Jan. 28, 1936. M. E. HAWORTH 2,028,834

COAL CLEANING APPARATUS

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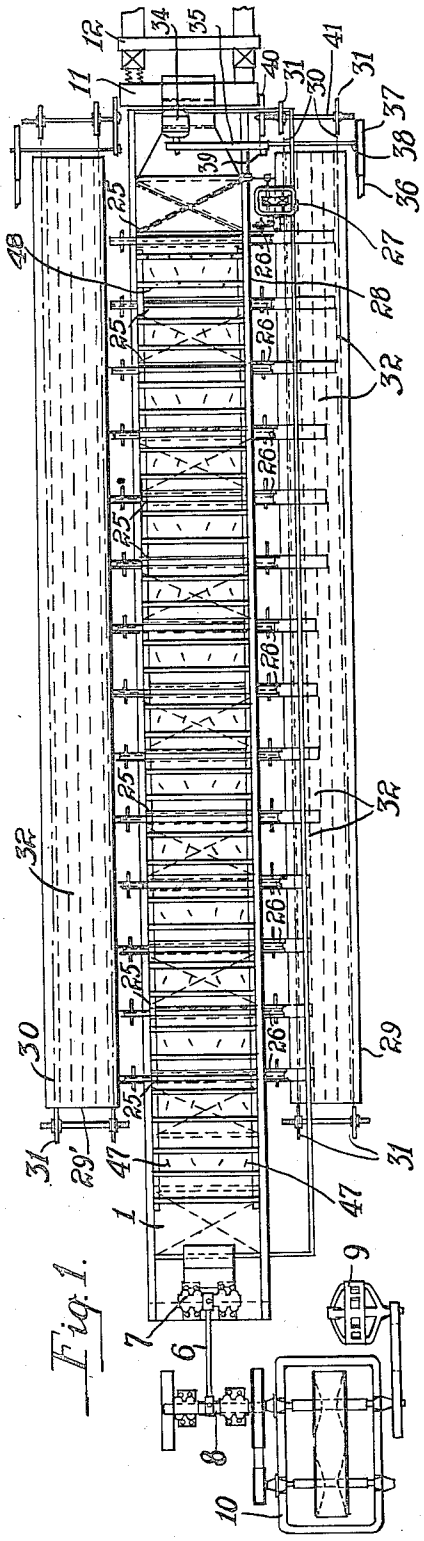


Fig. 1.

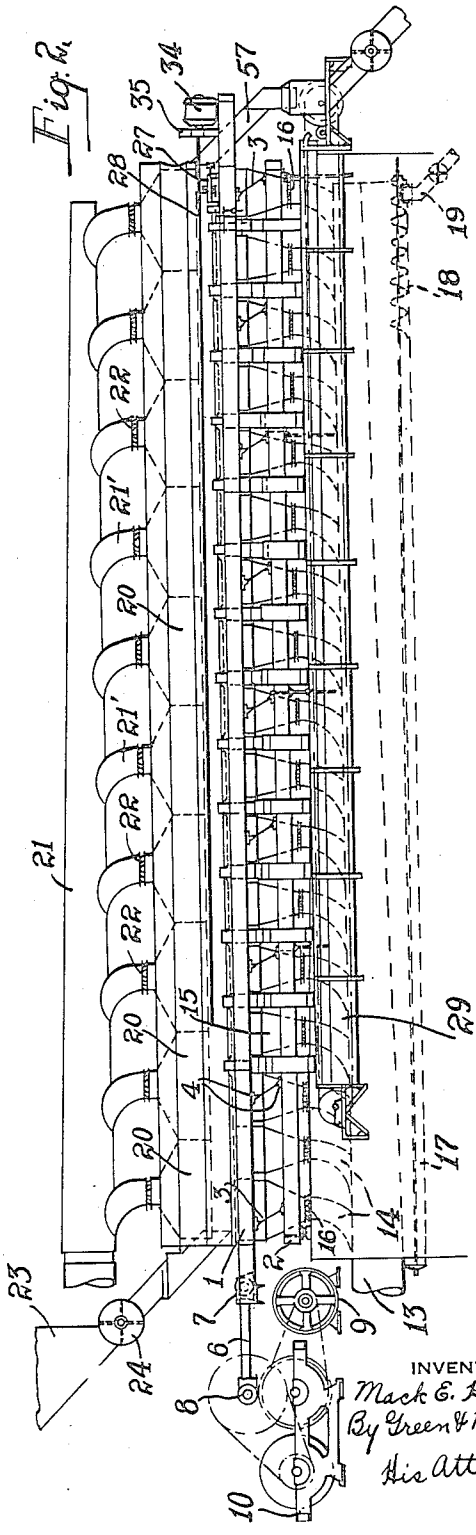


Fig. 2.

