July 4, 1950 C. V. ORE 2,513,960

MOVABLE DECK PNEUMATIC COAL CLEANER

Filed Feb. 13, 1947 2 Sheets-Sheet 1

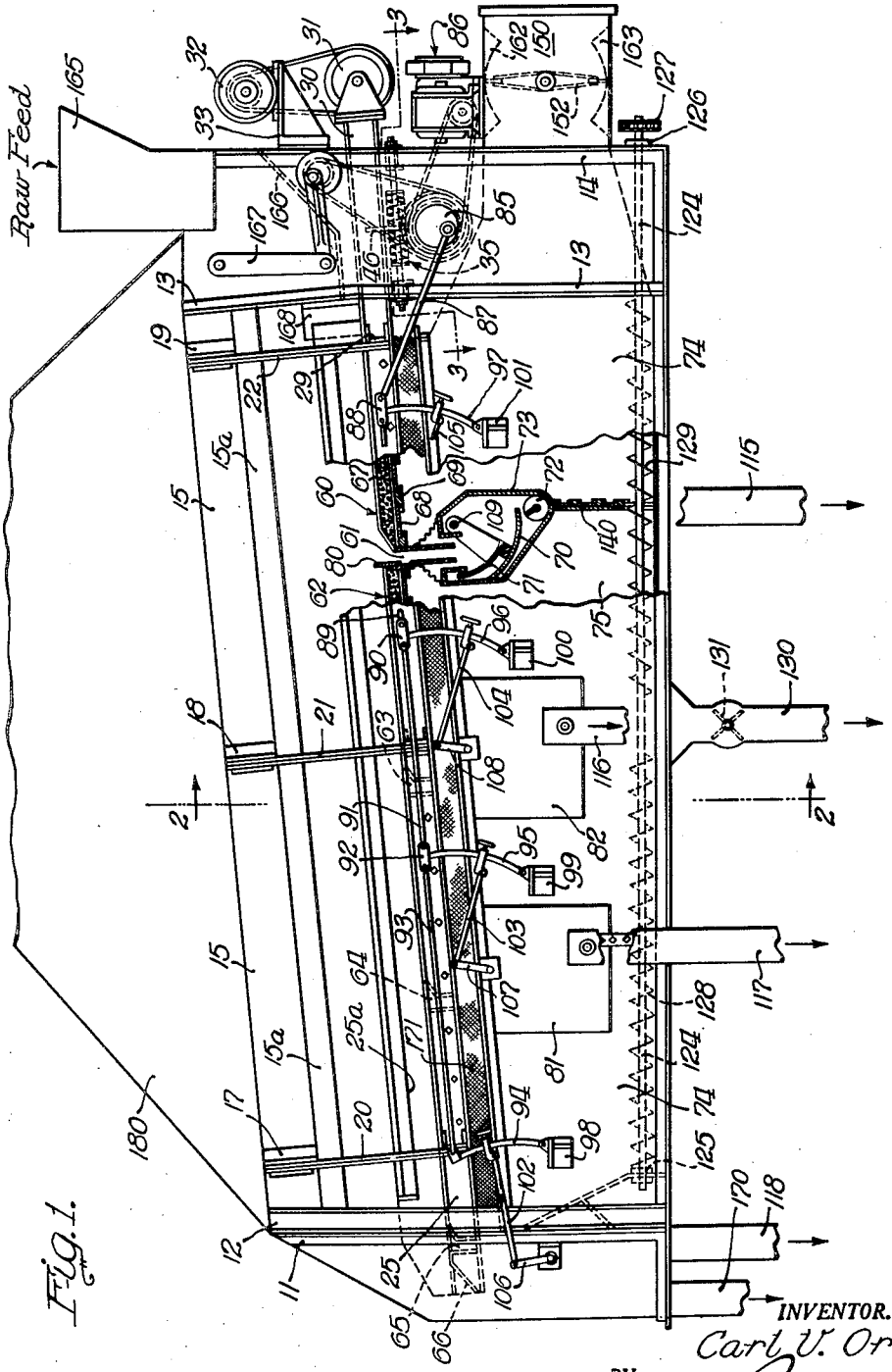

Fig. 1.

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Fig. 2.

