Jan. 31, 1950 J. STEPHAN 2,496,025

ORE CONCENTRATOR

Filed March 12, 1949 2 Sheets-Sheet 1

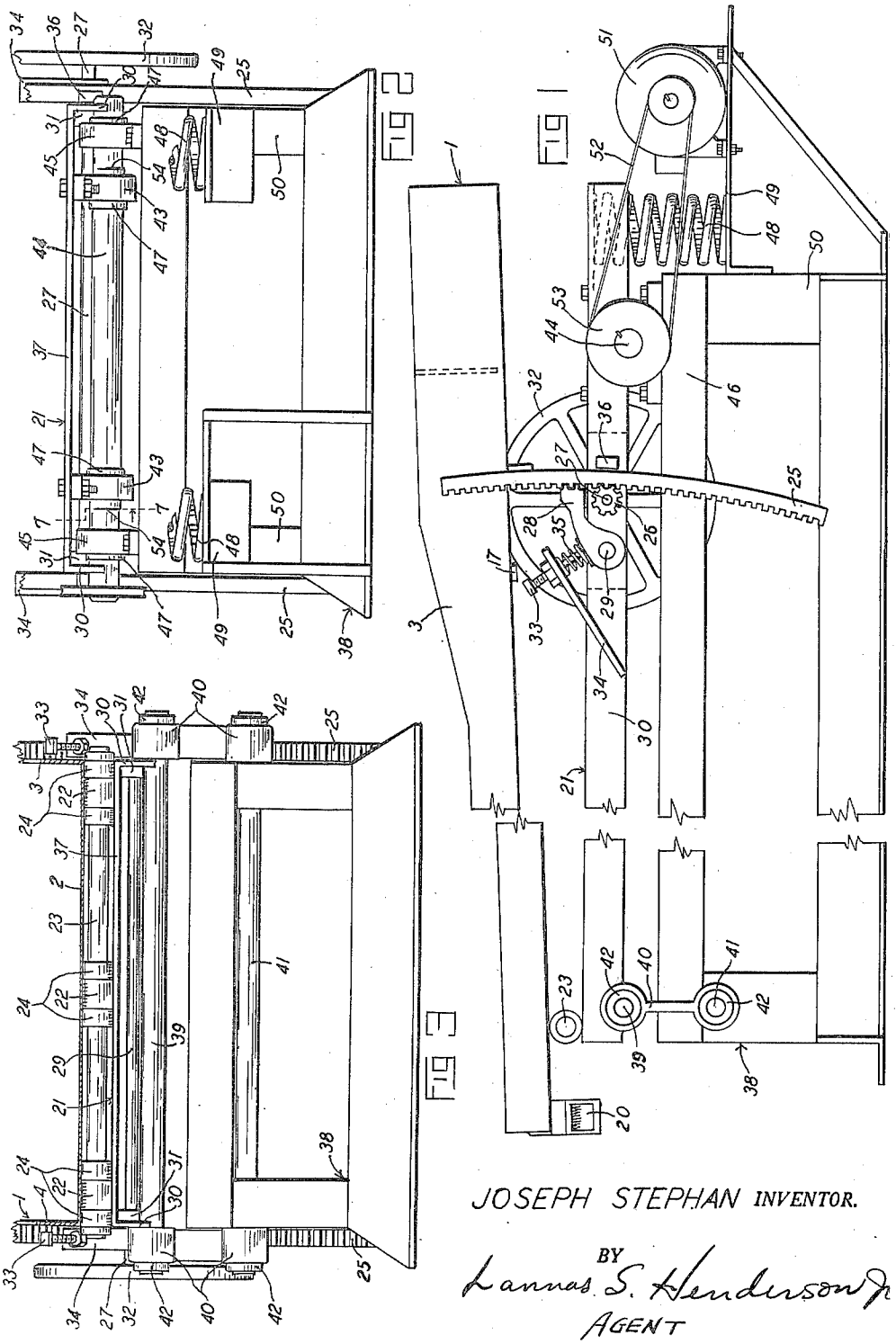


FIG 1

FIG 2

FIG 3

JOSEPH STEPHAN INVENTOR.

BY

Lannas S. Henderson Jr.

