July 7, 1953 H. B. CANNON ET AL 2,644,583

CONCENTRATION AND SEPARATION OF GRANULAR MIXTURES

Filed July 5, 1949

Fig. 1.

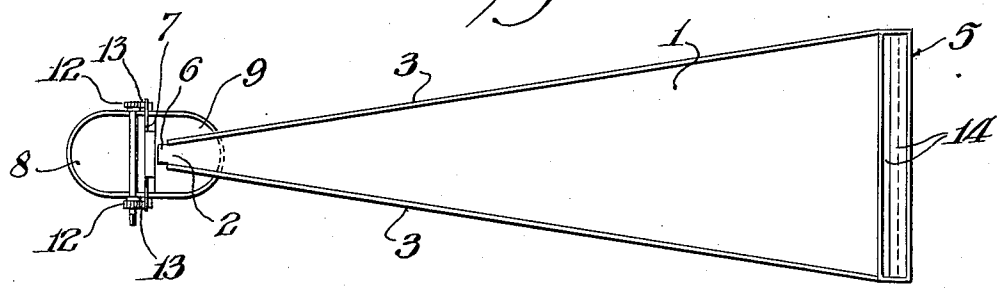


Fig. 2.

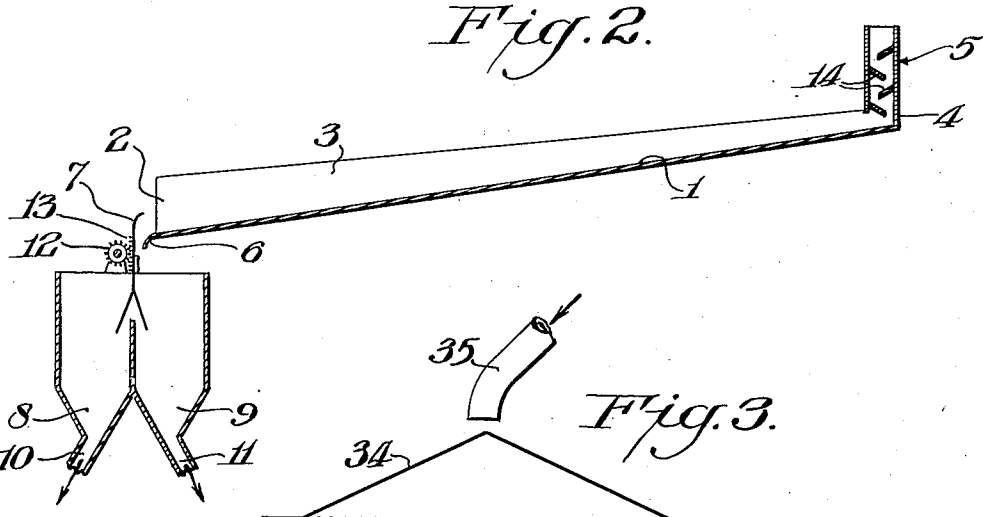
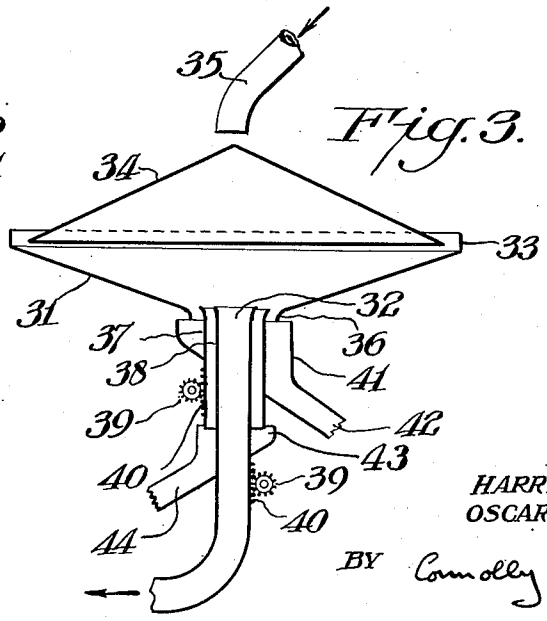


Fig. 3.



