Feb. 5, 1935. W. C. MENZIES 1,990,129

APPARATUS FOR SEPARATING MATERIALS OF DIFFERENT SPECIFIC GRAVITIES

Filed June 5, 1933 3 Sheets-Sheet 1

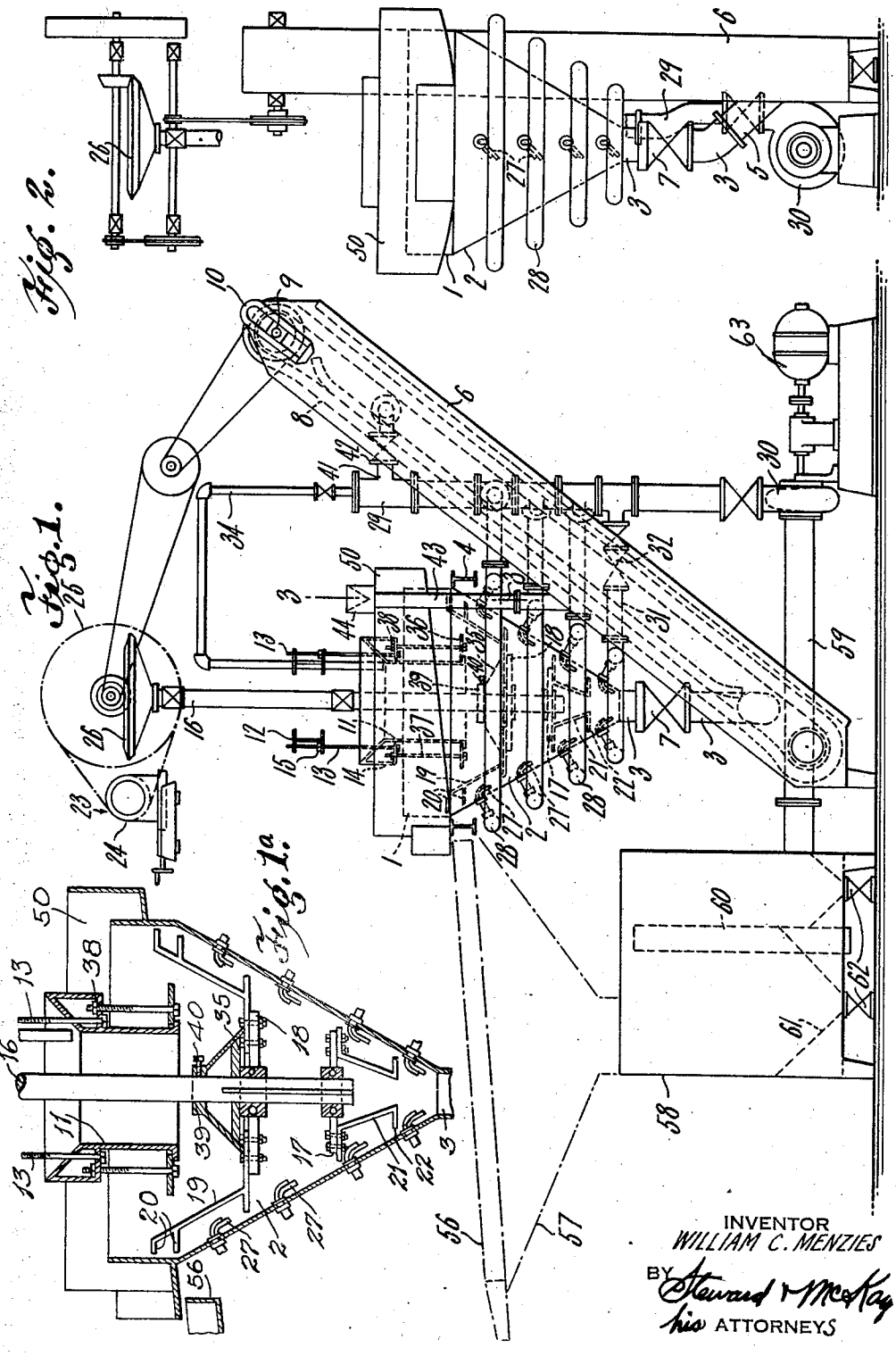

Fig. 2.

Fig. 1.

Fig. 1a.

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APPARATUS FOR SEPARATING MATERIALS OF DIFFERENT SPECIFIC GRAVITIES

Filed June 5, 1933 3 Sheets-Sheet 2

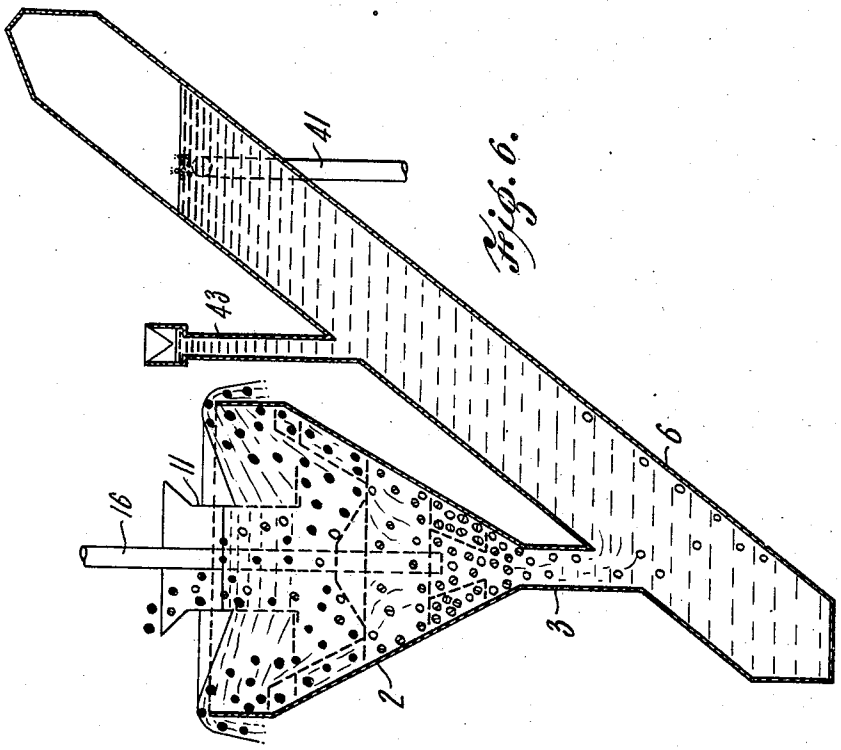

Fig. 6.

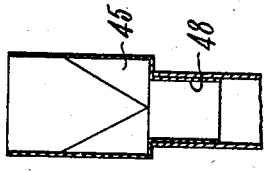

Fig. 5.

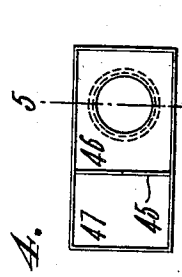

Fig. 4.

