

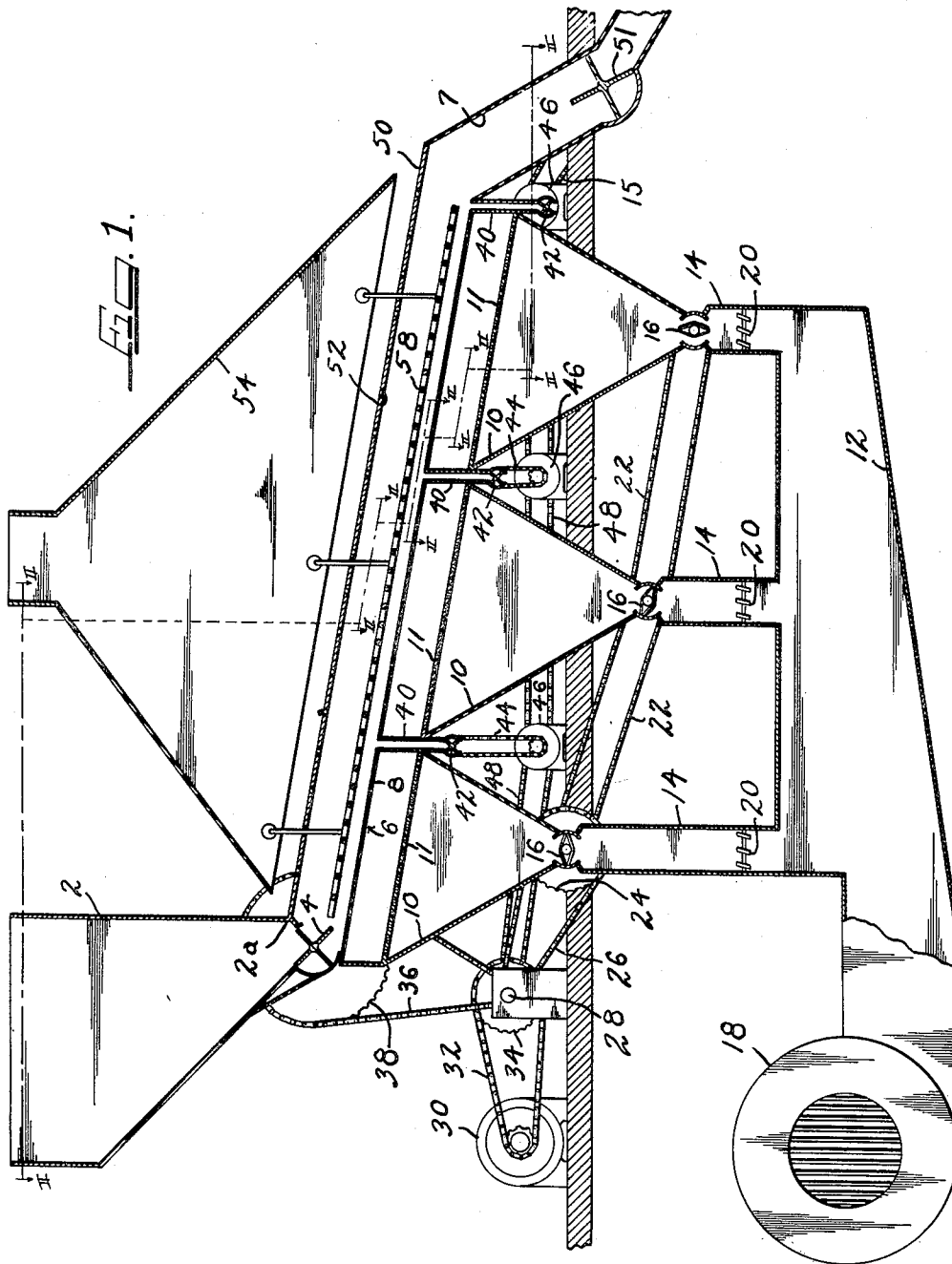
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J. H. FLETCHER ET AL
PNEUMATIC COAL CLEANER