AGENT

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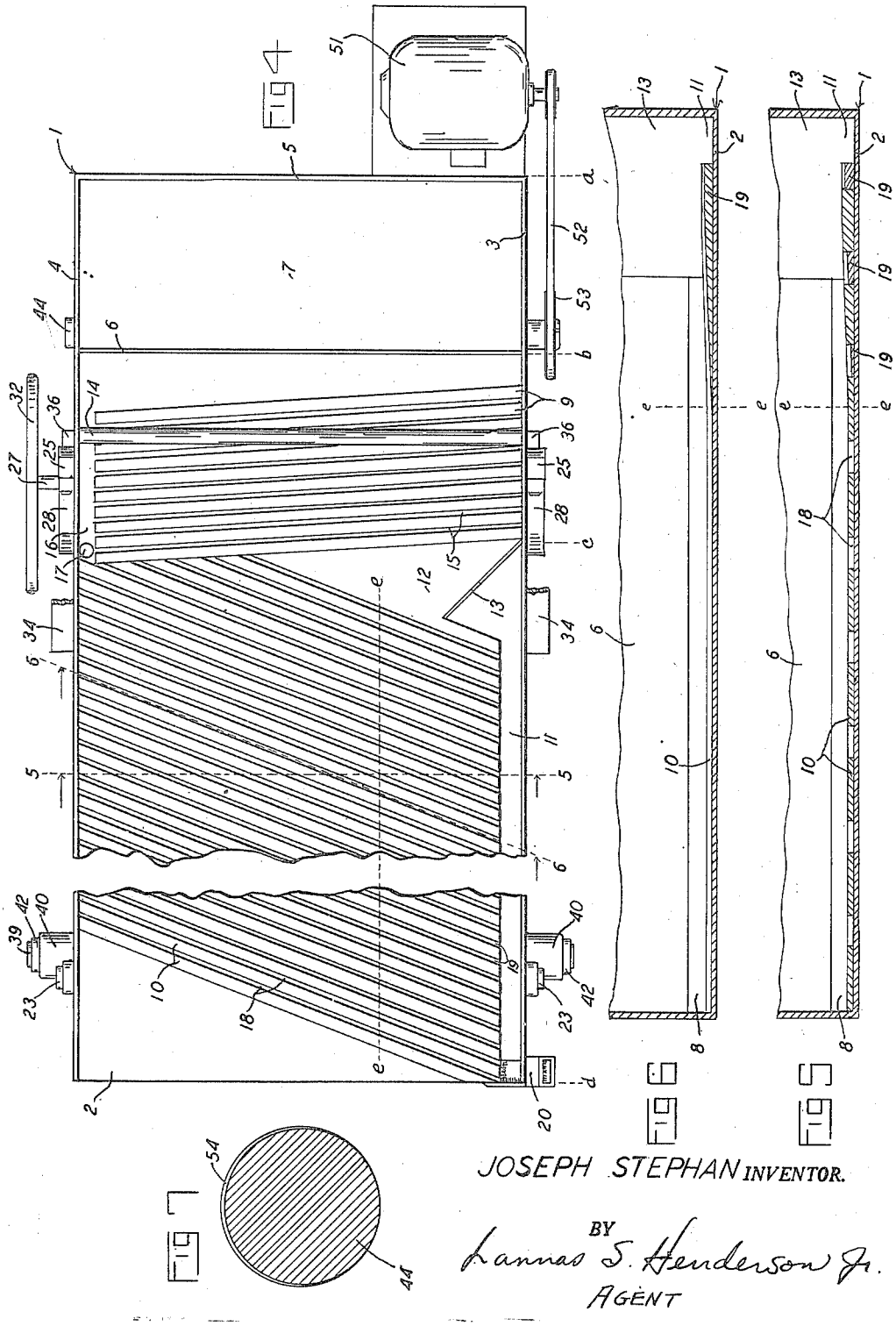


FIG 4

FIG 6

FIG 5

FIG 7

JOSEPH STEPHAN INVENTOR.

BY Lannas S. Henderson Jr.

AGENT

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UNITED STATES PATENT OFFICE

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ORE CONCENTRATOR

Joseph Stephan, Phoenix, Ariz., assignor to The Stephan Corp., a corporation

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8 Claims. (Cl. 209—441)

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The invention relates to a machine for concentrating milled ores and classified placer, and for selectively grading the concentrates into any desired specific gravity range. The machine operates partially on the well known gravity stratification and water-washing principles embodied in many concentrating tables known in the past. However, my machine differs from those of the prior art primarily in achieving a continuous, rapid and positive ejection of concentrate of any desired specific gravity range from ores varying widely in complexity, mineral content and specific gravity range.