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Fig. 3.

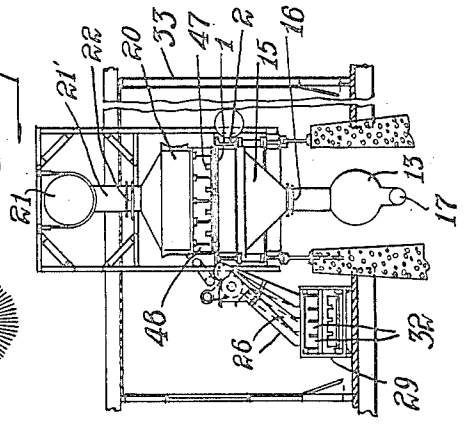
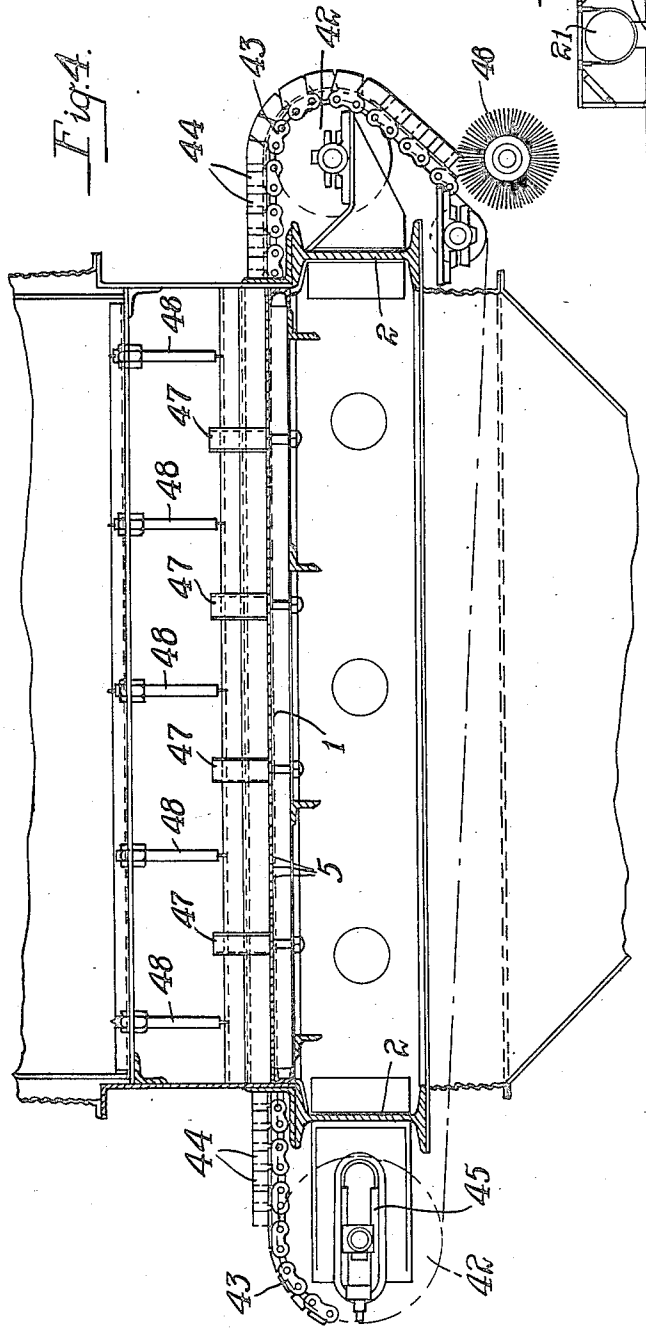


Fig. 4.



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Fig. 5.

