July 11, 1944. J. A. BRUSSET 2,353,543

APPARATUS FOR CLASSIFYING AND SEPARATING PARTICLES OF MATERIALS OF DIFFERENT SPECIFIC GRAVITIES

Filed April 13, 1942 3 Sheets-Sheet 1

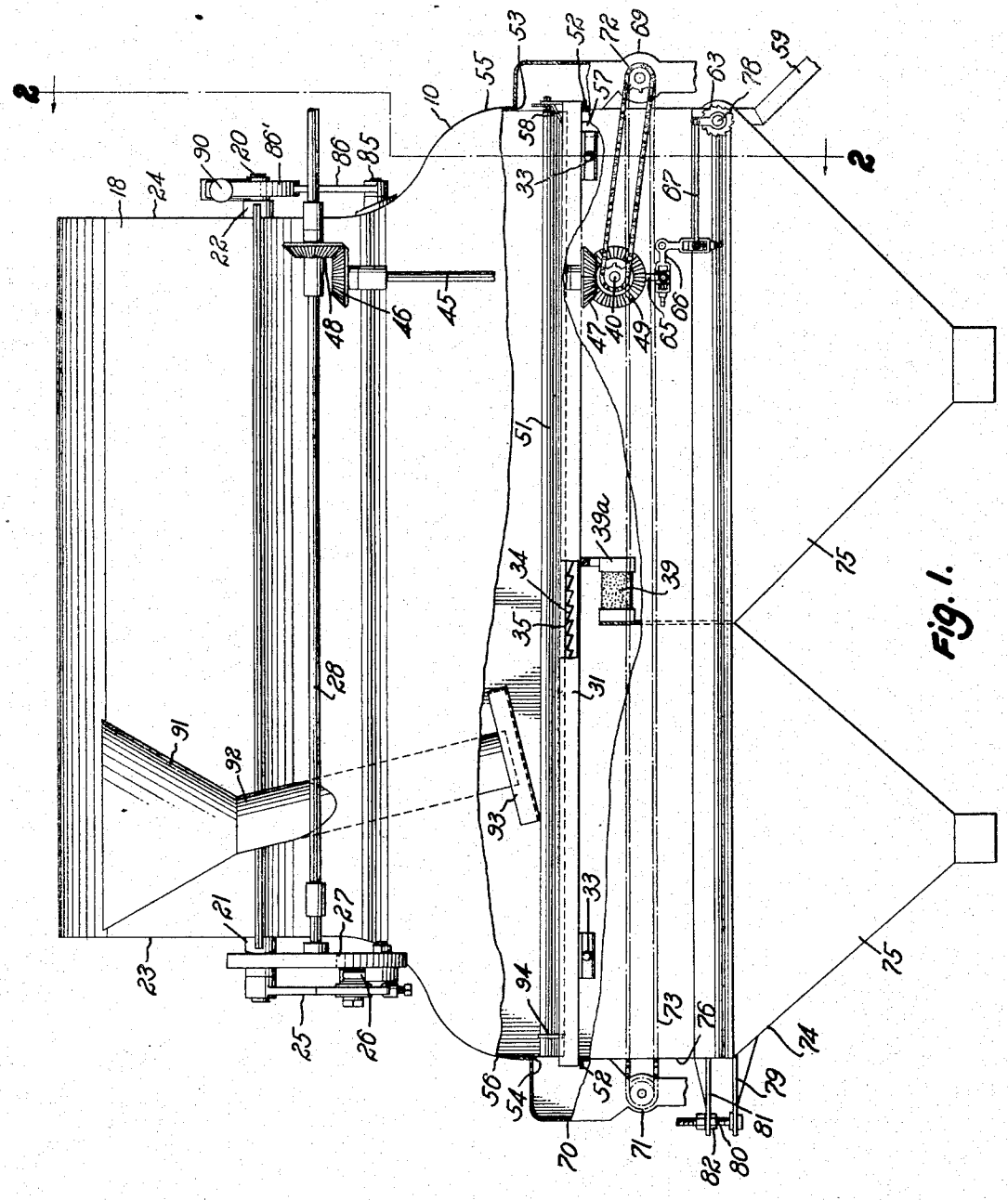


Fig. 1.

