Jan. 2, 1951 L. F. HEWETT ET AL 2,536,286

PROCESS FOR THE TABLE AGGLOMERATION CONCENTRATION OF ORE

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FIG. 1.

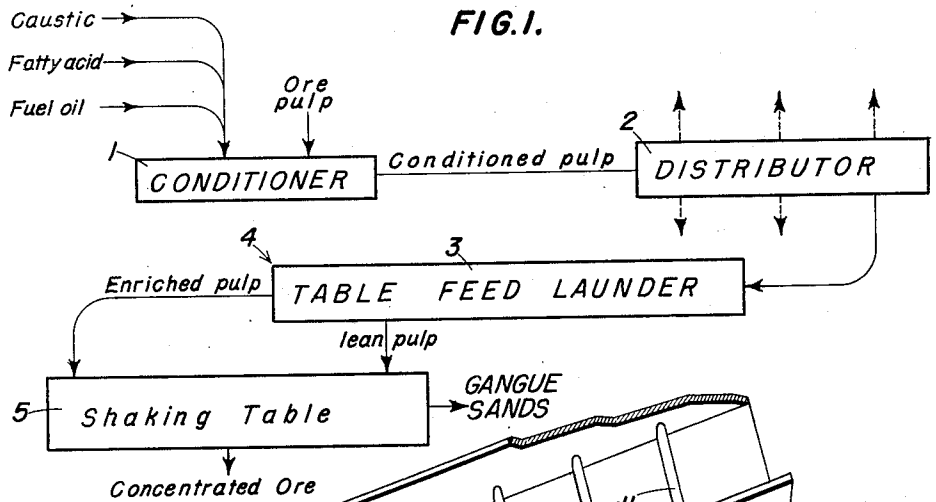
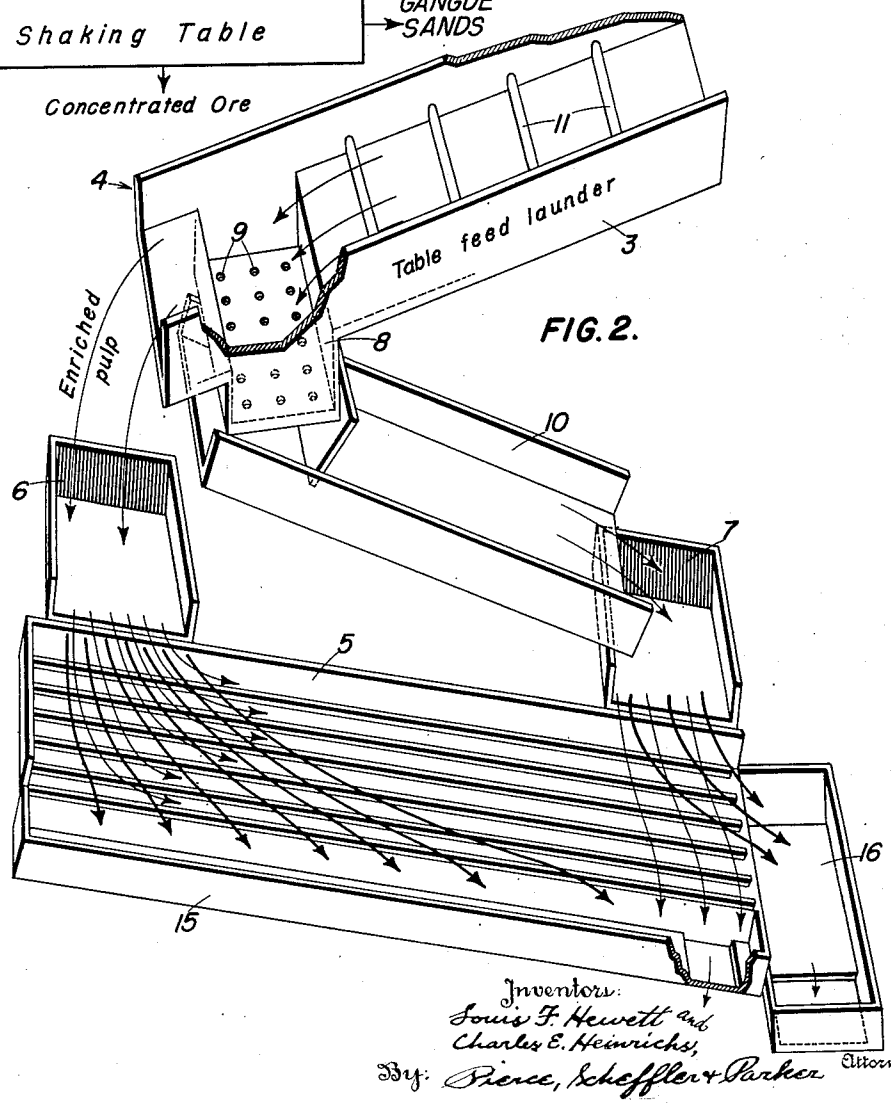


FIG. 2.



