

June 23, 1942.

S. B. McCLUSKEY

2,287,115

PROCESS OF CONCENTRATING ORES

Filed March 14, 1940

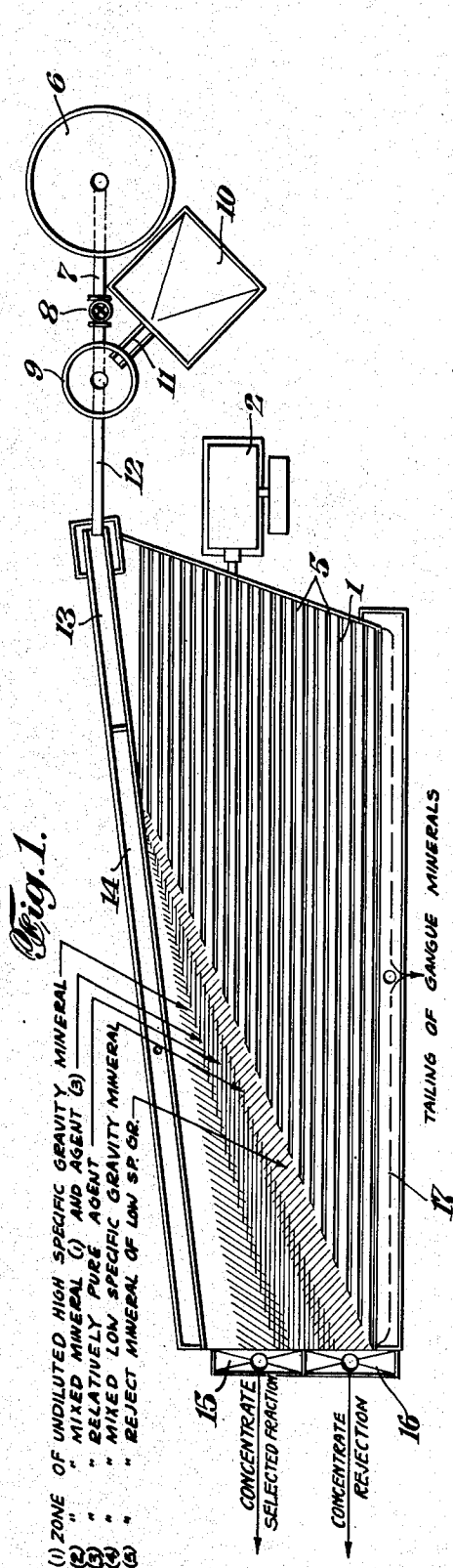


Fig. 2b.

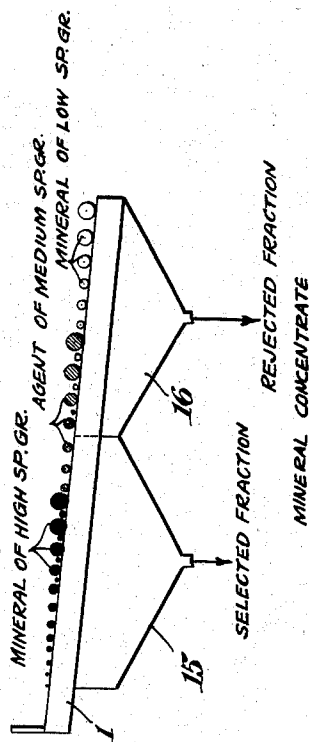
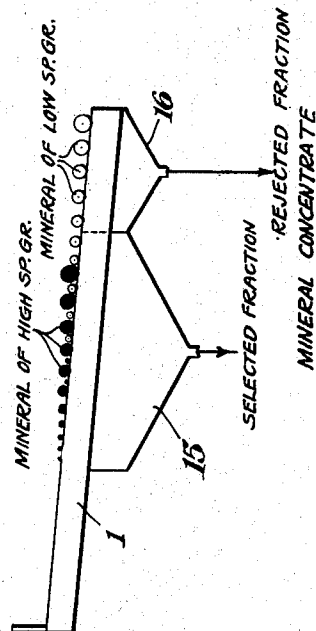


Fig. 2a.



