Nov. 14, 1944. M. E. HAWORTH 2,362,482

APPARATUS FOR SEPARATING PARTICULATE MATERIALS

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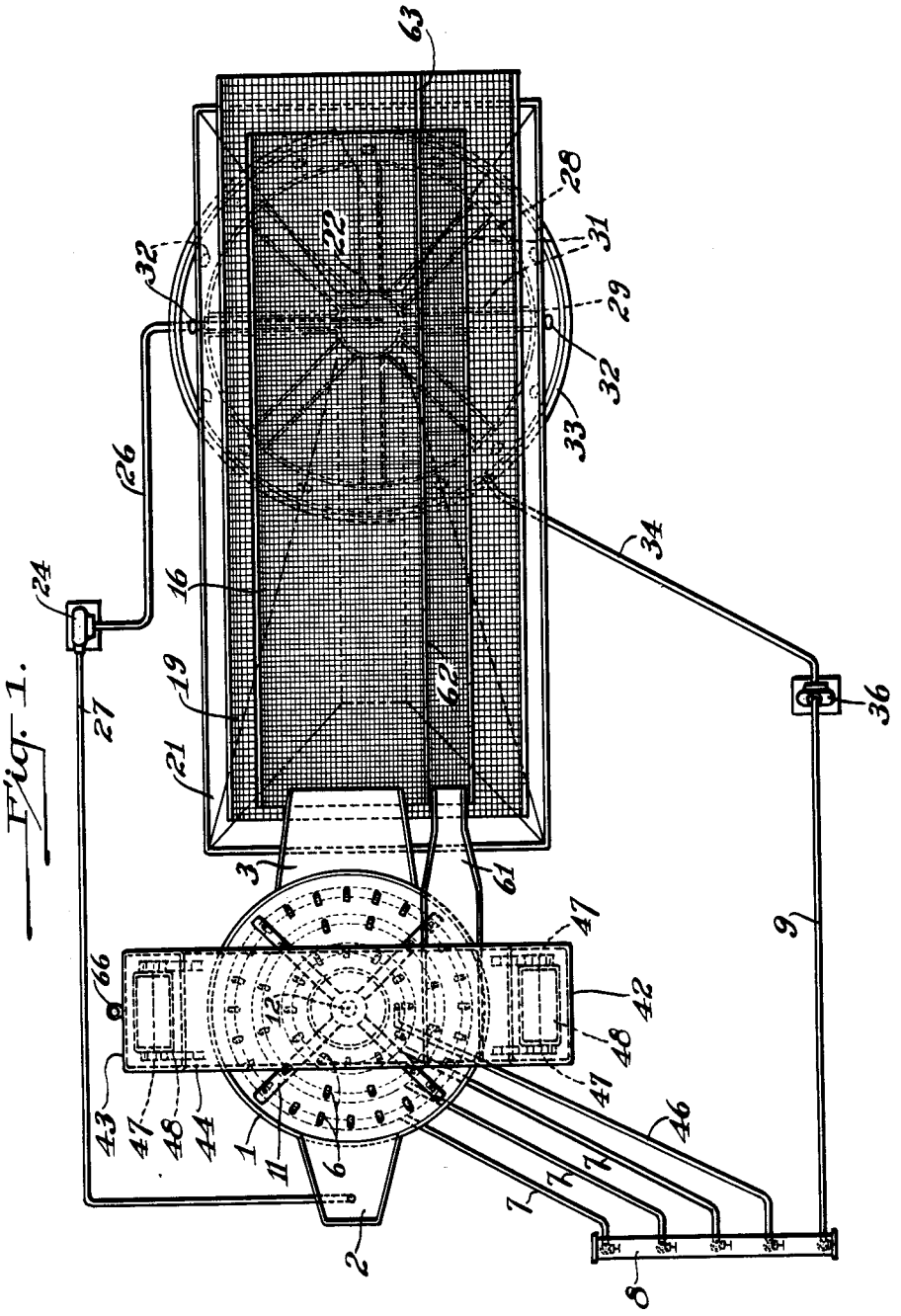


Fig. 1.