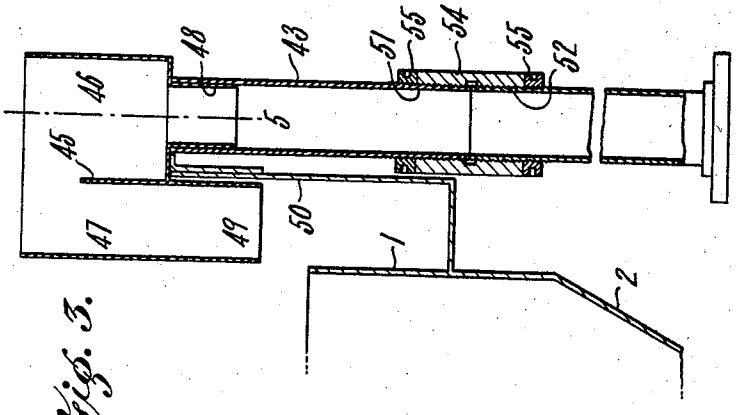

Fig. 3.

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APPARATUS FOR SEPARATING MATERIALS OF DIFFERENT SPECIFIC GRAVITIES

Filed June 5, 1933 3 Sheets-Sheet 3

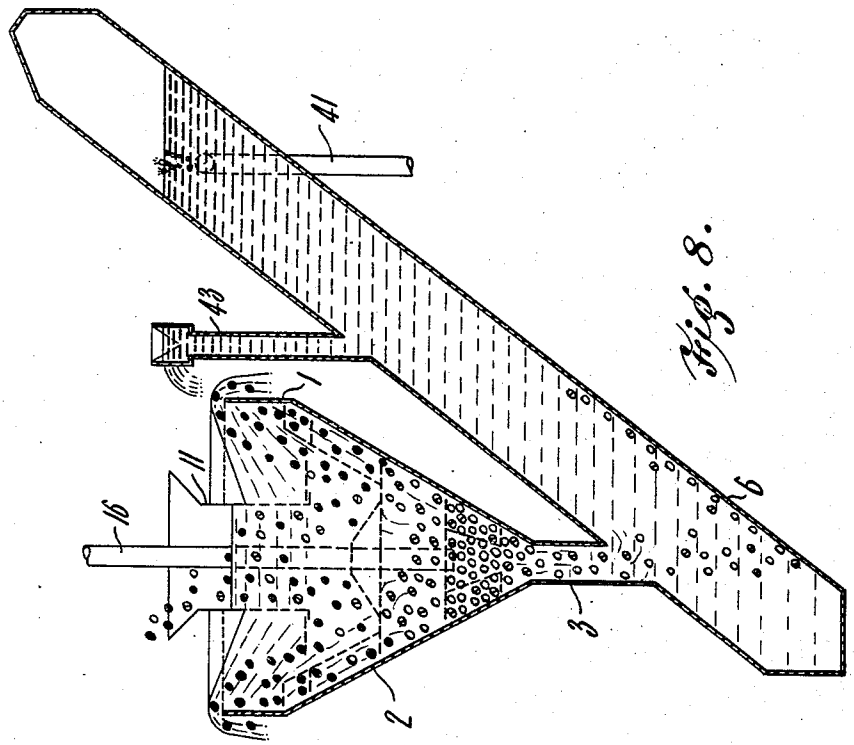

Fig. 8.

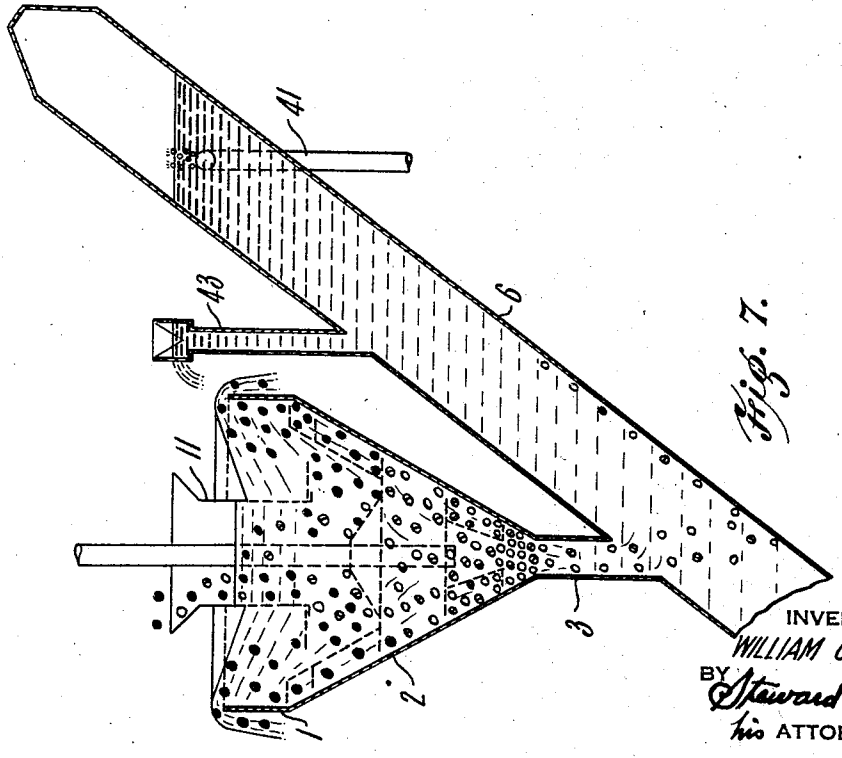

Fig. 7.

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Patented Feb. 5, 1935 1,990,129

UNITED STATES PATENT OFFICE

1,990,129

APPARATUS FOR SEPARATING MATERIALS OF DIFFERENT SPECIFIC GRAVITIES

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Application June 5, 1933, Serial No. 674,438

16 Claims. (Cl. 209—161)

My invention relates to apparatus for separating materials of different specific gravities. The invention pertains more particularly to apparatus for separating coal or other minerals from mixtures containing them, in which apparatus the mixture is subjected to hydraulic classification and separation of the materials.

While not confined to such use, the apparatus of my invention is particularly useful in the separation of coal from the usual mined mixture of coal and rock or other refuse; and as the difficulties sought to be overcome by my invention are well illustrated in the case of separation of coal, reference will primarily be made thereto in explaining the principles and advantages of the invention.

The impurities or refuse in the usual mined mixture are a very poor grade of coal called "bony", and rock, pyrites, slate and the like. The material of value, the high-grade coal, is of the lowest specific gravity, the rock and pyrites are the materials of the highest specific gravity, the slate is of the next highest specific gravity, while the "bony" is material of an intermediate specific gravity, sufficiently approaching that of the good coal to make it difficult to effect substantially complete separation of the two by hydraulic classification.

A primary object of my invention is to provide an apparatus for the hydraulic separation of coal and other minerals of value from mixtures containing them which will automatically operate, with a minimum of attention, to effect substantially complete separation of the coal or other mineral of value from the refuse even in cases where certain material of the refuse, such as the "bony" in the case of the separation of coal, for example, is of a specific gravity sufficiently approaching that of the mineral of value to ordinarily render the separation a difficult and uncertain one so far as substantially complete separation is concerned.

Another and more particular object of my invention is to especially adapt an apparatus of the foregoing character to the separation of coal and to the overcoming of the above-mentioned difficulty of substantially complete separation of the good coal from the "bony" by providing the apparatus with means automatically operating to vary the velocity of the hydraulic upflow current in response to changes in density of the fluid mass in the classification chamber as the materials accumulate in or separate out therefrom.

