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FLOTATION SEPARATING APPARATUS AND METHOD

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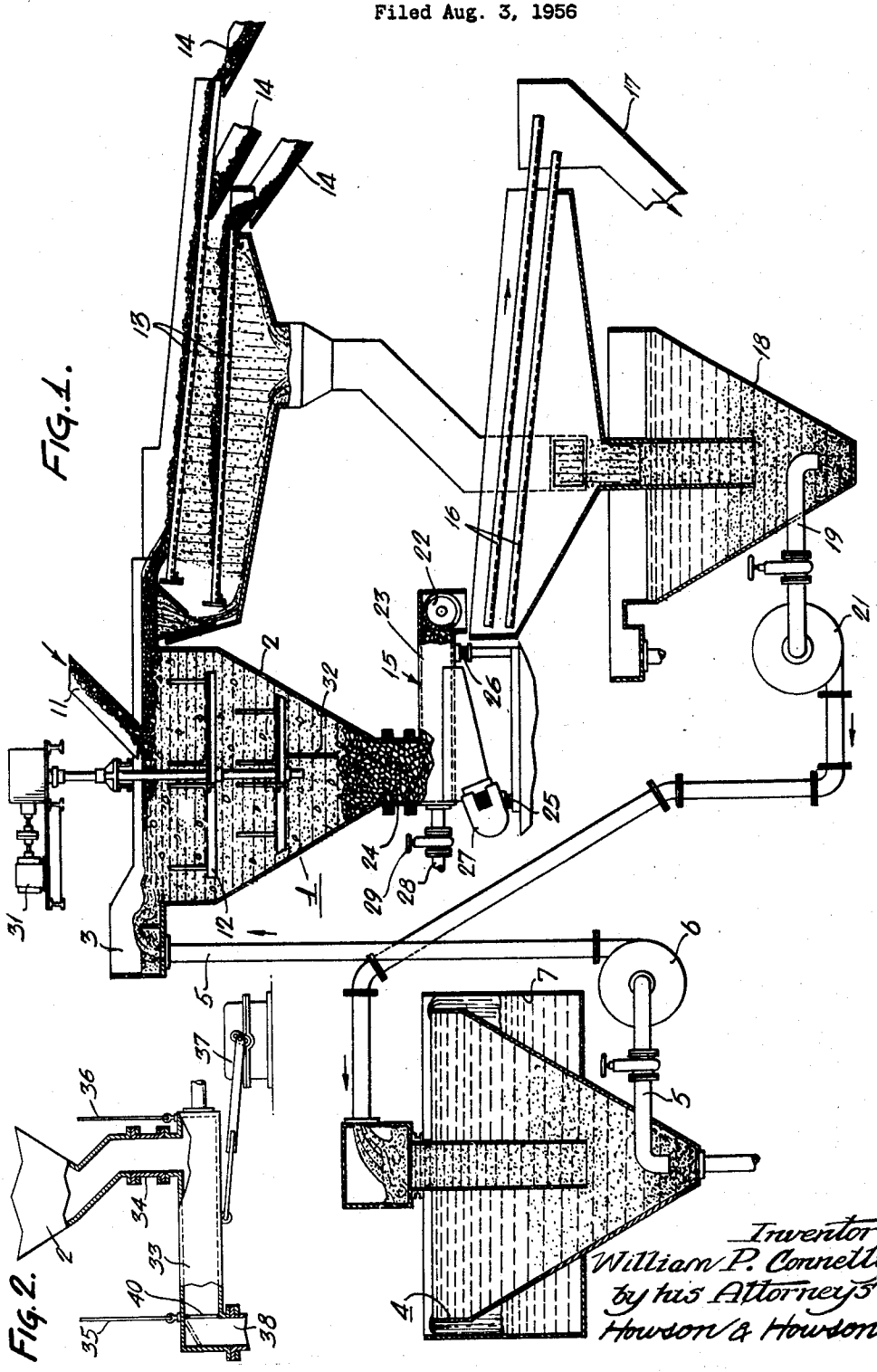


FIG. 1.

FIG. 2.