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Patented July 7, 1953

2,644,583

UNITED STATES PATENT OFFICE

2,644,583

CONCENTRATION AND SEPARATION OF GRANULAR MIXTURES

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Application July 5, 1949, Serial No. 103,048

2 Claims. (Cl. 209—459)

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Our invention relates to a method and apparatus for concentrating and separating mixtures of granular materials. More particularly it is concerned with the separation of ores contained in aqueous slurries into several portions one of which contains most of the minerals of value, while another contains so little that it may economically be discarded.

It is frequently desirable, if not essential, to concentrate the ore at the mine face and to discard the bulk of uneconomic material therein, before transporting the concentrated minerals to a location where the desired constituents can be recovered and refined. In many mining operations the ores are of such low grade that an economic recovery of desired constituents would otherwise not be possible.

A classic example of such an operation is the placer mining of gold and tin by means of dredges. It is essential therein that the great bulk of the worthless quartz sands be separated from their valuable mineral contents at the dredging site, thus greatly reducing the amount of material to be transported and subjected to subsequent processing. For this purpose various types of shaking tables, stationary tables, jigs, troughs, sluices and the like have been suggested. One of the most successful in recent years is the so-called "Humphreys Spiral." This consists of a chute in the form of a helix in which separation is performed by stratification of the material during its travel down the chute, the various fractions being drawn off through separate openings along the path of travel. This equipment is, however, quite heavy and bulky.

It is an object of our invention to improve the concentration and separation of granular mixtures. A further object is to provide a method and apparatus whereby such concentration of desired minerals may be effected cheaply at the mining site. Another object is to provide equipment for this purpose, that is readily portable, occupies a minimum amount of space and yet possesses a large capacity and high efficiency. Additional objects and advantages will become apparent as the description of our invention proceeds.

Broadly speaking, our invention involves the use of an inclined trough or sluice having converging sides and a relatively narrow outlet, over which the granular mixture, preferably in the form of an aqueous slurry, flows and where it becomes stratified. Combined therewith are means located in the zone of free fall beyond said outlet, whereby the effluent "fan" is divided

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into several portions containing widely varying concentrations of the constituents of the mixture.

The inclined trough employed according to our invention may have the form of a triangle with the narrow outlet at the apex and be provided with vertical sides, preferably of increasing height as the outlet is approached, to contain the material being processed. This form may aptly be described as a pinched sluice. If the angle at the apex is kept small, the supporting surface, i. e., the bottom of the trough, may be flat. As this angle is increased, there is an increasing tendency for the granular material to build up in depth along the sides, thereby creating high velocity and turbulence which tendency may be largely overcome by providing the pinched sluice with a rounded bottom.

It will be apparent that upon increasing the angle at the apex of flow to 360°, one will arrive at an inverted cone with a circular outlet at its apex. This constitutes a preferred embodiment of our invention, because it provides maximum capacity with minimum space and weight of equipment. It will be noted that the cone-shaped inclined converging trough has the rounded supporting surface required for best results whenever the angle at the apex is large.

A characteristic and distinguishing feature of our invention is the provision of dividing means located beyond the outlet of the trough, whereby the effluent is separated into several portions in a zone of free fall. We have found that the stratification into layers of varying composition which takes place during passage through the trough is accentuated in the fan formed beyond the outlet, and that the separation into portions of widely varying compositions can most effectively take place there. Any attempt to introduce the dividing means through the outlet and above the floor of the trough results in a piling up of the densest portion of the material treated and consequent loss of efficiency or even complete failure of the device.

The dividing means employed according to our invention is preferably formed by the edge of a metal sheet or the like, that is disposed in a plane of stratification at right angles to the direction of flow. Preferably this "splitter" is adjustable at right angles to the planes of stratification, in order to permit processing of various materials and to achieve optimum beneficiation of each.

In many cases, we employ two such splitters, thus dividing the effluent fan into three distinct

portions. For the sake of convenience the portion containing most of the desired constituents will be termed the "concentrate." The intermediate portion that is usually reprocessed will be termed the "middlings," while the portion having the lowest values, that is usually discarded, will be called the "tails." Obviously, it is possible within the scope of our invention to employ but a single splitter or more than two, depending upon the number of distinct fractions desired.

In a preferred embodiment of our invention a special rounded lip or guide plate is provided at the bottom edge of the narrow trough outlet, forming a downwardly curved extension of the trough bottom, whereby the effluent fan is spread due to surface attraction. The spreading of the fan and the further slowing up of the densest fraction thereby attained, renders the subsequent splitting into distinct fractions more effective.