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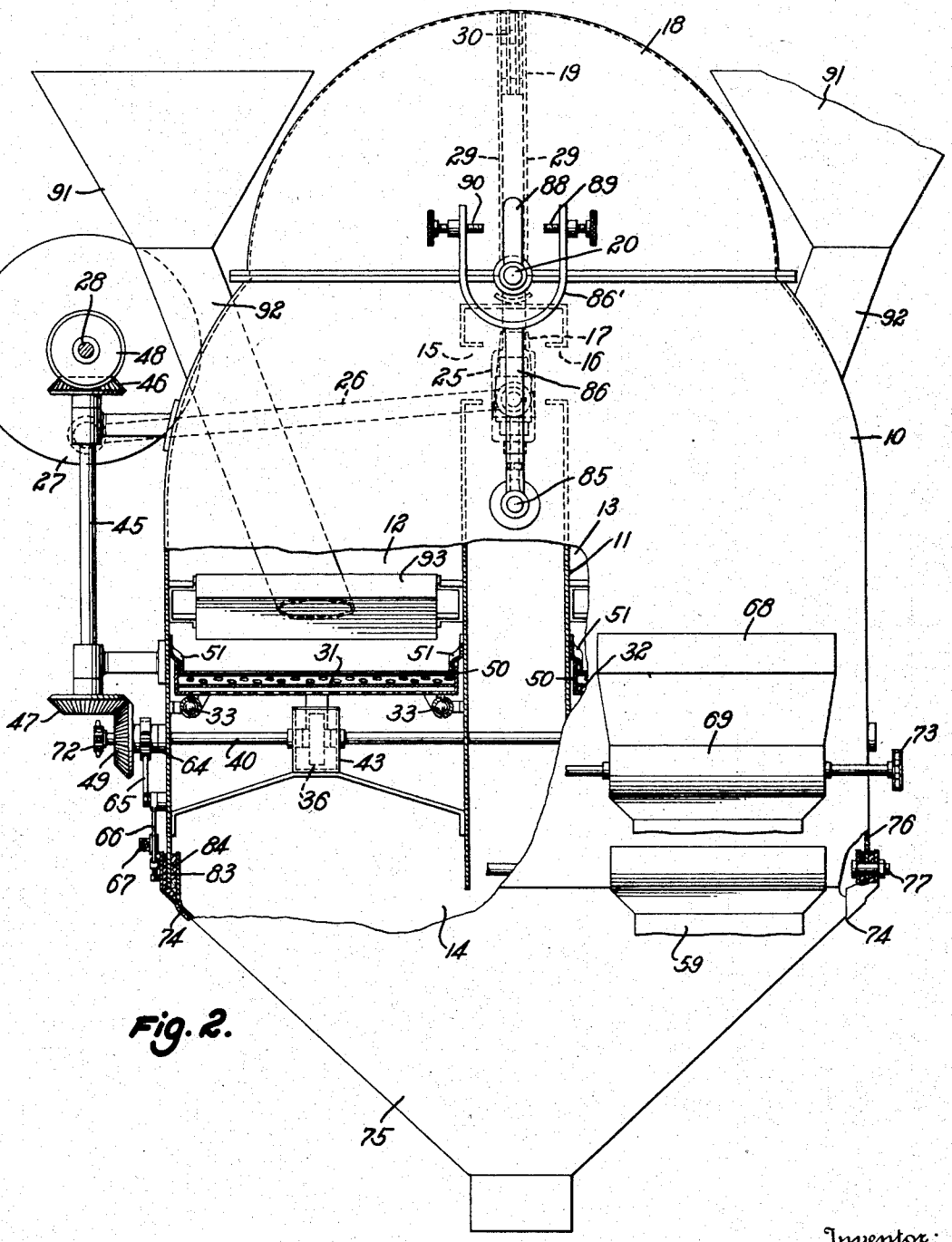


Fig. 2.