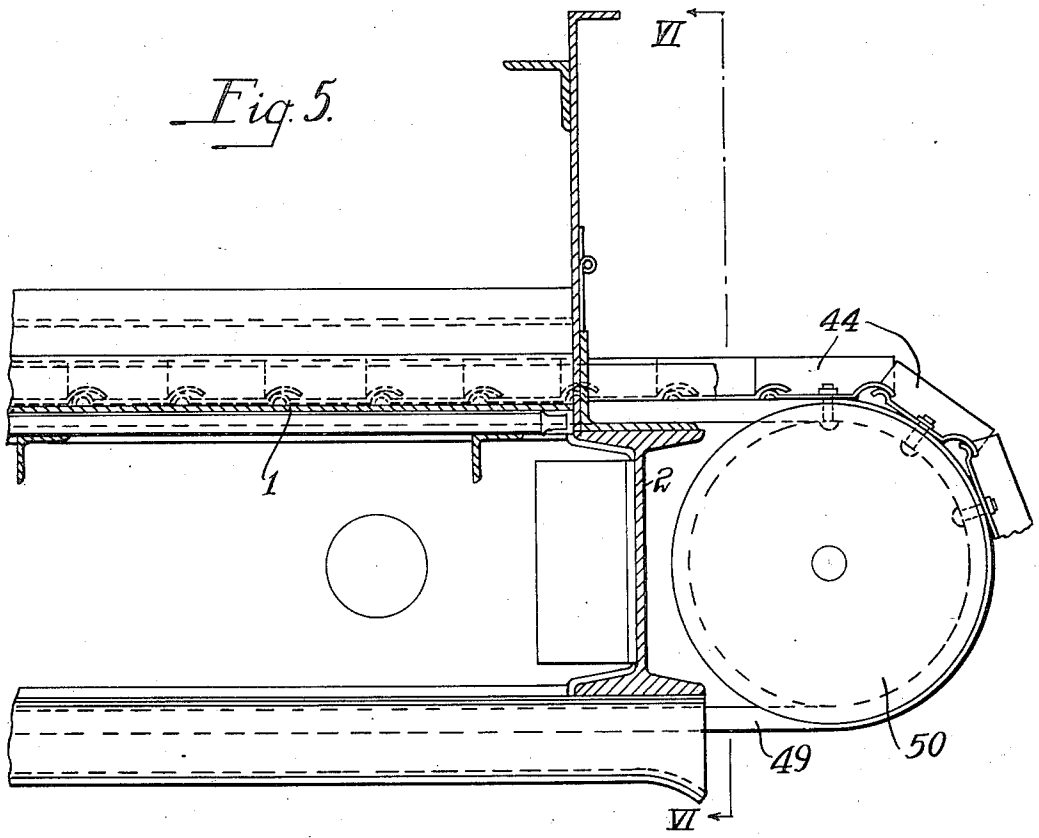
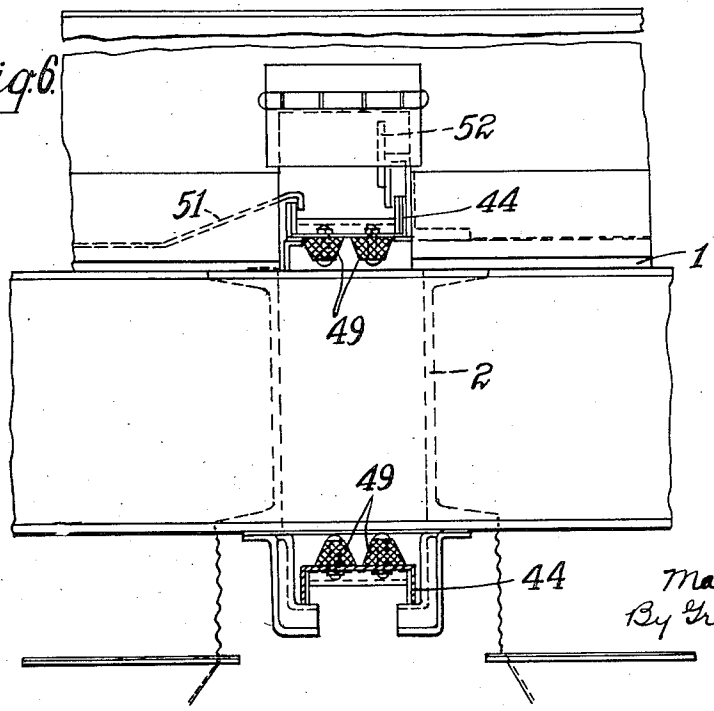


Fig. 6.



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Fig. 9.