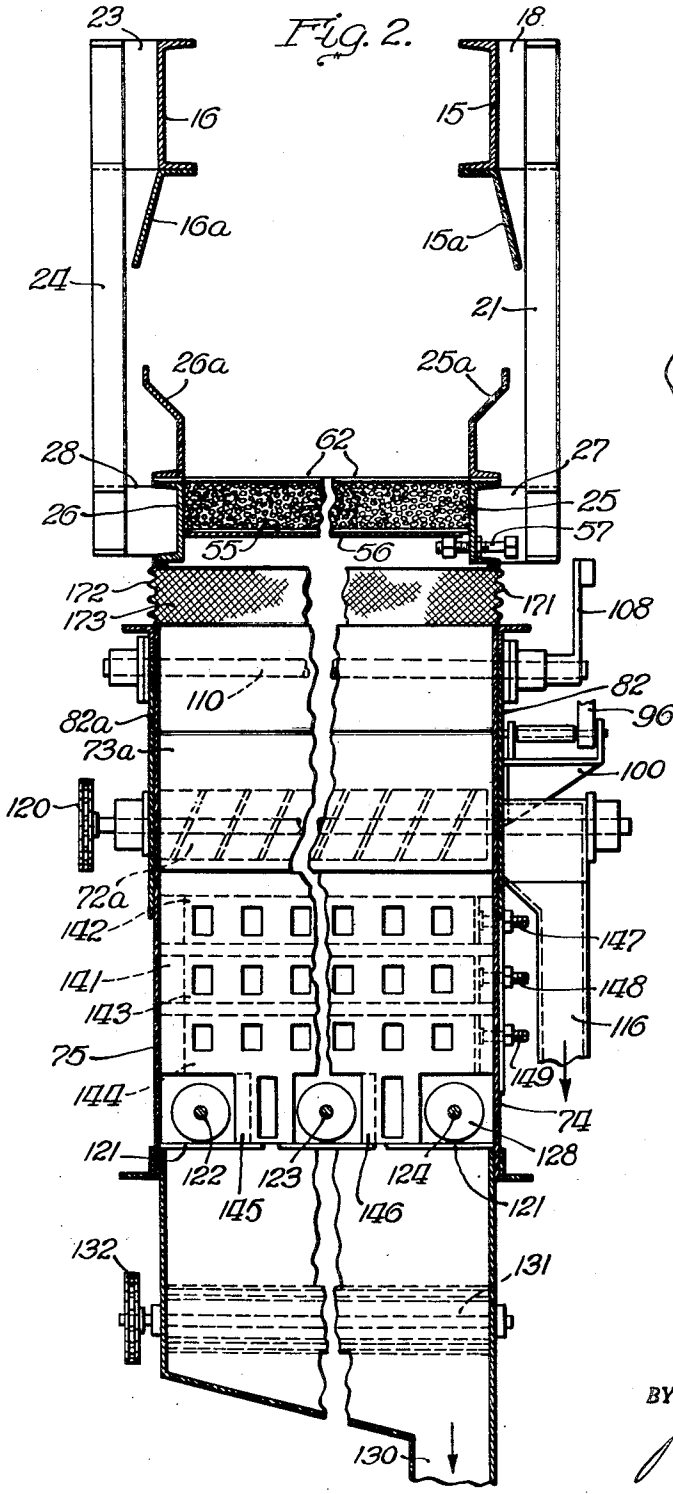
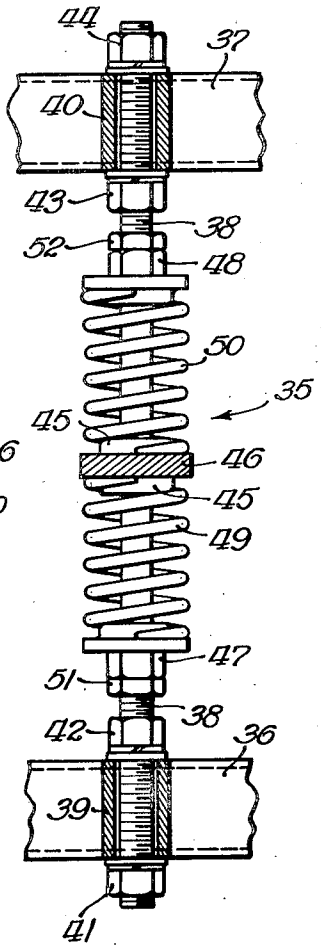


Fig. 3.



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2,513,960

MOVABLE DECK PNEUMATIC COAL CLEANER

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Application February 13, 1947, Serial No. 728,224

4 Claims. (Cl. 209—468)

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This invention relates to the separating or classifying of heterogeneously intermixed materials consisting of particles of different specific gravities and/or sizes, and is particularly concerned with improvements in a movable deck pneumatic coal cleaner for use primarily with raw coal of relatively small particle size.

The term "coal cleaner" is applied to apparatus such, for example, as described in U. S. Patents Nos. 2,245,942 and Re. 21,682. The apparatus disclosed in these patents comprises means forming an inclined trough-like passage provided with a perforated air-pervious deck plate disposed on top of a resistance pack containing marbles or the like, and means for directing air impulses into and through the resistance pack for escape upwardly through the perforations in the deck plate. The raw coal is fed to the deck plate at the elevated end thereof, moving along its inclined surface, and is subjected to the action of the air impulses which effect stratification of its particles in accordance with their specific gravities. Coal, which is the lightest component of the raw feed, orients itself on top of the material bed and heavier particles, constituting refuse, stratify underneath the coal. The various stratified products are drawn off for removal to their respective discharge points.

The principal object of the invention is to provide an airflow separator or cleaner of the general class described above for treating raw coal of small particle size varying, for example, from about three-eighths of an inch down to and including finely pulverized and comminuted dust-like particles, and for obtaining clean coal of a high degree of purity such as is required in metallurgical coal and in pulverized coal for numerous industrial operations including the operation of marine and locomotive boilers, cement-burning, central heating plant operation and the like.