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UNITED STATES PATENT OFFICE

2,287,115

PROCESS OF CONCENTRATING ORES

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Application March 14, 1940, Serial No. 323,851

15 Claims. (Cl. 209-441)

My invention relates to the concentration of ores and more particularly to the separation of ores into a plurality of fractions of different specific gravities upon concentrating devices, such as shaking tables, designed to use the specific gravity differential of the fractions to promote the separation, and in which the mineral grains are substantially in physical contact with each other as distinguished from free suspension in a fluid or emulsified medium of intermediate specific gravity, as in the so-called "sink and float" processes.

The invention is directed primarily to the separation of two or more valuable minerals for separate subsequent treatment in an appropriate manner, as distinguished from the primary concentration where the valuable mineral or minerals are separated from the worthless gangue. For example, when metallic gold is mixed with arsenopyrite in the primary concentrate, refining of the gold is facilitated if it is first substantially freed from the arsenopyrite, and treatment of the latter product for the recovery of locked, intercrystallized, or encased particles of gold will be more economically preformed, and less subject to loss, if all free gold is removed.

In the mechanical separation or concentration of minerals by any of the well known gravity concentration methods, numerous practical difficulties are encountered, and a high degree of efficiency is rarely attained.

In the operation of well known tables of the shaking type, such as the Wilfley, Deister, Overstrom, Butchart, etc., on which, in the final separatory, or cleaning stage, the mineral is extended over an inclined plane, usually to a depth not greater than one grain, the line of demarcation between the minerals of different specific gravity is not clearly defined, and it is therefore impossible to make a precise separation. This is due in part to the practical difficulties in the way of securing uniformity of grain size in the initial table feed, which results in a classification according to size, and therefore permits the coarser grains of one class to penetrate or overlay the adjoining zone through which travel the finer grains of the mineral next lower in the gravity scale. This difficulty extends equally to deeply bedded devices, such as full-riffled tables, jigs, etc.

This deficiency is ameliorated to some extent in practice by the separation of a "middling" fraction of mixed mineral grains, which is either sent to other machines for further fractionation, or is returned to join the feed to the same ma-

chine, thus constituting a continuously circulating "middling" or buffer zone. But this method is laborious and expensive. If some such method is not practiced, the efficiency of the separation is impaired, and one or another of the objectives is not attained; either an excessively diluted concentrate, or an inadequately impoverished residue results.

The object of my invention is to improve the efficiency of the separation of the fractions of different specific gravity.

In accordance with my invention, I introduce into the granulated body of ore, supplied to the concentrating device, an extraneous granular substance of specific gravity intermediate that of the fractions to be separated to thereby separate these fractions on the concentrating device so that their marginal limits are spaced edgewise from each other by the extraneous material. In other words, I introduce an artificial middling, providing a supplementary buffer zone between the ore fractions on their discharge from the concentrating device. The fractions thus separated may be readily diverted into different containers.

The essential qualities of the extraneous substance or agent to be employed are: First, it must be a homogeneous, granular, material characterized by a specific gravity intermediate between that of the two minerals, or the two groups of minerals, which it is desired to separate, and; second, it must be so prepared that the size of the particles approximates the median grain size of the minerals under treatment.

The separating agent should also be insoluble in the liquid, if any, used in the concentrating operation, and should be either inert and capable of being readily separated from the mineral fractions or capable of practical commercial use in the subsequent treatment of the fractions.

Various considerations, such as the cost of the material, the quantities consumed, the cost of recovery, its effect on subsequent processing, and the character of the material under treatment, will govern the selection of the medium for any specific application.

Suitable materials for use as separating agents are metals, or natural mineral compounds, or artificial alloys.

Because of their distinctive metallurgical characteristics, high specific gravity, wide distribution, and relatively low cost, compounds of lead and iron will be most generally applicable.

In the application of my invention to the treat-

ment of gold, silver and platinum ores, one suitable addition agent is lead oxide or litharge.

Litharge has a specific gravity of 9.0, exceeding that of any of the natural constituents of the ore except native gold, silver, and metals of the platinum group, and will therefore occupy the zone next to the precious metals, when stratified according to gravity by the action of the concentrating machine.

Litharge is a useful reagent in the subsequent treatment of both fractions of the concentrate. In smelting the selected concentrate fraction, with which may be mixed gold precipitates derived from other stages of the ore-treatment procedure, the litharge is a useful flux, effective in the elimination of other base metals, and producing, on cupellation, a doré bullion of exceptional purity and recovering the lead as litharge, which after granulation, will be suitable for re-use in the process. As the reject fraction from this stage of the process will invariably contain gold, usually in intimate physical association with the sulphides, it will be necessary to treat this product, in conjunction with concentrate produced in other stages of the treatment, by cyanidation. Litharge is likewise a useful reagent at this stage, and in common practice it is frequently employed as such, being effective, in the treatment of sulphide ores by cyanidation, both as an accelerant to the solution of gold, and as an agent to inhibit the formation of soluble sulphides, sulpho-salts, and other cyanide-solution fouling compounds.

