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CONCENTRATION OF MINERALS

Filed March 26, 1929

Fig. 1.

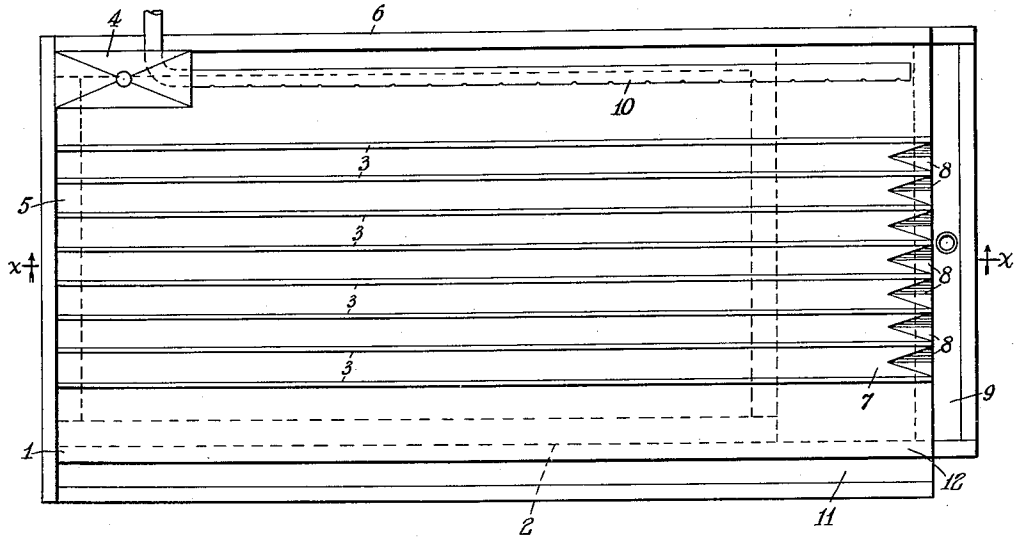


Fig. 3.

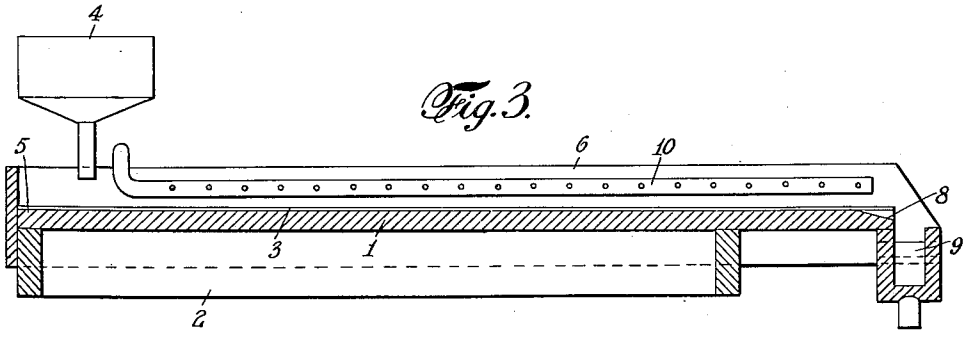
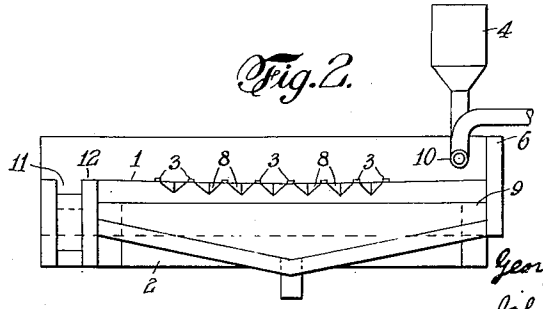


Fig. 2.



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CONCENTRATION OF MINERALS

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22 Claims. (Cl. 209—49)

This invention relates to the concentration of minerals, and is herein illustrated as applied to the concentration of the phosphate commercially known as bone phosphate of lime from naturally occurring phosphate-bearing material.

According to the present invention the concentration is effected by procedures which may include, skin or film flotation in which phosphate particles ride upon the surface of water while silica and other impurities are wetted by the water and tend to sink; and which may include differential separation under wet stratifying conditions, and which may include both skin flotation and wet stratifying classification. The process may be carried on or aided by table concentration wherein the silica, which tends to sink in the water flowing over the table, is carried off in the general direction of the riffles, while the phosphate particles, carried in or on the water flowing across the riffles of the table, are delivered to a concentrate launder, and are thereafter dewatered. The phosphate-bearing material is herein described as made easily amenable to such skin flotation or water-flowing separation or both by prior treatment, as with an alkaline substance, or with soap and oil, or with alkali and a saponifiable oil. Variations of treatment may produce skin flotation, water flowing separation with differential separation under wet stratifying conditions, or both. Where an oil is used the oil selectively coats phosphate particles, making them more amenable to separation.

