

No. 763,260.

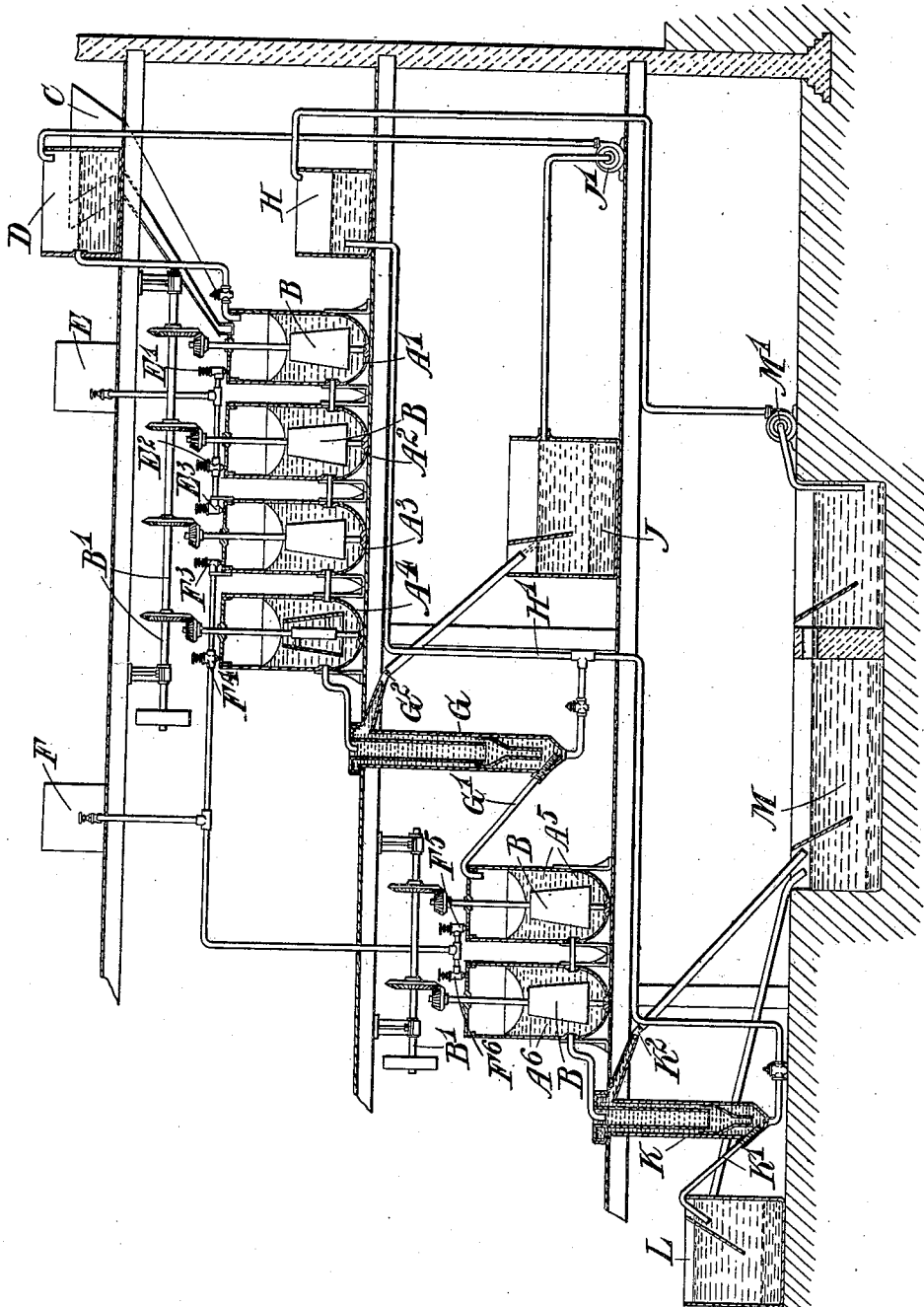
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A. E. CATTERMOLLE.

SEPARATION OF THE METALLIC CONSTITUENTS OF ORES FROM GANGUE.

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NO MODEL.



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UNITED STATES PATENT OFFICE.

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SEPARATION OF THE METALLIC CONSTITUENTS OF ORES FROM GANGUE.

SPECIFICATION forming part of Letters Patent No. 763,260, dated June 21, 1904.