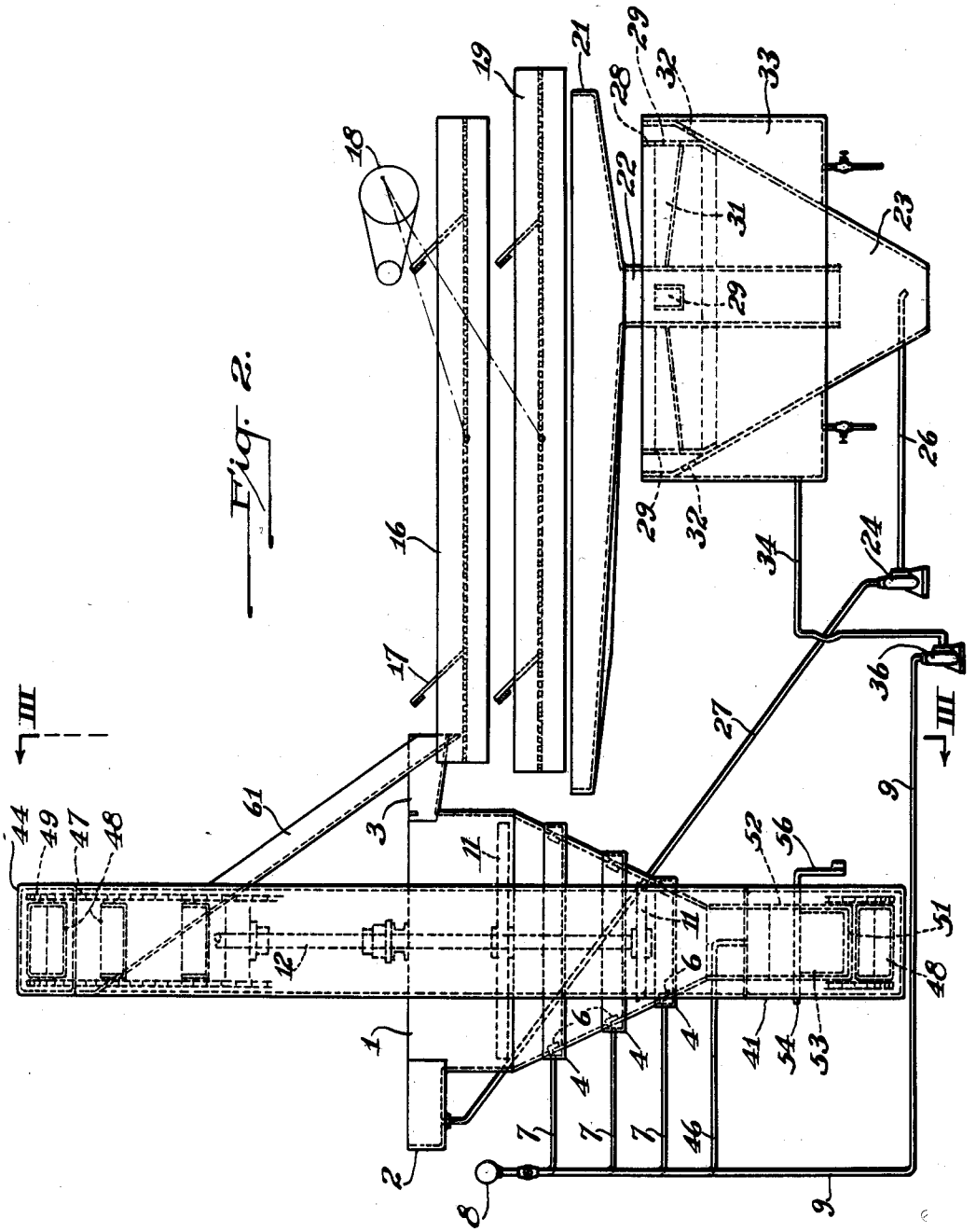
INVENTOR.
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Fig. 2.



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Fig. 3.

