient so that the amount of slimes removed from such medium equals that developed in the system and supplied by the fragmentary materials fed to the process. By this means the composition of the medium is maintained approximately constant. In such purification it is preferred to remove only those slimes which have a low sp. gr. and no metallic value, retaining in the medium those slimes of metallic value and higher sp. gr. and the medium thus cleaned or purified is returned to the main body of the medium in the tank in proportions and at a rate necessary to maintain the required sp. gr. of said main body of self-sustaining medium. In some cases, however, it may be of advantage to also remove some of the slimes of metallic value. The advantage of removing as little of the metallic slimes as possible resides in the fact that the metallic slimes are conserved and by their use the amount of high grade 7.0 sp. gr. material required in the medium is considerably reduced.

Having prepared a self-sustaining medium of the proper sp. gr. for the materials to be separated and the sp. gr. at or immediately below the surface being not less than 2.5, said materials are fed into the top of the medium with slimes and other finely divided substances, as well as some water, and the lighter portions of the materials to be separated rise in the medium and are removed therefrom together with a considerable portion of the lighter part of the medium itself. This top medium thus removed has a high percentage of slimes and their removal tends to materially lower the proportion of slimes remaining in the body of medium in the tank, while the incoming feed of materials adds water and slimes thereto. The heavier portions of the materials to be separated sink to near the bottom of the medium and are removed therefrom with a considerable amount of the heavier medium itself thus tending to reduce the amount of such

heavy medium in the main body of medium. All this tends to change the sp. gr. of the medium remaining in the tank, and if the operation were thus continued efficient and accurate separation of the materials would soon become impossible.

By the present invention steps are taken to neutralise this tendency and maintain the specific gravity of the body of medium in the tank at the proper point for accurate separation of the materials.

Let it be assumed that the fragmentary materials to be separated require a specific gravity at the top of the separating medium of 2.5 or higher, say 2.80, with the sp. gr. increasing downward until it is, say 2.96. When the fragmentary solids to be separated are fed into this medium, they are accompanied by slimes and other finely divided substances as well as water, and the lighter separated solids leaving the top of the tank are accompanied by water, slimes and other finely divided substances. Moreover, the heavier separated materials removed from the bottom of the tank are accompanied by some of the heavier medium. As above stated, all this tends to produce a change in the specific gravity and liquidity of the medium remaining in the tank, and this change tends to defeat efficient and accurate separation of the fragmentary materials under treatment. The extent of this change is determined by test experience or otherwise and will vary with different ores, with the rate of feed of said ores to the tank and for other reasons.

In the operation of our process there is developed a certain amount of slimes both in the ore feed and due to the degrading action of the ore itself during the process. This results in an accumulation of slime from the ore itself which would eventually increase the percentage of slime above that desired in the system if steps were not taken to avoid it. In our invention steps are taken to withdraw from some point in the system an amount of medium for purification sufficient so that the amount of slime removed from such medium is approximately the same as that developed in the system and supplied by the fragmentary materials fed to the process. This medium more or less "cleaned" or "purified" is continuously returned to the main body of medium in the tank in such amount and at such a rate as to constantly maintain the required sp. gr. and liquidity of the medium in the tank.

The preferred method of doing this will be understood by reference to the accompanying diagram in which 1 indicates any suitable separating tank, and 2 an ore feeding chute. The lighter separated material with accompanying medium overflows at 3 onto screen 4 and the medium passes through the screen into tank 5, while the separated materials with some of the solids of the medium clinging thereto pass down the screen 4 and over the tank 6 where they are sprayed with water, thus washing off the clinging solids, and the wash water and solids thus washed off pass through the screen and into tank 6. The heavier separated materials with accompanying medium are elevated through pipe 7 by an air lift device 8 and are delivered at 9 onto a screen 4'. The medium passes through the screen 4' onto a chute or pan 10 which delivers the main portion thereof into the separating tank. The separated materials falling upon the screen 4' pass down the screen over the tank 13, and while over said tank they are sprayed with water to wash off any of the solids of the medium which may be clinging thereto, the washed water and

solids thus washed off passing through the screen into the tank 13. From the tank 5 the medium therein is returned as indicated by the arrow to the top of the medium in the tank, preferably by way of the feed chute 2. It will thus be seen that by far the larger portion of the medium removed from the tank either from the top or from the bottom is returned directly to the medium in the tank. In ordinary practice this exceeds 90% of the medium thus removed, and provision is made for treating that portion of the medium which is not thus directly returned so as to clean or purify it by removing some of the natural slimes and degrading slimes. It will be noted that the medium as such and in the condition in which it is removed from the tank 1 is received directly into the tank 5 and the slotted pipe or trough 12, while the tanks 6 and 13 receive only the wash water with the solids washed thereby from the separated materials, which solids inevitably contain natural slimes and degraded slimes from the medium. For the purpose of removing these slimes and sands from the wash water in tanks 6 and 13, the wash water with associated slimes is conducted to any suitable cleaning means A', wherein any desired portion of the slimes and sands are removed, and the water with the remaining portions pass therefrom directly into the thickener tank 14. From the slotted pipe or trough 12 the portion of medium received therein is preferably first conducted to any suitable cleaning means A3, wherein any desired portion of the slimes and sands is eliminated, the medium thus cleaned passing into the thickener tank 14. If desired, however, the cleaning means A3 may be omitted and the medium passed directly from the slotted pipe or trough 12 to the thickener tank 14. Likewise, the medium from the tank 5 may be treated in the cleaning means A3. The medium thus treated is passed from the cleaning means A3 directly to the thickener tank 14. If found necessary, the medium in the thickener tank 14 may be passed through a cleaning means A2 and back from said means to the thickener itself as indicated in dotted lines. The cleaning means A', A2 and A3 thus provide means whereby the medium in the tank 14 may have any desired portion of the slimes and sands therein removed, and this proportion removed is so regulated that when the medium from the thickener 14 is passed therefrom by way of the conduit 15 back to the tank 1 they will be in such a condition as to sp. gr. and liquidity that they will serve to neutralize or overcome the tendency to the change of sp. gr. and liquidity due to incoming water and slimes in the tank mentioned above, thus maintaining in the tank a medium of constant composition. This return of the medium from the tank 5 and by way of the chute 10 and from the thickener 14 to the tank 1 is continuous, that from the thickener 14 being regulated in amount and rate to maintain constant the composition of the medium in the tank. The amount thus returned and the rate of return will vary with different ores, as well as with the rate of feed of the ore, and the operator determines by test and experience what the amount and rate of return is required in each particular case to maintain the composition of the medium in the separating tank constant.

