Sept. 16, 1969 A. MUSSCHOOT 3,467,594

SEPARATING METHOD AND APPARATUS

Filed Nov. 17, 1966 2 Sheets-Sheet 1

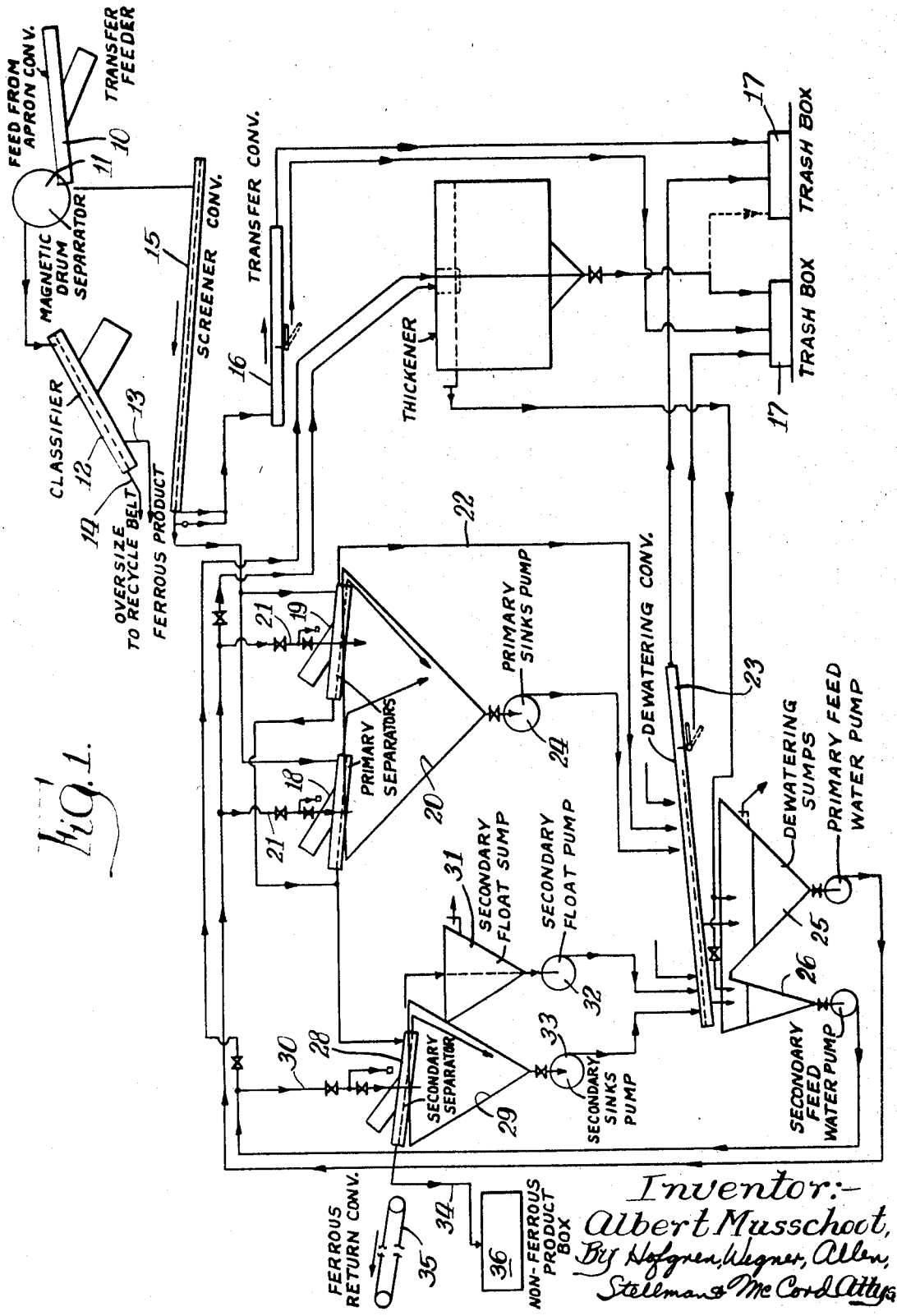



FIG. 1.