Inventor:
William P. Connelly
by his Attorneys
Howson & Howson

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FLOTATION SEPARATING APPARATUS AND METHOD

William P. Connelly, Philadelphia, Pa., assignor, by mesne assignments, to Provident Trust Company of Philadelphia, a corporation of Pennsylvania, as trustee

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This invention relates to improvements in the apparatus and methods for separating materials of differing specific gravities by flotation process.

In this process the materials to be separated are passed into a fluid mass of known specific gravity, consisting, for example, of a suspension of sand in water, in which mass the heavier components of the material to be separated are permitted to sink while the lighter components collect at and are recovered from the surface of the fluid mass. This separating process and its mode of operation is well known in the art and is used extensively in the mining and other industries and particularly in the processing of coal and other minerals for elimination of non-combustible refuse or waste.

Separating apparatus of the type involved in the present invention conventionally comprises a separating chamber, usually conical in form and contained within a similarly shaped vessel, and terminating at the bottom in a discharge opening. The high gravity separating medium which, as previously stated, may consist of a mixture of sand and water, is introduced into the chamber by suitable means and is kept in a state of agitation which maintains the sand in suspension. The coal with its refuse content (or the other materials to be separated) is fed into the top of the chamber and the refuse particles which are of relatively high specific gravity separate and sink to the bottom of the chamber, while the relatively light coal particles float at or near the surface of the high-specific-gravity fluid mass and are withdrawn by suitable means for subsequent de-watering and de-sanding operations and for grading. The refuse collects at the bottom of the chamber and is conducted away through the discharge opening. Obviously, both the removal of the refuse-free coal from the top of the chamber and of the refuse from the bottom of the chamber involve a certain loss of the flotation medium including both water and sand, and these lost components are replaced by suitable means not immediately involved in the present invention.

In order to avoid heavy losses of the flotation medium from the bottom of the chamber when the refuse is removed, it has been customary to employ a trap device consisting of a valve or gate-controlled refuse chamber in the discharge passage from the chamber. The refuse is permitted to build up to a certain extent in the bottom of the chamber and when the desired refuse level has been reached the gate valve at the top of the refuse chamber is opened to permit the accumulated refuse, or a part thereof, to pass downwardly into the refuse chamber. The admission valve is then closed and a second or discharge gate valve at the underside of the chamber is opened to permit discharge of the refuse from the chamber.

In order to conserve the fluid medium passing away from the vessel with the discharge refuse, it is customary to treat the refuse in suitable de-sanding apparatus which, variously, may be located either below the chamber or above the chamber and either as an independent unit or in operative association with the de-watering and de-

sanding apparatus for the coal passing from the top of the separating chamber. In the later case, it is customary to employ a suitable conveyor for elevating the refuse to the de-sanding screen. In any of the arrangements the overall height and cost of the apparatus is increased by use of the recovery apparatus.

It is an object of the present invention to provide a means for refuse withdrawal from the bottom of the separating chamber that will effect a material simplification in the structure and operation of the separating apparatus as a whole as well as a material economy both in initial cost and in the operating and maintenance expenses of the apparatus;

A more specific object of the invention is to materially reduce plant elevation, i.e., the overall vertical dimension of the separating apparatus;

Another object of the invention is to provide a practical means for removal of the refuse from the separating chamber by continuous operation as distinct from the intermitent operation inherent in the use of the conventional gate-controlled refuse chamber;

A further object of the invention is to utilize the refuse pack, either alone or with a supplementary mechanical gate means, as a gate or seal for the refuse discharge opening in the bottom of the cone, for conservation of the flotation medium, and

A still further object of the invention is to provide novel means for removal, continuous or intermittent, of refuse from the bottom of the separating chamber or vessel as hereinafter more specifically set forth.

The foregoing and other objects, hereinafter appearing, are achieved by means of apparatus of the character illustrated in the attached drawings, wherein:

Figure 1 is a diagrammatic vertical sectional and elevational view illustrating a separating unit made in accordance with my invention, and

Figure 2 is a fragmentary side elevation and partial sectional view illustrating a modification within the scope of the invention.