Briefly, the machine consists of an elongated rectangular table with transverse, diagonal, receding grooves over its entire concentration surface, adjustably but rigidly mounted on a bed to which is imparted a rapid longitudinal and vertical shaking motion. The longitudinal shaking motion is parallel to the direction of flow of pulp and tailings, and transverse to the concentrate flow, and to the grooves.

To my knowledge, no prior art machine satisfactorily achieves this overall aim, or the more specific objects of the invention which follow.

One principal object of the invention is to achieve a machine of greater capacity per square foot of table area than is possible with machines heretofore known. I achieve a higher capacity principally by providing extremely rapid vibration and a novel table contour which makes possible a hydraulic ejection of concentrates which assists the normal removal of concentrates by gravity and shaking alone.

Another important object of the invention is to provide a machine adjustable to yield a concentrate of any desired specific gravity range.

A specific object of the invention is to achieve a machine capable of rapidly and economically concentrating classified monazite bearing sands at least 6 to 1 by weight while still retaining all the valuable minerals in the concentrate, including the thorium containing monazite.

Still another object of the invention is to achieve a concentrator wherein the ejection grooves will not become blocked by black sands, and other troublesome materials.

Another object of the invention is to achieve economy of water, which is an important item in mining locations.

Still another object of the invention is to achieve a machine simple in operation and requiring a minimum of adjustments. These and other objects are achieved by the machine set forth in the drawings and more particularly described hereinafter.

In the drawings,

Figure 1 is a broken side elevation of the machine.

Figure 2 is a partial rear elevation of the machine, showing in detail the agitating mechanism.

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Figure 3 is a partial front elevation, showing the front table and shaker bed mountings.

Figure 4 is a plan view of the top of the table.

Figure 5 is a transverse cross section of the table top taken through line 5—5.

Figure 6 is a longitudinal projection of a transverse cross section of the table top taken through line 6—6.

Figure 7 is a cross section of eccentric drive shaft 44 taken through line 7—7.

In the detailed description which follows, and in interpreting the drawings, it should be understood that the structural elements of the machine illustrated are of steel plate varying in thickness from $\frac{1}{16}$ inch to ½ inch, and the rigid joints and seams are all welded so that the rapid vibration of the machine will not loosen the joints and dissipate any of the vibratory motion.

The table 1 may vary considerably in size, though it should preferably not be more than about 40 x 130 inches. I have found that much smaller tables than this are effective. The table comprises an elongated, rectangular bed-plate 2 of steel plate, which is divided functionally into three main sections. The rear, or upper portion from *a* to *b* comprises, with side walls 3 and 4, end wall 5, and baffle plate 6, a hopper 7 into which the wet pulp or placer is fed. The baffle plate extends down to within about an inch of the bed plate, providing a narrow slit 8 through which the ore is washed onto the second section of the table from *b* to *c*, which, with the metal strips 9, forms a bullion trap which entraps very heavy minerals. The third and major section of the table, from *c* to *d*, forms with metal strips 10, the concentrating area where the concentrate is separated from the tailings. A gutter 11 is provided along the side wall 3 to receive the discharged concentrate. An apron 12 and a deflector plate 13 are provided between the sections *a*—*b* and *b*—*c* for the purpose of transmitting the pulp onto the surface of the concentration table from the bullion compartment, and to keep it from flowing into the gutter 11. A cross bar 14 is provided just below the baffle plate for reinforcement.

The bullion compartment consists of a laterally level surface made up by elongated metal strips 9, uniformly rectangular in cross section and preferably of aluminum or aluminum alloy, which are riveted diagonally across the bed plate 2 at an angle sloping about 4° from a lateral axis of the table. These strips are preferably about 1 inch in width and about ¼ inch in height, and are spaced about ⅜ inch apart to form trap-grooves 15. At their upper ends they abut the side wall 3 at an angle of 86°, and their lower ends terminate an inch or two short of side wall 4, providing a cleaning gutter 16. A cleaning drain 17

is provided at the lower end of this gutter, which is kept closed during operation.