This object is realized by the provision of a structure having (1) an elastically suspended longitudinally resiliently balanced trough-like inclined material deck for receiving the raw material, the deck comprising a plurality of longitudinally serially related deck sections, each section including a perforated air-pervious deck plate and a resistance pack, the successive deck sections being separated by downwardly directed intermediate discharge passages for the removal from the material stream of successively separated relatively coarse heavy material particles; (2) means forming underneath the material deck a plurality of cells, one for each deck section,

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and means for injecting into each cell air impulses of controlled magnitude for adjusted upward escape through the associated resistance pack and perforated deck plate into the raw material thereon to impart controlled fluid mobility and buoyancy to such material; (3) means for reciprocating, vibrating or oscillating the material deck with all its deck sections at a relatively high frequency and relatively small amplitude for the two-fold purpose of imparting mechanical mobility to the material flowing over the various deck sections and to cause finely divided particles of intermediate specific gravities to move for discharge continuously downwardly through the deck plate and through the underlying resistance pack of each deck section in counter-current to the air impulses injected into the corresponding deck section; and (4) means common to all deck sections for receiving and removing the small particles of intermediate gravities which are continuously discharged therefrom in counter-current to the air impulses injected thereinto.

Details of the various objects and features, including those mentioned above, will appear from the description of the accompanying drawings, in which

Fig. 1 shows a more or less diagrammatic elevational side view of an embodiment of an airflow separator or cleaner made in accordance with the invention, with parts broken away to show interior structures;

Fig. 2 is a section, on an enlarged scale, through the new separator taken approximately along lines 2— 2 of Fig. 1; and

Fig. 3 illustrates, on an enlarged scale, the means for longitudinally resiliently balancing the material deck, as seen when looking in the direction of the arrows along lines 3—3 of Fig. 1.

Like parts are numbered alike throughout the drawings. Known details and elements will be referred to only to the extent required for conveying an understanding of the structure and operation of the invention.

Referring now to the drawings, the new separator comprises a framework including suitably positioned structural upright members 11, 12 and 13, 14 disposed on either side of the machine substantially at the opposite ends thereof. The uprights 12 and 13 on either side are joined by suitable sheet members forming the side walls 74 and 75 which extend throughout the lower part of the machine. Vertically extending sheet members join the uprights 13, 14 on either side in the rear and similar sheet members extend forwardly from the uprights 11 to the left as seen

in Fig. 1. The forward end of the machine may be closed by a suitable plate or the like. Secured to the top of the uprights 12 and 13 on either side and extending therebetween in longitudinal direction are the generally U-shaped girders 15 and 16, respectively, (see also Fig. 2). Secured to the girders 15 and 16 are downwardly extending and outwardly flaring shields 15a and 16a, respectively.

Each girder 15 and 16 carries a number of longitudinally spaced brackets such as 17, 18, 19, and suitably attached to each of these brackets is a downwardly depending resilient member, e. g., a composite or laminated leaf spring. The leaf springs secured to and depending from the brackets 17, 18, 19 on the girder 15 are marked 20, 21, 22, respectively. The top girder 16 extending on the other side, in back of the girder 15, as seen in Fig. 1, carries in a similar manner brackets corresponding to 17, 18 and 19, one such bracket being indicated in Fig. 2 at 23, and leaf springs corresponding to the springs 20, 21 and 22 are secured to such brackets, the leaf spring corresponding to spring 21 being indicated in Fig. 2 by numeral 24. There are thus three pairs of leaf springs 20, 21—24 and 22, which extend downwardly from the top girders 15 and 16.

The lower ends of the three pairs of leaf springs are secured to brackets which project laterally outwardly from longitudinally extending, generally U-shaped structural members 25 and 26 disposed slightly above and vertically spaced from the side walls 74 and 75, respectively. The structure is apparent from Fig. 2, showing the lower ends of the pairs of leaf springs 21 and 24 associated with the brackets 27—28, respectively, which extend laterally outwardly from the members 25—26. The lower ends of the pairs of leaf springs 20 and 22 are secured similarly to brackets extending laterally from the members 25 and 26. The longitudinally extending structural members 25 and 26 are thus elastically suspended from the longitudinally extending top girders 15 and 16 of the machine and are transversely spaced as is particularly apparent from Fig. 2. These members form part of the material deck and carry the serially related deck sections. Upwardly extending and outwardly flaring shields 25a and 26a are secured to the structural members 25 and 26, respectively, forming with the deck sections a longitudinally extending trough-like structure which is inclined at an angle of about 8 to 15 degrees.