Lead sulphide, or in its natural form, galena, has a specific gravity of 7.5 which is greater than any of the minerals commonly associated with precious metals. It provides a useful fluxing constituent to the concentrate of such metals, and is recoverable from the residue by flotation, or in smelting. The natural lead carbonate, cerussite, sp. gr. 6.5, may be used to replace, or to supplement the artificial oxide of lead, litharge, sp. gr. 9. Both of these compounds are useful fluxing agents in the concentrate, and although not recoverable from the tailing by flotation, are useful reagents in cyanidation. Metallic lead, in granular form (sp. gr. 11) may be used in conjunction with litharge, to enhance the efficacy of the separation, and to replace the normal consumption of the latter, as the bulk of metallic lead introduced in this manner will, due to its higher gravity, and relative uniformity of grain-size, be included in the concentrate fraction, and therefore recovered as litharge.

Iron, its compounds and ferro-alloys, such as granular iron or steel in the form of turnings, or filings, ferro-silicon or other ferro-alloys, or in the mineral form, magnetite, present a wide range in specific gravity, from 5.1 (magnetite) to 8.0 (steel), with a selection of intermediate gravities in the alloys. Other than in specific gravity, these substances exhibit almost identical physical and chemical characteristics, insofar as the application of my invention is concerned. All are amenable to magnetic separation, or if this is not economically warranted, are free from objection in such subsequent treatment as flotation or cyanidation.

In order that my invention may be better understood, several examples of the practical application thereof will be described.

I.—Treatment of gold ores associated with deleterious sulphides

In the treatment of gold ores it is common

milling practice to attempt to recover as much as possible of the gold in the free state at an early stage of the treatment procedure, by a simple form of gravity concentration on corduroy or blanket tables. Gold recovered in this manner is usually accompanied by a relatively large proportion of sulphides and granular gangue minerals. The gold may be separated by direct amalgamation, but this involves the treatment of a relatively large bulk of concentrate, by a non-continuous and laborious procedure, entailing excessive labor, and the risk of theft. A preferred method, likewise in common practice, is to re-concentrate the material on shaking tables or jigs, producing a relatively small bulk of concentrate, from which the gold may be conveniently recovered, either by amalgamation or by direct smelting.

When, as is a common occurrence with gold ores, the simple sulphides are accompanied by arsenopyrite, the separation of the gold is rendered more difficult. Arsenopyrite has a specific gravity approximating 6.0, while the more amenable sulphides, such as pyrite, marcasite, and pyrrhotite have specific gravities approximating 5.0, 4.9, and 4.6 respectively. In the re-concentration of a product containing these minerals, the specific gravity differential will cause the arsenopyrite to accompany the gold, where it is least desired, while the other sulphides will be largely rejected. The deleterious action of arsenopyrite is observed in the subsequent treatment of the concentrate. If amalgamation is resorted to "sickening" and "flouring" of mercury ensues, causing losses of both mercury and gold. If direct smelting is resorted to, preliminary calcination is advisable and the formation of an objectionable speiss is inevitable.

In accordance with my invention, a predetermined quantity of a suitable separation agent, such as litharge, is mixed in a finely divided granular form with the finely divided granular primary ore concentrate. The mixture is then fed to a shaking table where the mixture is classified into thin bands or zones of minerals of different specific gravities with the litharge or other like agent in a thin band or zone separating bands or zones of minerals respectively of higher and lower specific gravities. In the concentration of gold, the band or zone of greater specific gravity will contain the valuable concentrate from which the arsenopyrite has been substantially excluded, while the band or zone of lower specific gravity contains the arsenopyrite. The band or zone in which the litharge travels is thereupon subdivided, so that a portion of the litharge is diverted with the valuable concentrate, the remainder going with the arsenopyrite.

The accompanying drawing shows one method of practicing my invention.