Our method and apparatus are applicable to any well divided ore that may be caused to flow as such or suspended in a liquid over the inclined converging trough. It is particularly applicable to mineral bearing sands found in nature, such as sands containing ilmenite, rutile, zircon, cassiterite, pebble phosphate or like minerals. It may also be applied to ores that have previously been ground finely enough to free the minerals of value from the gangue materials, and to permit them to be flowed as such or as suspensions in a liquid medium.

While the concentration and separation of ores is probably the most important application of our invention, the method and apparatus may also be applied to the concentration and separation of other granular mixtures. Such mixtures must be flowable as such or when suspended in a liquid medium, and their constituents must vary sufficiently in density or particle size to cause stratification. For example, mixtures of seeds, grains and of various manufactured granular materials may be treated by our method in our apparatus.

In most cases of ore concentration, we prefer to treat an aqueous slurry containing a high percentage of ore, for example, one having a solids content of between about 50% and about 65%. If desired, flotation reagents may be added to the slurry in order to influence stratification of the various solid constituents. In such case the topmost portion of the fan usually constitutes the concentrate. The freshly-formed slurry is fed evenly to the wide upper end of the inclined converging trough, and the splitters beyond the narrow outlet are adjusted for optimum separation of the particular material processed. When using two splitters, we prefer to reprocess the middlings and sometimes also the tails. If desired, the concentrate may likewise be reprocessed to eliminate additional waste material before being transported to the refinery.

To facilitate a full comprehension of our invention and to illustrate how it may be carried out in practice, reference will now be made to the accompanying drawings in which

Fig. 1 shows a simplified plan view of an inclined converging table and single splitter according to one embodiment of our invention, and

Fig. 2 shows a side view of the device of Fig. 1, including also the feeding and collecting means.

Fig. 3 is a simplified vertical cross section of the cone-shaped embodiment with two splitters, including feeding and collecting means.

Referring now to the device shown in Figs. 1 and 2, 1 represents the inclined triangular supporting surface (bottom of the trough) and 2 the narrow outlet at its apex. 3 are the vertical sides of increasing height as the outlet is approached. 4 is a vertical back to prevent spilling of the material as it is fed to the wide upper end.

A feeding box 5 with baffles 14 is indicated in Fig. 2. It serves to distribute the material evenly along the wide upper end, whence it begins to flow down the inclined converging surface. A rounded lip or guide plate 6 is shown at the bottom edge of the outlet. This can be dispensed with, but generally improves the separation of the fan.

Beyond and below the outlet 2 are the dividing and collecting means. These consist of the splitter 7, which is preferably bent near the top, as shown in Fig. 2, so that its upper edge will cause a minimum of turbulence at the point of separation. On either side of the splitter are catch basins 8 and 9, separated thereby, in which the two distinct portions of the flow are collected and from which they are withdrawn through the separate outlets 10 and 11.

The splitter 7 may be adjusted vertically in the path of flow by raising or lowering it. This is accomplished, as can best be seen from Fig. 2, by means of the gears 12 and ratchets 13. Obviously, raising and lowering the splitter 7 in this manner will vary the portions of the flow divided thereby.

The pinched sluice shown in Figs. 1 and 2 is provided with a flat bottom 1 for simplicity of construction. If the angle at its apex is materially increased, it is advisable to substitute a rounded bottom, in order to minimize high velocity and turbulence along the vertical sides 3 and the adjacent bottom. The dimensions of the sluice may be varied widely and the optimum dimensions will depend largely upon the type of material to be processed. The same is true of the degree of inclination. When treating ilmenite bearing sands containing approximately 2% of ilmenite, we have obtained excellent results by employing sluices about 3 to 4 feet long, 12 to 14 inches wide at the upper end and having an outlet at the lower end from ½ to 2½ inches wide. In the case of the narrower outlets, the preferred inclination of the trough bottom 1 was about 17 to 18°, while for the wider outlets a lesser inclination of about 13 to 16° gave best results. The narrower outlets favored a sharper separation in relation to the specific gravities of the individual grains, whereas the wider outlets permitted the treatment of much larger quantities with a sharper separation in relation to the grain sizes. The specific figures given are obviously merely for purposes of illustration, since the optimum proportions of the pinched sluice will depend upon the type of material processed.