At the rear end of the material deck is disposed a generally U-shaped structural member 29 which extends transversely across the rear ends of the longitudinally extending resiliently suspended deck members 25 and 26. From the member 29 extends in rearward direction a connecting member, e. g., an I-beam 30. This connecting member is associated with suitable means for imparting vibrations thereto which are transmitted to the material deck, including all the deck sections disposed between the structural members 25 and 26, for example, with a vibrator 31. This vibrator may be of the rotary type known as "Eureka" Buhler Drive, manufactured by S. Howes Co., Inc., Silver Creek, N. Y., comprising two disk-like masses whose axes of rotation are radially offset such as illustrated by the Shaler Patents 1,999,213 and 2,059,784. These masses are rotated in common and produce thrusts which affect the connecting beam 30, thereby vibrating, reciprocating or oscillating the material deck. The vibrator is operated through the medium of a belt drive,

from a motor 32 mounted on a shelf 33 secured between the rearmost pair of upright members 14. Other suitable means for reciprocating, vibrating or oscillating the material deck may, of course, be used.

The frequency of the vibrations or oscillations imparted to the deck may be from about 800 to 1400 per minute; the amplitude may be approximately ⅛", that is, 1/16" in either direction from the normal position of the material deck. It will be seen, therefore, that the amplitude of the vibrations is relatively small, while the frequency is relatively high.

The suspended inclined material deck with its various deck sections is rather heavy, and the structure would normally tend to position itself by gravity in a forward direction; that is to say, it would tend to sag toward the left as seen in Fig. 1. Vibrations applied directly to the freely suspended structure would be distorted by the inertia of the masses in the presence of such sagging. In order to counteract the sagging and to control the vibrations, I have provided means for resiliently balancing the structure in longitudinal direction. This balancing means is indicated in dotted lines at the rear end of the machine, as seen in Fig. 1, and is there generally indicated by the numeral 35. It is shown on a larger scale in Fig. 3.

The balancing structure comprises a pair of transversely extending supports 36 and 37 which are attached to the pairs of uprights 13 and 14 in the front and in the back of the machine, respectively. Mounted on the members 36—37 and connecting such members is a shaft 38. It will be noted that the ends of the shaft are secured in bushings 39 and 40, by means of pairs of nuts 41, 42 and 43, 44, respectively, and that the shaft can therefore be positioned with respect to the transverse members 36, 37 as may be desired. The shaft carries a floating bushing 45 associated with a bracket member 46 which extends upwardly as shown in Fig. 1 and is secured to the connecting I-beam 30 projecting rearwardly from the transverse member 29 at the rear end of the suspended deck and carrying the vibrator or oscillator 31. Also secured on the shaft 38 of the balancing structure are a pair of flanged bushings 47 and 48, respectively, and between these bushings and the member 46 are disposed springs 49 and 50. The spring 49 extends between the bushing 47 and member 46, and the spring 50 extends between the bushing 48 and member 46. The position of the bushings 47 and 48 on the shaft 38 may be adjusted as desired, by the nuts 51 and 52, for the purpose of adjusting the tension or pressure of the springs 49, 50 against the member 46.

The structure thus permits adjustment of the spring pressure against the member 46 (which is connected with the connecting beam 30 projecting rearwardly from the elastically suspended material deck and carrying the vibrator 31) and also permits resilient adjustment of the position of the member 46 relative to the supports 36—37, and therewith adjustment of the connecting beam 30 and the material deck in a desired normal position. The operation of the vibrator 31 vibrates the material deck, and the vibrations are controlled by the springs 49, 50 pressing against the member 46 carried on the floating bushing 45.

The adjustment counteracts the forward sagging of the material deck, which would otherwise take place due to the incline at which it is disposed. The vibrations or oscillations imparted

by the vibrator 31 to the connecting beam 38 and thence to the forwardly extending material deck are damped and cushioned. Forces set up during the vibration, due to inertia, are effectively counteracted. The amplitude of the vibrations, as noted before, may be $\frac{1}{16}$'' to either side of a median center line which may be drawn through the member 46, as shown in Fig. 3, after completing the adjustment. The amplitude is, of course, not a fixed quantity and may be chosen as desired, $\frac{1}{16}$'' being given as an example.

There are four deck sections provided in the structure shown in the drawings. The rearmost or first deck section is indicated in Fig. 1 by the numeral 60. This deck section terminates at its forward end in a downwardly extending intermediate discharge passage indicated in Fig. 1 by the numeral 61, which separates it from the second deck section 62. A similar downwardly extending intermediate discharge passage 63 separates the forward end of the deck section 62 from the rear end of the third deck section, the forward end of which terminates in the downwardly extending similar discharge passage 64. The fourth or last deck section terminates in the discharge passage 65 near the forward end of the machine. Numeral 66 indicates the discharge for the clean coal.

A weir such as 80 is shown in Fig. 1 associated with the rear end of the deck section 62. This weir is a transversely extending plate which is vertically adjustable so as to provide a banking effect with respect to the raw material stream flowing from the deck section 60 over and onto the deck section 62. Similar weirs may be associated with each of the discharge passages 63, 64 and 65.

Each deck section comprises a perforated air-pervious deck plate on top of a resistance bed containing suitable members, for example, clay members or glass marbles of a desired size, say $\frac{1}{4}$'' to $\frac{7}{16}$'' in diameter. The structure of the deck sections, including the associated perforated deck plates and marble packs, will be apparent from consulting the previously mentioned Patents 2,245,942 and Re. 21,682.