The changes in the upflow current designed to be brought about by the automatically operating means just referred to are such as to produce a variably hindered settling of the materials fed to the classification chamber. For the maximum resistance to downward settling, the upflow current is at a predetermined maximum velocity designed to float the good coal off into the discharge at the top of the chamber while permitting the ready downward settling of the heaviest refuse to the bottom discharge. Under this maximum velocity of current upflow and consequent hindrance to settling, the lighter refuse, such as the "bony", tends to accumulate so near the top of the chamber under the stratum of good coal that, if the maximum upflow current were continued, more or less of this refuse would be carried by the upflow current over with the good coal into the valve discharge. This is avoided by the means automatically operating in response to the increased density of the materials in the classification chamber to reduce the velocity of the upflow current.

Under the condition of less hindered settling resulting from the reduction in velocity of the upflow current, of course all the materials in the classification chamber settle more rapidly downward so that if this condition were prolonged good coal, as the lightest material, would settle down with the heavier refuse to the bottom discharge. This is avoided by the means automatically operating in response to the decreased density of the materials in the classification chamber to increase the velocity of the upflow current and thus restore the maximum resistance to downward settling, which again forces the good coal upwardly while still permitting the heavier refuse to settle to the bottom discharge.

To thus make the density of the fluid mass in the classifying or separating chamber the factor controlling the velocity of the upflow current, my invention comprises means for supplying that chamber with water at a predetermined maximum volume and rate of flow sufficient for the maximum velocity of upflow current through the chamber required for a given density of the materials and associated means responsive to the increasing resistance offered by the increasing density of materials to the upflow current to divert varying amounts of the supply liquid from the chamber and thereby reduce the velocity of the classifying current.

Another object of the invention is the provision in a materials separating apparatus of the general character to which the invention pertains of a vertically adjustable feed-in chute which will

deliver the crude mixture to the classifying chamber in quantities and at levels so below its overflow rim as to ensure that none of the refuse will be swept over that rim by the hydraulic current upon entrance of the materials to the chamber.

A further object of the invention is the provision in such an apparatus of a mechanical agitator of the revolving blade type effective in maintaining the mixture in mobile condition in the classifying body of water without exerting a centrifugal force on the fluid mass disturbing the classifying action.

Still another object of the invention is the provision in the classifying chamber of deflector means effective to so divert and disperse the upflow current of water from the path axially of the chamber which it has a tendency to take as to avoid turbulence of upflow and improve the classifying action.

The foregoing objects, principles and advantages of my invention as well as other objects, principles and advantages thereof will more fully appear from the presentation hereinafter made by description and drawings of an apparatus embodying the invention in a form found particularly suitable for the separation of coal. It is to be understood, however, that the invention is not confined to this particular form of apparatus, nor its usefulness restricted to the separation of coal, and that the invention may include other forms of apparatus and applications of use within the scope of the appended claims.

In the drawings, which are somewhat diagrammatic:

Fig. 1 is a side elevational view, with interior parts shown in interrupted lines, of one form of the apparatus of my invention, particularly adapted, as stated above, for the separation of coal;

Fig. 1*a* is a partial vertical sectional view through the water-sorting chamber or tank of the apparatus shown in Fig. 1;

Fig. 2 is an end elevational view, with certain parts removed for clearness of illustration, of the apparatus shown in Fig. 1, the Fig. 2 view being that looking from left to right of the apparatus of Fig. 1;

Fig. 3 is a detailed vertical sectional view, on an enlarged scale, of a portion of the apparatus along the line 3—3 of Fig. 1;

Fig. 4 is a top plan view of the portion of the apparatus shown in Fig. 3;

Fig. 5 is a vertical sectional view along the section line 5—5 of Figs. 3 and 4; and

Figs. 6, 7 and 8 are diagrammatic views illustrating the functioning of the apparatus in the separation of coal.

Since the apparatus of my invention as applied to the separation of coal from its impurities involves substantially the same principles as when applied to the separation of other minerals, the present description will be confined to the separation of coal as a typical instance of use serving to present the essential principles of the invention.

The particular form of apparatus embodying my invention shown in the drawings includes a main receptacle or tank adapted to be so supplied with water as to function as a classification or sorting body for the coal mixture to be fed thereto. In the form shown, this tank has a cylindrical upper portion 1, an intermediate conical portion 2 with its walls converging downwardly to a tubular lower portion 3 of a substantially lesser diameter than that of the uppermost portion. The sorting tank is suitably supported adjacent its open top upon side rails 4 of a supporting frame, not further shown, and the lower tubular portion or member 3 of the tank is downwardly and laterally curved to connect, through a neck 5, with an upwardly inclined and elongated chamber 6, of tube-like form, closed at the bottom and open at the top, through which the water for the upflow current in the sorting tank is supplied in the manner hereinafter more fully set forth. A gate valve 7 in the tubular member 3 of the sorting column serves to open and close communication between the chamber 6 and the sorting tank.

The chamber 6 is provided with a conveyor for the refuse material so that this chamber also functions as a conveyor boot, receiving from the sorting tank the refuse materials settling downward therethrough. As the conveyor, indicated by the numeral 8 on Fig. 1, is the usual flight conveyor of well known construction, it is sufficient to here state that its receiving end is journaled in the bottom portion of the chamber or boot 6 in the line of discharge of the refuse materials through the tubular member 3 of the sorting tank, and its delivery end extends beyond the upper open end of the boot in which it is located. It is driven through a head shaft 9 adjustably mounted in the brackets 10.

Water is supplied to the sorting tank in the manner hereinafter set forth, not only to provide the upflow current of water hereinbefore referred to but also to provide a body of liquid to which the coal mixture can be fed and with which it forms a fluid mass.

In apparatus of this general type the only practical mode of feeding the coal mixture to the sorting tank is to feed it through the open top of the tank, but heretofore this has been attended with the disadvantage of some of the refuse of the fed-in mixture being swept over by the hydraulic current into the discharge for the good coal at the top of the tank before that refuse has time to settle downwardly away from that discharge. To avoid that disadvantage, the present invention contemplates a form of extended feed-in chute delivering the coal mixture well down into the tank below the water level therein, and well down into the fluid mass itself after the same has once been formed. The invention also proposes a form of the extended feed-chute which is vertically adjustable so as to adjustably vary the depth of its delivery of the coal mixture within the sorting tank, as this avoids that reduction in the capacity of the apparatus to handle different coal mixtures which has been found to attend an unvaried depth of submergence of the delivery end of the feed-in chute.

In the illustrated apparatus, the feed-chute is of the form shown in Fig. 1, having a funnel shaped mouth and an elongated cylindrical chute portion 11 extending down into the sorting tank below its rim. To enable the chute to be vertically adjusted, it is podily suspended from the overhead flanged beams 12 by the rods 13 extending through the flanges of the beams and through box lugs 14 on the outer circumference of the chute and nuts 15 engaging the threaded ends of the rods.

As is customary in apparatus of this type, means are also provided for mechanically agitating the fluid mass in the sorting tank, and the invention contemplates certain novel features of such agitating means which substantially con-

tribute to the efficiency of the apparatus as a whole especially for the separation of coal.