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FIG. 4.

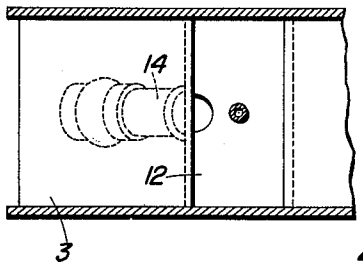
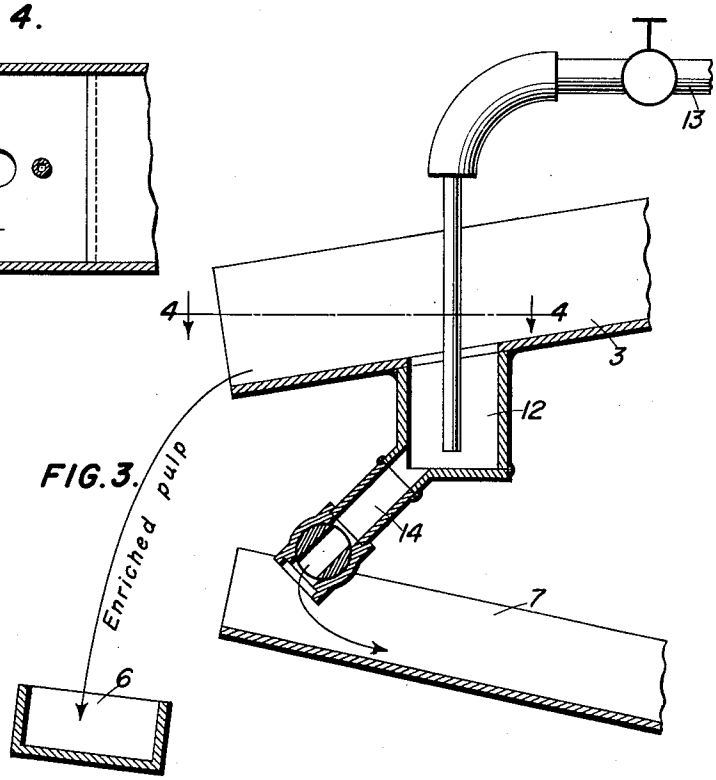


FIG. 3.



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2,536,286

PROCESS FOR THE TABLE AGGLOMERATION CONCENTRATION OF ORE

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2 Claims. (Cl. 209—9)

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The present invention relates to a process for the concentration of ores, and in particular it comprises a modification of the usual procedure for the table agglomeration concentration of ores by means of shaking tables.

In the employment of shaking tables for the table agglomeration concentration of ore material, the usual procedure is to first prepare the ore for tabling by agitating a thick pulp of the material containing gangue with the proper proportions of selective conditioning and agglomerating reagents, such as for example caustic, fatty acid and fuel oil in such a manner as to condition the pulp and to encourage the formation of loosely bonded agglomerates of mineral values as described in U. S. Patent No. 1,968,008 to Chapman and Littleford. When properly conditioned feed of this pulp is supplied to such tables some of the mineral values being in the form of agglomerates containing air bubbles, travel across the riffles and are discharged along the lower long edge of the table as a concentrate. Other mineral particles being coated with oils travel in the same direction in the form of a skin float, riding on the surface of the water. The gangue, which may consist principally of silica sand or other material is progressed in a direction parallel to the riffles and forms a lower layer on the deck of the table between the riffles. This sand is discharged from the narrow end of the tables furthest from the head end. The capacity of such tables is limited by their ability to effect the physical separation and discharge of the sand gangue.

The primary object of our invention is to provide means for greatly increasing the capacity of the shaking tables in terms of tons of ore pulp handled efficiently per hour of operation. A second object is the provision of means whereby the metallurgical recovery of a higher grade product is substantially increased.