2,512,422

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3 Sheets-Sheet 1



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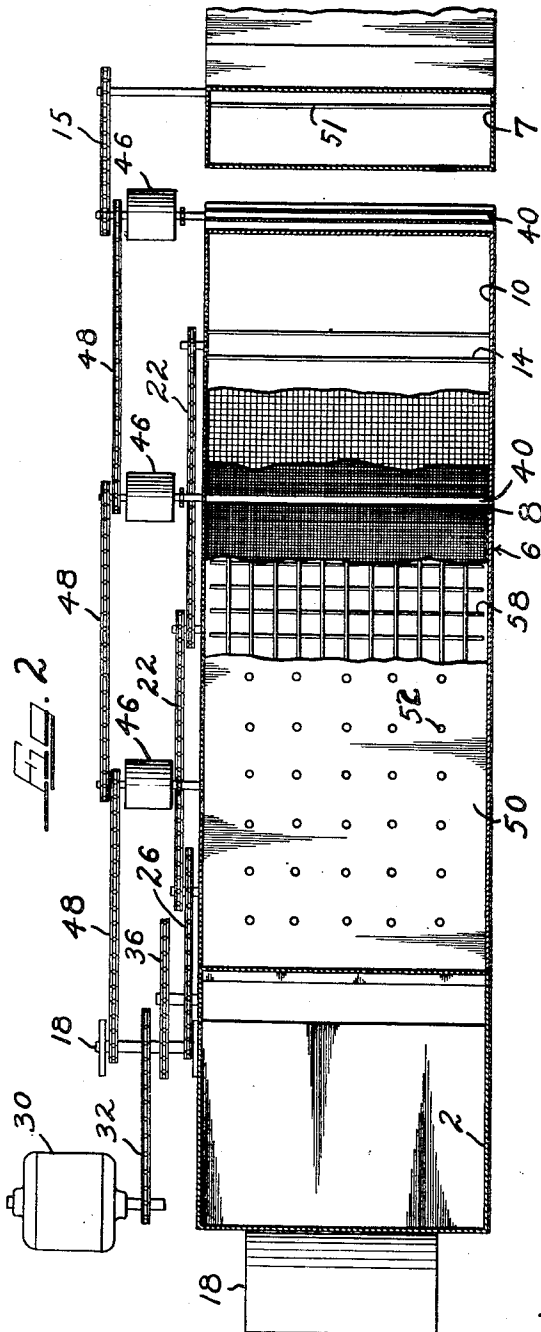
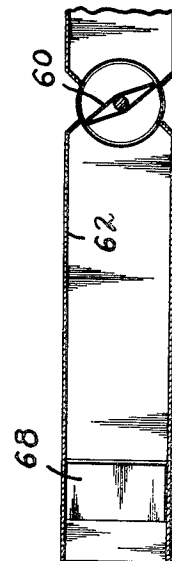
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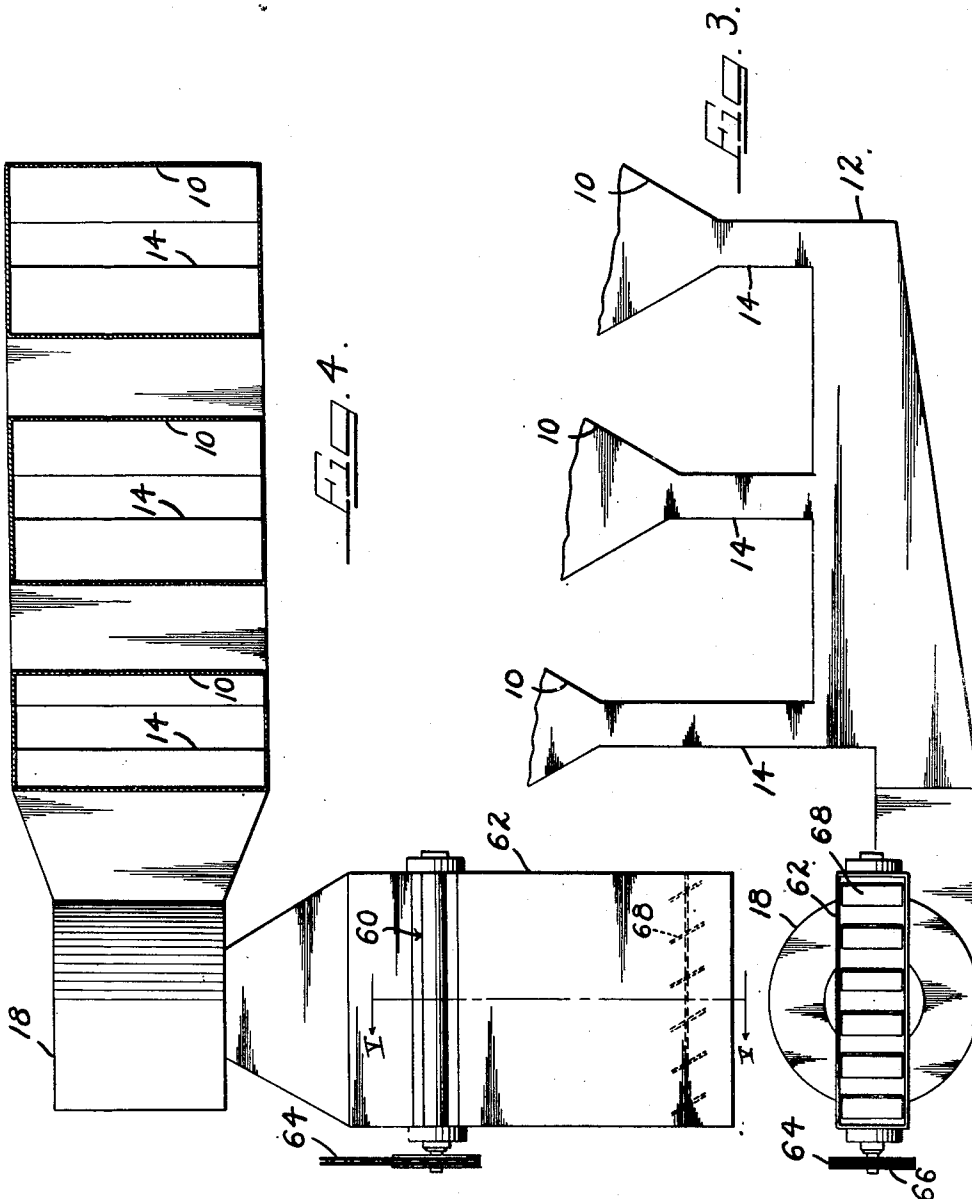
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PNEUMATIC COAL CLEANER