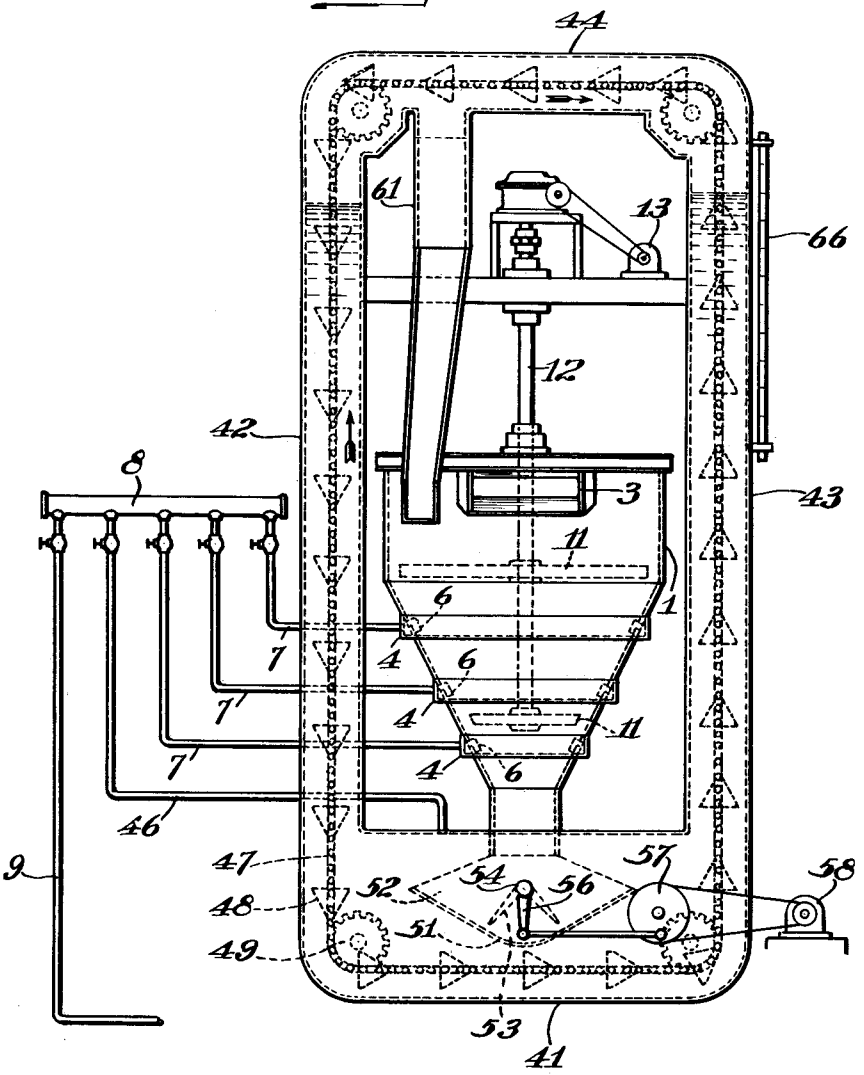
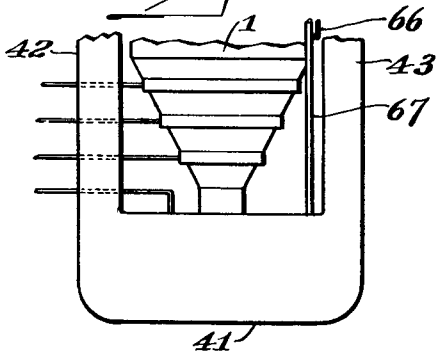


Fig. 4.



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APPARATUS FOR SEPARATING PARTICULATE MATERIALS

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Application September 21, 1939, Serial No. 295,923

4 Claims. (Cl. 209—173)

This invention relates to apparatus for separating or cleaning particulate materials in which light and heavy density particles are mixed together, and more particularly to such separation by a heavy density fluid process. For the purpose of illustration only, raw coal, by which is meant a mixture of pure coal, and heavy density impurities or foreign matter encountered in mining, such as bone coal, shale and pyrites, will be used as an example of such particulate material.