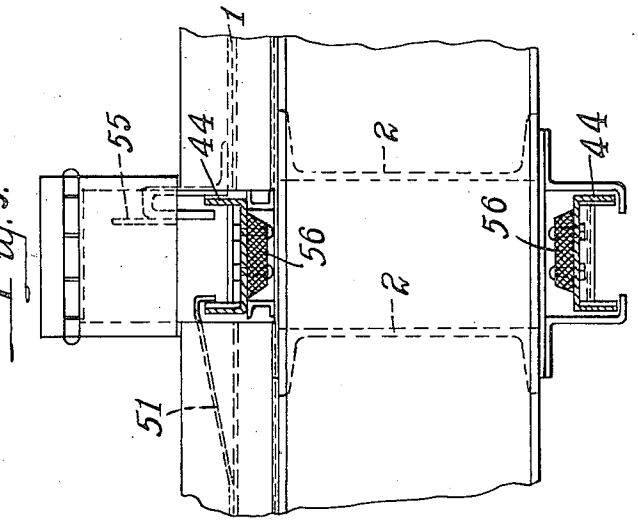


Fig. 8.

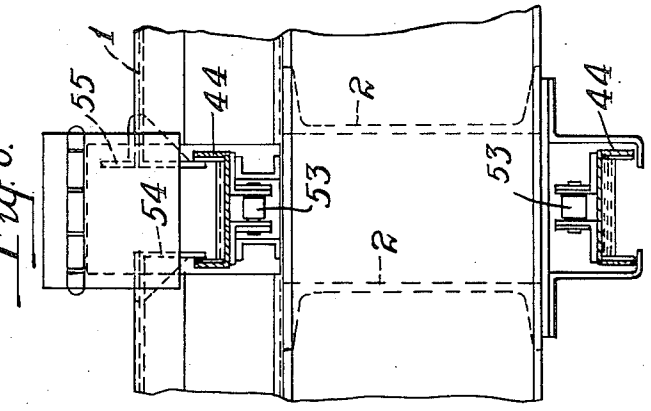
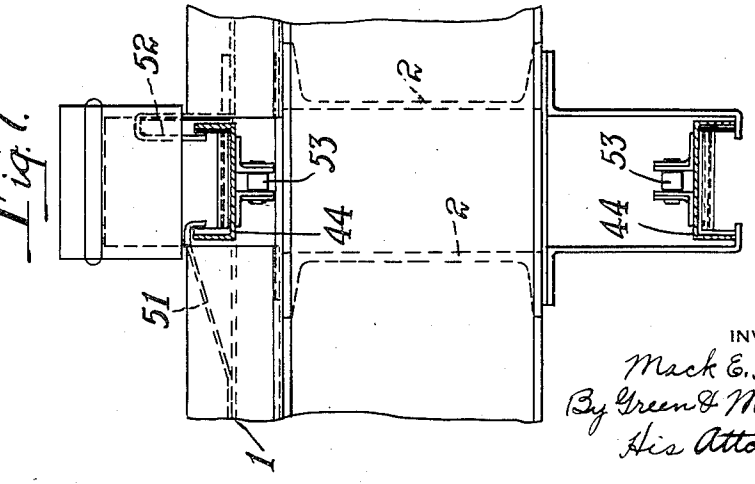


Fig. 7.



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COAL CLEANING APPARATUS

Mack E. Haworth, Pittsburgh, Pa., assignor to The Jeffrey Manufacturing Company, a corporation of Ohio

Application April 30, 1930, Serial No. 448,493

5 Claims. (Cl. 209—466)

This invention relates to an apparatus for cleaning and classifying mixtures of solid materials containing components of varying specific gravities and relates more especially to apparatus for the separation of impurities from bituminous or anthracite coal or the like.

Many attempts have been made prior to my invention to devise an effective apparatus for separating coal from refuse or impurities or to effect the separation of various mixtures of solid materials such as ores, but all such apparatus have had many inherent weaknesses and delicacies of operation with the result that they have been comparatively inefficient and inconsistent in operation. Furthermore, satisfactory separations have not been efficiently obtained due to the relative inflexibility of the apparatus.

One of the objects of this invention is to provide a highly efficient means of separating coal from its impurities which is consistent in performance and which contains the necessary auxiliary equipment and adjustability, thereby resulting in constant and positive control.

Another object of the invention is the provision of an apparatus whereby the materials may be separated into comparatively sharply defined fractions with a minimum loss of the material which is to be recovered or separated from the other materials.

A further object of the invention is the provision of an apparatus for separating various fractions of the material into predetermined and controllable portions in a continuous manner substantially entirely automatic in operation.

Still further objects are the provision of improved details in the apparatus forming the subject matter of this invention which contribute to a highly efficient separation.

Still further objects and advantages will be pointed out hereinafter or will be understood by those skilled in this particular art.