The perforated deck plates may be made of suitable material, e. g., brass, but are preferably made of stainless steel. The size of the holes in the deck plates is chosen so as to provide for a maximum open area of about 22% to about 30%. For example, there may be 108 holes per square inch, each hole of a diameter of .05'' resulting in an open area of 23%, or 400 holes per square inch, each hole of a diameter of .027'' also resulting in an open area of 23%; or there may be 225 holes per square inch, each hole of a diameter of .04'' resulting in an open area of 28%.

Underneath each deck section are disposed transversely extending valve slides such as 67—68 (shown in Fig. 1 in connection with the first deck section 60) which are movably mounted between guide members such as 69. Each valve slide is provided with openings coacting with openings in the bottom plate of the associated deck section and is movable or slidable transversely by a suitable means, for example, an adjusting screw, extending to the outside. The arrangement is apparent from Fig. 2, showing part of the deck section 62. Underneath the bottom plate 55 is indicated the valve slide 56 which is operable by means of an outwardly projecting screw 57. Each deck section is provided with such valve slides for the purpose of regulating the air supply into and through its marble pack for escape through the perforations in its associated deck plate. Further details of the structure and operation of the valve slides may be had from Patent No. 2,374,865.

Each downwardly extending intermediate discharge passage 61, 63, 64 and 65 separating the various deck sections terminates in a discharge mechanism comprising a transversely extending casing such as 73 containing an arcuate tray 70 and an oscillating scraper 71 as well as a rotatable transversely disposed screw 72. The casing containing these discharge elements extends transversely within the lower part of the machine underneath the associated intermediate discharge passage, that is, within the space defined by the side walls 74 and 75 (see also Fig. 2). The transverse plates forming the downwardly extending passage directed into the discharge mechanism are connected with the associated casing, such as 73, by suitable transversely extending flexible bellows-like sealing members, as indicated in Fig. 1, so as to prevent the escape of air into the discharge mechanism. The discharge casing 73*a* shown in Fig. 2 correponds to the casing 73 of Fig. 1, and contains the discharge mechanism for the intermediate discharge passage 63 including the screw 72*a* which corresponds to screw 72 indicated in Fig. 1. The transverse bellows-like seal 173 extends from the casing 73*a* and connects with the plate forming part of the discharge passage 63 to prevent the escape of air into the casing 73*a*.

Each discharge mechanism is associated with an end plate at the front and a similar end plate in the back, and these plates are mounted on the side walls 74 and 75, respectively. The end plates 82 and 82*a* are thus associated with the discharge mechanism for the intermediate discharge passage 63 (see Figs. 1 and 2); the front end plate 81 coacts with a similar end plate on the side wall 75 of the machine in connection with the intermediate discharge 64; and similar front and back end plates are provided for the discharge mechanism associated with the intermediate discharge passage 61. These end plates carry certain operating parts.

The discharge mechanisms are actuated from an eccenter 85 operated by a motor associated with a suitable speed reducer generally indicated in Fig. 1 at 86. An arm 87 extends from the eccenter 85 into pivotal engagement with a connecting member 88 which in turn is pivotally connected by means of a rod 89 with a connecting member 90, the latter being connected by a rod 91 with a connecting member 92 to which is pivoted the rod 93, and the forward end of the latter is pivotally mounted on the arm 94. When the eccenter 85 is actuated, it reciprocates the connecting rod 87 and therewith the gang of connecting rods 89, 91 and 93, oscillating in this manner the arms 94, 95, 96 and 97 which are pivotally or hingedly mounted on the brackets 98, 99, 100 and 101, respectively. The oscillation of the arms 94–97 is transmitted to connecting rods 102, 103, 104 and 105, respectively, to actuate associated arms such as 106, 107 and 108, respectively, and each of these latter arms is keyed to a shaft such as 109 (see the discharge mechanism associated with the intermediate discharge passage 61) to oscillate the scraper such as 71 for the purpose of feeding material to the discharge screw such as 72. The arm 108 is similarly keyed to the shaft 110 (Fig. 2) to oscillate the scraper associated with the discharge mechanism for the intermediate discharge 63 so as to feed separated ma-

terial onto the screw 72a. The connecting rods 102, 103, 104 and 105 are adjustable on their associated oscillating arms 94, 95, 96 and 97, respectively, so as to adjust the stroke of the respective oscillating scrapers actuated by these rods.

The discharge screws move the discharged material laterally at the bottom of the associated casings for discharge into downwardly directed chutes. Thus the discharge screw 72 within the casing 73 moves the material received from the intermediate discharge 61 into the chute 116; the screw 72a (Fig. 2) within the casing 73a moves the material received from the discharge 63 into the chute 116; and chute 117 receives in a similar manner the material from the intermediate discharge passage 64. The discharge mechanism associated with the discharge passage 65 at the forward end of the machine discharges directly into the chute 118.

The discharge screws associated with the various discharge mechanisms are operated by suitable drives, e. g., by chain and sprocket drives such as indicated in Fig. 2 at 120.