In heavy density fluid processes the particulate material is fed to a heavy density fluid through which the heavier density particles sink and on which the lighter density particles float. The heavy density particles are drawn off at the bottom of the fluid and the lighter density particles at the top. An example of this is found in the coal cleaning industry in which the coal, that is of lighter density than practically any of the refuse with which it comes from the mine, floats on a heavy density fluid in a cone-shaped hopper from which it is carried away by a light density fluid, such as water, that continuously circulates up through the cone. The heavier density particles, which is the refuse that it is desired to separate from the coal, sinks down through the heavy density fluid and into a chamber at the bottom of the cone. This chamber is provided with upper and lower gate valves, the lower one being closed and the upper one being open to permit the chamber to receive the refuse or sinks, and the upper one being closed to hold the fluid in the cone when it is desired to remove a batch of refuse by opening the lower valve.

It will thus be seen that in such apparatus the refuse can be removed only periodically and only in batches. Furthermore, every time the upper valve is opened after the chamber below it has been emptied, the heavy density fluid in the cone is disturbed and temporarily altered in character so that clean-cut separation can not occur at all times. Another disadvantage of this type of apparatus is that no way has yet been found to satisfactorily and continuously determine the density of the fluid in the cone so that the density may be maintained substantially constant. As a result, coal often passes out with the refuse or refuse passes off with the coal, giving either uneconomical separation or dirty coal.

It is among the objects of this invention to provide heavy density fluid apparatus in which the sinks can be removed continuously from the hopper, in which the character of the heavy density fluid is not disturbed periodically, and in which the density of the fluid can be accurately and readily determined at any moment.

The preferred embodiment of the invention is illustrated in the accompanying drawings in which Fig. 1 is a plan view of my apparatus; Fig. 2 is a side view thereof; Fig. 3 is a view taken on the line III—III of Fig. 2; and Fig. 4 is a fragmentary view on a reduced scale of a modification of this invention.

Referring to the drawings, a generally cone-shaped hopper 1 is provided at one side of its upper portion with an opening to which sand return box 2 is connected and at its opposite side with another opening from which an overflow spout 3 extends downwardly. Encircling the cone at vertically spaced intervals are a plurality of tubular rings or manifolds 4 from which nozzles 6 extend through the wall of the cone at circumferentially spaced points and project downwardly therein. Each ring is connected by a pipe 7 to a header 8 to which water is supplied through a pipe 9. Sand of a gravity and in an amount suitable for producing the desired heavy density fluid is introduced into the cone where it is thoroughly mixed with the water by the circulation of the water upwardly toward overflow spout 3, and also by mechanical agitation. The later may take the form of agitating blades 11 mounted on a vertical shaft 12 rotated by an electric motor 13 mounted above the cone (Fig. 3).

Raw coal or other particulate material is fed into the top of the cone in any suitable manner, and the foreign material or refuse, which is of heavier density than the coal, sinks down through the heavy density fluid. The coal itself floats submerged, partly in a body of water that maintains itself on top of the heavy density fluid and partly in the heavy density fluid, and flows out of the cone with that water and as much of the heavy density fluid as it contained in the interstices between the coal particles submerged in the fluid. The flow from the cone is through spout 3 and onto a a dewatering screen 16 which is hung on rocker arms 17 and is oscillated by a crank 18 (Fig. 2). The water, coal particles, and the sand that is carried out of the cone by the water pass through this screen to a second wider screen 19 below it which is mounted and oscillated in the same manner. This lower screen is finer than the top screen to prevent any coal from passing through it. The coal falls off the ends of the screens into a suitable conveyor or chute, not shown.

The water and sand from the lower screen pass

into a tray 21 that has a drain tube 22 extending down into a conical sand sump 23. The water flows upwardly from the tube and leaves the sand in the bottom of the sump from which it is returned by a pump 24 and pipes 26 and 27 to the box 2 that is connected to the top of the cone. To decrease the rate of flow of water out of the sand sump as much as possible so that it will not carry sand out with it, the upper portion of the sump is provided interiorly with an annular partition 28 provided at circumferentially spaced intervals with openings 29 (Fig. 2) from which trough-like weirs 31 extend radially inwardly to tube 22. The water in the sump flows over the tops of these weirs and flows out through them to and through openings 29 in the partition. From there the water passes downwardly through openings 32 in the sump and into a tank 33 encircling the sump. This tank is connected by a pipe 34 to pump 36 that returns the water through pipe 9 to header 8. As the total length of the weir over which the water in the sump must flow to escape therefrom is equal to twice the combined length of all the weirs 31, it will be seen that the water will rise very slowly in the sump and thereby deposit practically all of its sand therein.