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FIG. 2.

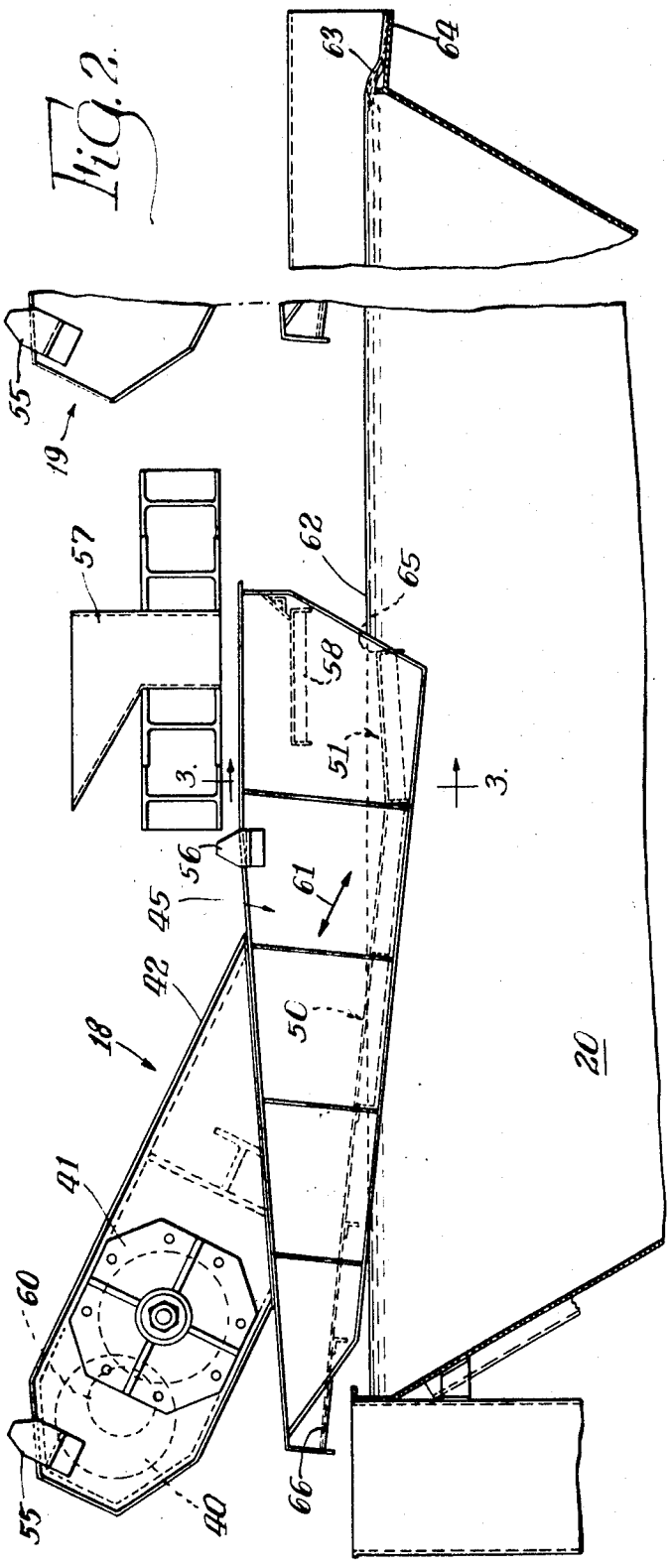
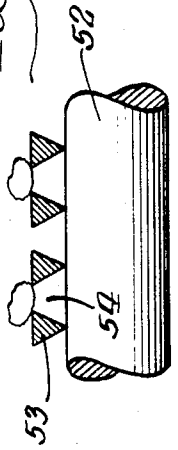



FIG. 4.