These objects are accomplished by our method in which the tables are assisted in separating and discarding gangue sands by means of a partial concentration of the mineral values before the feed is ever introduced onto the table, thereby reducing the amount of work which must be done on and by the tables with the result that the capacity of the tables is practically double, and as will be seen from the examples cited, the grade of concentrate is greatly improved. The matter of grade as well as the matter of capacity is very important. In the case of phosphate concentrates, for instance, the commercial value of 77 per cent concentrates is approximately double the value of 68 or 69 per cent concentrates.

In table agglomeration concentration of ores, it

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is customary to use several tables. Conditioning for all tables may be done in a single conditioner and the conditioned feed continuously discharged into a distributor which continuously divides the total feed into equal parts. Each part is conveyed by a separate table feed launder by gravity to the feed box of one of the tables.

It has now been found that not only is the oiled material levitated more readily than the unoiled sand, but that the effect becomes so pronounced during travel of the pulp through the launder that a partial separation may be accomplished in the launder by providing means whereby the upper stratum of pulp may be substantially separated from the lower stratum. That is to say, when a conditioned pulp moves in a launder or pipe there is a definite tendency for the sand fraction to segregate at a lower level than the mineral value fraction which is oiled and generally associated with air bubbles. We have found that the lower portion, higher in gangue content, may be drawn off from the bottom of the launder leaving the upper portion, richer in mineral values, remaining in the launder. We have also found that the tendency for the oiled and unoiled portions of the pulp to separate in the launder can be encouraged and assisted by the use of baffles or other devices for causing turbulence in the pulp. Such devices are of particular benefit where the total distance travelled by the pulp flowing in the launder is relatively short. We have further found that by introducing the thus separated portions onto a shaking table at separate feed positions, we can increase both the capacity of the shaking tables and the efficiency of the concentration operation performed by the tables.

The method of practicing the invention may be more readily understood by reference to the drawings in which:

Fig. 1 is a flow sheet of the preferred procedure,

Fig. 2 is a schematic perspective view of the feed launder and its accessories, a part being shown in section,

Fig. 3 is a longitudinal vertical section through one form of apparatus which may be employed for effecting the preliminary partial concentration in a launder, and

Fig. 4 is a longitudinal horizontal section on the line 4—4 of Fig. 3.

Referring to the flow sheet of Fig. 1, it will be appreciated that the invention resides in the new and improved method of concentrating ores comprising (a) treating the ore pulp with reagents which condition the desired values in such a way as to render them subject to agglomeration and levitation while leaving the gangue material

substantially unaffected, (*b*) passing the thus treated ore pulp into a launder, (*c*) accomplishing a preliminary separation of the pulp flowing through the launder into two portions, one portion being rich in the desired values while the second portion is high in undesired gangue material, (*d*) introducing the two portions onto a shaking table at separate feed positions, (*e*) accomplishing a final table separation simultaneously upon the two partially concentrated portions, and (*f*) separately collecting the thus separated desired values and the undesired gangue material.

In carrying out such a concentration of ore in accordance with our invention, the ore material is first made into a thick aqueous pulp of approximately 65 per cent solids. In order to be successfully concentrated by the process of the invention, it is apparent that the solids must have been previously ground and screened to obtain the optiumum particle size normally employed in the practice of table agglomeration separation (200 mesh to 8 mesh) of the particular ore being concentrated. The pulp is then run into a conditioner 1.

The conditioner may be of any commercially successful design such as the horizontal rotary type, and conditioning for all the tables may be accomplished by a single unit of suitable size. The reagents for oiling the ore are introduced into the conditioner, these reagents being identical in nature and quantity to those normally employed for conditioning the particular ore prior to concentration by means of a shaking table. The reagents illustrated in the flow sheet; to wit, caustic, fatty acid, and fuel oil, are those generally employed in operations upon phosphate rock.

The conditioned feed is discharged into a distributor 2 which divides the feed into equal parts, depending upon the number of tables to be supplied. If it be desired to operate only a single table, of course the distributor 2 may be omitted and the conditioned pulp passed directly from the conditioner 1 to a table feed launder 3. As illustrated, a six-way distributor may be employed to feed the conditioned pulp in equal quantities to six table feed launders, each leading to one of six tables, but it is obvious that any desirable number of tables may be employed in cooperation with a distributor capable of delivering to that number of table feed launders.