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This invention relates to apparatus for gravitationally separating particles of different specific gravity, and, while especially applicable to and useful in connection with cleaning of raw coal by air, it may be used equally well for separating other material particles both by the use of air or other fluid separating or floating media.

A variety of coal cleaning machines have been heretofore known and utilized which effect the separation of the coal particles from the higher specific gravity impurity particles mixed therewith by passing air upwardly through a bed of mixed coal and impurity particles to effect stratification of such bed according to the specific gravity of the particles, hence accomplish separation of the coal particles from the impurity particles. Such known apparatus has generally utilized a perforated underdeck to support the bed of mixed particles and applied periodic air pressure pulses to the underside of the underdeck to produce a periodic upward movement of air or other gases through the bed. The top area of the bed was either open to atmosphere or connected to a suction producing device.

It is generally recognized that such known apparatus will not successfully effect cleaning of the smaller sizes of raw coal on a commercial basis. In particular, it has been impractical to attempt the cleaning of raw coal particle mixtures of $\frac{1}{8}$ by 10 mesh size or smaller. We have determined that the major difficulty encountered in attempting to utilize known apparatus for cleaning of the smaller sizes of raw coal lies in the fact that when sufficient static pressure is built up beneath the bed to render the bed fluid, then the velocity pressure or the rate of movement of the air upwardly through the bed, when discharging to atmosphere or to a vacuum, is sufficiently high that the small particles of the higher specific gravity impurities are carried by the high velocity air to the top of the bed and the stratification action is defeated. Many devices have heretofore been resorted to in an attempt to overcome the foregoing undesirable condition, such as finely perforated underdecks to reduce the jet action of the upwardly moving air; also, air resistance beds such as a marble pack below the coal bed to minimize the effect of changes in the open area of the coal bed. None of such modifications has been successful by virtue of the fact that they do not solve the fundamental problem involved of raising the static pressure of air coming in contact with the bottom of the bed without increasing the volume

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and velocity of air passed upwardly through the bed.