In the form of the invention herein illustrated, film or skin flotation and other procedures are carried out together on a shaking table of a general type used in effecting the concentration of metalliferous minerals.

Many forms of apparatus may be used in carrying out the procedures of the present invention, but the tests described in detail below were carried out on a Wilfley table provided with a special deck as shown in the accompanying drawing:

In the drawing Figure 1 is a plan view of the deck.

Figure 2 is an end view, and

Figure 3 is a longitudinal vertical section thereof taken on a plane indicated by the line x—x in Figure 1.

The deck 1, is shown as mounted on a standard deck frame 2, which in turn is mounted in the usual manner for longitudinal vibration by the usual devices so that the whole vibrates as a unit. The deck 1 is provided with riffles 3, extending longitudinally of the deck. A thick pulp of phosphate-bearing material was fed, through a hopper 4 at the upper end 5 of the upper side, to the deck, and the vibrations of the table tended to carry the silica and other impurities lengthwise of the table and in the general direction of the riffles and to the lower end 7 of the table, discharging it, through V-shaped cuts 8 at the lower end 7 and between the riffles 3, into an end or tailings launder 9. The pulp particles were continually washed by streams of water flowing transversely across the riffles from a feed pipe 10 along the upper side 6, which carried and discharged phosphate particles into a concentrate launder 11 at the lower side 12 of the deck. The V-shaped cuts prevented gangue from building up along the lower end 7 of the deck. The surface of the deck was not quite flat, sloping about an eighth of an inch from each side toward the center so that a long pool of water tended to form between the central riffles.

Many phosphate particles float on the water surface as a skin or film float and are carried off into the concentrates launder 11 by the transversely flowing stream of water. Other phosphate particles, many of them in flocks associated with air bubbles, form aggregates or loosely bonded agglomerates and, in suspension in the water, or resting lightly on the silica or other impurities are carried transversely, separating themselves from the endwise movement of the other particles by the usual action of a table.

The following tests were carried out with the apparatus just described. The material used was the phosphate-bearing tails resutling from the concentration by screening of the product of the No. 11 Mine of the International Agricultural Corporation at Mulberry, Florida. The material was mostly finer than 14-mesh, and had been largely deslimed. The principal ingredient of the gangue was silica, but it also contained the objectionable ingredients iron and alumina.

In one test phosphate-bearing material was made into a thick pulp and treated with caustic soda in solution equivalent to 0.4 pounds per ton of solids, then mixed with 1.2 pounds red oil (oleic acid) and four pounds of fuel oil, both per ton of solids. This formed soap and left the fuel oil as an oily material which coated the phosphate particles. The thick pulp was then agitated as for flotation, fed to the table with more water and concentrated thereon by the vibrating action of the table and transversely flowing water as described above. The results are shown in the following table in which

B. P. L. means so-called bone phosphate of line, $Ca_3P_2O_8$.

	Wt. %	B. P. L.	B. P. L. recovery %
Heads	100	20.51	100
Conc	22	71.17	76.1
Tails	78	6.29	23.9

In another test the pulp containing about 30% moisture was mixed quietly, with the minimum of agitation, with the same proportions of the same agents and then separated by the same water-flowing and vibrating table procedure into concentrate, middling and tailing, the middling consisting of a concentratable mixture of phosphate and other material. The results are shown in the following table:

	Wt. %	B. P. L.	B. P. L. recovery %
Heads	100	20.55	100
Conc	27.3	71.4	94.9
Midd	3.7	5.76	1.0
Tails	69.0	1.22	4.1

A repetition of the last test, without attempting to separate the middling product, yielded the results shown in the following table:

	Wt. %	B. P. L.	B. P. L. recovery %
Heads	100	21.37	100
Concs	29.6	70.4	97.8
Tails	70.4	.96	2.2

One advantage of effecting the separation over the surface of a vibrating table lies in the great volume of material treatable with a given area of table.

The preliminary treatment with caustic soda improves the richness of the concentrate and the recovery, and reduces the amount of other agents required. So far as tested soap, especially sodium oleate, and unsaponifiable oil, such as the fuel oil used above, were the best agents for effecting concentration. The best method of adding the soap was to make it in situ from caustic soda and oleic acid, but other alkaline substances and other saponifiable oils proved useful, though less effective.

This process has also been found to be usefully applicable to the concentration of the following minerals: Cassiterite, copper carbonate, beauxite, manganese oxide, iron oxide, barytes, lead carbonate, zinc carbonate and zinc silicate.