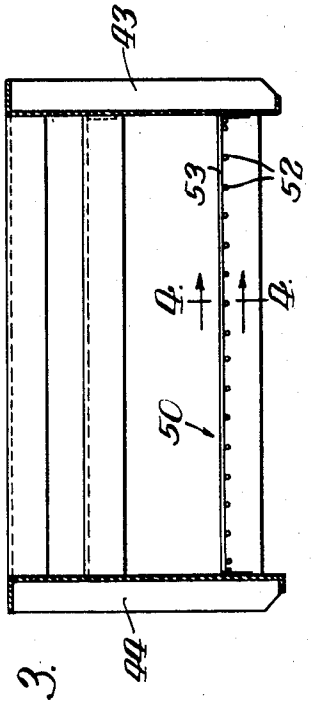




FIG. 3.

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3,467,594

# SEPARATING METHOD AND APPARATUS

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Int. Cl. B03b 3/26
U.S. Cl. 209—426 8 Claims

## ABSTRACT OF THE DISCLOSURE

There is disclosed an apparatus and method for separating materials on the basis of their specific gravities. The material to be separated is supported on a foraminous bed, one end of which is immersed in a liquid. A current of the liquid is caused to flow upwardly through the bed while at the same time the bed is giving a conveyong action tending to convey the material toward the upper end thereof. The effect of the current is to cause lighter materials (but of a specific gravity greater than the liquid) to move by gravity toward the lower end of the bed while the heavier materials are conveyed toward the upper end. Material having a specific gravity less than that of the liquid may be floated off by means of a continuous overflow.

This invention relates to separating methods and apparatus and more particularly to apparatus for separating materials of different specific gravities.

It is a general object of the present invention to produce new and improved separating apparatus and methods of the character described.

It is a more specific object of the invention to produce methods and apparatus which combine a vibratory conveying action with a liquid flotation and current creating system to produce separation of particles having specific gravities greater than the liquid by the combined interaction of gravity, the liquid current, and the vibratory conveying action.

While it will be readily apparent to those skilled in the art that the principles of the present invention have application in many fields, they will be shown and hereinafter described as used in a process for separating non-ferrous metals from ferrous metals in a metal reclaiming operation.

"Junked" automobiles contain a good deal of valuable metal. To reclaim such metal, it has been common practice to crush junked cars (after removal of the engine block and wheels) into a small cubical body which is then used by the steel industry for conversion into new steel. As such cubes of metal contain both ferrous and non-ferrous metals, the quality of steel so produced is relatively poor. Accordingly, new methods have been devised for reclaiming the metal, one of the more recent being an apparatus which is in the form of a large and powerful hammer mill, and which in a matter of seconds reduces a junked car to small particles, the largest of which is usually not much more than an inch in its longest dimension. Particles so formed can be separated into ferrous and non-ferrous groups by the use of magnetic separators and the reclaimed ferrous metal may be used in the manufacture of steel to produce a much higher quality steel.

Such methods, of course, do not separate the non-ferrous metals from the rest of the materials including glass, plastic, etc., making up the body of a junked car, and such non-ferrous metals (zinc and the like) have a substantial value. Yet, prior to the date of the present invention, there has been no efficient or economical way of separating such non-ferrous metals from the rest of the non-ferrous materials found in a used car body.

The present invention provides apparatus and methods



for recovering the valuable non-ferrous metals through the combined action of an inclined vibratory conveyor and the action of a current of liquid, the particles to be separated being initially immersed in the liquid during the course of the separation process.

For a complete understanding of the apparatus and methods of this invention, attention is directed to the folling description and drawing, in which:

FIG. 1 is in the nature of a flow diagram illustrating the separating process;

FIG. 2 is an enlarged view of a portion of the vibrator and liquid container apparatus shown in FIG. 1;

FIG. 3 is a sectional view taken along line 3—3 of FIG. 2; and

FIG. 4 is a vertical section taken along line 4—4 of FIG. 3.

While this invention is susceptible of embodiment in many different forms, there is shown in the drawings and will herein be described in detail a specific embodiment with the understanding that the present disclosure is to be considered as an exemplification of the principles of the invention and is not intended to limit the invention to the embodiment illustrated. The scope of the invention will be pointed out in the appended claims.