The feature of this invention is the provision of a method and means for providing the required relationship of static pressure and air velocity necessary for pneumatic separation of mixed particles of extremely small size, down to and including particles of minus 48 mesh size. The method and apparatus provided by this invention contemplates the provision of a top enclosure over a bed of mixed particles which are supported by and move along a perforated underdeck, and then subjecting such bed to periodic applications of controlled air pressure. A further feature of this invention is the provision of air discharge apertures in the top enclosure of the mixed particle bed which provide a total discharge area proportioned with respect to the volume, pressure, and periodicity characteristics of the air pressure applied beneath the bed to produce an optimum relationship between the static pressure beneath the bed and the volume and velocity of air passing through the bed.

Accordingly it is an object of this invention to provide an improved method of, and apparatus for, effecting the separation of mixed particles of varying sizes according to the specific gravity of such particles.

A particular object of this invention is to provide an improved method and apparatus for cleaning raw coal by the pneumatic separation of the coal particles from the higher specific gravity impurity particles contained therein.

A further object of this invention is to provide an improved method for purifying a bed of mixed particles of varying sizes according to the specific gravity of the particles by passing air or other flotation fluid upwardly through a bed of such particles, enclosing the top of the bed and controlling the rate of discharge of air from the top bed enclosure to provide a large static pressure under the bed without a corresponding large velocity of air passing upwardly through the bed.

Another object of this invention is to provide an improved coal cleaning apparatus comprising a perforated underdeck for supporting a bed of mixed coal and impurity particles, air pressuring apparatus for periodically subjecting the underside of such bed to controlled air pressure pulses to produce an upward movement of air through the bed, wherein an enclosure for the top of the bed is provided having air discharge apertures whose total area is selected to produce an optimum relationship between maximum

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static pressure beneath the bed of particles and maximum velocity of air passing through such bed.

The specific nature of this invention as well as other objects and advantages thereof will become apparent to those skilled in the art from the following description taken in conjunction with the appended drawings which illustrate one embodiment of this invention.

On the drawings:

Figure 1 is a diagrammatic vertical sectional view of a coal cleaning apparatus embodying this invention;

Figure 2 is a multi-plane sectional view taken along the plane II—II of Figure 1;

Figure 3 is a vertical elevational view of a modified form of pressure control equipment for the apparatus of Figure 1;

Figure 4 is a top elevational view of Figure 3; and

Figure 5 is a partial sectional view taken along the plane V—V of Figure 4.

Referring to Figure 1, the numeral 2 represents an input hopper into which the mixture of particles to be separated is supplied. For the purposes of illustration, it will be assumed that the apparatus to be described is employed for purification of raw coal. It will, of course, be understood that the raw coal particles supplied to hopper 2 have been heretofore screened to provide particles of only a limited size range.

At the mouth portion 2a of hopper 2, a feeding device 4 is provided which may comprise any one of several well known forms and is here shown as constituting a rotating starwheel. The starwheel 4 supplies a continuous stream of raw coal to the high end of an inclined underdeck 6. The base portion of underdeck 6 is provided with a plurality of equi-spaced apertures 8 which individually are sufficiently smaller than the general size of particles fed thereon so as to preclude the possibility of any substantial number of particles falling through such apertures. The total area of apertures 8, however, comprises a large percentage of the entire area of underdeck 6, hence a large percentage of the area of the bed of particles carried by underdeck 6. Such conditions may be obtained by forming the underdeck 6 from Alundum or Carborundum and utilizing the pervious nature of Alundum or Carborundum to provide the air apertures.

A plurality of pressure chambers 10 are provided which respectively communicate with the underside of successive areas of underdeck 6. Screens 11 are provided across the mouth portions of chambers 10. The chambers 10 direct air flow from a plenum chamber 12 to the successive areas of underdeck 6. The supply of air to chambers 10 is respectively controlled through conduits 14 which include pulsating valves 16. Plenum chamber 12 is supplied with air under pressure by a suitable blower 18. Individual adjustment of the air pressure supplied to each of the successive regions of underdeck 6 may also be obtained by manipulation of baffles 20 respectively provided in conduits 14.

