April 19, 1949. G. B. WALKER ET AL 2,468,005

THREE-PRODUCT HEAVY MEDIA SEPARATION PROCESS

Filed July 16, 1946

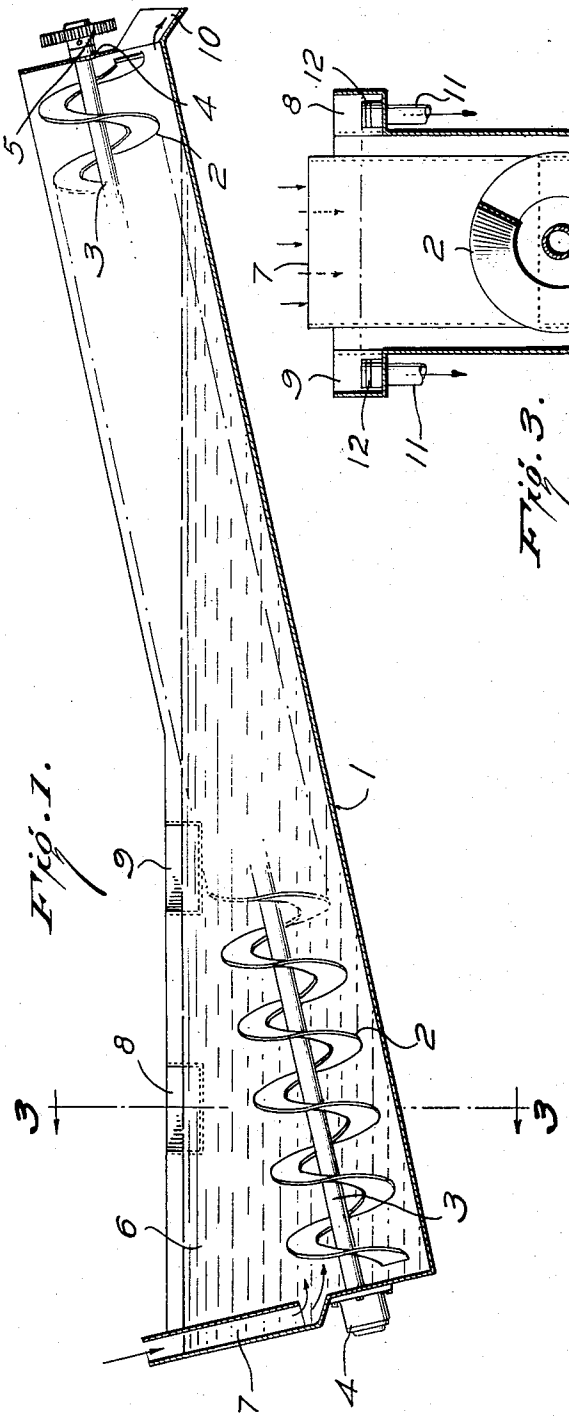

Fig. 1.

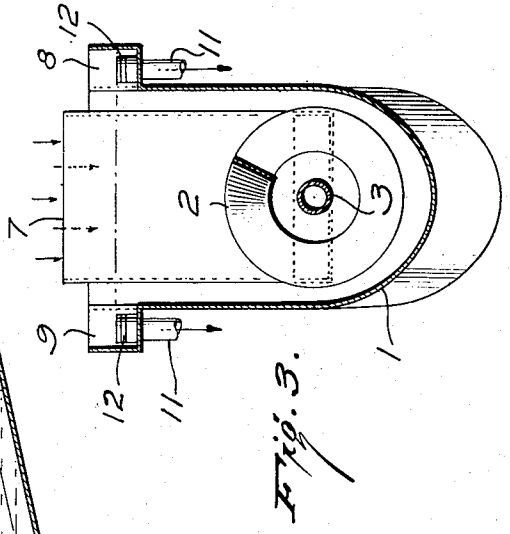

Fig. 3.