The apparatus illustrated in the drawings comprises the conventional conical separating chamber **1** contained within a metal vessel **2**. Sand is conducted to the chamber **1** through a pipe **5** and suitable inlet means **3** at the top of the vessel, and in the present instance, this sand is drawn from a sump **4** and is flowed through the pipe **5** by a pump **6**.

Assuming that the apparatus is to be used for coal cleaning purposes, the coal with its refuse content is introduced into the top of the chamber **1**, in the present instance through a suitable chute **11**. The flotation medium is maintained in a continuous state of agitation within the vessel **2** by suitable agitating means indicated at **12**, and the refuse particles of relatively high specific gravity greater than that of the flotation medium fall by gravity to the bottom of the vessel **2**, whereas the particles of clean coal of relatively low specific gravity, floating at or near the surface of the fluid medium, are discharged over a weir at the upper edge of the vessel, and after passing through suitable de-watering and de-sanding and grading screens indicated generally at **13**, are discharged through chutes **14** to suitable points of disposal.

The invention lies in the discovery by the applicant that in systems such as that described employing a flotation medium consisting of sand, or other solid component, in suspension in water, the refuse pack in the bottom of the chamber may in conjunction with said sand be made to function efficiently and in the absence of mechanical valving means as a seal for the bottom discharge opening to prevent escape of the said medium. In this sealing function the sand or other solid component fills the interstices between the particles in the pack to form in effect a solid mass in the bottom of the chamber,

It was discovered further that the said particles can be displaced either continuously or intermittently from the bottom of the pack without destroying the seal, said displacement being at a rate consistent with the maintenance of a sealing pack of adequate depth. Such losses of the flotation medium as may occur are of an order such that they may be readily and continuously replaced in accordance with the conventional practice by way of pump **6**, as hereinafter described, so as to maintain substantially constant the specific gravity of the said medium in the chamber.

In the present instance, a vibrating or shaking type conveyor indicated generally by the reference numeral **15** is employed to displace the refuse from the bottom of the separating chamber. The refuse so displaced is deposited by the conveyor into atmosphere upon suitable de-watering and de-sanding screens **16**, from which the refuse, freed from its sand and water, is discharged into a disposal chute **17**. The recovered sand and water are deposited in a sump **18** together with the sand and water recovered from the coal on the de-watering and de-sanding screens **13**. The sand and water thus recovered are removed through a pipe **19** and by means of a pump **21** to the main sump **4**, from which the sand and water may be returned to the separating chamber **1** by way of the pipe **5** and pump **6** as previously described. Where, as in this case, the refuse is discharged to the atmosphere, it may be desirable to employ a mechanical retarder to prevent too great acceleration of sink material or refuse water and flotation medium from the vibrating or shaking conveyor occurring as a result of failure of the sink material and separating medium to pack tightly enough to hold back the liquid mass in the separating chamber. This retarder may take the form of a rotary valve as indicated at **22** which functions in obvious manner to determine the rate of discharge of the sink material from the vibrating conveyor **15**. The valve may function, also, when the apparatus is initially placed in operation, to preclude discharge of the liquid mass during adjustment thereof to desired specific gravity and subsequent build-up of sink material in the bottom of the chamber to a depth consistent with the function of the pack to retain the liquid medium in the chamber. Obviously other forms of valves may be used for this purpose without departure from the principle of the invention, such for example, as the flap valve **40**, shown in Fig. 2.

The conveyor **15** comprises a duct **23** which extends approximately horizontally at the bottom of the vessel **2** and which communicates with the chamber **1** by way of a flexible tubular connector **24**. The duct **23** is supported in the present instance upon springs or other suitable resilient elements **25** and **26** and has connected thereto a magnetic vibrator unit **27** by means of which the duct is given a rapid vibratory movement effecting displacement of the contained refuse particles in accordance with a well known electro-mechanical principle. Vibrator devices of this general character are well known in the art and are available in the trade.

One end of the duct **23** is connected flexibly with a pipe **28** containing a control valve **29** through which water under pressure may be discharged into the duct and against the body of refuse collected therein. This pressure water may be used if necessary to augment the displacing effect of the vibrator so as to obtain a desired rate of displacement.