The pulsator valves 16 may constitute any one of several well known constructions, the purpose of which is to periodically permit the pressured air in conduits 14 to pass into pressure chambers 10 and hence be applied to the underside of underdeck 6. Preferably such valves are adjustable as to percentage of open to closed condition per cycle.

Pulsating valves 16 are rotated in timed re-

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lationship by any suitable mechanism, such as a chain drive 22. Chain 22 is in turn driven by a sprocket (not shown) secured to a common shaft with a sprocket 24, which is driven by a chain 26 forming a main drive shaft 28. Drive shaft 28 is in turn driven by a suitable motor 30 through chains 32 and sprocket 34. The main drive shaft 28 also drives the rotary feeder 4 through a chain 36 from sprocket 38.

Intermediate the adjacent extremities of pressure chambers 10 and at its lower end the top surface of underdeck 6 communicates with substantially vertical chutes 40 by which the particles immediately adjacent the top surface of underdeck 6 are withdrawn. Chutes 40 communicate, respectively, with rotary feeders 42 which force the removed particles into any suitable form of collecting device (not shown). The rotary feeders 42 are also driven from main drive shaft 28 by chains 44, speed reduction units 46 and a chain 48.

The lower end of the underdeck 6 connects with discharge conduit 7 which transmits the cleaned coal particles to a suitable storage receptacle or conveyor. To seal the top of the bed against air leakage at this point and to facilitate the discharge of the cleaned coal, a rotary feeder 51 is provided which is driven by chain 15.

In accordance with this invention, the top of the bed of particles supported on underdeck 6 is substantially enclosed by a cover plate 50. The particular shape and location of cover plate 50 is relatively unimportant so long as such cover plate effects a substantial air enclosure including the top of the bed of particles. Cover plate 50 includes any desired form of air discharge openings, such as a plurality of equi-spaced apertures 52. The total area of such air discharge openings in cover plate 50, is, however, selected to constitute a relatively small percentage of the total bed area, and as will be later described, is further proportioned as a function of the static pressure beneath the bed and the quantity and velocity of the air passing through the bed.

Since a certain amount of dust will escape through the apertures 52 in cover plate 50, we preferably provide a dust collecting hood 54 in overlying relationship to cover plate 50 which communicates with any conventional form of dust collector (not shown).

While not essential thereto, we have observed that the movement of the bed of mixed particles along the inclined underdeck 6 may be facilitated by the provision of an agitating device. Such device may take the form of a grill member 58 which is supported in a position spaced above and parallel to underdeck 6 where it may lie in the lower half of the depth of the bed of particles. The agitator 58 is supported for limited reciprocal movement parallel to underdeck 6 in any conventional manner and is reciprocated by conventional driving mechanism (not shown).

The operation of the apparatus described is as follows:

The rotary feeder 4 plus the reciprocating agitator 58 distributes the mixed particles from hopper 2 into a bed on underdeck 6 which gradually moves along such underdeck to the lower end thereof. At those portions of underdeck 6 overlying the pressure chambers 10, the bed of particles is periodically subjected to an upwardly directed pulse of air by the operation of the pulsating valves 16. Such pulsating air current floats the material, exerting a more pronounced effect on the lighter material, which in this case

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is the coal particles, than on the heavier material which is the coal impurities, so as to cause a generally horizontal stratification. In other words, the impurities which are of higher specific gravity tend to fall to the bottom level of the bed from which they are removed by falling into the vertical chutes 40.

The effect of the cover plate 50 on this operation is most important in as much as the small area of air discharge apertures 52, provided in cover plate 50, does not permit the air which has passed through the bed to escape as rapidly as it may tend to. Hence, a static air pressure is built up beneath the cover plate 50 and hence beneath and within the bed of particles. The relationship of the total discharge area of the apertures 52 in cover plate 50 is selected with respect to the pressure in plenum chamber 12 and the frequency of operation of pulsating valves 16 so that sufficient static pressure is maintained beneath the bed of particles to effect stratification while at the same time the maximum upward velocity of air passing through the particles is maintained below that value which would tend to raise the small particles of the higher specific gravity material above the bottom level of the bed from which they are removed by falling into vertical chutes 40. In every case the total area of the apertures 52 is a small percentage of the bed area. Such percentage obviously will vary for optimum results for the size of coal being cleaned but generally falls into a range of $\frac{1}{2}\%$ to 10 % open area.