In the drawing:

Fig. 1 is a diagrammatic plan view of the apparatus used, showing the course of the ore and the separating agent and the distribution of the products on the cleaning area of the table;

Fig. 2A is an end view of the table showing, at the point of the discharge of the concentrate, the conventional practice of separating two minerals, and

Fig. 2B is a view like that of Fig. 2A, but showing the practice of my invention.

The invention, as shown, is carried out upon a table 1 of the shaking type, of which the Wilfley table is a well known example, on which the final separation is effected on a substantially plane

surface. A longitudinal shaking action is imparted to the table by mechanism shown diagrammatically at 2.

As shown (in an exaggerated way) in Figs. 2A and 2B, the table has a slight inclination from the horizontal in a lateral direction. The table is provided with longitudinal riffles forming shallow grooves 5 tapering to nothing at the concentrate end, so as to form channels of diminishing depth. These channels terminate on a line extending diagonally across the table, as shown.

The ground mineral to be concentrated is supplied to the table 1 from a storage vessel 6, through a conduit 7 controlled by a valve 8 and leading to a mixer 9. The ground separating agent is supplied from a storage hopper 10 through a feeder 11 to the mixer 9. From the mixer 9, the mixture of mineral and separating agent is delivered through conduit 12 to feed launder 13 from which it is delivered to the upper edge of the riffled portion of the table.

A launder 14 provides a supply of wash water for the table. The separated fractions of the concentrate are delivered to containers 15 and 16 respectively. The tailing or gangue minerals are discharged into the launder 17.

In operation, the water borne mineral mixture flows across the table, the concentrate containing all of the minerals of high specific gravity passing into the channels 5, while the gangue minerals of relatively low specific gravity overflow into the tailings launder 17. The longitudinal shaking imparted to the table causes the grains of concentrate to travel along the channels towards the smooth unriffled portion of the table.

After emerging from the riffled section, the mineral grains are caused to extend over the plane surface of the unriffled area to a depth of approximately one grain. The direction of travel of the mineral is the resultant of two forces, the table mechanism impelling the mineral longitudinally while the flow of the wash water tends to carry it laterally. The travel of the mineral particles or grains depends upon both their specific gravities and their sizes. The result is a gradual classification; so that when the particles or grains reach the concentrate discharge end of the table, they are arranged in bands or zones of different specific gravities. The band or zone of highest specific gravity will be nearest the upper edge of the table, and the succeeding bands or zones towards the lower edge of the table will be of successively lower specific gravities. The efficiency of the separation is affected by variation in the size of the particles or grains, since the coarser grains of higher specific gravity tend to penetrate the upper section of the zone of next lower specific gravity containing the smaller grains of that fraction.

Figs. 2A and 2B show the arrangement of the mineral grains of the concentrate at the time of their discharge from the table. The grains of high specific gravity are illustrated by black circles, the grains of low specific gravity by white circles. The grains of the separating agent are illustrated by shaded circles. The gradation in the size of the circles represents the gradation in the size of the grains. As shown in Fig. 2A, where no separating agent is used, the larger particles of the concentrate fraction of high specific gravity are mixed with the smaller particles of the concentrate fraction of low specific gravity. When, however, a separating agent is used in ac-

cordance with my invention the two concentrate fractions are separated entirely from each other by the said agent. The smaller grains of the agent are mixed and delivered to the container 15 with the larger grains of the concentrate fraction of higher specific gravity, while the larger grains of the agent are mixed and delivered to the container 16 with the concentrate fraction of lower specific gravity.

The introduction of a separating agent of intermediate specific gravity serves to widen the zone separating the two minerals which it is desired to separate, and thus makes it possible to effect a clean cut between them. It is obvious that portions of the agent added will be included in both fractions, and the nature of this agent must therefore be determined by its effect on subsequent treatment of the products, or the ease with which it may be reclaimed.

In the concentration of gold ores containing arsenopyrite with litharge as a separating agent, the upper zone will contain the selected concentrate fraction and this will be separated by the litharge from the concentrate fraction containing the arsenopyrite. The arsenopyrite will be substantially excluded from the selected fraction by the litharge.

In the treatment of certain arsenical ores, it is occasionally necessary to resort to calcination prior to cyanidation. In such a case the presence of lead in the roaster-feed is undesirable, and in the practice of my invention on such an ore, another "addition agent" should be substituted for litharge. Similarly, in certain applications, economic or other considerations may preclude the employment of direct smelting and cupellation, and necessitate recovery of the gold by amalgamation. In this, as in the preceding case, the use of litharge is undesirable. In both instances, substitute addition agents are available, among which are several ferro-alloys. Probably the most suitable of these will be pulverized ferro-silicon. This material is comparatively low priced. Its specific gravity exceeds 7.0. It is resistant to oxidation and the bulk will be recoverable from both fractions by magnetic separation, while any inadvertent residual losses will be chemically inert to subsequent treatment. Likewise stainless steel may be used.