As previously indicated, the methods and apparatus of the present invention are particularly designed for use in conjunction with a hammer mill or hammer knife type of junked car disintegrator which reduces cars to particles of a size something of the order of an inch or less. These particles are dropped into a transfer feeder **10** which may be a vibratory conveyor which feeds the material to a magnetic drum separator **11** which separates the ferrous metals from the other various materials and delivers them to a classifier **12**. The classifier may also be a vibratory conveyor having a screen bottom and the smaller particles drop through onto conveyor **13** while the larger particles are carried onto the conveyor **14** to be recycled through the disintegrator. The non-ferrous metals drop to the screener conveyor **15** and the fine particles fall therethrough to a transfer conveyor **16** which transfers the small and hence unusable particles to trash boxes **17**. The larger non-ferrous pieces are delivered to a pair of primary separators **18** and **19**. The purpose of the primary separators is to separate the lighter non-ferrous material (such as plastics and the like) as well as floating materials (upholstery) from heavier non-ferrous materials which are sought to be recovered. While the details of operation of the primary separators will be described more fully hereinafter, suffice it to say that they are partially immersed in liquid (water) in a liquid containers **20** supplied with a constant flow of water through pipe and valving **21**. Lighter materials float on the surface of the water and are carried thereby to an overflow. Water overflowing the separator passes through pipe **22** to a dewatering screen conveyor **23**. As will be pointed out in detail hereinafter, some of the heavier-than-water material sinks to the bottom of the container and is delivered by a primary sinks pump **24** to the dewatering conveyor **23**. Water dripping through the conveyor drops into sumps **25** and **26** for reuse in the primary and secondary separators while the dewatered material is conveyed into the trash boxes **17**. The primary separators **18** and **19** deliver the balance of the heavier-than-water material to a secondary separator **28** constructed similarly to the primary separators but being one unit rather than a double unit, with the secondary separator **28** being partially immersed in water in the container **29**, the container being supplied with water through line **30**, with floating material being floated over an edge of the container into a float sump **31** and delivered therefrom by the pump **32** to the dewatering conveyor **23**, while some of the heavier-than-water material falling to the bottom of the container **29** is delivered by the

pump 33 to said dewatering conveyor. Material delivered by the secondary conveyor 28 to conveyor line 34 is subjected to a further magnetic screening by the magnetic separator 35 to pick up any ferrous metal that may still be left in the material while the remainder is delivered into the non-ferrous product box 36.

The foregoing generally describes the operation of the apparatus and process. The details of the important parts of the system, and the manner in which heavier-than-water material is separated into metallic and non-metallic particles follows.

Referring to FIGS. 2–4, there is illustrated the primary separators 18 and 19 which are similar in many respects to the vibratory conveyor construction shown in Musschoot et al. Patent 3,089,582, with the exception that no air bags for adjusting the rate of feed are used. The vibratory conveyors comprise an electric motor 40 carried by means of disk-shaped rubber bushings 41 to an outrigger section 42 fixed to the sides 43 and 44 of a conveyor trough 45. The bottom 50 of each trough is inclined upwardly from right to left as shown, except for an initial portion 51 which is substantially horizontal. The trough bottoms 50 and 51 are constructed as shown in FIGS. 3 and 4 of a plurality of tie rods 52 extending parallel to each other lengthwise of the trough and supporting a plurality of spaced tri-rods 53 which extend normal to the longitudinal axis of the trough. The tri-rods 53 (which are rods triangular in cross section) are separated from each other so as to provide spaces 54 therebetween, which spaces, it will be noted, narrow in an upward direction.

Each of the vibratory conveyors is supported by means of brackets 55 and 56 from an overhead support. A spring is provided in the supporting connection so as to provide a spring system of low natural frequency serving as an isolation mounting for the conveyors so that vibratory action thereof is not conveyed to the building.

Materials are delivered to the primary separators 18 and 19 from the transfer conveyor 15 through the medium of a hopper 57, the material falling initially on a foraminous shelf 58 which, by the vibratory action of the conveyor, feeds the material onto the flat portion 51 of the bottom of the trough.