Further details of the discharge mechanisms and their operation may be had from Patent No. 2,334,337.

At the bottom of the machine defined by a suitable bottom plate 121 (Fig. 2) are disposed three rotatably mounted pairs of screws, each pair being carried on a common shaft. The three shafts are indicated in Fig. 2 by the numerals 122, 123 and 124. The pair of screws associated with the shaft 124 are indicated by numerals 128 and 129. The forward ends of the screw shafts are mounted at 125 and the rear ends are suitably mounted at 126 (Fig. 1). The rear ends of the screw shafts project outwardly and each is provided with a suitable drive, for example, a sprocket, which may be actuated by a chain drive such as 127. The pairs of screws are arranged for right and left feed, respectively, to transport material accumulating at the bottom of the machine inwardly from its extreme ends toward the middle for discharge into the chute 130. In this chute is disposed an air seal comprising a star wheel 131 to prevent escape of air thereinto. The star wheel is operated by a suitable drive, for example, a chain and sprocket drive 132, indicated in Fig. 2.

Extending downwardly from each of the casings containing the discharge mechanisms associated with the intermediate discharge passages 61, 63 and 64, and secured to the respective casing, is a valve plate such as indicated at 140 in connection with the casing 73 (Fig. 1) provided for the discharge mechanism which receives material from the passage 61, or valve plate 141 (Fig. 2) associated with the discharge casing 73a which receives material from the passage 63. The valve plate extends in each case transversely across the space between the side walls 74, 75 and forms with the associated discharge casing a transverse partition within the lower chamber of the machine. Each valve plate is provided with a number of rows or openings, as seen in Fig. 2 in connection with the valve plate 141. Associated with each row of openings is a valve slide indicated at 142, 143, 144, respectively, these valve slides being similar to the valve slides 68 and 67 associated with the deck sections. Each valve slide is operable from the outside by a suitable device, for example, a screw, as indicated in Fig. 2 at 147, 148, 149. Each valve plate is provided with two extensions, as indicated in connection with valve plate 141 at 145 and 146, which project downwardly into the spaces between the screws carried on the shafts 122—123 and 123—124, respectively. Each of the extensions 145, 146 is likewise provided with an opening or openings, and the valve slide 144 carries extensions corresponding to the extensions 145, 146. Similar valve means carrying a valve plate and associated valve slides is also connected with the discharge casing which receives material from the intermediate discharge passage 64.

The chamber extending between side walls 74—75 underneath the various deck sections is in this manner divided into cells, one for each deck section, and each cell is provided with means for regulating the air supply that is to be admitted into it for use in its associated deck section.

The air supply may be from any suitable source by way of the duct 150 (Fig. 1) which is provided with a flutter valve 152 operating between shields 162, 163. The air pressure is relatively low and may vary from about 1.25 WG to about 2.00 WG. The flutter valve 152 is rotated at desired R. P. M. by a suitable drive, for example, by a chain and sprocket drive, from the motor and speed reducer 86. Air impulses of relatively low pressure are thus supplied into the space or cell below the deck section 60, and the amount of air which is admitted into this deck section is regulated by the valves such as 68 and 67 disposed directly underneath its resistance pack.

The admission of air into the second cell underneath the second deck section 62 is regulated by the valves associated with the valve plate 140 depending from the casing 73. The air which is admitted for use in the deck section 62 is regulated by the valve slides underneath its resistance pack.

Air is similarly admitted into the third and fourth cells underneath the corresponding deck sections by way of the valve plates 141 depending from the casing 73a (Fig. 2) and from the casing associated with the discharge passage 64, respectively.

Vertically extending valve openings may be provided in the partition valve plates such as 140, 141 instead of the rows of openings described, for valve coaction with similarly formed valve slides or sliding plates.

The raw material is supplied through a hopper 165 (Fig. 1) and drops onto an inclined surface formed by the transversely extending plate 166. This plate defines the bottom of a feed chamber in which is disposed an oscillating feed mechanism operable by the oscillating arm 167. The feed mechanism may be similar to the discharge feed mechanisms used in connection with the various discharge passages 61, 63 and 64, and details of it may be had by consulting Patent No. 2,334,337. Shields such as 168 extend on either side forwardly from the feed chamber to guide the raw material into the trough of the vibrating material deck.

The oscillating or vibrating deck comprising the various deck sections as described is connected with the lower part of the machine by means of flexible bellows-like sealing members 171, 172, the bellows 171 connecting the deck with the side wall 74 and the bellows 172 connecting with the side wall 75. Transverse bellows members of similar structure are provided at the forward and at the rear ends of the oscillating deck. The deck with its various deck sections is thus sealed against the escape of air except through the perforated deck plates and is movable on its suspension springs in response to the actuation of the vibrator.

The shields 15a—25a and 16a—26a extending from the top girders 15 and 16 and from the suspended deck members 25 and 26, respectively, may be connected by a suitable material such as canvas members so as to seal and close the top part of the machine, above the vibrating deck, to the outside.