50 II.—Treatment of ores of the platinum group metals

Another application of my invention will be in the treatment of ores of the platinum group metals. In certain occurrences, these ores include the metals both in the free and the alloyed state, and in intimate physical association with sulphides. In the treatment of these ores it is desirable to obtain as much metal as possible in the free state; as, in that case, the subsequent refining process is simpler, and the value more promptly and economically realized. The sulphides must be subjected to a laborious, complex, and expensive procedure for the recovery of the metals, realization on which is both decreased and deferred. In order, however, to adequately concentrate the free-metal into the first class, or fraction, the initial concentrate must be reconcentrated. Under current methods, a considerable percentage of the free metal inevitably finds its way into the sulphide fraction, with consequent economic losses.

The sulphides usually accompanying this type of ore are pentlandite (sp. gr. 4.6–5.0), chalcopyrite (sp. gr. 4.1–4.3), pyrite (sp. gr. 4.9–5.1),

and pyrrhotite (sp. gr. 4.6). Chromite, although not a sulphide, may accompany this ore. It also has a high specific gravity (4.3-4.6). In the application of my invention to the treatment of this type of ore, ferro-silicon (sp. gr. 7.0) or magnetite (sp. gr. 5.2) would be suitable separation agents, for example. Both of these would exclude the above named impurities from the selected metallic fraction. Both of these agents can be removed from the concentrate fractions by magnetic separation. The recovered agent could be returned to the head of the circuit.

III.—Separation of base metal oxides of moderate gravity difference

Certain oxides which exhibit minor differences in specific gravity, and are of limited flotative qualities, and which present serious difficulties to separation by ordinary gravity methods, may be successfully treated by my invention. An example of this is the association of tin and tungsten, occurring as cassiterite and wolframite. The specific gravity of the former approximates 7.0, the latter 7.5. The separating agent in this case would be preferably one of the ferro-alloys of intermediate specific gravity, such as a ferro-silicon of sp. gr. 7.25. The agent can be recovered from both fractions for re-circulation by magnetic separation.

My invention is adapted to deal with material of a size much finer than can be treated by the known "sink and float" processes. Using a Wilfley table of the kind described, mineral granules ranging between 200 mesh (74 microns) and 2 mm. may be effectively treated. Native gold as fine as 10 microns may be recovered, and large flakes of gold or fragments or tramp gangue up to ¼ inch do not derange the operation.

While I have described certain applications of my invention and certain separating agents to be used therein, it is to be understood that I am not limited to these applications and agents.

Having described my invention, what I claim is:

1. The process of concentrating ore to produce a plurality of fractions of different specific gravities which comprises mixing the ore in a finely divided state with a finely divided artificial middling of homogeneous, granular material characterized by having a specific gravity intermediate the specific gravities of said fractions, separating on a transversely inclined, longitudinally reciprocated plane surface the mixture thus produced to produce a thin surface layer on said plane surface comprising zones of material each lying on said plane surface and containing said fractions respectively and separated edgewise by said middling, and collecting separately from said surface the material of said zones.

2. The process of concentrating ore to produce a plurality of fractions of different specific gravities which comprises mixing the ore in a finely divided state with a finely divided artificial middling of homogeneous, granular material characterized by having a specific gravity intermediate the specific gravities of said fractions and having a grain size substantially the same as the median grain size of the ore, separating on a transversely inclined, longitudinally-reciprocated plane surface, in a surface layer the mixture thus produced to produce zones of material in said surface layer containing said fractions respectively and separated by said

middling, and collecting the material of said zones separately, the said zones each lying on said plane surface.

3. The process of concentrating ore to produce a plurality of fractions of different specific gravities which comprises mixing the ore in a finely divided state with a finely divided artificial middling of homogeneous, granular material characterized by having a specific gravity intermediate the specific gravities of said fractions and having a grain size substantially the same as the median grain size of the ore, separating the mixture thus produced in a surface layer upon a plane surface of a shaking table whose plane surface is transversely inclined to the horizontal and reciprocated longitudinally to produce zones of material in said layer containing said fractions respectively and separated edgewise by a region containing only said middling, and collecting the material of said zones separately, the said zones each lying on said plane surface.