In the illustrated apparatus, the mechanical agitator comprises a rotatable shaft 16 on which the agitator blades are mounted. It has been the customary practice heretofore in apparatus of this general type to employ a plurality of sets of blades spaced vertically apart through the sorting tank, with the top set fairly close to the discharge rim of the tank, the bottom set in the lowermost portion of the tank and with at least one intermediate set, and with the blades of each set extending horizontally from the shaft and practically across the entire width of the tank. It has been found, however, that which such an arrangement, when the agitator is run at the higher speeds of the range employed for different coal mixtures, the top set of long blades produces excessive centrifugal action on the fluid mass which seriously interferes with the classification of the materials therein, and especially with the classification of the larger sizes of the materials. To avoid this, and at the same time maintain sufficient speed of the agitator for the proper classification, the apparatus of the present invention eliminates the customary top set of long blades and employs two sets of relatively short horizontally extending blades in the lower and midway portions of the sorting tank, as indicated by the sets of blades 17 and 18 respectively in Fig. 1, and as a substitute for the top set of long blades the apparatus employs extremely thin blades having a stem portion 19 extending obliquely upwardly from the midway set of blades and short horizontally disposed spurs or blade portions 20, the uppermost of which are in approximately the location of the long top blades heretofore used. It has been found in the practical use of the apparatus that such blades sufficiently agitate the material near the upper part of the sorting tank to keep it in a fluent state while at the same time avoid that excessive centrifugal action hereinbefore referred to as interfering with the classification of the materials.

For a somewhat similar reason, the apparatus also employs extremely thin blades having a stem portion 21 extending obliquely downward from the lower set of horizontal blades 17 and horizontal spurs or blade portions 22 so as to agitate the materials in the small-diameter bottom portion of the sorting tank adjacent its outlet to the tubular section 3. These blades, instead of producing centrifugal action enough to throw the materials in the bottom portion of the sorting tank forcibly against its side walls and thereby divert those materials from the bottom outlet, provide just sufficient agitation of the materials to facilitate their discharge through that outlet.

The shaft 16 may be driven by any suitable means, preferably by a variable speed drive so that the speed of the agitator may be adjustably varied in correspondence with the size of the coal handled by the apparatus, experience having shown that the greater the size of the coal the greater the speed required of the agitator. The driving means employed in the illustrated apparatus, and indicated as a whole by the numeral 23 in Fig. 1, is a Reeves variable speed drive, which remains at a constant speed after the adjustment to the desired speed has been made. As this is a well known form of variable speed drive, it is unnecessary to describe the same in detail, and it is sufficient here to say that it comprises an adjustably mounted driving pulley 24 and a driver pulley 25 which latter in turn drives the gears 26 on the shaft 16.

To supplement the work of the mechanical agitator in maintaining the mass of materials in the sorting tank in fluid condition, water inlet nozzles 27 are disposed through opposite side walls of the sorting tank along its length, with each directed obliquely downwardly at an angle of approximately 45° to the horizontal and to the vertical axis of the tank, as shown in Figs. 1 and 2, the effect being to assist the agitator blades in rotating the mixture in the sorting tank and therefore facilitate the classification of the materials according to their differing specific gravities. The nozzles may be supplied with water from any suitable source, but in the illustrative apparatus each set of two oppositely disposed nozzles are connected to a ring pipe 28, and the ring pipes 28 are in turn connected to the water pipe 29 which is fed by the pump 30 as will hereinafter be more fully pointed out. The connections between the water pipe 29 and the ring pipes 28 and the valves therein for the control of the water to the inlet nozzles 27 are diagrammatically indicated at 31 and 32 in Fig. 1. A pipe 34 of inverted U-shape, with one arm connected to the upper end of the water pipe 29 and its other free arm disposed over the mouth of the chute 11, as shown in Fig. 1, serves to deliver water from the pipe 29 to the mouth of the chute to assist the delivery of the raw materials through the chute into the classifying area of the sorting tank, and the additional water at this point has been found to substantially increase the capacity of the apparatus.

When the upflowing current of water is established through the tubular section 3 and into the sorting tank, in the manner hereinafter to be described, unless provision is made to prevent it there is a tendency of the water current to concentrate in a rather turbulent upflow along the agitator shaft and along the sides of the cylindrical extension 11 of the feed-in chute, which would cause some of the refuse materials to be carried upwardly to the discharge for good coal over the rim of the tank. The provision to prevent this comprises a deflector plate 35 mounted on shaft 16 below the delivery end of the feed-in chute and another deflector plate 36, of ring shape, surrounding the cylindrical portion of the feed-in chute. Each plate is so mounted as to be vertically adjustable. The plate 36 is vertically adjustable by reason of its suspension from the box lugs of the feed-in chute through the rods 37 and the nuts 38 engaging the threaded ends of those rods.

The plate 35, which is vertically adjustable on the shaft 16 through the collar 39 and set screw 40, presents its flat circular base to the upflowing water current to divert the same away from the shaft, while its top face is beveled or cone-shaped to check the drop of the feed material from the delivery end of the chute and thereby prevent the good coal from being forced down too deeply into the strata of refuse within the sorting tank. Another advantage of the beveled top face of plate 35 is that its disperses all materials from the delivery end of the feed-in chute outwardly into the classification areas of the sorting tank and prevents that accumulation, especially of the heavier refuse, on the top of the plate and consequent clogging of the delivery end of the chute which would occur if the top face of the plate were flat. Thus, the plates 35 and 36 divert the upflowing current of water away from the axis

of the agitator shaft and disperse it into the fluid mass in the sorting tank, while the upper face of the plate 35 diverts the incoming material away from the axial center of the tank into the area of the classifying action of the water.

The hydraulic state of the entire fluid mass in the sorting tank, that is, its condition of motion, has an effect on the settling of the materials according to their different specific gravities, and both the mechanical agitator and the water inlets 27 in the wall of that tank are factors in this matter. But, since the speed of the mechanical agitator is adjusted to a predetermined constant rate and the water supplied through the inlets 27 is also adjusted to a predetermined amount by the valves in the pipe connections, for any given coal mixture, depending principally upon the size of the coal therein, the mechanical agitator and the water inlets 27 are constant factors in the classification of any given coal mixture. The other factor affecting the hydraulic state or condition of motion of the fluid mass in the sorting tank, and the one directly effecting the separation of the good coal from the refuse and its discharge over the rim of that tank, is the upflowing current of water which has been mentioned but which, together with the means in the illustrated apparatus for producing it, have not yet been described in detail. That factor, as hereinbefore pointed out, is made a variable one responsive to variations in the density of the materials in the sorting tank in order to so control the settling of the materials as to prevent any substantial amount of refuse from going with the good coal over the rim of the tank or any substantial amount of good coal setting downwardly with the refuse through the discharge at the bottom of the tank. Broadly considered, the means for doing this comprises means for supplying the sorting tank with water at a predetermined maximum volume rate of flow sufficient for the required maximum velocity of upflow current through that tank, and associated means responsive to the resistance offered by the materials to the upflow current to divert varying amounts of the supply water from that tank. Preferably, the diverting means is of a character operative to divert the supply water from the sorting tank in a proportion of greater increase of quantity diverted than the increase in the density of the materials in the sorting tank.