A dust hood 180, shown in Fig. 1, extends upwardly from the machine and terminates in a suitable exhaust duct for drawing dust-laden air off for cleaning and recirculation back to the intake 150.

The operation of the machine may now be briefly summarized as follows:

The raw coal is supplied to the hopper 165. The operation is started by switching on the motor 86 provided with a speed reducer, thus rotating the eccenter 85 and thereby oscillating the arms 94–97 which effect the oscillation of the discharge scrapers such as 71 of the discharge mechanisms associated with the various intermediate discharge passages 61, 63, 64 and 65. The arm 167 is at the same time oscillated for the purpose of actuating the mechanism for feeding the raw material onto the first deck section 60. Air under pressure is supplied to the duct 150, and the flutter valve 152 is rotated at a predetermined R. P. M. to admit air to the machine in the form of impulses. The operation of the vibrator 31 is started by switching on the motor 32. The discharge screws associated with the various intermediate discharges are actuated by the corresponding chain and sprocket drives such as 120 in Fig. 2.

The air admitted into the cell underneath the first deck section 60 flows upwardly through the resistance pack of this section and through the perforated deck plate in accordance with the setting of the slide valves such as 68 and 67. The amount of air to be admitted to the second deck section 62 is regulated by suitably adjusting the slide valves associated with the valve plate 140 depending from the discharge casing 73. The air admitted to the third and fourth deck sections is likewise adjusted by the slide valves associated with the discharge casings in back of the mounting plates 82 and 81, respectively. Each of the deck sections is provided with slide valves such as 68 and 67 for further regulating the air supply directed through the corresponding resistance pack for upward escape through the associated perforated deck plate in accordance with the needs of the material bed flowing over each deck section.

The raw material flows onto the first deck section 60 and is subjected to the action of the air impulses as well as to the action of the vibrations effected by the vibrator 31. The magnitude of the air impulses is adjusted to the needs of the raw material bed forming on this deck section. The material immediately orients itself in stratified layers as it flows along the first deck section, and upon arriving at the first take-off or intermediate discharge passage 61, the heaviest and largest components are positioned at the bottom of the material bed and drop down onto the discharge tray 70 from which they are scraped by the scraper 71 onto the screw 72 which feeds the discharged particles into the chute or duct 115. The weir 80 and similar weirs associated with the successive intermediate discharge passages 63, 64, 65 are adjusted to desirable heights so as to provide proper banking of the material stream at the corresponding discharge points. The heaviest and largest components of the raw material are thus discharged through the passage 61 and removed through the chute 115.

The remaining material continues to flow onto and along the second deck section 62 on which it is subjected, in the presence of vibrations, to air impulses of a magnitude adjusted to its needs, and the heaviest and largest components of the material, which stratify under the action of such impulses and vibration at the bottom, drop downwardly into and through the intermediate discharge passage 63 for removal into chute 116 by means of the discharge mechanism contained in the discharge casing 73a (Fig. 2) which is identical with the mechanism associated with the discharge passage 61, as shown in full lines in Fig. 1.

The material remaining after removal of heavy and relatively large particles at the intermediate discharges 61 and 63, as described, continues to flow along the third and finally over and along the fourth deck section, at the end of each of which the heaviest and largest components are discharged through the associated intermediate discharge passages 64 and 65, respectively, for removal through the ducts or chutes 117 and 118, respectively.

The clean coal flows over the inclined end section 66 of the vibrating deck for discharge through the chute 170.

Finely divided matter contained in the material as it flows along the various deck sections, consisting of particles of intermediate gravities and of maximum sizes corresponding approximately to the size of the openings in the various deck plates, works continuously and progressively downwardly through such openings and through the corresponding resistance packs, in counter-current to the upwardly directed air impulses, leaving the resistance packs through the bottom openings associated with the valve slides underneath each deck section. These particles drop downwardly to the bottom of the machine where they accumulate along the bottom plate 121. At a certain point of the operation the screws on the shafts 122, 123 and 124 on top of the bottom plate 121 are started by their respective drives such as 127, and the star wheel 131 is rotated by means of the chain and sprocket drive 132. The fine material of intermediate gravities that has accumulated will accordingly be moved from either end of the machine toward the middle and will drop onto the star wheel 131 which discharges the material in a controlled manner downwardly into the chute 130, and at the same time acts as an air seal to prevent the escape of air. The maximum size of the particles thus discharged is determined by choosing holes of corresponding size to be provided in the various deck plates.

The progressive and continuous discharge of the finely divided particles of intermediate gravities throughout the extent of each deck section, in counter-current to the air impulses, as described in the foregoing paragraph, is considered an important feature of the present invention. As intimated initially, this feature effects automatic cleaning of the resistance packs, permits more efficient utilization of the air at reduced pressures, accelerates stratification, thereby increasing the ton/hour capacity of the separator at reduced energy input, and thus permits the efficient treatment of raw coal of relatively small particle size without recourse to hydraulic separation, delivering clean coal of a high degree of purity.