4. The process of separating ore to produce a plurality of fractions of different specific gravities which comprises mixing the ore in a finely divided state with an inert finely divided water insoluble artificial middling of homogeneous, granular material adapted to be readily separated from the remainder of said fractions, having a specific gravity intermediate the specific gravities of said fractions and having a grain size substantially the same as the median grain size of the ore, removing gangue minerals from the mixture thus produced, and separating, on an inclined, longitudinally-reciprocated plane surface the remainder of the mixture in a surface layer into zones in said layer containing said fractions respectively and separated edgewise by said middling, and collecting the material of said zones separately, the said zones each lying on said plane surface.

5. The process of separating ore containing a precious metal to produce a plurality of fractions of different specific gravities which comprises mixing the ore in a finely divided state with a finely divided water insoluble artificial middling of homogeneous granular material of the kind which is useful as a flux for the elimination of base metals upon the smelting of one of said fractions, which have a specific gravity intermediate the specific gravities of said fractions and having a grain size substantially the same as the median grain size of the ore, removing gangue minerals from the mixture thus produced, and separating, on an inclined, longitudinally-reciprocated plane surface, the remainder of the mixture into a thin surface layer comprising zones containing said fractions respectively and separated by said middling, and collecting the material of said zones separately, the said zones each lying on said plane surface.

6. The process of separating ore containing gold associated with arsenopyrite to produce fractions containing the gold and arsenopyrite respectively which comprises mixing the ore in a finely divided state with a finely divided water insoluble artificial middling of homogeneous granular material of the kind which is useful as a flux for the elimination of base metals upon the smelting of one of said fractions and which have a specific gravity intermediate the specific gravities of the gold and arsenopyrite and a grain size substantially the same as the median grain size of the ore, separating the mixture thus produced in a thin surface layer on a plane

surface of a shaking table whose plane surface is transversely inclined to the horizontal and reciprocated longitudinally to produce separate fractions of gold and arsenopyrite respectively arranged in zones in said layer separated edgewise by said middling, and separately collecting the material from said zones, the said zones each lying on said plane surface.

7. The process of separating ore containing gold associated with arsenopyrite to produce fractions containing the gold and arsenopyrite respectively which comprises mixing the ore in a finely divided state with a finely divided water insoluble artificial middling of homogeneous granular material selected from the group of materials consisting of lead and those compounds thereof which act as an accelerant to the solution of the gold in cyanidation and which have a specific gravity intermediate the specific gravities of the gold and arsenopyrite and a grain size substantially the same as the median grain size of the ore, separating the mixture thus produced in a surface layer on a plane surface of a shaking table whose plane surface is transversely inclined to the horizontal and reciprocated longitudinally to produce separate fractions of gold and arsenopyrite respectively arranged in zones in said layer separated by said middling, and separately collecting the material from said zones, the said zones each lying on said plane surface.

8. The process of separating ore containing gold associated with arsenopyrite to produce fractions containing the gold and arsenopyrite respectively which comprises mixing the ore in a finely divided state with a finely divided water insoluble artificial middling of homogeneous granular material selected from the group of materials consisting of lead and those compounds thereof which act to inhibit the formation of cyanide solution fouling compounds and which have a specific gravity intermediate the specific gravities of the gold and arsenopyrite and a grain size substantially the same as the median grain size of the ore, separating the mixture thus produced in a surface layer on a shaking plane surface of a table whose plane surface is transversely inclined to the horizontal and reciprocated longitudinally to produce separate fractions of gold and arsenopyrite respectively arranged in zones in said layer separated by said middling, and separately collecting the material from said zones, the said zones each lying on said plane surface.

9. The process of separating ore containing gold associated with arsenopyrite to produce fractions containing the gold and arsenopyrite respectively which comprises mixing the ore in a finely divided state with a finely divided homogeneous metallic artificial middling having a specific gravity intermediate the specific gravities of the gold and arsenopyrite and a grain size substantially the same as the median grain size of the ore, separating the mixture thus produced in a surface layer on a plane surface of a shaking table whose plane surface is transversely inclined to the horizontal and reciprocated longitudinally to produce separate fractions of gold and arsenopyrite respectively arranged in zones in said layer separated by said middling, and separately collecting the material from said zones, the said zones each lying on said plane surface.