If desired, water may be added in the distributor to insure flow by gravity of the pulp in launder 3.

From the distributor 2, the pulp passes to the table feed launder 3. The table feed launder may consist of an open square-sided trough or of pipe or of any suitable design providing adequate cross-section for the flow of the conditioned pulp. The pulp is conveyed along the launder by gravity, and simultaneous with the flow of the pulp toward the lower end of the launder a levitation of the oiled pulp occurs while the unoiled gangue sands accomplish a settling out effect, the result being that the treated pulp flowing in the launder tends to arrange itself into two separate strata. The upper layer contains most of the mineral values while the lower layer comprises mainly gangue.

It is obvious that up to a certain point, the degree of levitation of the concentrate and of settling of the sands will be somewhat proportional to the amount of time the conditioned pulp is allowed to flow in the launder, this in turn being determined by the length of the table feed launder and the angle at which it is mounted. We have made no attempt to establish critical limits for any of these factors, as the maximum efficiency of our process will depend in each case upon the type of ore being concentrated and the particular characteristics of the pulp being handled.

Suffice it to say that at the lower or feed end 4 of the table feed launder 3, a separation of the lower stratum from the upper stratum is accomplished to give two separate cuts of pulp. This separation, which is in effect a partial concentration of the ore, may be accomplished by any suitable means. Properly disposed baffles may be used to assist the more rapid and complete formation of an upper layer of pulp rich in the desired mineral values, leaving a lower portion rich in gangue to continue its flow to the end of the launder. On the other hand, the lower layer high in gangue values may be drawn off through the bottom of the launder, leaving an upper portion richer in mineral values to continue its flow to the end of the launder.

In practice, we prefer the latter method, but in any event, the thus separated portions are separately conveyed to a table 5, the portion rich in concentrates being run into table feed box 6 disposed to introduce pulp onto the table at the upper or feed end of the table while the portion rich in gangue is introduced onto the table by means of feed box 7 disposed near the lower or tailings discharge end of the table.

The preliminary launder separation may be accomplished by any number of simple forms of apparatus, and although the practice of our invention is not limited to any particular form of apparatus, some of the forms which we have found to be operable are illustrated by the drawings.

According to the design illustrated in Fig. 2, wherein a section of feed launder 3 is represented having a receptacle 8 fastened to its under side and opening into the launder as indicated, we have shown that perforations 9 operate to draw off the lower stratum rich in tailings for delivery to the feed box 7 via a supplemental table feed launder 10. It may be desirable to equip the floor of the launder 3 with transverse riffles 11 in order to produce tumbling and turbulence in the pulp stream which may in some cases assist in the preliminary separation. The riffles may extend entirely across the floor of the launder or may be disposed in any pattern found to give the desired tumbling or turbulence to a particular ore pulp. In practicing our invention with ores of the type described below, we have found it satisfactory to employ riffles of about ½ inch in height extending across the entire floor of the table feed launder in conjunction with a receptacle of the type shown, in which the perforations comprise holes having a diameter of approximately ¼ inch.

The type of device illustrated in Figs. 3 and 4 consists of a receptacle 12 fastened to the under side of a table feed launder 3, the receptacle opening into the launder as shown. A supply of water (indicated by 13) is arranged so as to provide an adjustable jet or stream of water in receptacle 12. An outlet 14 from receptacle 12 is provided as indicated. In this application of the invention the flow of conditioned pulp is present in the launder at considerable depth (at times as much as 1 inch deep), the sand tends to work toward the bottom while the conditioned or oiled ore values tend to work upward. In the receptacle 12

these tendencies are further assisted by the turbulence created by the water jet and the incidental entrapment of air in the agitated mass. The result is that a substantial part of the sand settles to the bottom of recepacle 12 and passes out through outlet 14 together with a relatively small part of the ore values. At the same time, conditions in receptacle 12 are favorable to the levitation of the ore values, the major portion of which continues down the launder together with some sand in the direction indicated.