While the foregoing water-supply and diverting means may take other forms, the form employed in the illustrative apparatus, which is the preferred embodiment of the invention, comprises the chamber or boot 6 through which the water supply is delivered to the sorting tank for the upflow current therein, and a variable overflow device connected to that chamber. As will more fully appear as the description of this feature of the invention proceeds, the chamber 6 and the associated overflow device are so arranged as to produce an overflow of water from that chamber and a consequent diverting of the liquid from the sorting tank only upon a rise above a predetermined lower limit of the liquid level in the chamber 6, which rise is in turn dependent on the density of and consequently the resistance offered by the materials in the sorting tank to the upflow of water therethrough.

As shown in Fig. 1, the chamber or boot 6 has its closed lower end disposed beneath the tubular connection 3 to the sorting tank, and that chamber extends obliquely upward to a point disposing its open upper end substantially above the discharge rim of the sorting tank. Water is fed from the pump 30 through the water pipe 29 and the branch pipe 41 to the chamber 6 at a point therein also substantially above the discharge rim of the sorting tank. The branch pipe 41 is provided with a gate valve, diagrammatically indicated at 42, to control the feed of the water to the chamber 6.

The overflow device associated with the chamber or boot 6 comprises a standpipe 43 connected to and supported upon that chamber at a point substantially below the overflow rim of the sorting tank and extending upwardly to a point substantially above the overflow rim of the sorting tank. The open upper end of the standpipe 43 is surmounted by the casing or box of an overflow weir indicated generally by the numeral 44. That casing, which has an open top, is divided by an interior partition wall 45 into a water receiving chamber 46 and a water discharge chamber 47. The floor of the water receiving chamber is apertured and provided with a cylindrical extension 48 defining the boundary of the aperture and extending downwardly to fit within the upper end portion of the standpipe 43 so as to mount the entire casing or box of the weir on that standpipe and provide a free passage for the rise of water from the standpipe into the receiving chamber 46 of the casing, as shown in Fig. 3. The discharge chamber is provided with a discharge spout 49 extending downwardly into the launder 50 to discharge the overflow water into the launder between its boundary wall and the upper rim edge of the sorting tank, as shown in Fig. 3.

The overflow weir is designed of a form to present a progressively increasing area of overflow as the water rises in the receiving chamber of the weir box. One suitable form of the weir for this purpose is presented by the partition wall 45 in the weir casing, which wall is cut away in a V-shaped notch with the opposed edges of the V forming an angle of approximately 60° and with the apex of the V at the base of the water receiving chamber 46 and therefore at approximately the upper end of the standpipe 43, as shown in Fig. 5. It is to be understood, of course, that the angle of spread of the opposed overflow edges of the weir need not necessarily be 60°, as the angle of spread will depend upon the increase in the amount of overflow found advisable to provide for as the water rises in the receiving chamber of the weir casing. But a 60° angle of spread has been found suitable in the practical operation of the illustrative apparatus in the separation of coal. Also, while the vertical extent of the V-shaped notch is not necessarily restricted thereto, a vertical extent of approximately 3 inches has been found to give good results in the use of the apparatus for the separation of coal. It is to be understood, of course, that there is no partition wall between the water receiving and discharge chambers 46 and 47 above the V-notch of the weir. In other words, the weir occupies the lower portion only of the casing.

A further feature of the overflow device of some practical advantage is its vertical adjustability. This is attained by making the standpipe 43 in two sections with their adjacent opposed end portions exteriorly screw threaded with right and left hand threads as indicated at 51 and 52 in Fig. 3, to be engaged by a complementary threaded sleeve 54 which, when slipped over the opposed ends of the standpipe sections and rotated, draws

the two sections toward one another to the extent desired for adjusting the height of the standpipe. In Fig. 3, the standpipe is adjusted to its minimum height with the opposed ends of the two sections in contact. When the adjustment has been made, threaded collars 55 are screwed into engagement with the opposite ends of the sleeve 54 to secure the adjustment and to prevent leakage of water from the standpipe outwardly between the opposed sections. It is evident that this adjustability of the height of the standpipe 43 is in effect an adjustability of the overflow weir as to its height above the normal level of the water in the water chamber 6 and in the standpipe 43. By this arrangement, the overflow device can be adjustably regulated with respect to the degrees of increase and decrease in the density of the materials in the sorting tank required to begin and discontinue the overflow through the weir and consequent diversion of water from the sorting tank.

As already stated, the water overflowing the weir into the chamber 47 of the weir casing discharges from that chamber through the spout 49 into the launder 50. The fluent mixture of coal and water overflowing the rim of the sorting tank also goes into that launder, and the launder in turn discharges its burden of water and coal upon the dehydrating screen 56 which is of the usual vibrating or shaker type not necessary to fully illustrate here and therefore only diagrammatically illustrated in Fig. 1. The coal passes on from the screen to a suitable conveyor or receptacle while the water drains from the screen through the chute 57, also diagrammatically illustrated in Fig. 1, into the water storage tank 58, from which tank it is drawn by the pump 30 through the pipe 59 for re-use in the apparatus.

The water storage tank 58 is provided with an overflow pipe 60 which has its open end within the tank near the top thereof and which extends through the bottom of the tank to discharge outside the same. This is the usual overflow pipe to provide for any sudden rush of water to the tank beyond its capacity. The water storage tank is also provided with the usual bottom hoppers 61 and valved outlets 62 for drainage of sediment from the tank.

The pump 30 is driven by the motor 63, and the pump and the pipe connections to the water chamber are of a designed capacity amply sufficient, when the gate valve 42 in the pipe connection 41 to the water chamber 6 and the gate valve 7 in the pipe connection to the sorting tank are open, to feed water to the chamber 6 at a uniform volume rate sufficient to maintain a head therein and in the connected standpipe 43 at a level above the point of entrance of the pipe 41 to the chamber 6 and below the apex of the weir notch while producing the maximum velocity of upflow current required in the sorting tank.

The volume rate of water actually fed to the water chamber 6 is, however, controlled by the setting of the gate valve 42. The opening adjustment of that valve depends upon the maximum velocity of current upflow through the tubular section 3 to the sorting tank required for any given coal mixture to sustain the good coal in the tank above the lower outlet leading to the tubular section 3 when the bed of refuse in the tank is at a minimum. This condition of minimum density of materials in the sorting tank and the maximum velocity of upflow current required under that condition to sustain the good coal above the outlet for refuse into the tubular section 3 can be determined by varying the opening of the valve 42 and consequently the velocity of the current upflow through the tubular section 3 into the sorting tank from a low point which presents good coal in the delivered refuse upwardly until the point is reached when the good coal first fails to appear with the refuse. Having thus determined the maximum volume rate of water upflow required through the tubular section 3 into the sorting tank, the valve 42 is fixed for that maximum velocity, and thereafter, as long as the density of the materials in the sorting tank does not increase substantially above that obtaining when the valve adjustment was determined, the water will flow from the water chamber through the tubular section 3 to the sorting tank at substantially the rate at which it is supplied to the chamber 6, and the water level will stand at a constant height in that chamber and in the connected standpipe 43 above the point of supply of water to the chamber 6 through the pipe 41 and below the apex of the V-notch of the weir. This is the condition of no discharge over the weir diagrammatically illustrated in Fig. 6.