Another feature of this invention is that the rejects that settle down through the heavy density fluid in the cone may be removed continuously from the bottom of the cone instead of in batches as heretofore. Accordingly, the lower end of the cone is always open and empties into the top of a chamber 41 at the opposite ends of which are vertical conduits 42 and 43 connected together at their tops by a horizontal conduit 44. As shown in Fig. 3, the vertical conduits are tall enough to receive a high enough column of water to balance the heavy density fluid in the cone, thereby serving as stand-pipes. To prevent the heavy density fluid from settling out of the cone and down through the water in chamber 41, whereupon the water in that chamber would rise into the cone, water is continuously circulated upwardly through the cone from its bottom. For this purpose a pipe 46 leading from header 8 is connected to the top of the chamber. The water issuing from this pipe not only keeps the necessary amount of water in the chamber and vertical conduits, but also flows up into the cone, and, in effect, supports the heavy density fluid on the lighter density water.

To continuously remove the rejects from chamber 41 into which they fall from the cone, an endless chain 47 carrying buckets 48 extends through the chamber and connecting conduits through which it travels around sprockets 49 driven continuously by any suitable means. The sand and other particulate material in the heavy density fluid is prevented from dropping into chamber 41 and fouling the buckets, when the apparatus is shut down, by means of a concave plate 51 suspended from the bottom of the cone by side plates 52. Thus, when the apparatus is shut down the particulate material in the cone drops onto this plate above the buckets, and when the apparatus is started in operation again the current of water across the plate and up through the bottom of the cone will tend to lift this material back into the cone. During normal operation of the apparatus the sinks that settle onto plate 51 are removed therefrom and allowed to fall around the buckets by an oscillating gate 53 mounted on a shaft 54 journaled in side plates 52. This shaft projects from the side of the chamber 41 and is connected by a lever 56 to a crank 57 driven by a motor 58 (Fig. 3). The gate pushes the sinks off first one end and then the other of the concave plate.

The construction of this apparatus is such that during operation, or when the apparatus is shut down, or when operation is again started, the flow of water is always into and up through the cone. Water can not flow from the cone into chamber 41, the flow always being from the chamber into the cone. Consequently, sand can not be inadvertently discharged from the cone into the elevator, and mishaps that occur with other apparatus when both operating gates are opened simultaneously are thus avoided.

The sinks that are carried by the buckets to the upper horizontal conduit 44 are dumped into a chute 61 that extends down to one side of upper screen 16 which is separated by a partition 62 (Fig. 1) from the remainder of the screen. The lower screen 19 is likewise divided into sections by a partition 63. Consequently, the water and small amounts of sand that are carried up by the buckets are screened out and allowed to return to the sand sump, while the rejects pass on to a conveyor or the like by which they are removed from the screens.

A still further important feature of this invention is that the density of the fluid in the cone can be ascertained at any time by merely looking at a gauge. The height of the column of water in the vertical conduits depends upon the density of the fluid in the cone. The greater the density of that fluid the greater the height of the column of water that is required to balance it. The vertical conduits therefore serve as stand-pipes, and by connecting a properly calibrated gauge glass 66 or other similar indicator to the side of one of them the height of the water column therein, and consequently the density of the fluid in the cone, can be determined. It is preferred to connect the gauge glass to conduit 43 in which the buckets are moving downwardly, because in the opposite conduit there may be a small amount of sand that is carried up by the buckets and escapes therefrom. This sand will increase the density slightly of the column of water in conduit 42, but the water in the other conduit should be practically free of sand and is therefore a reliable gauge. If desired, the gauge may be connected with means for automatically feeding more sand to the cone whenever the gauge shows that the density of the fluid in the cone is decreasing.