By virtue of the controlled pressures set up by the cover plate 50, it is possible to effect purification of very small sizes of coal on a commercial basis. We have economically purified $\frac{7}{8}$ by 10 mesh coal, 10 by 48 mesh coal and minus 48 mesh coal by utilization of this method and apparatus. Obviously, the described method and apparatus is equally applicable to purifying of larger sizes of particles. We have also noted improved results when a cover plate with controlled discharge apertures was utilized with non-pulsating air flow, but optimum performance results with pulsating air flow.

One of the results obtained from the described apparatus is control of the pressure directly under the pervious deck supporting the coal over a wide range through selection of the open area of the cover plate, not possible with the open deck method; another result is that the same pressure may be obtained with a much reduced volume of air by adjusting the open area of the cover plate; another result is a much wider range of air can be passed through the bed without destroying stratification; another result is that normal variation in size of the coal has less effect on the coal cleaning.

Another result is control of the rate and force with which the air moves through the top of the bed of material to prevent the upsetting of the cleaning results; and still another result is that large quantities of air may be passed through the bed without blowing the coal off the table. This statement means that coal can be kept on the table and the air pressure and volume required to effectively clean the coal may be used and controlled by adjusting the top enclosure to the correct percent open area.

Another result is that the cover plate in conjunction with a valve adjustable as to percent open area and revolutions per minute gives control of the static and kinetic energy of the air passing through the bed of material so that a jig-

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ging action is transmitted to the bed of material, the bed is opened sufficient to permit movement of the separate particles composing the bed so that heavy particles of all sizes can settle toward the bottom and the required volume of air to do this does not create a velocity sufficient to carry the small particles of heavy material toward the top of the bed.

We have further discovered that improved separation action may be produced by locating the pulsating valves at the inlet of the compressor rather than between the outlet of the compressor and the underdeck 6 as shown in Figure 1. Referring to Figures 3 through 5, there is illustrated the necessary modification to the apparatus of Figure 1 to accomplish the location of the pulsating valve on the inlet of the compressor 18. Thus the plenum chamber 12 together with the plurality of conduits 14 and pressure chambers 10 are again provided as in Figure 1, but the pulsating valves 16 are eliminated. Instead, a single pulsating valve 60 is mounted in an inlet conduit 62 connected to the input side of blower 18. Pulsating valve 60 is rotated by a chain 64 and sprocket 66 from the main drive shaft 28. The intensity of the pulsations developed by compressor 18 may be controlled by a butterfly type valve 68 also disposed in inlet conduit 62 ahead of the pulsating valve 60.

The advantages of the modification illustrated in Figures 3 through 5 are particularly apparent in cleaning of very fine coal. When the pulsating valves are placed between the blower and the underdeck 6, there is a tendency for the pressure to rise in plenum chamber 12 during the period that the pulsating valves are closed. With the modified construction, where the pulsating valve is located at the inlet of the blower, such pressure rise does not occur.

While we have shown and described particular embodiments of our invention, we wish it to be understood that we do not intend to be restricted thereto, but that we do intend to cover all modifications thereof which would be apparent to one skilled in the art and which come within the spirit and scope of our invention.

We claim as our invention:

1. A controlled pressure apparatus adapted for cleaning coal by air including a foraminous inclined deck along which a body of coal is adapted to pass for cleaning, an air pressure chamber enclosing the space beneath said deck and leading to the entire area therebeneath to evenly distribute the air throughout the area of said deck, closure means for the sides of said deck, a cover adjacent and spaced above said deck and extending substantially parallel to said deck along said closure means from one end thereof to the other, a hopper at the receiving end of said deck and connected to said cover and closure means in air tight relation with respect thereto, an impurities discharge chute at the discharge end of said deck and a clean coal discharge chute leading from said deck and connected to said closure means and cover in air tight relation with respect thereto, said side closure means, hopper, impurities discharge chute, and clean coal discharge chute sealing the bed against the undesired leakage of air thereby, and said cover having a plurality of air discharge passages evenly distributed throughout its area, but having an air discharge area considerably smaller than the area of said deck, and maintaining a controlled static pressure under said cover within the bed of coal being cleaned on said deck, and also maintaining the

velocity of the air therein sufficiently low to prevent the small particles of higher specific gravity from rising within the bed of coal on said deck.