The surface of the concentration area of the table is formed by elongated metal strips 10, preferably of aluminum or aluminum alloy. From the side wall 4 to the line *e*—*e*, these strips are of uniform rectangular cross section, $\frac{3}{16}$ inch in height, 1 inch wide, and spaced ⅜ inch apart to form concentration ejection grooves 18. These strips are riveted to the bed plate 2 contra-diagonally to the trap grooves 15, at an angle of about 21° from the lateral axis of the table, which is perpendicular to the pulp flow, and abut the side wall 4 at an angle of about 69°. From the line *e*—*e* to a line an inch or two short of gutter 11, the height of the strips 10 above the bed plate 2 increases evenly from $\frac{3}{16}$ inch to a maximum of ½ inch, as shown in Figures 5 and 6. In this particular machine, I have found it convenient to form the tapered part of the strips separately from the level part, but they obviously may be made in one continuous strip, if convenient. These strips terminate about two inches from side wall 3 to form gutter 11.

It will be seen that the table surface formed by these strips is laterally level up to the line *e*—*e*. From the line *e*—*e* to the line of maximum height, a lateral distance of about 9 inches, the surface of the table rises $\frac{5}{16}$ inch. This corresponds to a lateral, upward slope of about 2° from the level area of the table.

In addition to the sloping table surface so formed, the plane of the floor of the ejection grooves or channels 18 formed between the strips 10, is also inclined upwardly at an even greater slope than the table surface from *e*—*e* to a line an inch or two short of gutter 11. This is accomplished by riveting tapered, ⅜ inch square aluminum bars 19 to the bed plate 2 between the strips 10, from *e*—*e* to gutter 11. The height of these bars above the bed plate rises evenly from nothing at *e*—*e* to ⅜ inch at their maximum. The maximum height of both the table surface and the channel floors above the bed plate 2 is reached about 2 inches from gutter 11. It will be seen that at this line of maximum height, the grooves are only ⅛ inch in depth.

The apron 12 consists of adjoining aluminum strips riveted to the bed plate 2, and appropriately bevelled to provide a flush juncture with the surface of the concentration area.

A concentrate discharge chute 20 is provided at the lower end of gutter 11.

The table 1 is mounted on shaker bed 21 at its front end through pivot bearings 22 welded to the table, and pivot shaft 23, journalled in pivot bearings 24 which are welded to the shaker bed. Toward the rear the table is mounted on shaker bed 21 through a pair of racks 25 welded to the table side walls 3 and 4, paired pinions 26 welded to shaft 27 and paired detent dogs 28 welded to shaft 29. Shafts 27 and 29 are journalled in bearings formed through shaker bed flanges 30 and heavy steel reinforcements 31 welded to the inner side of the flanges 30.

The angle at which the table is tilted may be varied by turning adjusting wheel 32, which is welded to pinion shaft 27. Pinions 26 engage racks 25 and raise or lower the table when the ratchet dogs or detents 28 are disengaged from the racks. The detent dogs are rigidly engaged with the racks during operation by tightening lock bolts 33 which are threaded into support bars 34, which in turn are welded to flanges 30. Springs 35 are not essential to the locking mechanism, merely serving to yieldably engage the detent dogs with the racks while the elevation of the table is being adjusted. Rack supporting blocks 36 are provided behind each rack opposite pinions 26.

The racks 25 and the detent dogs 28, as well as the locking mechanism and support blocks, should be constructed of heavy steel members of sufficient strength to transmit efficiently the vibration of the shaker bed to the table. All the vertical motion and part of the longitudinal motion imparted to the table must be transmitted through racks 25. Some, and probably most of the longitudinal vibration imparted to the table is transmitted through the pivot shaft 23.

The shaker bed 21 consist of a heavy steel plate 37, preferably ½ inch in thickness, with downwardly extending flanges 30 on each side, which may be of lighter material. If desired, the center portion of the plate 37 may be cut away in order to conserve weight, provided a wide enough margin is left along the sides and ends to preserve rigidity. Reinforcements may be used if desired.