Original application filed September 28, 1903, Serial No. 174,947. Divided and this application filed January 2, 1904. Serial No. 187,599. (No specimens.)

To all whom it may concern:

Be it known that I, ARTHUR EDWARD CATTERMOLLE, a subject of the King of England, residing at Highgate, London, England, have
 5 invented certain new and useful Improvements in the Separation of the Metallic Constituents of Ores from Gangue, of which the following is a specification.

This application is a division of my application filed September 28, 1903, Serial No. 174,947.

The present invention relates to improvements in the separation of the metalliferous constituents of ores and the like from gangue
 15 by means of the selective action of oils and certain tar products or similar compounds (all hereinafter referred to as "oil") on metallic or metalliferous matter.

The invention depends upon the application of the following facts: First, when a mixture of powdered metalliferous matter and gangue is treated with oil suspended in water—that is to say, in emulsion—the oil has a more or less selective action and will
 25 coat the particles of metalliferous matter in preference to the particles of gangue, while the particles of gangue will be wetted by the water; second, if the water be made alkaline and an emulsifying agent, such as soap, be
 30 present, the selective action of the oil will be rendered more marked and decisive; third, if the proportion of oil is kept within reasonably low limits (differing in different cases, according to the nature of the mineral to be
 35 treated and the consistency and nature of the oil) and if the mixture of water, oil, metalliferous particles, and gangue be thoroughly agitated, the metalliferous particles which have become coated with oil will adhere together and form granules, which granules,
 40 partly by reason of gravity or partly on account of their bulk as compared with the individual grains of gangue, will offer ready means for separation in an upcurrent-separator, a jig, or other similar appliance. This
 45 action is facilitated if the oil before addition to the liquor is brought into the condition of an emulsion in water containing a small percentage of free soap.

In some cases the pulp may contain mineral
 50 acid. Alkali must then be added in sufficient quantity to neutralize the acid and to leave some alkaline soap undecomposed—that is, free.

These facts are utilized for the purpose of
 55 separating the metalliferous constituents from the gangue of the ore in the following manner: In a suitable apparatus, an example of which will be hereinafter described, the
 60 ground or pulped ore is caused to be violently agitated, as by a revolving stirrer, in a mixture of water and oil, the liquor containing an alkaline emulsifying agent. As the agitation proceeds the particles of metalliferous matter
 65 agglomerate together and may be observed in the form of granules, the size of which will depend, among other things, upon the percentage of oil used. This granulation of the
 70 metalliferous constituents of the ore affords the means by which at a later stage of the process it is possible to separate the metalliferous material from the gangue, as will be
 75 hereinafter particularly described. In practice a continuous process is used—that is to say, water, ground ore, or pulp and oil, preferably emulsified, are continuously fed into
 80 a series of vessels and the products of the agitation are continuously fed into an upcurrent-separator or jig or similar device, which in the case of the upcurrent-separator separates the metalliferous granules from the
 85 gangue by allowing them to fall to the bottom of the vessel and to be carried away by a downward stream, while the particles of gangue are carried away by an upward stream.

The accompanying drawing is a diagram illustrating in sectional view one means of carrying out the process according to this invention.

A series of connected mixing vessels $A^1 A^2 A^3 A^4 A^5 A^6$ are provided with stirrers B, rotated from driving-shafts B'. Crushed ore from a hopper C and circuit-water from a tank D are introduced into the first vessels A^1 , and oil or emulsion is fed from a tank E,
 95 through pipes $E^1 E^2 E^3$, to the various vessels. The mixture is vigorously agitated to break up and emulsify the oil and to bring about in-