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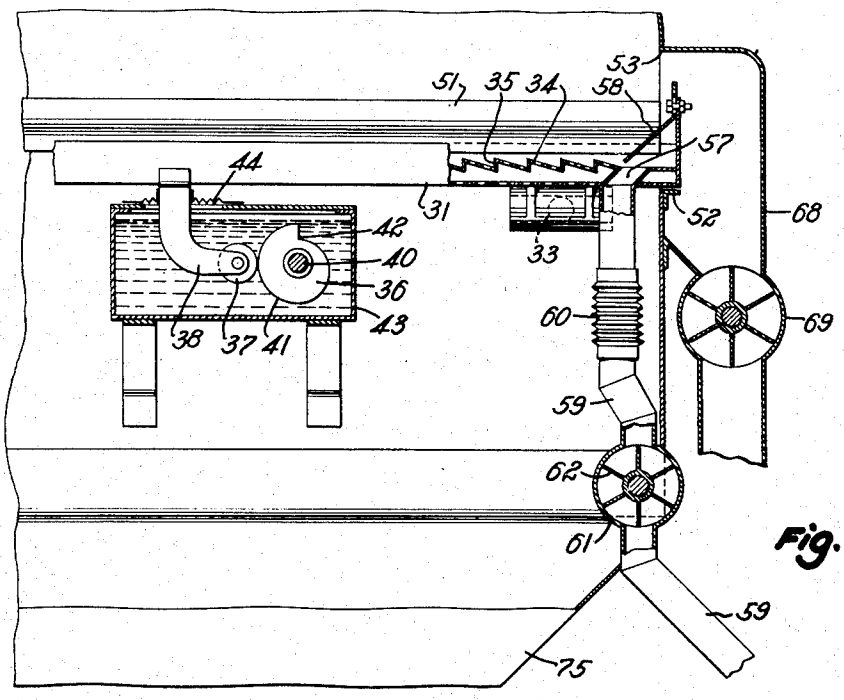


Fig. 3.

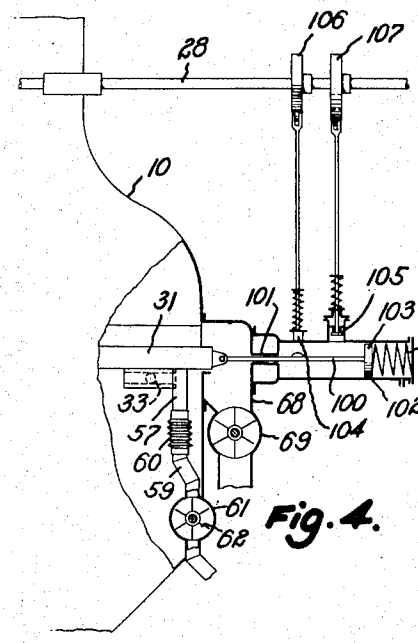


Fig. 4.

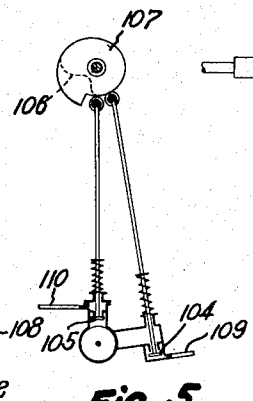


Fig. 5.

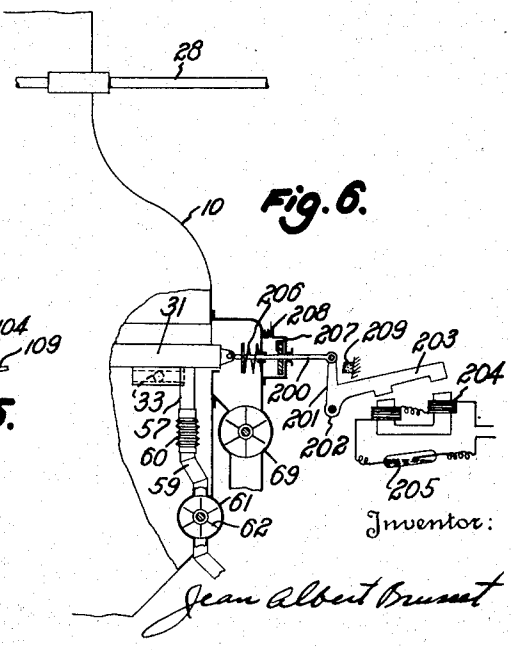


Fig. 6.

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UNITED STATES PATENT OFFICE

2,353,543

APPARATUS FOR CLASSIFYING AND SEPARATING PARTICLES OF MATERIALS OF DIFFERENT SPECIFIC GRAVITIES

Jean Albert Brusset, Blairmore, Alberta, Canada

Application April 13, 1942, Serial No. 438,810

10 Claims. (Cl. 209—469)

This invention relates to improvements in process and apparatus for classifying and separating mixtures of particles of materials of different specific gravities and particularly to improvements in the apparatus and process described and claimed in my prior United States Patent No. 2,241,842, granted May 13, 1941.

It is an object of the present invention to provide for better separation of mixtures including gritty and sticky components, which have heretofore presented difficulties, by providing more positive and energetic action, effecting a separatory translational movement of the heavier components to a discharge zone remote from the discharge zone for the light particles and intermediate weight particles or middlings.