The separated products, which are discharged

successively from the first, second and third deck sections by way of the intermediate discharge passages 61, 62 and 63 into the chutes 115, 116 and 117, respectively, consist predominantly of heavy particles constituting refuse. The fines, which are discharged from all of the deck sections in counter-flow to the air impulses dropping to the bottom of the machine for removal into the chute 130, have likewise been found to consist predominantly of heavy particles constituting refuse. The material entering the intermediate discharge passage 65 at the forward end of the fourth deck section for removal through the chute 118 will, however, usually contain valuable particles which are recovered by screening, the underflow being predominantly refuse and the overflow from the screen being either predominantly coal, which is mixed with the coal drawn off at the inclined forward end 66 of the deck, or a true middlings product which may be recirculated. It is understood, of course, that conditions may vary and, if it is found that one or the other intermediate product contains valuable material, such product may be screened and/or re-circulated as desired or necessary, to recover its valuable constituents.

The new apparatus and process has been described in connection with the separation or cleaning of coal for which it has been designed. Some or all of the new features may be used in related or different fields, including the beneficiation of minerals and ores.

Changes may be made within the scope and spirit of the appended claims which define what is believed to be new and desired to have protected by Letters Patent of the United States.

I claim:

1. In apparatus for separating raw coal of relatively small particle size having a longitudinally extending air-pervious material-receiving deck disposed above a resistance pack which forms an operating unit therewith and having means for feeding raw coal onto said deck at one end which forms the feed end thereof, relatively stationary supports disposed above said operating unit, resilient hanger means secured to and downwardly depending from said supports for suspending said operating unit at an incline with the feed end disposed at a higher level than the opposite end which forms the coal discharge end thereof, said incline being at an angle at which gravitational force will normally tend to move said operating unit causing sagging thereof forwardly away from said means for feeding raw coal onto the feed end thereof, means forming an arm disposed at the feed end of said operating unit and longitudinally rearwardly extending therefrom underneath said means for feeding raw coal thereto, an unbalanced weight vibrator solely supported on said arm at the free end thereof, balancing means coacting with said arm for longitudinally resiliently balancing said inclined operating unit in predetermined longitudinally adjusted position to counteract said gravitational force and to position the feed end thereof in predetermined normal position relative to said raw coal feeding means, said balancing means comprising a pair of spaced relatively stationary supports, a shaft extending between said supports, a bushing disposed on said shaft and floating thereon, means for relatively rigidly connecting said bushing with said arm, spring means disposed on said shaft on either side of said bushing and means disposed on said shaft for compressing each spring means against said bushing, and means for actuating said vibrator to vibrate said operating unit longitudinally for the two-fold purpose of imparting mechanical mobility and buoyant fluidity to the material particles on said deck and to cause particles of intermediate specific gravities to move downwardly through said air-pervious deck plate and through said resistance pack for downward discharge therefrom, whereby clogging of said resistance pack is prevented to maintain its air resistance characteristics substantially constant.

2. In apparatus for separating raw coal of relatively small particle size having a longitudinally extending air-pervious material-receiving deck disposed above a resistance pack which forms an operating unit therewith and having means for feeding raw coal onto said deck at one end which forms the feed end thereof, relatively stationary supports disposed above said operating unit, resilient hanger means secured to and downwardly depending from said supports for suspending said operating unit at an incline with the feed end disposed at a higher level than the opposite end which forms the coal discharge end thereof, said incline being at an angle at which gravitational force will normally tend to move said operating unit causing sagging thereof forwardly away from said means for feeding raw coal onto the feed end thereof, means forming an arm disposed at the feed end of said operating unit and longitudinally rearwardly extending therefrom underneath said means for feeding raw coal thereto, balancing means for longitudinally resiliently balancing said inclined operating unit in predetermined longitudinally adjusted position to counteract said gravitational force and to position the feed end thereof in predetermined normal position relative to said raw coal feeding means, said balancing means comprising a pair of stationary supporting members disposed underneath said arm transversely with respect thereto and vertically spaced therefrom, a shaft extending between said members, means for adjustably securing each end of said shaft with one of said stationary supporting members, a bushing disposed on said shaft about midway thereof and floating thereon, means for relatively rigidly connecting said bushing with said arm which extends rearwardly from said operating unit underneath said means for feeding raw coal thereto, spring means disposed on said shaft on either side of said bushing, means disposed on said shaft for compressing each spring means against said bushing, an unbalanced weight vibrator solely supported by and secured to said arm at the free end thereof, and means for actuating said vibrator to vibrate said operating unit longitudinally for the two-fold purpose of imparting mechanical mobility and buoyant fluidity to the material particles on said deck and to cause particles of intermediate specific gravities to move downwardly through said air-pervious deck plate and through said resistance pack for downward discharge therefrom whereby clogging of said resistance pack is prevented to maintain its air resistance characteristics substantially constant.

3. Apparatus as set forth in claim 2, wherein said suspended operating unit is disposed at an angle in excess of about 8°.

4. Apparatus as set forth in claim 2, wherein said vibrator is actuated to vibrate said operating unit longitudinally at a frequency lying within a range from about 800 to about 1400 oscillations per minute, the amplitude of such oscillations being approximately ⅛".

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