10. The process of separating ore containing gold associated with arsenopyrite to produce fractions containing the gold and arsenopyrite

respectively which comprises mixing the ore in a finely divided state with litharge finely divided to a grain size substantially the same as the median grain size of the ore, removing gangue minerals from the mixture, separating on a plane surface of a shaking table the remainder of the mixture to produce separate fractions of gold and arsenopyrite arranged in zones in said layer separated edgewise by the litharge, and separately collecting the material from said zones.

11. The process of separating ore containing a precious metal associated with a deleterious mineral and gangue minerals of lower specific gravity than said deleterious mineral to produce fractions containing said metal and said deleterious mineral respectively which comprises mixing a primary concentrate of the ore in a finely divided state with a finely divided water insoluble artificial middling of homogeneous, granular material having a specific gravity intermediate the specific gravities of the metal and the deleterious mineral and having a grain size substantially the same as the median grain size of the ore, removing said gangue minerals from the mixture, and separating the remainder of the mixture in a thin surface layer on a plane surface of a shaking table whose plane surface is transversely inclined to the horizontal and reciprocated longitudinally into separate fractions of metal and deleterious mineral arranged in thin zones of said layer separated edgewise by said middling, the said zones each lying on said plane surface.

12. The process of separating ore containing a precious metal associated with a deleterious mineral and gangue minerals of lower specific gravity than said deleterious mineral to produce fractions containing said metal and said deleterious mineral respectively which comprises mixing a primary concentrate of the ore in a finely divided state with an artificial middling consisting of homogeneous, granular, finely divided metallic compound having a specific gravity intermediate the specific gravities of the metal and the deleterious mineral and having a grain size substantially the same as the median grain size of the ore, removing said gangue minerals from the mixture, and separating the remainder of the mixture in a thin surface layer on a shaking plane surface of a table whose plane surface is transversely inclined to the horizontal and reciprocated longitudinally into separate fractions of metal and deleterious mineral arranged in thin zones of said layer separated edgewise by said metallic compound, the said zones each lying on said plane surface.

13. The process of concentrating ore to produce a plurality of fractions of different specific gravities which comprises mixing the ore in the finely divided state with a finely divided artificial middling of homogeneous, granular material having a specific gravity intermediate the specific gravities of said fractions, subjecting the mixture on an inclined plane surface simultaneously to agitation by longitudinal reciprocation of said surface and to the force of a stream of fluid acting in a direction parallel to said inclined plane surface to separate said mixture into a thin layer on said plane surface consisting of zones containing respectively said fractions separated by a thin layer of said middling, the said zones each lying on said plane surface.

14. The process of concentrating ore to produce a plurality of fractions of different specific gravities which comprises mixing the ore in a

finely divided state with a finely divided artificial middling of homogeneous, granular material having a specific gravity intermediate the specific gravities of said fractions, subjecting said mixture to agitation on an inclined plane surface to separate said mixture into a layer on said surface having a depth substantially of one grain and consisting of zones of substantially one grain depth containing respectively said fractions separated edgewise from each other by a zone having substantially one grain depth of said middling.

15. The process of concentrating ore containing a precious metal of one specific gravity associated with deleterious minerals of different specific gravity to produce fractions of said metal and said deleterious mineral respectively which comprises mixing a primary concentrate of the ore in a finely divided state with a finely divided

5 water insoluble artificial middling of homogeneous granular material having a specific gravity intermediate the specific gravities of said fractions and having a grain size substantially the same as the median grain size of said finely divided ore, feeding said mixture on to an inclined surface undergoing agitation and subjecting said mixture on said surface to the action of said agitation and to the force of a stream of liquid acting in a direction parallel to said inclined surface whereby the resultant of all forces acting on said mixture will separate said mixture on a plane portion of said surface into a thin layer consisting of zones each lying on said surface and containing respectively the fractions separated edgewise from each other by a zone consisting solely of said middling.

SIBLEY B. McCLUSKEY.

CERTIFICATE OF CORRECTION.

Patent No. 2,287,115.

June 23, 1942.

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It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 5, first column, lines 46 and 47, and second column, line 50, claims 8 and 12 respectively, for "shaking plane surface of a table" read --plane surface of a shaking table--; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 4th day of August, A. D. 1942.

Henry Van Arsdale,
Acting Commissioner of Patents.

(Seal)