Another object is to provide for the separation of the mixture into a light product, a middlings product and a heavy product and to provide novel means effective to impart translational movement in opposite directions to the middlings and heavy products and to separately extract the same at different points.

Another object of the invention is to provide for adjustment in the rate of middlings discharge to provide control of the quality, or ash content of the middlings in the case of coal.

Other objects and advantages of the invention will be disclosed in the following detailed description with reference to the accompanying drawings which illustrate preferred embodiments of the invention. In the drawings:

Fig. 1 is a side elevation of a preferred embodiment of the invention, with parts in section,

Fig. 2 is an end elevation with parts in section on line 2—2 of Fig. 1,

Fig. 3 is a sectional detail on an enlarged scale,

Fig. 4 is a fragmentary side elevation, with parts broken away and in section, showing a modified form of deck driving means,

Fig. 5 is an end view of control means on Fig. 4, and

Fig. 6 is a side elevation, with parts broken away and in section, showing another form of deck drive.

Referring more particularly to the drawings, 10 indicates an elongated housing which is longitudinally divided by a central vertical partition wall 11 to provide two similar separating chambers 12 and 13. The partition wall 11 is hollow and is closed at its upper end but opens at its lower end into the space 14 in the lower portion of the housing 10 which extends beneath both separating chambers. The separating chambers 12 and 13 are in controlled communication with the interior of the hollow partition wall 11, and through it to the space beneath, through valved openings 15 and 16, respectively, which are opened and closed by a double-acting swinging flap valve 17 mounted within the hollow wall.

The upper end of the housing 10 is closed by a semi-cylindrical shell or cap 18 which extends longitudinally of the housing and is centered with respect to the partition wall 11 and the classifying chambers 12 and 13. The inner surface of the shell 18 forms a working surface for a double acting oscillating piston in the form of a pivoted wing 19 which is welded along one edge to a rock shaft 20 mounted at the upper end of the partition 11. The rock shaft 20 is journalled at its ends in bearings 21 and 22 carried by the end walls 23 and 24, respectively, of the housing 10 and is provided at one end with a crank arm 25 which is connected through a link 26 and eccentric 27 to the power shaft 28 which is power driven as by an electric motor, not shown. Suitable means are provided for varying the effective length of the arm 25 and stroke of the eccentric 27 in order to adjust the stroke of the wing piston 19 to suit varying conditions encountered in the operation of the apparatus.

The wing piston is preferably formed of spaced metal sheets 29 with two or more steel blades 30 secured between them. This construction produces a cascade seal of four joints between the edge of the piston and the inner wall of the semi-cylindrical cap 18 which forms the walls of the double-acting pump and the seal thus effected permits a clearance of about $\frac{1}{32}$ of an inch between the piston and wall to avoid wear due to dust particles in the atmosphere within the chamber while providing an efficient seal.

Mounted in each of the compartments 12 and 13 is a pervious support for a bed of materials to be processed, the supports being in the form of inclined decks 31 and 32, respectively, mounted on ball bearings 33 for reciprocation in their own planes. The decks 31 and 32 are formed of perforated sheet metal of stepped formation providing slanting faces 34 upwardly inclined toward the high end of the decks and steep, substantially vertical shoulders or faces 35 joining the upper and lower edges of adjacent slanting faces 34.

A differential drive is provided for imparting reciprocating motion to the decks 31 and 32 so that they are driven relatively slowly in the forward direction, that is, toward the higher end thereof and are snapped back quickly in the opposite direction. Preferably the differential drives comprise rotary cams 36 acting on rollers 37 car-

ried by depending arms 38 rigidly attached to the decks for imparting the slow forward motion thereto. The accelerated return or backward motion of the decks is under the influence of resilient rubber blocks 39 which act as springs to urge the decks to the retracted position. The rubber blocks are mounted between brackets 39a on the decks and a stationary part of the casing. The cams 36 are identical except that they are adjusted on the drive shaft 40 with one rotated 180° with respect to the other so that the decks reciprocate in opposite phase. The cams 36 are provided with a profile having a gradually rising portion 41 which imparts the slow movement to the decks in the forward or upward direction and a sharply falling portion 42 at the top of the portion 41 which permits rapid return of the decks under action of the resilient rubber blocks 39. The cams 36 run in an oil bath in casings 43 and the arms 38 extend into the casings 43 through flexible rubber seals 44 which prevent dust and dirt from reaching the working surfaces of the cams and rollers. The shaft 40 is driven from the power shaft 28 by a transmission shaft 45 having bevel gears 46 and 47 at opposite ends thereof which mesh with bevel gears 48 and 49 on the shafts 28 and 40, respectively.