If it should be found that sufficient sand falls continuously in both conduits 42 and 43 to increase the fluid density far enough above the specific gravity of water to affect the reading of gauge 66, which would then indicate a water level somewhat lower than the level that would be indicated by water having a density of 1.0, the gauge may be attached to a stand-pipe 67 connected to the top of chamber 41, as shown in Fig. 4. The water in the stand-pipe will rise to the level required to balance the fluid mixture in the cone, and since the water in the stand-pipe can not contain sand in suspension, the level of that water will be a true indication of the specific gravity of the fluid mixture in the cone.

Instead of the gauge glass, a pressure gauge or other appropriate device may be attached to the elevator casing conduits 42 or 43 or to the stand-pipe, which will indicate the hydraulic pressure at the base of the cone or at other convenient

levels and thereby indicate the specific gravity of the fluid mixture in the cone above the level at which the stand-pipe is attached.

Where it is desired to attach a gauge to existing apparatus not fitted with an elevator arrangement as described above, the stand-pipe may be attached to agitating water pipes similar to pipes 7, and by observing the elevation of the pipe relative to the overflow level of the weir, the gauge may be calibrated.

According to the provisions of the patent statutes, I have explained the principle and mode of operation of my invention and have illustrated and described what I now consider to represent its best embodiments. However, I desire to have it understood that, within the scope of the appended claims, the invention may be practiced otherwise than as specifically illustrated and described.

I claim:

1. Heavy density fluid flotation apparatus for separating the sinks from the floats of particulate materials, comprising a hopper for a heavy density fluid and having a downwardly facing opening in its bottom for the substantially unimpeded fall of sinks from particulate material in the hopper, a chamber below said hopper opening for receiving the sinks therefrom, a concave plate disposed in said chamber below said opening in the path of the falling sinks, means for pushing the sinks over the edge of said plate, a conduit extending upwardly from said chamber, said chamber and conduit being adapted to contain a high enough level of a light density fluid to balance the fluid in the hopper, means for continuously circulating a light density fluid up through the hopper to maintain the heavy density fluid therein, and means for removing said sinks from said chamber up through said conduit.

2. Heavy density fluid flotation apparatus for separating the sinks from the floats of particulate materials, comprising a conical hopper for a heavy density fluid and having a downwardly facing opening in its bottom for the substantially unimpeded fall of sinks from particulate material in the hopper, a chamber below said hopper opening for receiving the sinks therefrom, a concave plate disposed in said chamber below said opening in the path of the falling sinks, means for periodically pushing the sinks over the edge of said plate, an upright conduit extending upwardly from each end of said chamber, a conduit connecting the upper ends of said upright conduits and provided with an outlet in its bottom, an endless conveyor traveling through said chamber and conduits and including buckets for carrying said sinks up through one of said conduits and discharging them through said outlet, said chamber and first-mentioned conduits being adapted to contain a high enough level of a light density fluid to balance the fluid in the hopper, and means for continuously circulating a light density fluid up through the hopper to maintain the heavy density fluid therein.

3. Heavy density fluid flotation apparatus for separating the sinks from the floats of particulate materials, comprising a hopper for a heavy density fluid and having a downwardly facing opening in its bottom for the substantially unimpeded fall of sinks from particulate material in the hopper, a chamber below said hopper opening for receiving the sinks therefrom, a plate disposed in said chamber between said opening and the bottom of the chamber in the path of the falling sinks, means for removing sinks from the plate, a conduit extending upwardly from said chamber, said chamber and conduit being adapted to contain a high enough level of a light density fluid to balance the fluid in the hopper, means for continuously circuiting a light density fluid up through the hopper to maintain the heavy density fluid therein, and means for removing said sinks from said chamber up through said conduit.

4. Heavy density fluid flotation apparatus for separating the sinks from the floats of particulate materials, comprising an endless conduit having laterally spaced upright side portions and vertically spaced top and bottom portions, an endless conveyor traveling in said conduit, the top of said lower portion being provided with an opening, a hopper in the general form of an inverted cone surrounded by said conduit and having an opening in its lower end communicating with said conduit opening, means for supplying water to said conduit and for circulating it up through said hopper, means for delivering sand to the hopper to create a heavy density fluid therein, the bottom of said upper portion of the conduit being provided with an outlet opening, and a chute extending downwardly away from said outlet opening.

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