Under the foregoing condition of maximum volume rate of water upflow through the tubular section 3 to the sorting tank, the heaviest refuse, such as rock and pyrites, readily settle downwardly to and through the discharge outlet at the bottom of the sorting tank. But the hindrance to settling of all but the heaviest refuse is such that, if the coal mixture being fed to the tank should contain an unusually large amount of refuse, or even with the normal proportion of refuse if the maximum velocity of upflow current continues for some time, there is a tendency for both the slate and the still lighter bony to so accumulate in the tank, with the slate at the bottom and the bony above it, as to form a bed of refuse in the bottom of the sorting tank over the outlet therefrom to the tubular section below it. This bed of refuse presents a very substantially increased resistance to the upflow of water from the water chamber 6 through the tubular connection to the sorting tank. Were it not for the overflow device this increased resistance to the upflow of water through the tubular section 3 to the sorting tank would be counterbalanced by the constant feed of water to the water chamber 6 and the rise of the pressure head therein so that the upflow current through the tubular connection 3 to the sorting tank would continue substantially undiminished with a consequent forcing of some of the bony with the good coal over the rim of the tank.

When the foregoing condition in the sorting tank occurs, however, although the increase in the density of the materials in the sorting tank may be comparatively slight, if it is substantial enough to cause an undiminished water upflow to force an appreciable amount of refuse with the good coal over the rim of the sorting tank, the water will rise through the standpipe 43 sufficiently above the apex of the V-notch of the weir to produce an overflow diverting a sufficient amount of water from the sorting tank to reduce the upflow current therein to a degree causing the refuse to settle downwardly away from the rim of the tank. The diverting of the water over the weir under this condition is diagrammatically illustrated in Fig. 7.

Reverting now still more particularly to the varying conditions of operation of the apparatus as diagrammatically illustrated in Figs. 6 to 8 inclusive, these views show varying densities of

the materials in the sorting tank as the apparatus is used for separation of coal. In each of these views, the particles of good coal, as the material of lowest specific gravity, are represented in solid black. The particles of the heaviest refuse, such as rock and pyrites, are represented in circular outline with a clear center and the particles of the lighter refuse, such as the slate and the bony, are represented in circular outline with a single line through the center.

Fig. 6 illustrates the condition of minimum density of materials within the sorting tank and the consequently required maximum volume rate or velocity of water flow from the water chamber 6 upwardly through the tubular connection 3 to the sorting tank as determined by the setting of the control valve in the feed line to the chamber 6 in the manner hereinabove explained. Under this condition, the sorting tank contains a comparatively small amount of refuse, and there is comparatively little resistance to the upward current of water, with the result that the head of the water in the chamber 6 and in the standpipe 43 is below the apex of the V-shaped notch of the overflow weir.

Under the foregoing condition, let it be assumed that the maximum volume rate of water for the upflow current through the tubular connection 3 to the sorting tank which will allow heavy refuse to drop out of the tank but will sustain the good coal therein amounts to 370 gallons per minute, for example. Then, as long as there is no discharge through the V-notch of the weir, the total of 370 gallons per minute passes through the tubular connection to the sorting tank. Fig. 7 shows a slight increase in density of materials in the sorting tank which has resulted from a continued feed to that tank of the coal mixture while the maximum upflow current was still on, and this increase in density of the materials has produced a sufficient resistance to the upflow current through tubular connection 3 to the sorting tank to cause, under the constant feed of water to the water chamber 6, a rise of the water level therein elevating the water through the standpipe 43 to a point slightly above the apex of the V-notch of the overflow weir. There is consequently a slight discharge through the V-notch of the weir, and the water passing through the tubular connection 3 into the sorting tank is slightly decreased, which permits a slight increase in discharge of the refuse but sufficient to prevent its lightest particles, such as the bony, from going with the good coal over the rim of the sorting tank.

As an illustration of the last foregoing condition, and under the assumption above of a feed of water to the water chamber 6 at the rate of 370 gallons per minute, if the density of the materials in the sorting tank has sufficiently increased to cause a rise in the water through the standpipe 43 to a point, say, one inch above the apex of the V-notch of the weir, this will permit a discharge over the weir of approximately 2 gallons of water per minute. Then, there will be 370—2 or a total of 368 gallons of water per minute upflowing through the tubular section 3 into the sorting tank.

Fig. 8 shows a still further accumulation of refuse in the sorting tank which has resulted from a continued feed to that tank of the coal mixture while the only slightly reduced upflow current established by the conditions illustrated in Fig. 7 was on, and in consequence of the increased resistance offered by the accumulated materials in the tank to the upflow current the water has risen through the standpipe 43 to a further extent above the apex of the V-notch of the weir. Let it be assumed, for example, that the water has risen another inch above its level shown in Fig. 7, so that it now stands two inches above the apex of the V-notch of the weir. Due to the spread of the notch or overflow edges of the weir there is now a considerably greater overflow than resulted from the first rise of one inch as in the Fig. 7 example. The discharge over the weir for the second rise illustrated in Fig. 8 may be taken, for example, as 12 gallons per minute, and there is thehefore 370—12 or a total of 358 gallons per minute of upward flow of water through the tubular section 3 into the sorting tank. This marks a substantial reduction in the velocity of the upflow current and a consequent substantially less hindered settling which substantially increases the discharge of refuse from the tank and avoids that forcing of the lighter refuse, such as the bony, with the good coal over the rim of the tank which would occur had not the upflow current into the sorting tank been so substantially reduced.

Under usual working conditions, where the refuse contained in the feed is of normal amount, the condition of density of the materials illustrated in Fig. 8 will seldom be exceeded. However, should that condition be exceeded in respect to the amount of refuse accumulated in the sorting tank, so as to cause a further rise of 1 inch, for example, of the water through the standpipe 43 and over the weir, there would, because of the spread of the V-notch of the weir, be a substantially greater overflow than occurred on the last rise of the water in the Fig. 8 example. The third rise may be taken to give a discharge over the weir of 70 gallons per minute. There would therefore be a reduction from the originally assumed rate of 370 gallons per minute to 300 gallons per minute of water upflow into the sorting tank, with a correspondingly more rapid downward settling of the materials in the tank and discharge of the refuse.

Even under the foregoing example of extreme reduction in volume rate of upflow current of water into the sorting tank, there would not, however, be a dropping of good coal to any substantial amount with the refuse through the discharge outlet at the bottom of that tank. This is so because of the substantial bed of refuse which has accumulated in the lower part of the sorting tank and which must discharge through the outlet from the tank into the tubular section 3 below it before the good coal above it is in position to be discharged, and by the time the refuse has settled through the discharge outlet sufficiently to enable the coal to follow, the density of the materials and consequent resistance to the upflow of water into the sorting tank has so decreased as to drop the water level in the overflow device below the apex of the V-shaped notch of the weir, and substantially the initial full volume flow of water to the sorting tank is restored, which, as hereinbefore explained, is sufficient to sustain the good coal within the sorting tank.