The spaces between the side edges of the decks 31 and 32 and the side walls of the casing and partition wall 11 are sealed against free passage of air between the spaces above and below the decks by upstanding flanges 50 carried at the edges of the decks and cooperating depending sealing flanges 51, mounted on the casing walls and on wall 11, which overlap the lips 50. Air seals at the ends of the decks comprise flat flanges 52 mounted along the bottom edges of openings 53 and 54 in the end walls 55 and 56 of the casing through which the ends of the decks project. The decks at the ends thereof are formed with flat imperforate under surfaces parallel to and in close proximity to the flanges 52.

Adjacent the lower, or right-hand ends of the decks, as viewed in the drawings, the stepped surfaces thereof terminate in middlings discharge slots or channels 57. The upper ends of the channels are disposed beneath inwardly inclined strike-off plates 58 which are mounted at the ends of the deck frames and are vertically adjustable with respect to the surface of the decks to control the depth of the passage between the lower edge thereof and the surface of the decks and thus the amount and quality of the middlings cut.

The middlings discharge channels 57 each discharge into a discharge tube 59 to which they are connected by a flexible connection 60, and the discharge tubes are provided with star extractors 61 providing an air seal. The star wheels 62 of the extractors 61 are driven by adjustable pawl and ratchet drives 63 driven by a cam 64, link 65, bell crank 66 and link 67 from the shaft 40. By adjusting the points of connection of the links 65 and 67 on the bell crank the throw of the pawls and thus the speed or rotation of the middlings discharge extractors is varied to regulate the rate of middlings discharge. By adjusting the volume of middlings discharged by extractors 61 the depth of the lower coal bed containing the middlings is correspondingly controlled. Increasing the volume of middlings discharged will result in removal of a greater portion of the lower bed through the middlings discharge channel 57, resulting in a middlings cut of lower ash content, while decreasing the volume will result in removal of a lesser portion, resulting in a middlings cut of higher ash content.

The lighter materials, clean coal in the case of coal separation, are discharged over the strike-off plates 58 at the lower end of the decks into discharge channels 68 mounted on the housing 10 and likewise each equipped with a star extractor 69 to provide an air seal preventing passage of air into the chambers 12 and 13 through the outlet passages.

The heavy tailings or refuse, which during operation of the machine travel upwardly along the decks due to the reciprocating action and stepped formation thereof, pass over the upper ends of the decks into discharge channels 70, also each equipped with a star extractor 71 providing an air seal. The star extractors 69 and 71 in the clean coal and refuse discharge channels 68 and 70, respectively, are preferably driven by chain drives 72 and 73 from shaft 40 at a speed calculated to discharge the maximum amount of material to be handled thereby so as to prevent undue backing up of coal or refuse in the respective discharge channels.

In order to provide for adjustment of the slope of the decks to suit requirements for handling various types of mixtures, the housing 10 is formed in two main parts. The lower part 74 comprising the base and dust hoppers 75 is stationary while the upper part 76, mounting the decks and other operative mechanism is tiltable on the lower part about a horizontal pivotal axis 77 at the right-hand end of the apparatus, substantially coincident with the axis of the shaft 78 of middlings star extractors 61. At the opposite end the stationary part 74 carries at each side a bracket 79 mounting a jack screw 80 and the tiltable part 76 carries at each side a bracket 81 for cooperation with jack nuts 82 threaded on the respective jack screws. The jack screw arrangement provides for adjustment of the tilt of the upper casing half over a range of about 6° so that the decks 31 and 32 which are mounted in the upper half with an initial slope of about 4° are adjustable over a range of slopes of from 4° to 10°.

In order to seal the meeting edges of the upper and lower parts of the casing, the lower half is provided with a U-shaped channel 83 along the upper edge thereof which is lined with felt 84, or the like and the lower edge of the upper half is fitted within the channel in contact with the felt lining therein.

