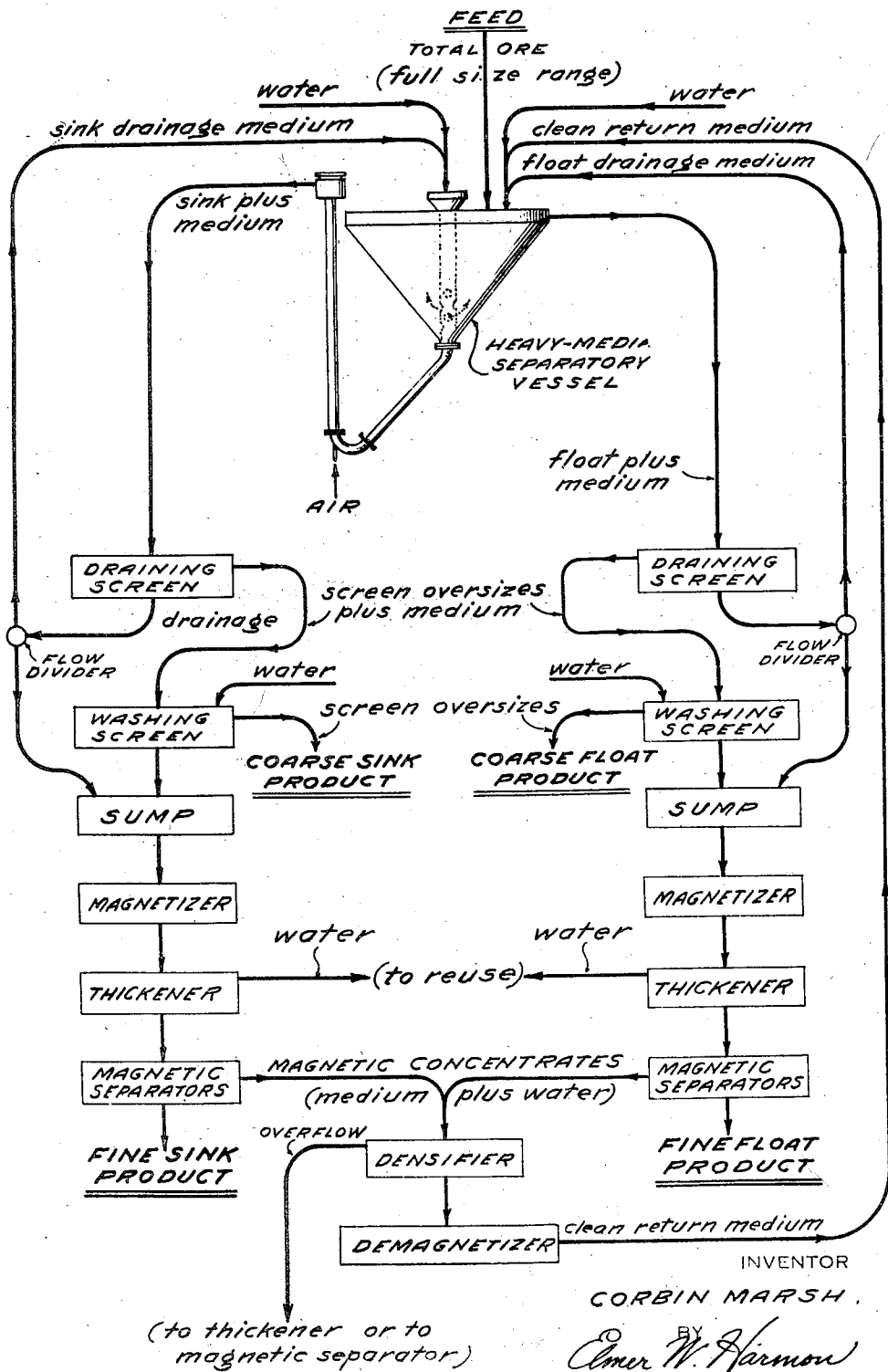


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HEAVY-MEDIA SEPARATION PROCESS
FOR ASSORTING SOLIDS
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HEAVY-MEDIA SEPARATION PROCESS FOR
ASSORTING SOLIDSCorbin Marsh, Old Greenwich, Conn., assignor to
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1 Claim. (Cl. 209—173)

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This invention relates to the separation of heterogeneous mixtures of solid particles having different apparent densities and contemplates an improved method of effecting such separation. More particularly, the invention relates to an improved handling process whereby more effective reuse of the medium solids in a heavy-media separation may be effected and even more specifically, may be effected when each of the materials to be separated is present in a widely different size range.