The cone shape of the sorting tank and its termination below in the tubular member 3 also assists in preventing a dropping of good coal downwardly with the refuse from the tank into the tubular section below it. As already stated, the heaviest refuse, such as rock and pyrites, settles so rapidly downward under all conditions of the hydraulic current that they do not accumu-

late in the sorting tank, and it is the lighter refuse, such as the slate and the still lighter bony, which accumulates as a body of materials in the bottom of the tank. With the cone shape of the sorting tank and its relatively restricted bottom discharge outlet at the apex of the cone, the discharge of the slate and bony at the bottom of the tank is sufficiently delayed to present a barrier against the drop of good coal into the refuse outlet to any substantial extent; and, as already stated, by the time the bony and slate materials of the refuse have dropped out of the sorting tank down through the tubular section 3, the upflow current is restored to substantially its initial velocity or volume rate of flow of water.

In the foregoing description, the chamber 6 has been variously termed a water supply chamber and a boot because of its different functions. That chamber, under the feed of water from the pump thereto, serves as a water supply chamber for the hydraulic current to the sorting tank. It also serves as a boot for the refuse conveyor. That chamber, in association with the standpipe 43 connected thereto, also functions as a water expansion chamber since the water level rises and falls therein in response to increase and decrease in density of the materials in the sorting tank.

As shown in the diagrammatic view of Fig. 6, the inlet connection of the pipe 41 to the water expansion chamber 6 is but slightly below the minimum water level in that chamber, and as shown in the diagrammatic views of Figs. 7 and 8 that inlet connection is never very far below the water level. With such a disposal of the water inlet to the chamber 6 but slightly below the water levels maintained therein, any air trapped in the circulating water from the pump is very readily dispelled to the surface of the water in the chamber 6, thus ensuring the feed of a continuous solid mass of water, without air bubbles, from the water chamber 6 upwardly through the tubular connection to the sorting tank. This is a feature of considerable practical advantage, for air bubbles in the upflowing current of water to the sorting tank seriously interfere with the classification and separation of the materials in that tank.

What I claim is:

1. An apparatus for the hydraulic separation of coal or other mineral of lower specific gravity than the refuse materials mixed therewith comprising, in combination, a water-sorting chamber having an overflow at the top for discharge of the coal, a lower discharge for refuse materials and an hydraulic inlet formed for the delivery therethrough into said water-sorting chamber of water at a sufficient volume rate to produce a materials-classifying upflow current of water through said chamber, a water-expansion chamber connected to said hydraulic inlet and extending above said overflow discharge, means for continuously feeding water to said expansion chamber at a uniform volume rate sufficiently high to produce a materials-classifying upflow current in said sorting chamber at all times preventing settling of the coal downward to said lower discharge, said expansion chamber being so arranged that when thus fed with water the water level therein rises from and falls to a minimum height in response to increase and decrease in density of the materials in said sorting chamber, and a variable overflow device for said expansion chamber operating over the range of said rise and fall of the water level in said expansion chamber and arranged to deliver overflow water at a point outside the boundary walls of said water-sorting chamber at variable volume rates correspondingly reducing the volume rate of flow of the materials-classifying current of water through said sorting chamber.

2. An apparatus for the hydraulic separation of materials of different specific gravities comprising, in combination, a water-sorting chamber having discharges at different levels for classified materials, an hydraulic inlet at the bottom of said chamber formed for the delivery therethrough into said water-sorting chamber of water at a sufficient volume rate to produce a materials-classifying upflow current of water through said chamber, a water-supply chamber connected to said hydraulic inlet for the supply of water thereto and extending upwardly from said connection to an open top, said water-sorting chamber being arranged to receive its supply of water wholly from said water-supply chamber, means comprising a pump and a pipe leading from said pump to said water supply chamber below the open top thereof for feeding water to said water-supply chamber at a volume rate sufficiently high to produce an upflow current of sufficient velocity in said sorting chamber for the classification of materials therein and to maintain the water level in said water-supply chamber at all times above the water-feed inlet thereto but sufficiently near said water-feed inlet to permit the ready escape of entrained air from said pipe upwardly through the water in said water-supply chamber to atmosphere.

3. An apparatus for the hydraulic separation of materials of differing specific gravities comprising, in combination, a water-sorting chamber having discharges at different levels for classified materials, means supplying water to said sorting chamber, and means for mechanically agitating the fluid mass of water and materials comprising a rotatable shaft extending along the vertical axis of said chamber and a set of blades having a mounting on said shaft substantially below the uppermost discharge of said chamber and horizontally disposed blade portions above said mounting in the region of the upper discharge and spaced radially from the axis of said chamber.

4. An apparatus for the hydraulic separation of materials of differing specific gravities comprising, in combination, a water-sorting chamber having an open top for the discharge thereover of water and the lightest of said materials and a bottom discharge for heavier materials, a feed-in chute for said materials extending concentrically of said chamber through its top to a delivery end substantially below said top, means supplying water to said chamber, and means for mechanically agitating the fluid mass of water and materials comprising a rotatable shaft extending along the vertical axis of said chamber and a set of blades having a mounting on said shaft below the delivery end of said chute and horizontal blade portions supported from said mounting and disposed about said chute above its delivery end.

5. An apparatus for the hydraulic separation of materials of differing specific gravities comprising, in combination, a water-sorting chamber of cone shape having its small end at the bottom and open for the flow of water upwardly therethrough and downward discharge of heavy materials, means for feeding a mixture of said materials to said chamber through its top, means

for supplying water to said chamber through its open bottom, and means for mechanically agitating the fluid mass of water and materials in the bottom portion of said chamber comprising a rotatable shaft extending along the vertical axis of said chamber and a set of blades having a mounting on said shaft substantially above the opening at the bottom of said chamber and horizontally disposed blade portions below said mounting adjacent the open bottom of the chamber and spaced radially from the vertical axis of said chamber.

6. An apparatus for the hydraulic separation of coal or other mineral of lower specific gravity than the refuse materials mixed therewith comprising, in combination, a cone-shaped water-sorting chamber having its small end at the bottom and open and its larger end at the top and open, means for feeding a mixture of said materials into said chamber through its open top, means supplying water to the open bottom of said chamber in a constantly flowing stream under sufficient head to provide a materials-classifying flow of water upwardly therethrough of constant velocity for a constant density of materials in said chamber and at all times sufficient to sustain the coal as the lightest material above the open bottom of said chamber, and means responsive to an increase in resistance offered to the entrance of said supply water to said chamber by accumulation of refuse in the bottom thereof to divert water of said stream from a point therein on the supply sides of said chamber directly to a point outwardly of the outer boundary wall thereof at such a volume rate and so progressively increasing with increase in said resistance as to progressively reduce the velocity of said materials-classifying flow of water upwardly through said water-sorting chamber and thereby speed the discharge of refuse materials through the open bottom of said chamber while still sustaining the coal as the lightest material above the discharge refuse within said chamber.