In the accompanying drawings forming a part of this application:

Figure 1 is a more or less schematic plan view of an apparatus by means of which the present invention can be carried out.

Fig. 2 is a side elevational view of Fig. 1.

Fig. 3 is an end view looking from the right-hand end of Fig. 2 and showing the apparatus enclosed in a suitable house or housing.

Fig. 4 is a cross-section through the apparatus at one of the cross-conveyors associated therewith.

Fig. 5 is an enlarged view of a somewhat modified form of cross-conveyor showing one end thereof.

Fig. 6 is a view taken substantially on the line VI—VI of Fig. 5.

Fig. 7 is a view similar to Fig. 6 of a modified form of arrangement.

Fig. 8 is a view similar to Fig. 7 of a further modification; and

Fig. 9 is a view similar to Fig. 8 of a still further modification.

In its general aspects, the apparatus includes a flat horizontal perforated deck or table having a number of troughs or stations spaced therealong, at each of which a cross-conveyor continuously operates and the cross-conveyors deliver the material deposited thereon to a longitudinal conveyor, the material which is not conveyed away being progressively moved along the deck or table until it is discharged at the end opposite the point where the material is fed on to the deck or table. A fluid stream is caused to pass through the deck which is at the same time oscillated, reciprocated or vibrated so that the material stratifies on the deck according to the specific gravities of the various components and, as will hereinafter more clearly appear, the thus stratified components are separated into fractions of predetermined or desired specific gravities. The number of stations and cross-conveyors is variable as is likewise the distance between them which is, however, appreciable.

Referring now to the drawings in detail and especially to Figs. 1, 2 and 3, it will be noted that there is a flat horizontal deck 1, which may have a textile fabric covering thereon (not shown) of considerably greater length than width. A suitable supporting framework 2 is provided and between the upper surface of the support and the lower surface of the deck are a number of flexible springs 3 suitably fixed to the support and to the deck as by means of sockets or the like 4, the inclination of the springs being variable and adjustable. The surface of the deck is suitably perforated at 5 (Fig. 4) and the apertures thereof may be of any suitable size and spacing or of varying size and spacing depending upon the particular material which is to be separated and in order not to render the drawing confusing, the perforations have been omitted from Figs. 1, 2 and 3.

This deck is suitably vibrated, oscillated or reciprocated and the stroke thereof is both controllable and variable again as to extent and frequency depending upon the particular material fed to the machine. This motion is imparted by

means of a link 6 which at one end is suitably fastened to the end of the deck at 7 and at the other end to a suitable crank 8 which is rotated by means of a motor 9 and an intermediate variable speed gear mechanism designated as a whole by 10. This variable speed stroke imparted to the deck is further controlled by providing at the opposite end a bumper block 11 attached to a suitable framework 12 and against which the deck strikes near or at the end of its stroke, thus imparting an additional impulse to the material on the deck as will be more fully explained hereinafter. It is clear that by adjusting the position of the bumper block, and suitable means is provided therefor, the stroke of the deck can be controlled and the force of the impact against the bumper block thereby also controlled.

Beneath the deck is provided a main 13 through which, for example, fluid under pressure, such as air, if desired, may be passed and by means of the connections 14 therewith fluid streams are passed upwardly into ventilating ducts 15 which have at their lower end louvers or regulating means 16 for regulating the volume of the fluid stream passing thereby. The upper ends of these ventilating ducts 15 terminate just beneath the perforated deck 1 so that the fluid stream passes up through the perforations in the deck for a purpose to be explained. A suitable blowing fan may be provided (not shown). The lowermost portion of the main 13 may have a conduit 17 in which operates a screw conveyor 18 partially and schematically illustrated in Fig. 2 and at the end of this conduit is a suitable fluid-tight discharging means 19 for the materials conveyed thereto by the screw conveyor.

Just above the deck 1 is a series of hoods 20 as shown in Fig. 2 and each hood communicates with a main 21 by a connection 21' which may be partially exhausted by a suitable exhaust fan (not shown) thereby providing a partial vacuum and at the top of each hood 20 are louvers or regulating means 22 similar to those already described in connection with the ventilating ducts 15. It is clear that by providing a positive pressure below the deck and a negative pressure above the deck, a particularly efficient fluid stream is set up, but, depending on the materials used and the conditions encountered in operation, I find that I may use either the pressure beneath the deck or the partial vacuum above the deck separately from the other and still obtain efficient results.