It will be noted that the medium in the tank 5 is the top medium from the separating tank, and that the portion of the medium in the tank 5 that passes to the cleaner A3 is an overflow from the tank 5 to said cleaner. The result of this is that

the medium that passes to the cleaner A3 is the medium that contains not only the slimes of the ore being treated but also the finer particles of the solid, such as galena, contained in said medium; and it is these exclusively fine particles of both kinds that unless removed before the medium is returned to the separating tank, would tend to materially change the proportions of grain size in the medium, thereby changing its composition and specific gravity and destructively increasing the viscosity and decreasing the liquidity of the medium in the separating tank. It is in order to avoid this deleterious change in the composition of the medium in the tank that slimes are removed from some of the medium before it is returned to the tank.

It will thus be seen that those constituents entering into the composition of the medium which would tend to produce undesirable viscosity of the medium are removed to such an extent as operating conditions may require in order to maintain the composition of the medium constant, i. e., approximately that of the medium at the initiation of the operation.

By these steps the heavier solids (such as galena or metals) in the medium, as well as the valuable portion of the natural slimes are conserved in the thickener, only valueless portions of the natural slimes and sands being discarded by way of the cleaning means A', A2 and A3.

While for the purpose of description, more particular reference has been made herein to galena (and metals) is is to be expressly understood that the invention is not limited to the use of galena as the heavy solid in the medium. It has been demonstrated that iron (by which term as herein used steel is included) in powdered form, either alone or with magnetite or other magnetic minerals are of high efficiency when substituted for galena in the detailed description heretofore given.

One of the outstanding advantages resulting from the use of iron, either alone or with magnetite, or other magnetic minerals lies in the fact that they are readily recovered from the medium by well-known magnetic means. The heavier solids (galena, metals, etc.) of not less than 7.0 sp. gr. designed to be employed in the process are much more expensive than clays, sands and the like which have heretofore been employed in the art, and it is, therefore essential from an economical standpoint that these heavier solids be recovered for re-use without waste. When this is accomplished the initial cost of the heavier solid in the medium is practically the entire cost of such medium. Furthermore, by adding to the galena metallic slimes other than galena, such as natural slimes of the metallic minerals being treated or those produced by degradation, there is an appreciable saving in the capital cost of the medium itself.

It will be further appreciated that by using minerals or metals having a specific gravity of 7.0, the quantity of such minerals or metals required in the medium when mixed with the natural slimes of the ore and those produced by degradation is below that which would be

required if minerals or metals of a lower specific gravity were employed and thus the capital cost of the medium is appreciably reduced.

An additional advantage lies in the fact that minerals or metallics having a specific gravity of 7.0 are readily recovered at a low cost by well known cleaning processes. Galena, for example, is easily and cheaply recovered by flotation processes; and, because of its specific gravity, by tabling or classification. Steel and magnetite are easily and cheaply cleaned or purified by magnetic concentration means or other means. The conservation of water is also of importance particularly in localities where water is scarce, and in the closed circuit of the process herein described the water is used over and over in the washing of the medium remaining attached to the removed rock, and hence a minimum amount of water is required.

It is to be particularly pointed out that by the use of metals such as steel, iron, copper, zinc, etc., having a specific gravity of 7.0 or higher, as the heavy solid in the medium, it is rendered possible in treating any particular ore to avoid contamination of the values recovered from the ore resulting from the use of the medium. For example, in treating iron ore, steel or iron or its alloys may be employed as the heavy solid in the medium rather than galena, since steel or iron would not contaminate the recovered values, whereas the lead in galena would. The same is true if copper were used as a solid in the medium for treating copper ores or zinc were used as a solid in treating zinc ores.

What is claimed is:

1. In a process of separating ores the use of a liquid self-supporting separating medium comprising water containing slimes of the ore to be separated together with a comminuted solid of not less than 7. specific gravity, the slimes and comminuted solids being in such proportion that the mixture of slimes and comminuted solid shall have a specific gravity of not less than 5.9, the said slimes and comminuted solid constituting in excess of .70%, by weight, of the separating medium.

2. In a process of separating ores the use of a liquid self-supporting separating medium comprising water containing slimes of the ore to be separated together with granulated galena, said slimes and galena being in such proportions that the mixture of slimes and galena shall have a specific gravity not less than 5.9, and the slimes and galena constituting not less than 70%, by weight, of the separating medium.

3. In a process of separating ores, the use of a self-supporting separating medium comprising water and a finely granulated solid of a specific gravity of not less than 7. suspended in the water by natural slimes of the ore being treated, the slimes and granulated solid being in such proportions that the specific gravity of the mixture of the two is not less than 5.9, and the said slimes and granulated solid constituting in excess of 70% by weight, of the separating medium.

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