Considerable interest has been shown in recent years in so-called "Heavy-media separation" processes. Particularly is this true of the continuously-operating modifications which have been developed. These latter, because of their economy in operation and adaptability to large scale operations, have been found highly advantageous in the minerals-dressing field.

In such heavy-media processes, various liquids of high specific gravity may be employed as the separatory fluid. Actually, however, the only practicable fluids for use on a large scale comprise suspensions in water of suitably-sized solids or "medium" of relatively high specific gravity. A part of this medium is usually colloidal or semi-colloidal in size. Particles in this size range not only remain suspended, but also are capable of maintaining the somewhat larger particles of medium in more or less permanent suspension. By properly selecting the solids, fluids of substantially any desired density can be obtained.

Materials to be separated are immersed therein. Those particles having an apparent density greater than that of the separatory fluid sink therein and the lighter-gravity fraction floats thereon. The light or "float" and the heavy or "sink" fractions are then separately, and preferably continuously, collected. Using fluids of properly selected density, it is readily feasible to separate solids which differ in specific gravity by 0.01 to 0.05 of a point.

Because the medium solids have an appreciable real value, they must be separated from the collected fractions and reused if the process is to be economically effective. Again a number of proposed procedures have been developed. It is in this field of recovering and reusing the medium that the process of the present invention has its greatest value.

Despite the obvious advantages of heavy-media separation, it has been considered subject to certain limitations. Most serious of these limitations has been the fact that from a cost standpoint the earlier procedures became less and less efficient as the particle size of the materials to be separated decreased. This is principally due to the fact that as the particle sizes decrease,

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separation becomes slower and medium losses increase.

Recently, much work also has been done in an effort to extend the size range to include finer-size particles without losing the economic advantages of the process. One of the best of the procedures adapted for this purpose is the use of the so-called "twin-cleaning" circuits set forth in the application for U. S. Letters Patent 2,387,866 to G. B. Walker. In this process a total ore may be fed, the "float" and "sink" fractions being separately collected in the usual way; using a magnetizable medium. The collected fractions are then treated in novel identical circuits whereby a clean, coarser-sized portion is first removed from each fraction and the magnetic medium is then magnetically removed from the small-sized residual particles of each fraction leaving the latter as clean finer-size products.

As noted above, the medium is recovered and reused, since without this provision such processes become uneconomical to operate. In the Walker disclosure and other similar processes, the major portion of the recovered and cleaned medium is brought to the proper density by the addition of water and recycled to the bottom of the separatory vessel. In practice this presently results in a gravity differential in the main fluid body in separatory vessel between fluid in the upper and the lower levels thereof. This differential will increase until a condition is reached at which near-gravity material is too light to be discharged with the sink and too heavy to be discharged with the overflow. Particularly is this noticeable when a wide size-range feed is being treated, including sizes which, because of their relatively large area for their mass, in any case tend to be slow in separating into either the float or sink fractions.

The process loses much of its efficiency and desirability under these conditions because of the accumulation of material which cannot be discharged from the separatory vessel. Sufficiently powerful agitation to prevent the differential would interfere with proper separation since a flow equilibrium is necessary to permit the sink and float fractions to seek their proper levels. As a result, operation must be stopped until the vessel is cleared of the accumulation, the differential overcome and equilibrium regained. There remained a demand for some method of preventing the occurrence of this condition.

It is, therefore, the principal object of the present invention to devise a heavy media separation process for assorting solids which is not subject to the objectionable gravity differential features which characterize the usual practice. Particularly is it an object to devise an overall

operating procedure in which the media solids are recovered, cleaned, and recycled without being subject to this difficulty not only when used in ordinary operations but in connection with Walker's "twin-cleaning" process.

Actually and surprisingly, the difficulty encountered with gravity differentials in the separatory fluid body may be largely overcome by combining two operating procedures. Both of these procedures involve the use of screen under-size from the drainage screens as medium. These undersizes contain medium, water and either fine-size sink or fine-size float particles. In the present discussion these drainage screen undersizes will be referred to as "sink drainage medium" and "float drainage medium" respectively.