At one end of the deck, which may be termed the feed end, a suitable hopper mechanism 23 is provided for supplying material to the surface of the deck and as shown at 24 suitable means is provided for preventing dust and the like from being thrown into the air, and such may consist, for example, of a hollow cylindrical portion lined with some suitable material like rubber or felt in which operates a multi-bladed wheel having the blade ends lined with a material similar to the material of the lining of the hollow cylinder thereby forming a wiping contact therewith which is substantially fluid tight. In practice it is to be understood that the material fed to the deck may be raw product obtained from the mine or the like or it may be previously or predeterminedly partially or wholly sized or stratified as the case may be.

It has already been stated that the deck is flat, horizontal and perforated and it is to be further noted that in contradistinction to many prior art devices the deck is not transversely inclined in any case, although if desired or found necessary it may be longitudinally inclined, that is, the discharge end may be either somewhat higher or somewhat lower than the feed end, and such an arrangement has certain advantages in dealing with some materials. Further than this it is also contemplated that the center of the deck might be lower than either of the ends. This too is advantageous in some special cases, so that the deck declines from its feed end to a mid-portion which is the lowest point and thereafter ascends to the discharge end which is higher than the mid-portion, but in no case, is the deck transversely inclined, that is, at any cross-section of the deck both sides are at the same level and in the same plane.

As has also been above mentioned along the length of the deck are a plurality of so-called troughs or stations 25 and these together with the cross or transverse conveyors 26, to be now explained, form an important feature of my invention. Since all these conveyors such as those shown in Fig. 1 are of similar construction, it is only necessary to describe one in detail as it will be understood that except as hereinafter noted the other stations and conveyors are similar. Referring to Fig. 1, therefore, the station and conveyor at the righthand end will be used as an example as this is shown in more complete form than the other conveyors.

The trough and conveyor 25 and 26 in question is formed by inserting at that station a generally U-shaped apron which may be, depending on circumstances, either slightly below the surface of the deck or slightly above the surface of the deck as will be hereinafter more fully understood from Figs. 7, 8 and 9, for example. Whichever trough is used the same moves continuously at right angles to the length of the deck, or it may move obliquely or at any angle to the deck, and this may be effected by attaching in overlapping relation a plurality of the U-shaped aprons to an endless belt, chain or the like passing over a pulley at either side of the deck and suitably operated by means of intermediate variable speed gearing 27 from a shaft 28 which may be a common shaft for all the cross-conveyors which, accordingly can be operated therefrom either at the same speed or at varying speeds and the arrangement is such that the speed of each conveyor can be independently varied by means of the variable speed gearing interposed between the pulley operating gear and the pinion on the shaft from which the particular gearing is driven. The shaft may be driven by a suitable motor 34 with a belt and gear drive 35. Not only can each cross conveyor be operated at an independently adjustable speed, but the cross conveyor itself is adjustable both as to width and as to depth and the means for accomplishing these adjustments will be hereinafter pointed out. The quantity of material discharged by each conveyor is therefore variable and predeterminable.

It will be apparent from Fig. 1 that the cross conveyors are constructed and arranged to discharge the materials deposited thereon at varying points and four such points are shown in Fig. 1, the purpose of which will now be explained.

It is apparent even at this point that the cross conveyors receive materials of somewhat different kinds and that these fractions of the original material may have common components which progressively vary, or may have different components which may vary as to specific gravity from one end of the deck to the other. Depending upon

the ultimate result desired in the particular instance the materials deposited on the cross conveyors may be separately collected or may be combined in any desired manner so that the material will be classified according to requirements.

Extending longitudinally along the side of the deck is a longitudinal conveyor **29** which, for example, may be composed of endless chains **30** operating on sprocket wheels **31** at each end of its path and, for example, an apron or the like may be secured to said chain having longitudinal channels **32** therein for the reception of the materials of the cross conveyors and it is now clear that the cross conveyors can discharge their materials into selected or predetermined channels of the longitudinal conveyor **29** so that at the end of the conveyor where the materials deposited in the channels are discharged, certain definite and predetermined fractions of the original material are collected. An additional similar longitudinal conveyor **29'** is shown on the other side of the deck and this is for alternative or auxiliary use either with the deck shown or with an additional unit of which any desired number may be provided. Each longitudinal conveyor may be operated by a suitable motor (not shown) connected by a belt **36** to a pulley **37** on a shaft **38** having a pinion **39** meshing with a pinion **40** on shaft **41** carrying sprockets **31**.