7. An apparatus for the hydraulic separation of materials of differing specific gravities comprising in combination, a water-sorting chamber having discharges at different levels for classified materials, means for feeding a mixture of said materials to said chamber, an hydraulic inlet to said chamber at its bottom, means comprising a water-supply duct connected to said hydraulic inlet and supply means delivering water to said duct at a predetermined volume rate providing a constantly flowing stream of water to said hydraulic inlet sufficient to produce a materials-classifying upflow current of water through said chamber at a predetermined velocity for a given density of materials therein, and means comprising a standpipe connected to said duct on the supply side of said chamber and having an overflow outlet at a higher level than said hydraulic inlet and a point of direct delivery outside the boundary walls of said chamber automatically operating upon increase in density of said materials in said sorting chamber and consequent increase in resistance to said upflow current to divert water of said stream away from said chamber at a volume rate increasing with increase in density of said materials and sufficient to progressively reduce the velocity of said upflow current through said chamber below said predetermined velocity.

8. An apparatus for the hydraulic separation of coal or other mineral of lower specific gravity than the refuse materials mixed therewith comprising, in combination, a cone-shaped water-sorting chamber having its small end at the bottom and open and its larger end at the top and open, means for feeding a mixture of said materials into said chamber through its open top, a water-expansion chamber connected to the open bottom of said water-sorting chamber and extending above the open top thereof, means for continuously feeding water to said expansion chamber at a uniform volume rate sufficiently high to produce a materials-classifying upflow current in said sorting chamber at all times preventing substantial settling of coal downward through the open bottom of said sorting chamber, said expansion chamber being so arranged that when thus fed with water the water level therein rises from and falls to a minimum height in response to increase and decrease in density of the materials in said sorting chamber, and a standpipe connected with said water-expansion chamber having a V-shaped over-flow outlet out of delivery relation to said water-sorting chamber with the apex of said outlet downward and so slightly above said minimum level of the water in said expansion chamber as to cause no discharge of water through said outlet at said minimum level of water but to cause variable discharge of water through said outlet during said rise and fall of the water level in said expansion chamber.

9. An apparatus for the separation of coal or the like mineral of lower specific gravity than the refuse materials mixed therewith comprising, in combination, a water-sorting tank having a main body portion of cone shape with smaller end downward and an upper cylindrical portion with an open rim at the top for the discharge thereover of separated coal, said cylindrical portion being of sufficient depth to effect the accumulation therein of a substantial body of coal when separated from the mixture, means supplying water to said tank at its bottom and in line with its vertical axis for upflow therethrough and over its rim for separation of the coal and overflow discharge of the same, a cylindrical feed-in chute for the coal mixture disposed concentrically of the vertical axis of said tank at the top thereof and having its delivery end portion extending below but sufficiently close to the lower level of said cylindrical portion of said tank to avoid substantially limiting the cross-sectional flow area of classifying current in the cone-shaped portion of said tank, a rotary deflector member disposed concentrically with the vertical axis of said tank immediately below the delivery end of said chute and spaced therefrom a less distance than its spacing from the bottom of said cone-shaped portion of said tank, said deflector member having a bottom face adapted to deflect the upflowing water away from the vertical axis of said tank and to paths of travel avoiding the delivery end of said chute and a top face adapted to deflect the materials delivered from said chute into the path of the deflected water, and an additional deflector member disposed about said feed-in chute above its delivery end, spaced from the side boundary walls of said tank and adapted to deflect the upflowing water away from said feed-in chute toward the side walls of said cylindrical portion of the tank.

10. An apparatus as defined in claim 9 and further characterized by said additional deflector member being vertically adjustable to different levels including a position substantially at the delivery end of said feed-in chute.

11. An apparatus for the hydraulic separation of coal or other mineral of lower specific gravity than the refuse materials mixed therewith comprising, in combination, a water-sorting chamber having an overflow outlet at its top for the coal and a discharge outlet in its lower part for the refuse materials, a water-supply conduit connected to the bottom of said chamber for the supply of water thereto to form the classifying current, means automatically operating to continuously feed water to said conduit at a uniform volume rate producing a stream of water flowing through said conduit toward said chamber and at a sufficient volume rate of flow into said chamber for a given density of materials therein to form a materials-classifying upflow current separating coal from the refuse and discharging said coal over said overflow outlet, and means automatically operating in response to changes in density of said materials through a range of densities above said given density to divert water of said stream from a point therein in said conduit directly to a point of delivery located outwardly of said conduit and outwardly of the boundary walls of said sorting chamber at a volume rate so progressively increasing and decreasing with increase and decrease in density of said materials as to reduce in varying degrees dependent on the changes in density of said materials the velocity of said upflow current through said chamber.

12. An apparatus for the hydraulic separation of coal or other mineral of lower specific gravity than the refuse materials mixed therewith comprising, in combination, a water-sorting chamber having an overflow outlet at its top for the coal and a discharge outlet in its lower part for the refuse materials, a water-supply conduit connected to the bottom of said chamber for the supply of water thereto to form the classifying current, means automatically operating to continuously feed water to said conduit at a uniform volume rate producing a constantly flowing stream of water through said conduit into said chamber at a sufficient volume rate to produce a materials-classifying upward current therein at all times preventing settling of substantial amounts of coal downward to said lower discharge, stand-pipe means connected to said water-supply conduit and so arranged that when said conduit is thus fed with water the water level rises from and falls to a minimum height in said stand-pipe means in response to increase and decrease in density of the materials in said sorting chamber, and variable-overflow means for said stand-pipe means automatically operating over the range of said rise and fall of water level to divert water from said stream at a point therein on the supply side of said sorting chamber through said stand-pipe means and overflow therefrom directly to a point outside said conduit and outside the boundary walls of said sorting chamber at volume rates so progressively increasing and decreasing with said rise and fall of said water level as to reduce the velocity of the materials-classifying current of water through said sorting chamber in varying degrees dependent upon the extent of change in density of said materials.

13. An apparatus for the hydraulic separation of materials of differing specific gravities comprising, in combination, a water-sorting chamber having discharges at different levels for classified materials and an hydraulic inlet at its bottom for the supply of water for the classifying current, a water-supply column connected to said hydraulic inlet and extending above the uppermost discharge from said chamber, means automatically operating to continuously feed water to said column at a uniform volume rate sufficient to maintain said column at a given head level for a given density of materials in said chamber and produce for said given density of materials an upward classifying current separating out material of lowest specific gravity and discharging the same from said chamber, and overflow means for said water-supply column comprising an overflow wall disposed above said given head level in said column within the range of rise of water therein consequent on increase in density of materials in said sorting chamber and having an overflow boundary of increasing area in the direction of the water rise, said overflow means having its point of delivery located outwardly of the outer boundary of said sorting chamber.

14. An apparatus as defined in claim 13 and further characterized by said overflow wall having its overflow boundary or rim extending in opposed lines diverging upwardly from a common point.

15. An apparatus as defined in claim 13 and further characterized by said overflow wall having its overflow boundary or rim of V-shape.

16. An apparatus as defined in claim 13 and further characterized by means for vertically adjusting said overflow wall.

WILLIAM C. MENZIES.

CERTIFICATE OF CORRECTION.

Patent No. 1,990,129. February 5, 1935.

WILLIAM C. MENZIES.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 1, second column, line 17, for "valve" read value; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 23rd day of April, A. D. 1935.

Leslie Frazer

(Seal)