In any event, any form of apparatus may be used which will accomplish a partial concentration or enrichment of the ore by means of a preliminary separation in the table feed launder before the feed is introduced onto the table 5. The enriched portion flows to the feed box 6 in the usual manner and is there distributed on the head end of the deck of the table 5 where the usual separation of gangue from the concentrate proceeds in the manner already described and as is well-known. The portion flowing through the holes 9 and consisting largely of gangue is led and delivered to the upper edge of the table at a point nearer the tailings discharge end. The small remaining part of ore concentrate floats across and on top of the gangue and discharges into the concentrate collecting launder 15 whereas the gangue being already well on its way toward the tailings end of the table and already separated from the ore concentrates is progressed by the motion of the table until it discharges into tailings collecting launder 16.

The particular type of table 5 employed is of no importance to our process as long as the proper degree of concentration is obtained; however, the apparatus which we most favor is the shaking table of the type of the Deister diagonal deck table or the Wilfley No. 6 table.

While the degree of preliminary concentration is not sufficient to give commercial results direct, the partial concentration is accomplished by unusually cheap and simple means and the results of the practice of the process are extremely outstanding. It is apparent that any ore amenable to table agglomeration separation will respond in the same manner when concentrated according to our process, but it will be appreciated by those familiar with the art that our process is of especial value in the concentration of non-metallic ores due to the fact that ordinary specific gravity methods of separation or concentration cannot be utilized in the non-metallic mining industry generally, since the specific gravity of non-metallic ores and of their respective gangues is often identical for all practical purposes. As regards Florida Pebble phosphate, which was concentrated in the examples given below, not only is there a practical identity in the specific gravity of the phosphate rock and its silica gangue, but in the ore-gangue mixture as prepared for table agglomeration separation, the particle-size of both materials is practically the same. Therefore, further sizing or classification results in no useful concentration and so the separation of the two materials must be made by some means such as froth flotation or agglomeration tabling.

In actual practice in a phosphate flotation plant the following results were obtained in full scale commercial operation.

The six primary tables were arranged in two rows of three each. The table feed was conditioned continuously in a rotary conditioner which discharged continuously into a six-way distributor. For the purposes of the test the feed launders to the northeast table and to the northwest table (located side by side) were equipped with the device described in Figs. 3 and 4 and so arranged that the devices could be blanked off at will.

In the first test, the device on the northeast table launder was in operation, but the device on the northwest table launder was not in operation. Samples were taken simultaneously from both tables which were in continuous operation and receiving feed prepared and distributed as described above. In the second test the device on the northwest table launder was in operation, but the device on the northeast table was not in operation.

Test 1

Northeast Table—Device Operating			Northwest Table—Device Not Operating	
B. P. L.[1]	Insol.		B. P. L.	Insol.
54.96	30.03	Conditioned Feed	53.22	32.95
68.78	13.81	Discharge at 6		
29.26	61.80	Discharge from 14		
76.18	4.02	Concentrates	67.98	14.33
10.28	85.60	Tails	25.98	65.55
94%		B. P. L. Recovery	83%	

[1] Bone phosphate of lime.

Test 2

Northeast Table—Device Not Operating			Northwest Table—Device Operating	
B. P. L.	Insol.		B. P. L.	Insol.
54.30	31.30	Conditioned Feed	59.00	24.98
		Discharge at 6	61.80	21.42
		Discharge from 14	20.06	72.71
75.83	4.28	Concentrates	76.41	3.88
11.97	83.46	Tails	7.75	88.85
92.5%		B. P. L. Recovery	96.5%	

Test data for the same two tables were taken again and indicate clearly the improved performance of the tables when the invention is practiced. The results of the second run were as follows:

Test 3

Northeast Table—Device Operating			Northwest Table—Device Not Operating	
B. P. L.	Insol.		B. P. L.	Insol.
54.59	35.09	Conditioned Feed	54.96	32.67
57.47	29.42	Discharge at 6		
15.74	79.85	Discharge from 14		
76.56	4.39	Concentrates	67.31	17.17
8.30	89.39	Tails	19.36	76.06
95.1%		B. P. L. Recovery	90.9%	

Test 4

Northeast Table—Device Not Operating			Northwest Table—Device Operating	
B. P. L.	Insol.		B. P. L.	Insol.
46.26	41.83	Conditioned Feed	55.70	30.23
		Discharge at 6	63.56	19.88
		Discharge from 14	23.38	71.54
69.33	13.48	Concentrates	76.73	3.84
11.80	84.28	Tails	12.61	80.50
89.8%		B. P. L. Recovery	92.6%	