The displacing devices may be operated intermittently or continuously. In either case, the rate must be adjusted so as to maintain a refuse pack of sufficient depth to function as a seal precluding undue losses of flotation medium. This may be accomplished by regulating the action of the conveyor **15** or by adjustment of valve **29** or both. If automatic regulation is desired, a device may be employed similar to that disclosed in copending application for United States Patent Serial No. 218,880, which matured into Patent No. 2,766,886, dated October 16, 1956, wherein the refuse discharge means was made responsive to variations in the load imposed upon the electric motor driving the agitating means for the fluid mass in the separating chamber, said load variations being in turn responsive to changes in the level of the refuse pack in the bottom of the separating chamber. A control of this nature is illustrated in Figure 1 of the drawings wherein the agitator drive motor is indicated at **31**, the agitator **12** being provided with an eccentric depending arm **32** (see Figure 1) the lower end of which is approximately at the desired level for the refuse pack in the separating chamber. Increasing loads on the motor **31** imposed through the arm **32** as the pack increases in height results in an increased amperage in the motor circuit. This variable flow of current responsive to changes in the level of the refuse in the bottom of the chamber may be utilized as described to actuate or regulate the conveyor or valve as required to maintain an adequate depth of refuse.

While the vibrating type of conveyor illustrated in Figure 1 and described above is considered desirable by reason of its relative simplicity and freedom from mechanical failure, it will be apparent that other types of conveyors may be used without departure from the principle of the invention. One such conveyor is illustrated, for example, in Figure 2 of the drawings, wherein the sink material in the separating chamber is deposited in a conveyor duct **33** which is flexibly connected to the lower end of the vessel **2** by means of a flexible tubular connector **34**. This duct is suspended in the present instance upon flexible support elements **35** and **36**, and is connected to a suitable mechanical reciprocating unit **37** which imposes a longitudinal shaking movement on the duct **33** of a character to displace the refuse particles therein to the discharge opening **38**. Shaking conveyors of this general character are well known and available in the art.

While the foregoing description has been directed to the separation of refuse from coal employing a flotation medium of sand and water, it will be understood that the invention is not limited as to the nature of the materials under treatment nor to the use of any particular fluid separating medium within the general class indicated.

I claim:

1. Apparatus for separating materials of differing specific gravities in fluid separating media of the type consisting of solid particles suspended in water comprising; a solid walled container forming a separating chamber, the side walls of said container converging downwardly and inwardly and defining at the bottom of said chamber an open discharge opening through which the components of said materials of higher specific gravities which settle at the bottom of said chamber are discharged, means defining a second chamber positioned directly beneath said discharge opening and in fluid communication with said separating chamber, said second chamber having means forming a first opening therein at one end thereof in communication with said discharge opening and means forming a second opening therein at the other end thereof in communication with the atmosphere, a bottom wall for said second chamber spaced from and positioned directly beneath said discharge opening, said bottom wall operable to support the said settled materials at said discharge opening to produce in the bottom of said container a pack of the said settled materials of sufficient depth above said discharge opening to form with the solid particles of the flotation medium a solid mass effectively sealing said discharge opening against loss of said medium through the otherwise unsealed discharge opening, means in association with said second chamber for progressively displacing the said settled materials along said second chamber in a lateral direction away from said discharge opening relative to said discharge opening to effect discharge of the materials from

said separating chamber, and valve means at the said other end of the said second chamber to control the discharge of said settled material from said second chamber.

2. Apparatus according to claim 1 wherein mechanical conveyor means is provided in operative association with said second chamber for progressively displacing said settled materials in said lateral direction away from said discharge opening.

3. Apparatus in accordance with claim 1 wherein means is provided for vibrating the walls of said second chamber to progressively displace the said materials laterally away from said discharge opening.

4. Apparatus in accordance with claim 1 wherein hydraulic means is provided in association with said second chamber to displace said settled materials from said second chamber in said lateral direction away from said discharge opening.

5. Apparatus according to claim 1 including means for automatically regulating the rate of discharge of the said materials of higher specific gravity so as to maintain continuously a predetermined accumulation of the materials in the bottom of the chamber.

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