Referring to Fig. 3, it will be apparent that substantially the whole apparatus may be enclosed in a suitable housing **33** having the necessary doors and windows and in practice a slightly negative pressure will exist within the housing thereby preventing dust or the like from being thrown into the surrounding atmosphere and causing a nuisance or menace to health and property.

Fig. 4 illustrates a cross section through the deck of Fig. 1 and shows an exemplary cross conveyor and certain agitating and controlling means for the material on the deck in order to enhance the results secured if the materials being treated require the same. The perforated deck **1** is suitably supported as has been above explained and the supporting members **2** may be provided for that purpose. On either side of the deck is shown a suitable sprocket **42** on which operates an endless chain **43** and secured to the upper surface of the chain are the aprons hereinabove referred to here designated as **44**, and as shown in this figure these are a number of overlapping U-shaped metallic pieces forming a continuous channel into which material settles and from which the material is discharged as already explained. The usual provision may be made for tightening or loosening the chain on the sprockets and such is diagrammatically illustrated at **45**. A brush **46** may be provided to clean the passing aprons.

If desired, a number of riffles **47** may be secured to the deck and as shown in Fig. 1 predeterminedly inclined, if desired, so as to keep the materials passing along the deck from packing and thereby preventing proper stratification. These riffles **47** are diagrammatically shown also in Fig. 1 and it is to be understood that these are auxiliary only and may be omitted altogether. Depending from a suitable framework are the rods **48** shown clearly in Figs. 1, 3 and 4 and these project down into the materials on the deck between the riffles when used, as is clearly shown in Fig. 3, for the purpose of further preventing undue packing of the material on the deck. The material may, in a proper case, form a bed in the neighborhood of six to eight inches in depth, although the depth may be, however, more or less, depending on the material being separated, and such depth may be so regulated as to be uniform over the entire area of the deck.

Instead of the chain and sprockets of Fig. 4, a textile rope **49** and pulleys **50** as shown in Fig. 5 may be used and in such case the U-shaped overlapping aprons **44** are securely fastened to the textile rope. This construction is shown further in Fig. 6 which also shows that the particular form of cross conveyor is above the surface of the deck **1** which is provided immediately before the cross conveyor with the inclined plate **51** which causes the bed of material to rise in accordance with the incline of the plate and in passing by the cross conveyor deposits its lowermost portion in the conveyor, the remaining material passing up over the baffle arrangement **52** which prevents the material from moving past the conveyor too rapidly, in which case it would not have time to deposit the predetermined amount of lowermost material.

The modification of Fig. 7 is substantially similar to that of Fig. 6 except that in place of the textile rope a roller chain **53** is provided to which the U-shaped overlapping aprons **44** forming the conveyor are secured.

Fig. 8 shows a modification wherein the construction of Fig. 7 may be provided below the surface of the deck instead of above and except for this distinction no particular comment appears to be required, except that whether above or below the surface of the deck, the distance is not great and may be in the neighborhood of about ½ inch. A depending flange **54** is used instead of plate **51** and a baffle **55** similar to **52** is provided.

Fig. 9 shows an arrangement similar to Fig. 6 wherein a belt **56** is utilized instead of textile ropes and it is clear thus that a number of materials and types of belts are satisfactory for securing to them the overlapping U-shaped aprons **44**, forming the trough of the conveyor.

In operation the deck **1** is vibrated, oscillated or reciprocated by means of the mechanism provided therefor, and the springs **3** connecting the deck and support, therefore change their direction permitting a predetermined stroke of the deck, the material being charged onto the feed end of the deck. The motion of the deck together with the fluid stream passing therethrough which has meanwhile been turned on, causes the material to stratify according to the specific gravities of the various components, and naturally due to the action of the force of gravity the heaviest materials sink to the bottom of the material and the lightest rise to the top, the intermediate particles gradually arranging themselves according to graduating specific gravities from bottom to top as will be understood. This is efficiently brought about due not only to the motion of the deck, but because the fluid stream passes up through the material in a direction opposite to that of the force of gravity. These factors together with the riffles on the deck, when used, and the depending rods, keep the material from packing. Consequently, proper stratification is effected immediately, even before the material reaches the first cross conveyor. The stroke of the deck may, if so desired, be adjusted so that the return stroke is more rapid than the forward stroke and this when used in conjunction with the other features including the bumper block, causes the material to pass along the length of

the deck, the lowermost or heaviest gravity particles being deposited in the conveyors as they are reached so that by the time the material reaches the end of the deck and has passed the last cross conveyor it consists only of the lightest fraction of the material, which in the case of a coal mixture, is the coal itself. Of course, the fractions deposited in each conveyor have some common material, but since there are a number of cross conveyors and the apparatus and process are very flexible, being adjustable and variable to suit the material used, the materials deposited in the conveyors may be combined in any desired order or kept separate, if preferred. The material deposited in the first few cross conveyors is generally refuse, but as the material extracted approaches the specific gravity of the coal, a small amount of coal may be deposited in the conveyors and the product there is termed middlings. It is clear that where any of these fractions contain material which is desired, such fraction may be collected separately and where any of the conveyors contain desired material along with refuse such fractions may be retreated either by passing the same again through the same apparatus or by passing them through a similar additional or auxiliary unit.