The first operating procedure consists in recycling the clean recovered medium, which is obtained by any suitable conventional cleaning procedure, together with all or a part of the float drainage medium to the upper levels of the main fluid body, at or near the surface thereof. At the same time sufficient water is added to maintain the desired density value. The second operating procedure consists in recycling all or a part of the sink drainage medium, together with sufficient water to maintain the desired density value, directly to the lower levels in the main fluid body.

Surprisingly, when it is considered that the primary difficulty is due to a gravity differential and the resulting accumulation of near-gravity and smaller size particles which cannot be discharged, the return of small size particles in the drainage mediums does not aggravate this condition. Actually it has been found that the particles returned at or near the surface remain in the "float" section of the fluid body and do not have to rise through a large body of fluid. Similarly, the considerable body of fine sink particles returned with the sink drainage medium remain in the "sink" portion of the separatory fluid. From these respective portions the fine particles are quickly removed in normal operation and do not tend to add to the accumulation of solids in the fluid.

In thus returning the "sink" and "float" solids in the draining screen medium to some level below the surface and a level at or near the top of the vessel respectively, the process differs from the prior art. For example, in the previously identified Walker disclosure, all return is to the bottom of the cone. In other cases, all of the medium may return to the top of the fluid. By the present procedure not only is an additional control of the medium in the vessel effected but control of the sharpness of separation and the gravity control is simplified.

The invention may be more clearly illustrated in conjunction with the accompanying drawing which diagrammatically illustrates a typical flow sheet employing the practice of the present invention.

As will be seen from the drawing, the feed to the separatory vessel comprises a "total ore" in which the several constituents are present in particle sizes varying over a wide size range. In accordance with the usual practice, the heavy fraction settles to the bottom of the separatory vessel and is removed as a "sink" or underflow fraction and the lighter particles are removed as a "float" or overflow fraction. In the drawing the separatory vessel has been indicated as a conventional cone. However, the process is not limited to this particular type of apparatus and

any other suitable separatory vessel may be used.

Each separated solids fraction is then taken to a separate draining screen, the oversize from which comprises particles of the respective "sink" and "float" fractions being separated, plus adhering medium. The drainage screen underflows comprise medium, water and fine "sink" or fine "float." Screen oversizes are taken to washing screens on which the adherent medium and under-size float or sink are washed off, resulting in one case in the production of a coarse, clean "sink" product, and in the other, a coarse, clean "float" product.

It should be noted that, as discussed above, in accordance with the present invention the screen under-size from the draining screens is in each case passed to a flow divider or "splitter" from which at least a part is returned to the separatory vessel. That part not recycled directly to the separatory vessel is collected in a sump or the like, along with the screen under-size from the washing screens. The amounts recycled, in the case of the "sink" fraction, below the surface of the medium in the vessel and of the "float" fraction at or near the surface, is dependent upon several factors. These include for example the total amount of solid fines other than medium in the fluid; the amount of fines other than medium which can be tolerated in the cone without slowing the throughput; the viscosity conditions in the cone and the like. In all cases, however, except in starting a new operation, some of the drainings, and preferably for reasons of economy the maximum that can be tolerated, is thus returned.

In an ordinary "sink and float" operation, which in the past has been considered to be limited to the treatment of plus 10 mesh particles, there is no problem of the treatment of fines. Consequently the screen underflow from both washing screens would be carried to a common sump and thence through a medium recovery system from which the clean return medium would be returned to the separatory fluid; in accordance with the present invention, being returned to a level at or near the surface of the contained fluid.

However, the advantages of the present process are even more apparent in treating a full-size range feed using the twin-cleaning circuit of the Walker disclosure as illustrated in the accompanying drawing. Since a total ore is being treated the screen under-size from both washing screens is separately collected. The collected washings are combined with that portion of the respective draining screen under-size which is not returned directly to the separatory vessel. The sump or collecting tank thus serves the double purpose of enabling the collection of the screen underflow fluids and the provision of a steady flow to the remainder of the cleaning circuits. Both fluids to be cleaned are first passed through magnetizers which magnetize and coagulate the medium solids thus facilitating faster settling and removal of water in the thickener to which they then pass. A considerable portion of the water overflowing the thickener may be reused for washing, dilution or the like. This magnetic flocculation and thickening step is preferable, but alternatively, the washing screen underflow may be sent directly to the magnetic separators. In each case the thickened fraction is then subjected to the action of one or more magnetic separators. These may be of any conventional type, as for example the well known Crockett

separator which removes magnetically-susceptible portions or medium from each fraction. In the present instance, these magnetically-susceptible portions constitute medium plus some adherent water. In each case the magnetic separation leaves a concentrate of the fine size particles, in the case of the "sink" solids, a fine "sink" product, and in the case of the "float" solids, a fine "float" product.