Having thus described certain embodiments of the invention what is claimed is:

1. The process of concentrating phosphate ore which comprises adjusting the water content of the finely-divided ore to insure having all the particles thoroughly wetted and adding a selective flocculating agent to the ore, mixing said agent with the ore until loosely bonded agglomerates of phosphate mineral particles are formed which are adapted, when a mixture of said agglomerates and the gangue particles contained in the ore is agitated under wet stratifying conditions, to settle at a less rate than the gangue, then subjecting the mixture to agitative wet stratifying classification according to the relative settling values of said agglomerates and the gangue and gathering the phosphate mineral in an overlying stratum.

2. The process of concentrating phosphate ore which comprises adjusting the water content of the finely-divided ore to insure having all the particles thoroughly wetted and adding a selective flocculating agent to the ore, mixing said agent with the ore to form a thin film or coating of said agent on each phosphate mineral particle and to at least in part form loosely bonded agglomerates of said particles, then subjecting the mixture to agitative wet stratifying classification according to the relative settling values of the treated mineral and the gangue and gathering the phosphate in an overlying stratum.

3. The process of concentrating phosphate ore comprising adjusting the water content of ore of a degree of fineness such that the desired mineral particles are substantially free from attached gangue particles, to insure having all the ore particles thoroughly wetted, adding selective agents to the thus wetted ore and mixing said agents with the ore to form loosely bonded agglomerated bodies of phosphate mineral particles which are adapted when agitated under wet stratifying conditions to settle more slowly than the said gangue particles, then subjecting the resulting mixture to agitative wet stratifying classfication according to the relative settling values of said bodies and said gangue and gathering the phosphate mineral in an overlying stratum.

4. The process of concentrating a finely divided phosphate-bearing material which consists in agitating the material with a fraction of one percent of sodium soap and a fraction of one percent of petroleum oil in the presence of enough water to wet the particles and adding water to form a freely flowing pulp and subjecting this pulp to agitative wet stratifying classification according to the relative settling values of the phosphate material and the gangue and recovering phosphate concentrate in an overlying stratum.

5. The process of concentrating a finely divided phosphate-bearing material which consists in agitating the material with a fraction of one percent of sodium soap and a fraction of one percent of petroleum oil in the presence of enough water to wet the particles and adding water to form a freely flowing pulp and subjecting this pulp to table concentration so that phosphate concentrate is discharged transversely of the vibration of the table and tailings are discharged in the general direction of the vibration of the table.

6. The method of separating phosphate from fine phosphate-bearing silica-containing material which consists in admixing a small proportion of soap and unsaponifiable oil with the material so as to selectively coat the phosphate particles with oil and flowing a stream of water carrying the treated material across an obstruction so as to tend to retain the silica while the water carries onward the phosphate particles, and collecting the phosphate particles.

7. The process of concentrating a finely divided phosphate-bearing material which consists in agitating the material with a fraction of one per cent of soap and a fraction of one per cent of petroleum oil in the presence of enough water to wet the particles and adding water to form a freely flowing pulp and subjecting this pulp to agitative wet stratifying classification according to the relative settling values of the phosphate material and the gangue and recovering phosphate concentrate in an overlying stratum.

8. The process of concentrating a finely divided phosphate-bearing material which consists in agitating the material with a fraction of one per cent of soap and a fraction of one per cent of petroleum oil in the presence of enough water to wet the particles and adding water to form a freely flowing pulp and subjecting this pulp to table concentration so that phosphate concentrate is discharged transversely of the vibration of the table and tailings are discharged in the general direction of the vibration of the table.

9. The process of concentrating mixed minerals wherein the values to be concentrated contain a metal and oxygen in combination which comprises adjusting the water content of such finely divided minerals to insure having all the particles thoroughly wetted and adding a selective flocculating agent, mixing said agent with the minerals until loosely bonded agglomerates of particles to be concentrated are formed which are adapted, when a mixture of said agglomerates and the other particles is agitated under wet stratifying conditions, to settle at a less rate than the other particles, then subjecting the mixture to agitative wet stratifying classification according to the relative settling values of the agglomerates and the other particles and gathering the agglomerated particles in an overlying stratum.

10. The process of concentrating finely divided ores of non-sulphide minerals which comprises adjusting the water content of such an ore to insure having all the particles thoroughly wetted and adding a selective flocculating agent, mixing said agent with the ore to form a thin film or coating on particles to be concentrated and to at least in part form loosely bonded agglomerates of said particles, then subjecting the mixture to agitative wet stratifying classification according to the relative settling values of the coated mineral and the other particles and gathering the coated mineral in an overlying stratum.

11. The process of concentrating mixed minerals wherein the values to be concentrated contain an element of the alkaline earth group, comprising adjusting the water content of such mineral particles of a degree of fineness such that the particles to be concentrated are substantially free from attached gangue particles, to insure having all the particles thoroughly wetted, adding selective agents and mixing said agents with the minerals to form at least in part loosely bonded agglomerated bodies of the particles to be concentrated which are adapted under wet stratifying conditions to settle more slowly than the other particles, then subjecting the mixture to agitative wet stratifying conditions according to the relative settling values of the material to be concentrated and the other particles and gathering the material to be concentrated in an overlying stratum.