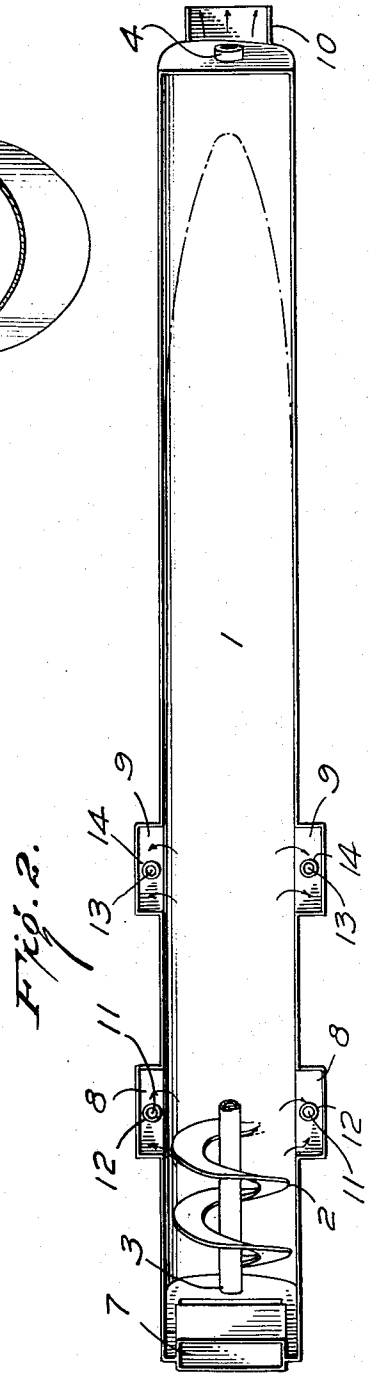

Fig. 2.

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Patented Apr. 19, 1949 2,468,005

UNITED STATES PATENT OFFICE

2,468,005

THREE PRODUCT HEAVY MEDIA SEPARATION PROCESS

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Application July 16, 1946, Serial No. 683,888

5 Claims. (Cl. 209—173)

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This invention relates to an improved process for the beneficiation of ores by heavy media.

The use of heavy media, that is to say, suspensions of finely divided, high gravity solids in water or other liquids, for the beneficiation of ores by a sink and float process, has achieved great commercial utility in the past decade. It has been customary to use separatory vessels in the shape of cones, and for the most part the successful operations have recovered two products, a sink product and a float product. In certain operations vessels of different shapes have been used, including elongated trough-shaped vessels in which the separatory medium is present in a wedge-shaped pool. Among such operations are those in which an inclined-trough spiral type classifier has been employed, that is to say, an inclined trough with a rotating spiral conveyor gripping a considerable depth of liquid for removing sink product. It is more particularly with this inclined trough-type that the present invention deals.

Many ores have presented a serious problem because they contain particles having a gravity approaching that of the separating medium. These products, which are often referred to as middlings, create great difficulties, particularly because they tend to accumulate in the cone, and particularly because much of them eventually are either removed as part of the sink product, reducing the grade thereof, or are removed with the float product, resulting in loss of recoverable mineral values. Many attempts have been made to deal with the problem of middlings. For instance, vertical currents have been established in cones or similar separatory vessels by which the middlings are thrown into the float product or are removed at different levels by means of separate air lifts. These various proposals have in general not been successful in the practical production of three products in commercial operation, although some of them are capable of such separations when operated with especial care or under special test conditions. The problem of ores having middlings which approach the gravity of the medium, but which yet are too rich to be rejected economically, was still far from solved.

The present invention constitutes a method in which three products can be recovered by a heavy media separation in a particular type of fluid body, namely, a wedge-shaped pool provided with a mechanical device such as an Archimedes screw, special wide rakes, or the like, which grip a column of medium which is of considerable

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depth in relation to the maximum depth of the inclined pool. Since one of the simplest and most practical apparatus in which the process of the present invention may be carried out is an inclined trough spiral type classifier, the invention will be described more particularly in connection with the operation of the process in such a type of installation. While many of the elements of the apparatus are very old in the art, the invention does not lie in a new apparatus and is a new process which operates apparatus of known type in a particular manner to remove three products.

Three essentials are necessary to the operation of the process of the present invention. First, the feed of materials to be separated must be deeply submerged at the deep end of the wedge-shaped pool, the feed being discharged adjacent to the column gripped by the mechanical conveyor. Second, this column must be of considerable size in comparison to the maximum depth of the deep end of the pool. In other words, it cannot be a drag with narrow flights or similar types of mechanical conveyors which are capable of scraping a thin layer of solids but which do not grip a column of considerable cross-section. The third essential is a plurality of discharge points at or adjacent to the level of the liquid for float and middlings products, the float product discharge points being located at a considerable distance above the column of liquid acted upon by the mechanical conveyor combined with middlings discharge points located adjacent to the upper edge of the column acted upon by the mechanical conveyor. Even these three essentials will not result in a performance of the process of the present invention because it is further necessary to operate the mechanical conveyor at a particular speed or speed range in relation to the characteristics of the ore and separating medium and the locations of the overflow discharge points. Particles of ore which are fed below the surface adjacent to the column moved by the mechanical conveyor are subjected to three different forces. One is a vertical force which is dependent primarily on the specific gravity of the ore particle, that is to say, a force which will cause it either to rise if it is lighter than the separating medium or to sink if it is heavier. The second motion is one which is substantially horizontal, although it will normally have a slight upward component which results from the fact that ore and medium is introduced at a relatively low point in the deep end of the

pool and float and middlings product with medium are removed near the surface at points distant from the deep end. This causes a slow flow from the feed point to the discharge openings. The third force is imparted by the mechanical conveyor and is normally a diagonal force having a horizontal component which is greater than its vertical component. The magnitude of this force is of course dependent on the speed at which the mechanical conveyor is operated and on its shape and size. It tends to move the column gripped by the conveyor in said diagonal direction.