Continuing with the medium recovery system, the magnetic concentrates from each set of separators, being substantially free from all solid particles other than medium, are combined and passed through a densifier in which the combined material is further dewatered. The normal operation of the thickeners and the densifier results in its being at an appreciably higher density than the separatory fluid in the vessel. Since the medium to be effective must be in a dispersed condition in the separatory vessel, the dewatered medium then passed through a demagnetizing operation. From this point it is normally returned directly to the separatory vessel, as shown in the drawing. It is also possible to send it to a storage chamber, not shown, from which it is drawn as needed.

As shown in the accompanying drawing, the purpose of the present invention in controlling gravity differentials is obtained by varying several operating conditions. First, the sink solids draining screen medium is returned to the fluid in the separatory vessel below the surface and the float solids draining screen medium is returned at or near to the surface of the contained medium. In each case the amount returned depends upon the setting of the flow divider. The recovered medium from the cleaning circuit is returned at or near to the top of the separatory vessel together with the float drainage medium, usually being introduced with the fresh feed although for clarity in the drawing it is shown being separately added. In addition, water in controlled amounts, may be added in each case to the drainage medium being returned in order to control the gravity at the desired value.

In addition to the float solids drainage medium which is returned to the zone of principal separation in the upper levels just below the surface of the separatory fluid in the vessel, there is also returned thereto the cleaned, densified medium from the magnetic cleaning system and if necessary an amount of water. This latter amount of water may be very small or negligible in many cases. By varying the proportional amounts of fluid which is supplied from each of these five sources, it is possible to control the gravity differential without which control the fluid at the bottom of the vessel becomes too heavy and the fluid at the top of the vessel becomes too light. Separation by this procedure may be carried on indefinitely without being troubled by an accumulation in the separatory vessel of excessive amounts of near-gravity particles.

The process of the present invention may be therefore summarized as utilizing:

1. Return of the sink drainage screen medium, which may contain fine "sink," below the surface of the separatory fluid;

2. Return of the float drainage screen medium which may contain fine float, at or near the surface of the separatory fluid; and in addition has as essential distinguishing features;

3. Return of the cleaned, recovered, densified

medium at or near the surface of the separatory fluid;

4. Addition of controlled amounts of water to the medium recycled to the lower part of the separatory fluid and, if necessary, to the mediums added at or near the surface thereof.

While the invention has been principally discussed in connection with a particular adaptation of the Walker disclosure, it is obvious that as long as the distinguishing process steps of recycling the medium are present the operation may be varied considerably from that illustrated. For example as noted above, the separatory cone may be substituted by a chamber of any type such as a drag separator or the like. The number and location of the screens, thickeners, magnetic separators etc. may be varied. As noted previously, when the feed contains little or no fines, only a single medium cleaning circuit is needed. Various arrangements of storage tanks and pumps may be utilized. To escape the necessity of twin-cleaning circuits, the fluids may be passed alternately for fixed periods through the same cleaning circuit for example. These variations, however, form no part of the present invention.

I claim:

In a heavy-media separation of mixed particles of different specific gravities and of a wide size-range by immersing the mixture in a main fluid body, said fluid being a suspension in water of a sufficient amount of finely-divided magnetically-susceptible particles to produce an apparent fluid density lower than that of the higher-gravity particles and higher than that of the lower-gravity particles; separately collecting the higher-gravity particles which sink and the lower-gravity particles which float and recovering and reusing the magnetizable solids carried therewith from the "sink" and "float" fractions: the improved process in which the collected "sink" and "float" fractions are separately drained; a part of the drainings from each said fraction being returned separately and respectively to the lower levels and to the upper levels of the main fluid body; a finite amount of water is added to said lower levels, sufficient in amount to maintain the fluid density value in said lower levels thereof; the drained fractions are separately washed, the washings are separately collected; the non-recycled portions of the drainings are added to the washings; the magnetizable solids in drainings and washings mixtures is magnetized; the magnetized solids are magnetically collected; the magnetically collected material is densified; the densified material is demagnetized and the demagnetized material is recycled to the principal separatory zone in the upper levels in the separatory chamber together with only a finite amount of water sufficient to maintain the density of said zone in the upper levels of the fluid of the main fluid body at the desired value.

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