During the operation of the apparatus, a small amount of air will be drawn through the beds on the decks from the space underneath, which if allowed to accumulate above the beds would soon affect the value of the reduced pressure produced on the suction stroke of the wing piston 19. The excess air thus drawn through the beds at each stroke of the piston is returned to the common space beneath the decks by means of the relief valve 17 and hollow partition 11. The valve is preferably formed of a thick piece of rubber carried on a rock shaft 85 which is actuated from the piston shaft 20. As seen in Fig. 3, an upstanding arm 86 is mounted on the end of the shaft 20 and is provided at its upper end with a U-shaped yoke 86' which straddles the end of the rock shaft 20. A cam finger 88 is keyed on the end of the rock shaft 20 and the arms of the yoke 86' are provided with adjustable stops 89 and 90 which are engaged by the finger 88 to shift the valve 17 in synchronism with the motion of the shaft 20 and wing piston 19 so that it is closed during the latter part of the compression stroke

and remains closed during the greater part of the suction stroke and is then opened during the latter part of the suction stroke on each side.

The mixed material to be classified is fed into each stratifying chamber from hoppers 91 through chutes 92 which deliver the material onto distributing trays 93 mounted on the respective decks 31 and 32 in elevated position about one-third of the length of the decks from the upper ends thereof. The trays 93 are open on the side facing the upper end of the decks and mixed material fed onto the trays through chutes 92 is spread onto the beds on the decks as the same falls from the open side of the trays due to the reciprocating motion thereof.

The drive to the reciprocating decks 31 and 32 is timed with respect to the oscillation of the wing piston 19 and the inclination of the decks is such that at the beginning of the upstroke of the piston in relation to one compartment, the deck in that compartment is moving in the direction of the high end thereof and when the suction stroke has progressed to the point at which the greatest vacuum is produced above the bed, the deck will be moved rapidly in the opposite direction. During the latter part of the suction stroke and during the return stroke of the piston, the deck will again be moved slowly in the direction of the high end. This timing and action of the deck and piston causes the heavier material to travel against the force of gravity toward the high end of the decks. The reason for this is that the heavier material stratifies into a lower layer in frictional contact with the decks, but during the portion of the suction stroke at which the greatest vacuum is produced and during which the lighter constituents are lifted, the deck is kicked away from under the lower layer as the deck moves quickly in the direction of its lower end. The bed then falls back into full contact with the deck and by frictional contact therewith the heavy under layer moves with the deck toward the high end thereof as the cam moves the deck forwardly slowly, with no tendency of the heavy materials to slide toward the light materials extractors.

As the heavier material travels toward the high end of the decks it passes under a transverse baffle weir 94, which acts as a stop for lighter material in the upper layer, and discharges over the upper edge of the decks into the delivery chute 70. The lighter and middling material, which rises in the beds and is thus not subjected to the frictional action of the decks, travels toward the lower end of the latter and discharges respectively under and over the strike-off plates 58 into the delivery chutes 57 and 68.

Referring to Figs. 4 and 5 wherein a modified form of drive for the decks 31 and 32 is illustrated, a connecting rod 100 fastened to one end of the deck extends through a seal 101 in the casing wall into a cylinder 102 and is connected to a piston 103 slidable within the cylinder. The cylinder is provided with fluid pressure admission valve 104 and exhaust valve 105 controlled by cams 106 and 107, respectively driven from the shaft 28. The piston 103 is moved by fluid pressure against a spring 108 in the end of the cylinder to move the deck in one direction and upon relief of fluid pressure to spring returns the piston and deck in the other direction. Fluid pressure, which may be air or a liquid under pressure, is supplied to admission valve 104 through a line 109 connected to a suitable source, not shown, and flows off from exhaust valve 105 through a line 110 which may be open to atmosphere if compressed air is used or may lead to a low pressure sump if oil or other liquid is employed as the pressure fluid. The contour and disposition of the cams 106 and 107 is such that the decks on each side will be driven in timed relation to the operation of the piston and with a differential motion as described more particularly heretofore. In the operative cycle, the valve 104 is opened wide to admit fluid pressure into the cylinder for a short period corresponding to the desired portion of the vacuum period above the deck, thereby causing a rapid motion of the deck toward its lower end and compressing the spring 108. The valve 104 then closes and the relief valve 105 is opened by cam 107 to relieve the fluid pressure within the cylinder. The relief of fluid pressure from the cylinder is gradual as compared with its admission so that the spring 108 returns the deck and piston more slowly in the upward direction. The return motion may be made as slow as required by varying the shape of the cam to regulate the amount of opening of the relief valve so that the fluid escaping therefrom causes the piston and cylinder to act as a dashpot to slow the return of the piston under the influence of the spring.