When the motor 40 is operated, an eccentric weight 60 carried thereby causes the trough to vibrate generally along the path indicated by the arrow 61. Such vibratory movement tends to move particles on the bottom of the trough from right to left toward the upper end of the trough. The vertical component of such motion also causes the tri-rods 53 to cause those portions of the tri-rods 53 which are immersed in the liquid, i.e., are below the liquid level 62, to act as pumps. The fact that the spaces 54 narrow upwardly causes water surrounding the tie rods to be forced upwardly through the spaces 54 and outwardly into the general body of liquid in the container 20. As water is constantly being supplied to the container 20, a portion 63 overflows over the edge 64 and any floating material emptied into the trough 45 is carried by the current thus created over the edge 64 and into the pipe 22. Lighter weight non-ferrous material (such as plastic and the like) having a specific gravity greater than water is, in effect, reduced in weight by virtue of the fact that such particles are exposed to the current of water generated and flowing upwardly through the spaces 54. Their effective weight is reduced to the point where the conveying action of the trough, i.e., its vibratory movement in the direction of the arrow 61 is insufficient to overcome the effects of the current, and thus such lighter weight material is carried by the current to the right (as shown in FIG. 2) and is discharged over the end 65 of the trough to fall into the container 20 and to be discharged therefrom by the "sinks" pump 24. The current materials, which are urged against the bottom of the trough by gravity with sufficient force in spite of the current so as to be subjected to and governed by vibratory action of the conveyor, and hence travel therealong in a right to left direction and are eventually discharged over the end 66 thereof into the conveyor for discharge into the secondary separator. In the secondary separator, the process just described is repeated, the single vibratory separator 28 being in all respects like the separators 18 and 19 just described.

Summarizing the foregoing, it can be seen that the material, after removal of the ferrous metals, is dropped into the liquid filled container 20 and the floating materials are carried off over the edge of the container by the constant flow of liquid therein. The heavier-than-water materials drop toward the bottom of the trough to be subjected to the action of a current of water flowing upwardly through such bottom, the velocity of the current being so arranged that materials below a certain specific gravity (but greater than the specific gravity of water) are carried by the current outwardly of the trough while the heavier materials overcome the effect of the current so as to contact the bottom of the trough and be conveyed thereby to a collecting point. By reason of the foregoing system, valuable non-ferrous metals such as zinc, etc., may be collected, while other non-ferrous materials such as plastics are discarded.

I claim:

1. Separating apparatus comprising a liquid container, a vibratory conveyor having a foraminous trough mounted in an inclined position to locate the discharge end of the trough above the level of liquid in the container and to locate the opposite end of the trough below said liquid level, means for vibrating the trough along a path inclined to the horizontal to move material thereon toward said discharge end, the vertical component of the trough vibration creating a current in the liquid in the container, said current flowing upwardly through the submerged end of the trough, said current having a velocity such as to cause lighter non-floating material to move toward the lower end of the trough while retaining heavier non-floating material on the trough to be conveyed thereby to the discharge end.

2. Separating apparatus comprising a liquid container, a vibratory conveyor having a foraminous trough mounted in an inclined position to locate the discharge end of the trough above the level of liquid in the container and to locate the opposite end of the trough below said liquid level, means for vibrating the trough along a path inclined to the horizontal to move material thereon toward said discharge end, the vertical component of the trough vibration creating a current in the liquid in the container, said current flowing upwardly through the submerged end of the trough, means for continuously adding liquid to the container to cause liquid therein to flow outwardly over an edge of the container to carry floating materials therewith, said current having a velocity such as to cause lighter non-floating material to move toward the lower end of the trough while retaining heavier non-floating material on the trough to be conveyed thereby to the discharge end.

3. Separating apparatus comprising a liquid container, a vibratory conveyor having a foraminous trough mounted in an inclined position to locate the discharge end of the trough above the level of liquid in the container and to locate the opposite end of the trough below said liquid level, means for vibrating the trough along a path inclined to the horizontal to move material thereon toward said discharge end, said foraminous trough comprising spaced particle supports with the space between supports narrowing in an upwardly direction whereby vibratory movement of said trough causes said supports to act as pumps to create a current flowing upwardly through the submerged end of the trough, said current having a velocity such as to cause lighter non-floating material to move toward the lower end of the trough while retaining heavier non-floating material on the trough to be conveyed thereby to the discharge end, means for continuously adding liquid to the container to cause the liquid therein to flow outwardly over an edge of the

container to carry floating material therewith, and means for introducing particles to be separated onto the submerged end of the trough.