We have found that for any particular fragmentary material having middlings of certain gravity characteristics, if the rate of feed which determines the horizontal flow and the movement of the column of liquid acted upon by the mechanical conveyor are adjusted so that the resultant of these two motions and the vertical motion due to specific gravity produces a trajectory of a particle of float from the feed to the float discharge point and a trajectory of average middling particle to the middling discharge point, three products are produced, a relatively clean sink and relatively clean float and the major of the middlings as a separate third product. When the feed and speed of mechanical conveyor have once been adjusted to produce the desired trajectories for a given ore, the machine will operate continuously to produce three products without further attention. Changes in the composition of the ore, of course, require adjustment of the mechanical conveyor and rate of medium return if they are of sufficient magnitude to alter the trajectories of the float and middlings particles to an excessive extent. It is an advantage of the present invention that relatively extended discharge points may be chosen and that there is a considerable leeway before the trajectories miss the discharge openings. This is of great practical value because it is a matter of extreme difficulty in ordinary operation to keep ore feed absolutely constant in composition. A process which requires absolutely constant control of feed is therefore subject to very serious practical operating disadvantages. The present process, however, gives sufficient altitude so that with most ores having middlings of a gravity capable of separate separation, long continued reliable operation may be effected without constant adjustment, once the factors of the process have been adjusted for initial proper operation.

The invention is not dependent on any particular single rate or range of rates of mechanical conveyor speeds. As this is only one factor of three which are acting simultaneously on the float and middlings product, a particular value is without significance apart from the other factors. Each ore, therefore, requires a different relation of feed, medium return speed, medium gravity and mechanical conveyor speed. The adjustment to produce satisfactory initial operation is not difficult, although in some cases it may take several hours, or even several days. Once the adjustment is made the machine operates reliably and changes in operation are normally not necessary unless factors are changed. Continuous critical, skilled supervision is normally not necessary and practical operation with a high degree of reliability results.

It should be understood that the present invention is not an answer to the problem of treating all fragmentary materials which contain middlings. It can only be used on ores in which the middling gravity is such in comparison to that of the sink and float product that separation is within the practical limits of mechanical construction. However, a very large number of materials which contain middlings and which otherwise are amenable to heavy media separation may be treated by the process of the present invention to produce three products with maximum concentrate recovery and a minimum loss of values.

The invention will be described in detail in conjunction with its operation in the preferred type of installation, namely, a separatory vessel having some of the elements of an inclined trough spiral type classifier. This is shown in the drawings, in which:

Fig. 1 is a vertical section;

Fig. 2 is a plan view with part of the conveyor screw broken away; and

Fig. 3 is a vertical section along the line 3—3 of Fig. 1.

The separatory vessel itself, which bears the numeral 1, is of the general shape of an inclined trough spiral type classifier, that is to say, an inclined trough provided with an Archimedean screw 2, rotating on an inclined shaft 3, which is mounted in bearings 4 at the ends and driven through a gear 5 from a suitable source of power, not shown. This portion of the machine is substantially the same as in an ordinary inclined trough spiral type classifier, and it is an advantage that to a large degree standard equipment may be used with only small modifications, a wedge-shaped pool 6 of a suitable heavy medium, for example, finely divided ferrosilicon or finely divided galena, in the case of a high gravity separation, or magnetite in the case of a low gravity separation. Feed is through a feed duct 7 which introduces the ore and return medium to a medium point adjacent to the column of liquid gripped by the screw 2. Float product weirs are located at 8, a considerable distance above the column acted on by the screw at that point. The level of overflow may be adjusted by spacing rings 12 on the discharge pipes 11 (Fig. 3).