An electrically operated differential drive is shown in Fig. 6. In this embodiment of the invention the deck 31 is connected by a rod 200 to one arm 201 of a bell crank lever 202, the other arm of which forms the armature 203 of electromagnetic coils 204 the energization of which is controlled by mercury tilt switch 205 operated in timed relation to the shaft 28 so that the deck is rapidly moved in the direction of its lower end upon energization of electromagnets during the desired portion of the vacuum period above the deck. The deck is returned by a spring 206 and its motion is slowed by a dash-pot 207, the piston of which is mounted on the connecting rod 200. An adjustable outlet 208 controls the action of the dash-pot. A rubber stop block 209 for the arm 201 and the strength of spring 206 control the length of stroke imparted by the electromagnet.

The construction and operation of the remaining portions of the modified apparatus of Figs. 4 to 6 is otherwise the same as that of the preferred form and for this reason only so much of the apparatus has been illustrated as deemed necessary to afford a clear understanding of the alternative drives. Although the drive for only one deck is shown in Figs. 4 to 6, it will be understood that the drives are duplicated for the other deck in a double unit.

Although a preferred embodiment of the invention has been described and shown by way of example, it will be understood that various modifications in the details of construction and operation may be resorted to without departing from the spirit of the invention within the scope of the appended claims.

I claim:

1. In apparatus for classifying a mixture of materials according to specific gravity, a closed compartment, a reciprocating inclined stepped deck mounted in said compartment with the faces of the steps thereof facing the higher end thereof, means for establishing successively vacuum and pressure conditions above the deck, and means for imparting reciprocating motion to said deck, said means effective to advance said deck relatively slowly in the facing direction of the steps thereof and to retract the deck rapidly in the opposite direction in timed relation to the

establishment of said vacuum and pressure conditions above the deck, the timing being correlated so that the retraction of said deck occurs during the establishment of vacuum condition above the deck whereby the retraction of the deck is effected without producing retrograde movement of heavy particles in contact with the deck.

2. In apparatus for classifying a mixture of materials according to specific gravity, a closed compartment, a reciprocating inclined stepped deck mounted in said compartment with the faces of the steps facing the higher end thereof, means for establishing successively vacuum and pressure conditions above said deck, and means for imparting differential reciprocating motion to said deck in the plane thereof in timed relation to establishment of said vacuum and pressure conditions said means comprising cam means for advancing said deck relatively slowly in the direction of the higher end thereof and resilient means for returning said deck quickly in the opposite direction the timing of the motion of said deck to the establishment of vacuum and pressure conditions above the deck being such that the quick return motion of the deck occurs during the vacuum period above the deck whereby the return motion of the deck is effected without producing retrograde movement of heavy particles in contact with the deck.

3. In apparatus for classifying a mixture of materials according to specific gravity, a closed compartment, a reciprocating inclined stepped deck mounted in said compartment with the faces of the steps facing the higher end thereof, means for establishing successively vacuum and pressure conditions above said deck, and means for imparting differential reciprocating motion to said deck in the plane thereof in timed relation to establishment of said vacuum and pressure conditions said means comprising fluid pressure means for moving said deck rapidly in the direction of the lower end thereof, resilient means for returning the deck in the opposite direction and means for retarding the return motion of the deck.

4. In apparatus for classifying a mixture of materials according to specific gravity, a closed compartment, a reciprocating inclined stepped deck mounted in said compartment with the faces of the steps facing the higher end thereof, means for establishing successively vacuum and pressure conditions above said deck, means for imparting differential reciprocating motion to said deck in the plane thereof in timed relation to establishment of said vacuum and pressure conditions said means comprising electromagnetic means for moving said deck rapidly in the direction of the lower end thereof, resilient means for returning the deck in the opposite direction and means for retarding the return motion of the deck.

5. In apparatus for classifying a mixture of materials according to specific gravity, a closed compartment, a reciprocating inclined stepped deck mounted in said compartment with the faces of the steps facing the higher end thereof, means for establishing successively vacuum and pressure conditions above said deck, means for imparting differential reciprocating motion to said deck in the plane thereof, said means comprising cam means for advancing said deck relatively slowly in the direction of the higher end thereof and resilient means for returning said deck quickly in the opposite direction, and means for driving said cam means in timed relation to the means for establishing vacuum and pressure conditions above the deck to effect the quick return motion of the deck during the establishment of vacuum conditions above the deck whereby the retraction of the deck is effected without producing retrograde movement of heavy particles in contact with the deck.