5 timate contact of the divided oil with the
 metalliferous mineral particles and of the
 oiled particles with each other. An alkaline
 emulsifying agent, such as soap, is introduced
 10 into one or more of the vessels from a tank
 F, having discharge-pipes F³ F⁴ F⁵ F⁶. It is
 found under these conditions that the metalliferous
 mineral particles abstract the oil and be-
 15 come coated with a thin oily film which is in-
 sufficient to materially lessen their specific
 gravity and that under agitation such slightly-
 oiled particles adhere, nucleate, and agglom-
 erate into small more or less rounded masses
 20 or granules disseminated throughout the mass
 of gangue, which remains free and practically
 devoid of oil. After agitation to a certain
 extent (in four vessels, as illustrated, for ex-
 25 ample) the mixture is passed into an upcur-
 rent-classifier G, which is supplied with a
 stream of circuit-water from a tank H through
 a pipe H'. As the granules remain specific-
 ally heavier than the gangue or can by suit-
 ably adjusting the amount of oil and the agi-
 30 tation be obtained of a size larger than that
 of the gangue particles, the granules, with a
 certain amount of heavy sands, sink to the bot-
 tom and are discharged through a pipe G'
 into vessel A⁵, while the lighter sands are car-
 35 ried away by the upward current and dis-
 charged through outlet G² to a light-sands
 tank J, from which the circuit-water may be
 returned by a pump J' to the feed-tank D for
 reuse. In order to separate the granules from
 40 the heavy sands, the mixture is subjected to
 further agitation in the vessels A³ A⁴ and is
 then passed into a second classifier K, from
 which the granules are removed at the bottom
 by the pipe K' into the metalliferous-mineral
 45 tank L, while the heavy sands are discharged
 from the upper pipe K² into a heavy-sands
 tank M. The circuit-water from the tanks L
 and M is returned by a pump N' to the feed-
 water tank H. This apparatus is illustrated
 only as one convenient method of carrying
 50 out this invention, and it is to be understood
 that its nature and arrangement can be con-
 siderably varied.

55 The water throughout the circuit is alkaline
 and contains a suitable proportion of soap or
 other emulsifying agent. The agitation ves-
 sels may be separate, with arrangements for
 charging and discharging, the charging with
 pulp and the addition of oil or emulsified oil
 60 and the agitation and discharge successively
 in the series of vessels being so timed that the
 output of treated ore is kept continuous and
 constant. The classifiers used may be jigs,
 shaking-tables, or the like or sizing appar-
 65 atus whereby the comparatively larger min-
 eral granules may be separated from the finer
 gangue, and one or more classifiers may be
 employed.

The proportion of oil used depends upon its
 viscosity, the fineness of the ore, and other
 65 factors, and the consistency and size of the

mineral granules desired. The more oil used
 the larger, softer, and less numerous the gran-
 ules. With, say, ten per cent. of oil to the
 weight of metalliferous mineral a few pasty
 masses of oil agglomerated metalliferous min- 70
 eral matter will generally result. Oil in excess
 of this may cause all the granules to coalesce
 into one soft mass. Usually an amount of oil
 varying from four per cent. to six per cent.
 75 of the weight of metalliferous mineral matter
 present in the ore yields granules of suitable
 size, consistency, and specific gravity for ready
 separation from the gangue in the upcurrent
 or other apparatus used for classification.

The amount of emulsifying agent, if used to 80
 form the oil-emulsion, depends upon the vis-
 cosity and nature of the oil. When soap is em-
 ployed, an amount varying from three per cent.
 to five per cent. of the weight of oil usually suf-
 85 fices, this being dissolved in, say, ten times
 its weight of water. For emulsification a low
 alkalinity of the emulsifying agent is gener-
 ally best.

The oil used may be animal, vegetable, 90
 or mineral oil, or mixtures of these, or such
 coal or wood tar products or other substances
 which exercise, like oils, a preferential phys-
 ical affinity for metallic mineral matter as dis-
 tinguished from gangue.

The emulsifying agent may be any substance 95
 capable of holding the oil in a fine state of di-
 vision in suspension in water without acting
 on the mineral matter or preventing the action
 of the oil—for example, soap, alkaline cresy-
 100 lates, or other substances solutions of which
 in water froth on agitation. The emulsifying
 agent appears to have a decided effect in bring-
 ing about the granulation as described. In
 some cases, as with wood-tar and some coal-
 105 tar products, these when agitated in weak
 alkaline solutions provide their own emulsi-
 fying agents, soluble resinates, cresylates,
 &c., being thereby formed, which emulsify
 the bulk of the tar or product.

Emulsification in some cases, as with the 110
 heavier residuum oils or tars, may be assisted
 by first mixing therewith a small amount of
 fatty oil or fatty acid. Preferably one emul-
 sifying agent is employed throughout the
 115 process.