Turning now to Fig. 3, 31 represents the inverted cone that forms the inclined converging trough. 32 is the narrow outlet at the apex of said cone. At the upper end of the cone 31 an upright edge portion 33 is provided to prevent splashing over of the materials fed. Disposed above the inverted cone 31 and fitting within its upright edge 33 is an upright feeding cone 34. This acts to distribute the materials fed through the feeding line 35 evenly to the outer and upper edge of the inverted cone 31.

The lower edge of the inverted cone 31, that forms the narrow outlet 32 has a rounded lip 36 to aid in spreading the fan. Within the outlet 32 and a zone free fall of the effluent material are

two concentric tubular splitters **37** and **38**. The upper edges of these splitters are preferably flared outwardly to minimize turbulence. The splitters are adjustable vertically by means of gears **39** and ratchets **40**, as in the case of the embodiment shown in Figs. 1 and 2.

A catch basin **41** with an outlet **42** is provided to collect and carry off the densest fraction of the material passing through the outlet **32**. Another catch basin **43** and outlet **44** are provided for the intermediate fraction, while the tube that forms the splitter **38** serves to carry off the lightest fraction. Here again it is apparent that the relative width of the outlet **32** and the inclination of the inverted cone side will be varied depending upon the material processed.

The operation of our ore concentrators is believed to be evident from what has been said above. A few more details will be given to assist in a thorough understanding of the practice of our invention.

It is possible to feed a readily flowable, dry material, in which case some means of imparting vibration to the inclined converging trough may be provided. We have obtained best results when employing a rather concentrated aqueous slurry. The feed must be distributed evenly along the upper, wide edge of the trough, so that it will flow to the narrow outlet with a minimum of turbulence. The narrowing of the width of flow as the outlet is approached, greatly assists in bringing about a far-reaching separation and thorough stratification of the various constituents, thereby increasing the efficiency of the dividing means that are inserted into the fan beyond the outlet.

It is essential for the efficiency of our concentrator that these dividing means be located in a zone of free fall of effluent materials. Best results are obtained when the upper edge of the dividing means is located just beyond the supporting surface of the trough. The splitter should, furthermore, cut sharply across the entire width of the fan. By observing these precautions detrimental turbulence and undue impedance or stoppage of the flow can be avoided.

In most cases our separators can be used most efficiently in groups, one above the other, so that the fractions separated in one group can immediately be reprocessed, after suitable combination, in a group below. The great saving in space and weight achieved by our devices, becomes most evident when they are employed in groups. For example, it becomes possible to mount a number of them on a barge floated behind a dredge and to thus provide adequate capacity for all material raised by the dredge.

Extensive tests of our pinched sluice embodiment employing ilmenite sands containing about 4% of heavy minerals, have demonstrated that we can consistently obtain a concentrated product containing about 85% of heavy minerals with

a loss of only about 15% of the total heavy minerals present in the original sands. This can be accomplished at a high rate of throughput employing three to four stages, i. e., several countercurrent reprocessings, with a relatively small investment for equipment and in relatively little spacing, as compared with other concentrating devices now being employed.

It will be obvious that the details of our method and apparatus are subject to considerable variation without departing from the spirit and scope of our invention. Some of the variations have been referred to in the foregoing and others will be evident to those skilled in the art. All such variations are included within the scope of the appended claims, unless expressly excluded by limitiations set forth therein.

We claim:

1. A separator of granular mixtures, which comprises an inverted cone having a circular outlet at its apex, means for evenly feeding a flowable material to the upper edge of said cone, and dividing means located within said outlet in the normal path of flow from said cone, said dividing means including a substantially tubular member whose upper edge is disposed horizontally across the path of flow in a zone of free fall and spaced from the periphery of the said apex.

2. A separator of granular mixtures, which comprises an inclined, flow converging portion having the configuration of an inverted frustrum of a cone, said portion terminating in a centrally located discharge opening, and dividing means located within said discharge opening in the normal path of flow from said portion, said dividing means including a substantially tubular member whose upper edge is disposed horizontally across said path of flow in a zone of free fall and spaced from the periphery of the discharge opening.

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