4. The apparatus of claim 3 in which said particle supports comprise rods having a triangular cross section.

5. Separating apparatus comprising a liquid container, a vibratory conveyor having a foraminous trough mounted in an inclined position to locate the discharge end of the trough above the level of liquid in the container and to locate the opposite end of the trough below said liquid level, means for vibrating the trough along a path inclined to the horizontal to move material thereon toward said discharge end, said foraminous trough comprising spaced particle supports with the space between supports narrowing in an upwardly direction whereby vibratory movement of said trough causes said supports to act as pumps to create a current flowing upwardly through the submerged end of the trough, said current having a velocity such as to cause lighter non-floating material to move toward the lower end of the trough while retaining heavier non-floating material on the trough to be conveyed thereby to the discharge end, means for removing said lighter non-floating material from the bottom portion of said container, means for receiving said heavier non-floating material discharged over the discharge end of said trough, means for continuously adding liquid to the container to cause the liquid therein to flow outwardly over an edge of the container to carry floating material therewith, and means for introducing particles to be separated onto the submerged end of the trough.

6. The method of separating non-floating materials of different densities which comprises, supporting the material on a foraminous upwardly inclined bed one end of which is immersed in a body of liquid, vibrating the bed along a path inclined toward the higher end thereof to create a conveying force tending to move particles toward the upper end of the bed and against the tendency of said particles to move by gravity toward the lower end of said bed, the vertical component of the vibration of the bed creating a current in the liquid moving upwardly through the bed, the current having a velocity sufficient to overcome said conveying force to cause lighter non-floating materials to move downwardly along the bed, with said current having insufficient velocity to overcome the upwardly moving tendency of the bed vibration to cause heavier particles to move toward the upper end of said bed.

7. The method of separating non-floating materials of different densities which comprises, supporting the material on a foraminous upwardly inclined bed one end of



which is immersed in a body of liquid, vibrating the bed along a path inclined toward the higher end thereof to create a conveying force tending to move material toward the upper end of the bed and against the tendency of said materials to move by gravity toward the lower end of said bed, the openings in the bed being formed to cause the same to act as a pump when said bed is vibrated to create a current in the liquid moving upwardly through the bed and thence over the top of the bed, the current having a velocity sufficient to overcome the upwardly moving tendency of the bed vibration, thereby to cause lighter non-floating materials to move downwardly along the bed, with said current having insufficient velocity to overcome said tendency to cause the heavier materials to move toward the upper end of said bed.

8. The method of separating particles of different densities which comprises, immersing the particles in a body of liquid having a lesser density than said particles, supporting the particles on an upwardly inclined foraminous bed, subjecting the particles to an upwardly moving current of said liquid passing through the bed while simultaneously subjecting the particles to a conveying movement toward the upper end of the bed, said current and conveying movement being generated by vibration of the bed along a path inclined toward the upper end of the bed, the velocity of the current so generated being such as to subject particles having a specific gravity greater than a predetermined value to a current insufficient to overcome said conveyor movement to cause the same to move upwardly along said bed, and to subject particles having a lesser specific gravity to a current of sufficient velocity to overcome said conveying movement to cause the same to move downwardly along said bed.


**References Cited**

UNITED STATES PATENTS

| | | | |
|---|---|---|---|
| Re. 17,272 | 10/1920 | Lide | 209—500 |
| 1,786,739 | 12/1930 | Davis | 209—467 |
| 538,596 | 4/1895 | Pardee | 209—430 |
| 2,151,007 | 3/1939 | Belknap | 209—173 |
| 3,089,582 | 5/1963 | Musschoot | 198—220 |
| 3,249,226 | 5/1966 | Watson | 209—172.5 |

FOREIGN PATENTS

| | | |
|---|---|---|
| 825,504 | 12/1959 | Great Britain. |



FRANK W. LUTTER, Primary Examiner

U.S. Cl. X.R.

209—12, 486