The coal itself which is the lightest fraction in case of a coal mixture, reaches the end of the deck and is discharged therefrom through a suitable conduit **57** having interposed in its length a fluid tight valve arrangement **24'** such as that at **24** described above in connection with the hopper mechanism **23**, for the purpose of preventing air from being sucked up therethrough into the hoods which is not desired, although some small leakage is relatively unimportant.

During the operation of the machine certain of the lightest components of the agitated material pass in the form of a dust up through the hoods **20** and into the main **21** from which they are discharged in any suitable way, and if such dust contains material which is desired, it may be suitably treated in any well known way to separate the material to be recovered therefrom or the fluid may be passed through cleaners or dust arresters and then re-circulated in whole or in part. Also, certain very fine and very heavy materials may pass down through the perforations in the deck and through the ventilating ducts, even though a fluid stream is passing up therethrough all the time, and such fine heavy material passes down into the lowermost conduit **17** in which the screw conveyor **18** operates thereby discharging said material from the main and passing it through the discharge conduit **19** also having a fluid tight valve **24''**, as above explained.

The width and depth of the aprons **44** and hence the trough of the conveyor may be varied by suitably bending them with a greater or less side flange or even by changing the aprons, if preferred. This enables the conveyor to take out the predetermined amount of material from the mixture and in conjunction with the independently variable speed control of each cross conveyor provides an exceedingly flexible arrangement adapted for any mixture of solid materials containing components of different specific gravities.

The above is more illustrative than limitative as I find that many variations, modifications, substitutions, and omissions may be made without departing from the spirit and scope of the invention.

What I claim as new and desire to secure by Letters Patent is:

1. A coal cleaning and classifying apparatus comprising a flat horizontal perforated deck, a supporting framework beneath said deck, inclined springs connecting said supporting framework and deck, means for oscillating said deck, means for passing a fluid stream upwardly through said deck, thereby agitating and stratifying the material thereon, transverse conveyors for removing predetermined portions of said stratified material, and means for isolating a predetermined fraction of said stratified material, the oscillations of the deck being variable and the stroke being terminated by contact with an adjustable bumper block.

2. In a coal cleaning apparatus, a horizontal perforated deck, of greater length than width, a plurality of spaced stations along said deck, continuously operating transverse conveyors at said stations, said conveyors consisting of endless carriers and associated receptacles, means for independently adjusting the effective capacity of said conveyors, a longitudinal conveyor having channels lengthwise thereof, said transverse conveyors discharging into predetermined channels of said longitudinal conveyor.

3. In coal cleaning apparatus, the combination with a perforated deck, of a plurality of transverse stations distributed along said deck, a plurality of cross-conveyors one at each station, a pneumatic pressure main, a plurality of ducts one leading from said main to each section of said deck between stations, louver regulators one for each duct, a suction main above said deck, a housing, a plurality of hoods in said housing above said deck, a plurality of ducts connecting said hoods to said suction main, and a plurality of louvers one in each of said last-named ducts.

4. In coal cleaning apparatus, the combination with a perforated deck, of means for producing a positive pneumatic pressure below said deck, a plurality of transverse stations distributed along said deck, a plurality of cross-conveyors one at each station, means for regulating the pneumatic pressure for each section of said deck between stations, mechanism for producing a negative pressure above said deck, means for controlling the operation of said conveyors individually, and means for collecting and classifying the material discharged from said conveyors.

5. In coal cleaning apparatus, the combination with means comprising a perforated deck for moving material along the same and stratifying such material, of a plurality of cross-conveyors distributed along said deck and each having an endless driving element with a plurality of U-shaped aprons attached thereto, the bottom of each apron being approximately in the plane of said deck and the side plates thereof projecting upwardly above the surface of said deck, and means for operating said conveyors during movement of material along said deck to remove the lowermost stratum from the layer of material on said deck.

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