The discharge openings for middlings 9 are located much further from the deep end of the pool and at a level adjacent to the column moved by the screw. These are shown in Fig. 2 as launders, and their level may be adjusted in the same manner as those of the float product launders by rings 14 on pipes 13, or ordinary weir sticks. Sink discharge is through a chute 10 at the raised end of the vessel and is shown as similar in design to the ordinary type of discharge for an inclined trough spiral type classifier. It will be noted that when using the preferred type of installation the only substantial change in the structural design of a commercial inclined trough spiral type classifier is the provision of the feed duct and float and middlings launders.. The possibility of using so much of standard equipment constitutes a practical advantage of the preferred type of installation, but of course the invention is not limited thereto and any suitable type of mechanical conveyor which grips a relatively deep column of liquid may be used.

The operation of the process will be described in the following examples which represent typical types of materials.

Example 1

A zinc ore containing a light gangue, lumps of sphalerite and a middlings product which consists of particles of rock having some sphalerite disseminated therethrough is sized to a suitable size range for heavy media treatment and is in-

troduced into the duct 7, the medium, which may be a galena or ferrosilicon medium, being adjusted to a gravity just above that of the average gravity of middlings. The speed of the conveyor 2 is adjusted in relation to the rate of medium and ore feed so that the trajectory of gangue particles leads to the discharge launders 8, and the trajectory of the middlings particles leads to the discharge openings 9. The flows are shown diagrammatically by arrows on Fig. 2. As long as the ore remains the same and the feed and screw speed is kept constant, three products are produced, a relatively barren gangue which is discharged from the launders 8, a relatively clean sphalerite sink discharge from the chute 10, and a major proportion of the middlings which are discharged from the launders 9. Sink and float are treated in the usual manner and the middling may be retreated by grinding and flotation or my any other suitable method.

Example 2

A bituminous coking coal containing 40.7% of material averaging 5.6% ash, 19.2% material averaging 12.5% ash and 40.1% of material averaging 69% ash is sized to a suitable size range for heavy-media treatment and is then introduced into the duct 7, the medium being a suspension of finely divided magnetite, its gravity adjusted to a point just above the gravity of the portion of the coal averaging 12.5% ash which constitutes the middlings product. The speed of the conveyor tube is adjusted in relation to the rate of medium and coal fed so that the trajectory of the low ash coal particles leads them to the discharge launders 8 and the trajectory of the middlings particles leads them to the discharge openings 9.

The low ash coal is drained on the conventional drainage screens and washed with water sprays and constitutes premium coal suitable for the production of metallurgical coke. The middlings are similarly drained and washed and constitute commercial steam coal. The high ash sink product which is discharged from the chute 10 is likewise drained and washed and constitutes the reject.

A portion of the drained and washed medium is thickened and reused and another portion cleaned from slime by magnetizing, thickening in a magnetic thickener and magnetic separation on a suitable magnetic separator. The magnetic concentrate from the separator is then demagnetized by passing through an alternating magnetic field and is used as make-up medium.

It is an advantage of the present invention that it does not require any changes in medium cleaning or product handling operations. The float, middling and sink products are passed over screens where medium is drained off and then washed off by sprays in the usual manner, and the medium thus recovered is reused after subjecting the customary portion of it to the conventional cleaning operations, which may be magnetic, in the case of ferrosilicon, or may involve flotation where galena is used.

We claim:

1. A method of producing three products from fragmentary material having products of three different gravities by means of a heavy medium consisting of a suspension of finely divided, high gravity solids in a liquid, which comprises introducing the material to be separated together with makeup media into an elongated wedge-shaped pool of heavy medium at the deep end thereof and below the surface, agitating a diagonal column of heavy medium extending from the low point of the medium pool to the shallow end, said column being of the width of the pool and substantially less than the depth at the deep end thus leaving a smaller wedge-shaped pool of unagitated media above the column, discharging material of minimum gravity from the level of said smaller pool at a point a considerable distance above the diagonal column, discharging sink material from the shallow end of the pool by said agitation, discharging middlings from the surface of the smaller pool at a point adjacent to said column, the feed introduction point being adjacent the upper edge of the column and at the bottom of the smaller pool, and adjusting the rate of agitation of said column, the predominantly horizontal movement of medium from feed entrance to float and middlings discharge point being such that the resultant of these forces with the buoyancy of the float products produce an average float particle trajectory from the feed inlet to the float discharge point and a trajectory of an average middling particle from the feed inlet to the middlings discharge point.

2. A method according to claim 1 in which the agitation of the column is produced by a rotary raking motion.

3. A method according to claim 1 in which the return medium is introduced at the same level as the feed.

4. A method according to claim 1 in which the material is a zinc ore containing sphalerite particles, gangue particles and sphalerite containing middlings particles.

5. A method according to claim 1 in which the material is coal containing a portion of very low ash material, another portion of moderate ash content and a high ash culm.

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