In order to recover the oil from the gran-
 ules after their separation from the gangue,
 they may be agitated with the emulsifying
 agent in a stronger or more active condition
 or proportion than was used in the emulsifi- 120
 cation of the oils initially, and the action of
 this emulsifying agent in stripping the oil
 from the metalliferous mineral particles may
 be aided by attrition. The strengthening of
 125 the emulsifying agent may be effected by in-
 creasing the proportion of the agent or of the
 alkaline base in solution, or both, the percent-
 age strength of the solution needed depend-
 ing upon the oil used and the nature of the
 130 metalliferous mineral matter with which it is

associated. Usually if oleic soap is employed and caustic potash amounts varying from one-quarter of one per cent. to three per cent. or four per cent. of one or the other in solution suffices, the less readily emulsified oils, as the residuum oils, requiring the larger amounts. The removed oil is obtained as a dilute emulsion, which on standing some time separates. The "cream" or concentrated emulsion may then be used for making fresh emulsion for treating fresh ore. To hasten this separation of cream, mechanical devices may be employed.

Generally with wet crushed ore removal of the bulk of the water for reuse in the mill is necessary. In such case the pulp is settled and the wet ore only fed into the agitators, emulsifying agent of suitable strength being added to thin them. The circuit of such liquids can thus be kept distinct from that of the mill-water, suitable arrangements being made for settling the mineral-depleted sands and slime and for addition of emulsifying agent and fresh water as required from time to time.

In certain cases, as where but little mineral is present in the ore, to increase the nucleating or granulating factor pulverized mineral matter obtained in a previous operation or other matter having an affinity for oil from a different source may be introduced into the ore, or a portion of already granulated and separated mineral matter may be returned to maintain the necessary amount of mineral in the ore under treatment.

In carrying out the process the ore may be roughly sized into two or more parts, which are then treated separately. With certain ores it may be preferable to use in some stages of the process a rolling form of agitation, as in cylinders or barrels, to obtain good granulation of the mineral.

It is preferable to use circuit-waters of varying degree of alkalinity, according to the nature of the mineral being treated, provided always that about one-half of one per cent. of soap or other emulsifying agent is present.

It is found advisable to keep the amount of free alkali low in proportion to the free soap present when such is the emulsifying agent used. Thus in one example 0.25 per cent. of free soap with 0.025 per cent. of free alkali was sufficient to keep calcite free from oil, 0.3 per cent. free soap and 0.03 per cent. free alkali kept quartz free from oil, while rather stronger solutions—as, for instance, 0.5 per cent. free soap and 0.05 per cent. free alkali—prevented garnet from becoming oil-coated. These figures refer to cases where a light oil was used—namely, paraffin. When the free soap was increased to about one per cent. or when the free alkali was increased to about one-fourth of one per cent., difficulty was found in agglomerating certain metalliferous

substances, such as rosin-blende and iron or copper pyrites. Care must therefore be taken that neither the soap nor the alkali is in excess of that required for preventing agglomeration of the gangue.

I am aware that the selective action of oils and the like on metallic matter has been made the basis of previous processes for separating the metalliferous constituents of ores from gangue. For example, oil has been used to float off metalliferous mineral from ore-pulp, and its use has also been proposed to form a pasty mass of crushed ore from which the gangue could afterward be washed out by means of water, and I do not claim the employment of oil in any such manner.

What I claim as my invention, and desire to secure by Letters Patent, is—

1. The herein-described process of separating metalliferous matter from gangue, which consists in agitating a mixture of powdered ore and water with oil in emulsion in water containing an alkaline emulsifying agent, so as to agglomerate the oil-coated particles into granules, and subjecting the mixture to classification to remove the small non-coated particles from the granules.

2. The herein-described process of separating metalliferous matter from gangue, which consists in agitating a mixture of powdered ore and water with oil in emulsion in water containing an alkaline emulsifying agent, so as to agglomerate the oil-coated particles into granules, and subjecting the mixture to up-current classification to remove the small non-coated particles from the granules.

3. The herein-described process of separating metalliferous matter from gangue, which consists in forming granules by agitating a mixture of powdered ore and water with oil in emulsion in water containing an alkaline emulsifying agent, separating out the light sands, and thereafter further agitating the pulp to increase the size of the granules and separating out the heavy sands from the granules.

4. The herein-described process of separating metalliferous matter from gangue, which consists in agitating a mixture of powdered ore and water with oil in emulsion in water containing an alkaline emulsifying agent, adding particles of material having an affinity for oil to assist in the formation of granules of oil-coated particles, and subjecting the mixture to classification to remove the small non-coated particles from the granules.

In testimony whereof I have signed my name to this specification in the presence of two subscribing witnesses.

ARTHUR EDWARD CATTERMOLLE.

Witnesses:

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