6. In apparatus for classifying a mixture of materials according to specific gravity, a closed compartment, a reciprocating inclined stepped deck mounted in said compartment with the faces of the steps facing the higher end thereof, means for establishing successively vacuum and pressure conditions above said deck, means for imparting differential reciprocating motion to said deck in the plane thereof, said means comprising fluid pressure means for moving said deck rapidly in the direction of the lower end thereof, resilient means for returning the deck in the opposite direction and means for retarding the return motion of the deck, and means for controlling actuation of said fluid pressure means in timed relation to the means for establishing vacuum and pressure conditions above the deck.

7. In apparatus for classifying a mixture of materials according to specific gravity, a closed compartment, a reciprocating inclined stepped deck mounted in said compartment with the faces of the steps facing the higher end thereof, means for establishing successively vacuum and pressure conditions above said deck, means for imparting differential reciprocating motion to said deck in the plane thereof said means comprising electromagnetic means for moving said deck rapidly in the direction of the lower end thereof, resilient means for returning the deck in the opposite direction and means for retarding the return motion of the deck and means for energizing said electromagnetic means in timed relation to the means for establishing vacuum and pressure conditions above the bed.

8. In apparatus for classifying a mixture of materials according to specific gravity, a closed compartment, means for supporting a bed of materials to be separated comprising a reciprocating inclined stepped deck mounted in said compartment with the faces of the steps facing the higher end thereof, means for establishing successively vacuum and pressure conditions above said deck, means for imparting differential reciprocating motion to said deck in the plane thereof, said means being effective to advance said deck relatively slowly in the facing direction of the steps thereof and to retract the deck rapidly in the opposite direction in timed relation to establishment of said vacuum and pressure conditions, the timing being correlated so that the retraction of said deck occurs during the establishment of a vacuum condition above said deck whereby the retraction of said deck is effected without producing retrograde movement of heavy particles in contact with said deck, means for withdrawing heavy separated products from the bottom of the bed of materials adjacent the higher end of said deck, means for withdrawing separated middlings from adjacent the bottom of the bed of materials at the lower end of said deck, means for withdrawing lighter separated products from the top of the bed adjacent the lower end of the deck, and means for adjusting the rate of middlings withdrawal independently of the rate of withdrawal of the lighter separated products.

9. In apparatus for classifying a mixture of materials according to specific gravity, a closed compartment, means for supporting a bed of materials to be separated comprising a reciprocating inclined stepped deck mounted in said compartment with the faces of the steps facing the higher end thereof, means for establishing successively vacuum and pressure conditions above said deck, means for imparting differential reciprocating motion to said deck in the plane thereof, said means being effective to advance said deck relatively slowly in the facing direction of the steps thereof and to retract the deck rapidly in the opposite direction in timed relation to establishment of said vacuum and pressure conditions, the timing being correlated so that the retraction of said deck occurs during the establishment of a vacuum condition above said deck whereby the retraction of said deck is effected without producing retrograde movement of heavy particles in contact with said deck, means for withdrawing heavy separated products from the bottom of the bed adjacent the higher end of said deck, means for withdrawing separated middlings from adjacent the bottom of the bed adjacent the lower end of said deck, means for withdrawing lighter separated products from the top of the bed adjacent the lower end of the deck, said middlings withdrawal means comprising a star wheel extractor and adjustable drive means for adjusting the rate of rotation of said star wheel extractor whereby to adjust the rate of middlings withdrawal independently of the rates of withdrawal of the heavy separated products and of the lighter separated products.

10. In apparatus for classifying a mixture of materials according to specific gravity, a closed compartment, a reciprocating inclined stepped deck mounted in said compartment with the faces of the steps facing the higher end thereof, means for establishing successively vacuum and pressure conditions above said deck, means for imparting differential reciprocating motion to said deck in the plane thereof, said means being effective to advance said deck relatively slowly in the facing direction of the steps thereof and to retract the deck rapidly in the opposite direction in timed relation to establishment of said vacuum and pressure conditions, the timing being correlated so that the retraction of said deck occurs during the establishment of a vacuum condition above said deck whereby the retraction of said deck is effected without producing retrograde movement of heavy particles in contact with said deck, discharge chutes for delivering of heavy material from the bottom of the bed adjacent the upper end of said deck, middlings from adjacent the bottom of the bed at the lower end of said deck and light material from the upper part of the bed at the latter end, rotatable star wheel extractors in each of said chutes to maintain a sealing body of separated materials in said discharge chutes against admission of air into said compartment through said chutes, and means for adjusting the speed at least of the star extractor in the middlings discharge chute independently of the speeds of the other extractors.

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