The shaker bed 21 consists of a heavy steel plate the front end through stationary shaft 39 welded to the shaker bed, double pivot bearings 40, and stationary shaft 41 welded to frame 38. The double pivot bearings 40 are held onto the trunnions of shafts 39 and 41 by means of retaining collars 42, which are locked onto the shafts in known manner by means of set screws, not shown. The shaker bed is rigidly mounted to the frame at the rear through paired journal boxes 43 which are bolted securely to the rear of shaker bed plate 37, eccentric drive shaft 44, and paired journal boxes 45 which are bolted securely to frame cross beams 46. The journal boxes 43 and 45 house a conventional type of ball or roller bearings, which are not shown. Eccentric drive shaft 44 is held in position laterally by conventional retaining collars 47.

The rear of the shaker bed 21 is also yieldably mounted to the frame 38 through paired springs 48 and spring mounts 49 which are welded to frame legs 50. These springs should be of heavy enough scale to support the full rear weight of the shaker bed and table, plus another inch or two of mounted deflection. The springs are mounted under more deflection than the weight of the machine parts mounted thereon normally provides. This is done in order that the upward thrust of the shaker bed will be sharper and faster than the downward return stroke. This action assists greatly the gravity settling of the heavier materials close to the surface of the table. The lighter materials are not as greatly affected, since they are largely water borne. In the present case, I have found that about a ¾ inch spring is required. These springs also serve the purpose of equalizing the upward and downward thrust on the drive shaft 44 and bearings 43 and 45.

The frame 38 is composed of steel 4 x 6 inch L-beams about ½ inch thick, and welded together at all joints to form an elongated rectangular box. Obviously, any other type of strong, rigidly constructed frame would be suitable.

Driving mechanism

Vibratory motion is imparted to the shaker bed 21 through the eccentric drive shaft 44. This shaft is driven by motor 51 through belt 52 and V-belt drive wheel 53, keyed to shaft 44. The shaft itself is a solid steel rod about 2½ inches in diameter at each end where it is jour-

nalled into frame mounted bearings **45**, and the central portion, which is journalled into shaker bed mounted bearings **43**, is $\frac{1}{16}$ inch larger in diameter than the frame mounted extremities, and its axis is offset $\frac{1}{32}$ inch from the axis of the extremities. This offset **54** may begin and end at any point between the two outer bearings **45** and the two inner bearings **43**. Each journal mounted in bearings **43** and **45** is ground very slightly oval to fit into the inner bearing races, which are also slightly oval. This prevents any rotational slip of the journals on the bearing races.

Type of motion

One of the principal operative features of my invention which, in combination with the table design, distinguishes it from other machines, is the type of motion which is transmitted to the table. In the first place, I employ a very rapid and shallow vibration compared to most concentrators. I preferably operate the drive shaft **44** at about 1000 R. P. M., and since the offset of the shaft axes is only $\frac{1}{32}$ inch, the whole vibration cycle is only $\frac{1}{16}$ inch in stroke. I have found that in my machine, this rapid, shallow vibration provides a very rapid and efficient separation of concentrate, preventing the grooves from "blocking" and allowing the concentrates to reach the floor of the grooves.

Since the shaker bed **21** is freely mounted on the drive shaft at the rear, and laterally pivoted on shaft **39** and double pivot bearings **40** at the front, it is obvious that the rotation of the drive shaft will impart to the rear part of the shaker bed **21** and the concentration table **1** a longitudinal and vertical rotation. However, since vertical motion is not possible at shaft **39**, this rotation becomes more and more elliptical progressing toward the front of the shaker bed, until, at the shaft **39**, it becomes horizontally, longitudinally reciprocating. This variety of vibratory motion over different parts of the concentration table gives each groove slightly different concentrating effects, and makes the table more versatile in handling various types and classified sizes of ore.

The backward thrust of the table, opposite to the pulp flow, would obviously compress a thin ribbon or prism of water against the lower wall and floor of each channel where the concentrate stratifies. The slope of the groove, from the lateral table axis, causes this water to move sharply but briefly toward the concentrate discharge side of the table, thus hastening the ejection of the concentrate, which would move more slowly by gravity and shaking alone. Due to the longitudinal slope of the table, however, and the short stroke of the backward table motion, this hydraulic effect is very local and does not cause excessive ejection of water and tailings into the concentrate. The lateral slope of the table surface and the floor of the channels, as well as the decrease in the depth of the grooves from *e*—*e* to gutter **11**, form a longitudinal weir, as shown in Figures 5 and 6, which counteracts either wholly or partially, depending on the angle at which the table is tilted longitudinally, the tendency of the water in the grooves to flow into the gutter **11**. The shear of the larger body of water flowing over the top of the grooves also tends to pull the water out of the grooves and toward the tailings discharge. The fact that the trap-grooves **15** are arranged contra-diagonally to the concentrate ejection grooves **18** also assists in

pulling or diverting the flow of water away from the concentrate discharge side of the table.