12. The process of concentrating finely divided mixed minerals wherein the values to be concentrated contain a metal and oxygen in combination, which consists in admixing a small proportion of soap and unsaponifiable oil with such minerals so as to selectively coat particles to be concentrated with oil and flowing a stream of water carrying the treated material across an obstruction so as to tend to retain the other particles while the water carries onward the particles to be concentrated, and collecting the particles to be concentrated.

13. The process of concentrating finely divided ores of non-sulphide minerals which consists in admixing a small proportion of a soap-forming radical and an alkali and an unsaponifiable oil with such an ore so as to selectively coat particles to be concentrated with oil, and flowing a stream of water carrying the treated material across an obstruction so as to tend to retain the other particles while the water carries onward the particles to be concentrated, and collecting the particles to be concentrated.

14. The process of concentrating phosphate ores which consists in admixing a small proportion of a soap-forming radical and alkali and an unsaponifiable oil with such an ore so as to selectively coat phosphate particles with oil forming agglomerates, and flowing a stream of water carrying the treated material across a stratifying support so as to tend to retain gangue particles while the water carries phosphate particles onward, and collecting phosphate particles.

15. The process of concentrating finely divided ores of non-sulphide minerals, which consists in agitating the particles of such an ore with a fraction of one per cent. of soap and a fraction of one per cent. of petroleum oil in the presence of enough water to wet the particles and adding water to form a freely flowing pulp and subjecting this pulp to agitative wet stratifying classification according to the relative settling values of the material to be concentrated and the other particles, and recovering the material to be concentrated in an overlying stratum.

16. The process of concentrating finely divided ores of non-sulphide minerals which consists in agitating such an ore with a fraction of one per cent. of soap and a fraction of one per cent. of petroleum oil in the presence of enough water to wet the particles, forming agglomerates and adding water to form a freely flowing pulp and subjecting this pulp to table concentration so that the material to be concentrated is discharged transversely of the vibration of the table and the tailings are discharged in the general direction of the vibration of the table.

17. The process of concentrating phosphate ores comprising adjusting the water content of such a finely divided ore to insure having all the particles thoroughly wetted and adding a selective flocculating agent to the ore, admixing said agent with the ore to form agglomerates of phosphate particles and subjecting the mixture to stratifying classification to separate the agglomerates from gangue particles according to their relative settling values, and gathering the phosphate agglomerates.

18. The process of concentrating finely divided ores of non-sulphide minerals comprising adjusting the water content of such an ore to insure having all the particles thoroughly wetted and adding a selective flocculating agent and mixing said agent with the ore to form agglomerates of valuable mineral particles, and subjecting the mixture to stratifying classification to separate valuable agglomerates from gangue particles according to their relative settling values, and gathering the valuable agglomerates.

19. The process of concentrating minerals comprising adjusting the water content of an ore (of a sufficient degree of fineness to liberate the valuable mineral from the gangue) to thoroughly wet the particles thereof, adding a selective flocculating agent to and mixing it with said particles to form agglomerates of the valuable mineral content, subjecting the mixture to stratifying classification to separate the agglomerates

from the gangue according to their respective settling values and collecting the agglomerates.

20. The process of concentrating phosphate-bearing materials comprising adjusting the water content of an ore (of a sufficient degree of fineness to liberate the phosphate from the gangue) to thoroughly wet the particles thereof, adding a selective flocculating agent to and mixing it with said particles to form agglomerates of the phosphate, subjecting the mixture to stratifying classification to separate the agglomerates from the gangue according to their respective settling values and collecting the agglomerates.

21. The process of concentrating phosphate ores which consists in adjusting the water content of the finely divided ore to insure having all the particles thoroughly wetted and adding a selective flocculating agent to the ore, mixing said agent with the ore to form a thin film or coating of said agent on phosphate particles and to at least form in part loosely bonded agglomerates of said particles, then subjecting the mixture to agitative wet stratifying classification, and collecting a portion of the phosphate as a float on the water and a portion of the phosphate in an overlying stratum in the water.

22. The process of concentrating ores of non-sulphide minerals which consists in adjusting the water content of such a finely divided ore to insure having all the particles thoroughly wetted and adding a selective flocculating agent, mixing said agent with the minerals to form a thin film or coating of said agent on particles to be concentrated and to at least in part form loosely bonded agglomerates of said particles, then subjecting the mixture to agitative wet stratifying classification, and collecting a portion of the coated mineral as a float on the water and a portion of the coated mineral in an overlying stratum in the water.

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