2. A controlled pressure apparatus adapted for cleaning coal by air, including a foraminous deck along which a body of coal is adapted to pass, an air pressure chamber enclosing the space beneath said deck and leading to the entire area therebeneath to evenly distribute the air throughout the area of said deck, closure means for the sides of said deck, a cover adjacent said deck and spaced thereabove in substantially parallel relation with respect thereto and extending along said closure means and deck from one end thereof to the other, a hopper at the receiving end of said deck and connected to said cover and closure means in air tight relation with respect thereto, a rotary feeder in said hopper and engageable with the walls thereof to seal the receiving end of said deck against leakage of air thereby, a discharge chute for the clean coal leading from the discharge end of said deck, a rotary feeder at the discharge end of said chute engaging the walls thereof to seal the top of the deck against leakage of air through said chute, and said cover having a plurality of apertures throughout its area and providing a discharge area for the air considerably smaller than the area of said deck and the bed of coal thereon, to build up a controlled static pressure under said cover within the bed of coal being cleaned but maintaining the velocity of the air passing through the bed below that which would tend to raise the small particles of higher specific gravity within the bed of coal.

3. A controlled pressure apparatus adapted for cleaning coal by air including an inclined sectional foraminous underdeck having a plurality of aligned and spaced apart apertured deck sections along which a body of coal is adapted to pass, an air pressure chamber enclosing the space beneath each said deck sections and leading to the entire area therebeneath, to evenly distribute the air throughout the area of said deck, closure means for the sides of said deck, a hopper at the receiving end of said deck for feeding the coal thereto and connected to said closure means in air tight relation with respect thereto, a clean coal discharge chute leading from the discharge end of said deck and connected with said closure means for the sides of said deck in air tight relation with respect thereto and having a material discharge means at the discharge end thereof engageable with the walls of said chute to prevent leakage of air thereby, an impurities discharge chute at the discharge end of each of said deck sections and having a material discharge means engageable with the walls of said chute to prevent leakage of air thereby, and a cover adjacent but spaced above said deck and extending along said closure means in generally parallel relation with respect to said deck and connected between said hopper discharge chute in air tight relation with respect thereto, said

cover having a plurality of apertures extending therethrough and providing an air discharge area evenly distributed throughout its surface and considerably smaller than the area of said deck and building up a static pressure within the bed of coal being cleaned, but maintaining the velocity of the air therein below that which would tend to raise the small particles of higher specific gravity within the bed of coal.

4. A controlled pressure apparatus adapted for cleaning coal by air comprising an inclined sectional foraminous underdeck along which a body of coal is adapted to pass and including a plurality of aligned apertured deck sections, the discharge end of one deck section being spaced from the receiving end of the other for the discharge of impurities from the bed of coal therefrom, and having discharge chutes leading from the discharge end of each of said deck sections with discharge feeders therein engaging the walls of the chutes to seal the chutes against leakage of air therefrom, a hopper at the receiving end of said sectional deck and a feeder therein engaging the walls of said hopper to seal said hopper against the leakage of air therefrom, a discharge chute for the clean coal spaced in advance of the last impurities discharge chute and leading from the discharge end of said sectional underdeck, a feeder therein engaging the walls of said discharge chute to seal said chute bed against the leakage of air therefrom, and a cover spaced above and extending along said deck between said closure means and between said hopper and discharge chute and sealed thereto, said cover being adjacent and extending in substantially parallel relation with respect to said deck and having a plurality of apertures extending therethrough apertured throughout its area and the portions thereof providing an air discharge area considerably smaller than the area of the bed and building up the static pressure within the bed of coal being cleaned, but maintaining the velocity of the air below that which would tend to raise the small particles of higher specific gravity within said bed of coal.

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