Operation

In operation the table **1** is, as previously described, first tilted to the desired angle on pivot shaft, or hinge **23**. This angle must be determined by experimentation, since such a wide number of variables is presented by different ores, but I have found that to recover concentrates of specific gravity about 7 and lower from monazite bearing sands, the table should tilt about 11° from the horizontal. The wet ore, for example a monazite bearing sand, which should be classified to contain no material larger than $\frac{1}{16}$ inch, is fed into hopper **7**. The slope and vibration of the table carries the sand under baffle plate **6** onto the bullion compartment, where the larger and heavier particles of specific gravity higher than about 7 are entrapped in the trap-grooves **15**, from which they may be periodically removed by cleaning, if desired.

The de-bullionized sand then flows over apron **12** onto the concentration area of the table, where the materials of specific gravity between about 3.5 and 7 are stratified in the ejection grooves **18** by gravity and shaking, and are ejected into gutter **11** as previously described. This concentrate contains virtually all the monazite and garnets contained in the ore, as well as very fine gold particles which escaped the trap-grooves **15**. The concentrate flows down the gutter **11**, through chute **20**, into a suitable receptacle. The materials of specific gravity less than about 3.5 are ordinarily silicates of no great value, and due to their lightness, are more susceptible to water flow than the heavier materials, and hence flow over the grooves and off the table at the lower, or discharge end, forming tailings.

By operating in the above manner I have found that monazite bearing sands classified through a 16 mesh screen may be concentrated 6 to 1 in one run over the table, and still retain in the concentrate nearly all the valuable materials, including thorium containing monazite. Moreover, this concentration is accomplished at the rate of 100 pounds of feed material per minute. Thus, in one simple classifying, and one rapid concentrating run, a very substantial reduction and concentration of the raw, bank-run material is obtained, amounting to as much as between 60 and 200 to 1 by weight.

Milled ores, including refractory and free milling ores, may be treated in a similar manner to the above, except that the table elevation should be adjusted to obtain the desired reduction in volume, or specific gravity range of concentrate. It may be necessary to classify these ores to between about 30 and 100 mesh.

I have found that my machine is remarkably selective in picking out the concentrate desired. If the tailings from a particular run are reconcentrated at the same table elevation, practically no concentrate is obtained. Conversely, a reconcentration of a concentrate at the same table elevation yields practically no tailings.

In the claims, when I refer to the lateral axis of the table, I mean an axis perpendicular to the general direction of pulp flow, and to the sides of the table.

While I have described my invention in detail with respect to a specific machine, I do not intend to limit my invention to the precise details disclosed. The depth of the trap-grooves may

vary slightly, and their longitudinal slope may vary somewhat. Also the longitudinal slope of the ejection grooves may vary from about 10° to 25°, provided their depth and lateral slope from the table bed is appropriately adjusted. The angle at which the table is elevated is also an interrelated factor with the other variables, and can only be determined by experiment. The bullion trap, or trap grooves, may be omitted, if desired.

It is obvious that various modifications can be made in the details without departing from the spirit of the invention which I intend to include in the scope of the appended claims.

I claim:

1. An ore concentrating machine as described, comprising a longitudinaly inclined concentration table divided longitudinally, in the direction of pulp flow, into a major, laterally level area and a minor area sloping upwardly from said level area at an angle of about 2° therefrom, said table being grooved over its operative surface with ejection grooves extending diagonally across said table at an angle of between about 10° and about 25° from its lateral axis, means for adjusting the elevation of the upper end of said table, and means for imparting to said table a rapid, longitudinal shaking motion.

2. An ore concentrating machine as described comprising a longitudinally inclined concentration table divided longitudinally, in the direction of pulp flow, into a major, laterally level area, and a minor area sloping upwardly from said level area at an angle of about 2° therefrom, said table being grooved over its operative surface with grooves extending diagonally across said table at an angle of about 21° from its lateral axis, said grooves being of uniform depth over the level area of said table and slightly diminishing in depth over the sloping area of said table, means for adjusting the elevation of the upper end of said table, and means for imparting to said table a short, rapid vertical and longitudinal rotating motion at its upper end, and longitudinal, reciprocating movement at its lower end.