The above examples illustrate clearly that when the tables are assisted by the method of the invention, a very much higher grade concentrate and a higher metallurgical recovery invariably result. Measurements were made to determine to what extent the capacity of the tables was affected. Experience in the phosphate field shows that the Wilfley No. 6 tables will do excellent work at a feed load of about 1½ gross tons per hour per table and may under very favorable conditions do a good job at 2 gross tons per hour of feed. In the above detailed tests the tables received a total of 3.83 gross tons per hour of feed each and it was found by measurement that out of this total, 1.66 gross tons per hour were diverted through outlet 14. It was therefore possible to process with excellent metallurgy a tonnage of feed representing more than 90 per cent overload or expressed in other terms the capacity of the tables was nearly doubled.

An additional run was later made using launder separation means similar to that disclosed in Fig. 2, but in this case the apparatus was even more simple than that illustrated. Riffles 11 and receptacle 8 were not employed. The apparatus was prepared merely by drilling six ¼ inch holes in the floor of a table feed launder at a point about three feet from the normally used table feed box 6. The launder 10 was arranged to receive the discharge from these holes.

At the time of the test, the conditioned feed in the launder before it reached the holes analyzed 53.29 per cent B. P. L. and 33.70 per cent insolubles. The discharge from the six ¼ inch holes, amounting to 0.5 gross ton per hour, analyzed 14.83 per cent B. P. L. and 80.80 per cent Insol., indicating that considerable segregation had taken place in the launder. Samples were taken to determine table performance under these conditions with the following results:

Test 5

	B. P. L.	Insol.
Total Table Feed in Launder	53.29	33.70
Feed In Launder After Passing Over Holes	59.10	27.33
Discharge From ¼ Inch Holes	14.83	80.80
Table Concentrate	74.05	7.33
Table Tails	10.81	86.96
Recovery	93.3%	

In this test the ¼ inch hole discharge was sent direct to tailings launder without being treated on the table at all. Thus, while it is found that the degree of preliminary concentration accomplished in the launder ordinarily is not sufficient to give commercial results, yet under certain conditions it may be necessary to treat only one of the separated portions on the table thereby increasing the over-all efficiency of the operation still more.

It will be appreciated from the foregoing that the invention is not limited to any specific means for accomplishing the preliminary separation, but that any means or device which takes advantage of the different levitation tendencies of oiled ore values and unoiled gangue or which encourages or accentuates these varying degrees of levitation, whether by purely mechanical means or with the assistance of air in association with the

oiled ore values, is capable of greatly increasing the tonnage capacity of a shaking table for the concentration of ore material and at the same time of considerably improving its metallurgical efficiency.

In the claims as well as the specification, for the sake of convenience, the terms "ore values," "mineral values," "desired values," and "concentrates" have been used as synonomous to describe the material which it is desired to obtain from an ore pulp by concentration. These terms have been used to distinguish from "gangue," "tails," "sand," and "gangue sands" which terms have been used to describe the undesired content of an ore.

We claim:

1. A process for concentrating a non-metallic ore comprising selectively conditioning an aqueous pulp of the ore for agglomeration tabling on a riffled shaking concentrating table, forming a flowing stream of said pulp down an incline, continuing the flow of said stream until substantial stratification takes place in said stream, dividing said stream into two flowing portions, one of said portions consisting of a lower stratum of said stream relatively rich in gangue and the other of said portions consisting of an upper stratum relatively rich in concentrates, continuously normally introducing onto said table the flowing portion consisting of the upper stratum, simultaneously continuously introducing the flowing portion consisting of the lower stratum onto said table at a point nearer the tailings discharge end of said table, simultaneously concentrating both of the thus introduced portions by the action of said table and collecting the concentrates discharged from said table.

2. A method for concentrating a finely divided and sized phosphate ore comprising treating an aqueous pulp of the ore with agents which will selectively condition said ore for a riffled shaking table agglomeration separation, introducing a stream of said pulp into a launder, conducting said stream down said launder by gravity until substantial stratification of solids within said stream has occurred, continuously separating said stream into two flowing portions consisting of an upper portion and a lower portion, delivering said upper portion in normal manner onto a riffled shaking concentrating table, delivering said lower portion onto said table abnormally in the respect that it is delivered nearer the tailings discharge end of the table, tabling both of said portions simultaneously, and collecting the ore concentrates delivered from said table.

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CHARLES E. HEINRICHS.

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