3. An ore concentrating machine as described comprising a longitudinally inclined concentration table divided longitudinally, in the direction of pulp flow, into a major, laterally level area, and a minor area sloping upwardly from said level area at an angle of about 2° therefrom, said table being grooved over its operative surface with ejection grooves extending diagonally across said table at an angle of about 21° from its lateral axis, said grooves being about $\frac{3}{16}$ inch in depth over the level area of said table and diminishing in depth over the sloping area of said table to a minimum of about $\frac{1}{8}$ inch, means for adjusting the elevation of the upper end of said table, and means for imparting to said table a rapid, vertical and longitudinal rotating motion at its upper end tapering to longitudinal, reciprocating motion of about $\frac{1}{16}$ inch stroke at its lower end.

4. A machine as set forth in claim 3 including means for accelerating the upward vertical movement of said table and decelerating the downward vertical movement thereof.

5. An ore concentrating machine as described comprising a longitudinally inclined concentration table divided longitudinally, in the direction of pulp flow, into a major, laterally level area and a minor area sloping upwardly from said level area at an angle of about 2° therefrom, said table being grooved over its operative surface with ejection grooves extending diagonally across said table at an angle of about 21° from its lateral axis, said grooves being about $\frac{3}{16}$ inch in depth over the level area of said table, and diminishing in depth over the sloping area of said table to a minimum of about $\frac{1}{8}$ inch, said table being pivotally mounted at its lower end to a shaker bed, a pair of supporting racks secured laterally toward the upper end of said table, pinions engaging said racks and mounted on a transverse shaft journalled in bearings attached to said shaker bed, an adjusting wheel attached to said pinion shaft, a pair of detent dogs adapted to rigidly engage said racks, locks adapted to hold said detent dogs in place, said shaker bed being mounted toward the front and through trunnions and double pivot bearings, and toward its rear end through an eccentric shaft and bearings, to a rigid frame, and operative means for driving said eccentric shaft.

6. A machine as set forth in claim 5 including springs deflected between the rear part of said shaker bed and said frame, and adapted to accelerate the upward thrust of said shaker bed and decelerate the downward thrust thereof.

7. An ore concentrating machine as described, comprising a longitudinally inclined table, said table being divided laterally into an upper, minor area grooved over its operative surface with trap-grooves extending diagonally across said table at an angle of about 4° from its lateral axis, and a lower, major area, said major area being divided longitudinally into a major, laterally level concentration area, and a minor concentration area sloping upwardly from said level concentration area at an angle of about 2° therefrom, said concentration areas being grooved over their operative surfaces with ejection grooves extending across said table contra-diagonally to said trap-grooves at an angle of about 21° from the lateral axis of said table, said table being pivotally mounted at its lower end to a shaker bed, a pair of supporting racks secured laterally toward the upper end of said table, pinions engaging said racks and mounted on a transverse shaft journalled in bearings attached to said shaker bed, an adjusting wheel attached to said pinion shaft, a pair of detent dogs adapted to rigidly engage said racks, locks adapted to hold said detent dogs in place, said shaker bed being mounted toward the front end through trunnions and double pivot bearings, and toward its rear end through an eccentric shaft and bearings, to a rigid frame, and operative means for driving said eccentric shaft.

8. A machine as set forth in claim 7 including springs deflected between the rear part of said shaker bed and said frame, and adapted to accelerate the upward thrust of said shaker bed and decelerate the downward thrust thereof.

JOSEPH STEPHAN.

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The following references are of record in the file of this patent:

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Certificate of Correction

Patent No. 2,496,025 January 31, 1950

JOSEPH STEPHAN

It is hereby certified that errors appear in the printed specification of the above numbered patent requiring correction as follows:

Column 4, line 24, strike out the words "consists of a heavy steel plate" and insert instead *is mounted to frame 38 at*; column 8, line 16, for "front and" read *front end*;

and that the said Letters Patent should be read with these corrections therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 20th day of June, A. D. 1950.

[SEAL]

THOMAS F. MURPHY,
Assistant Commissioner of Patents.