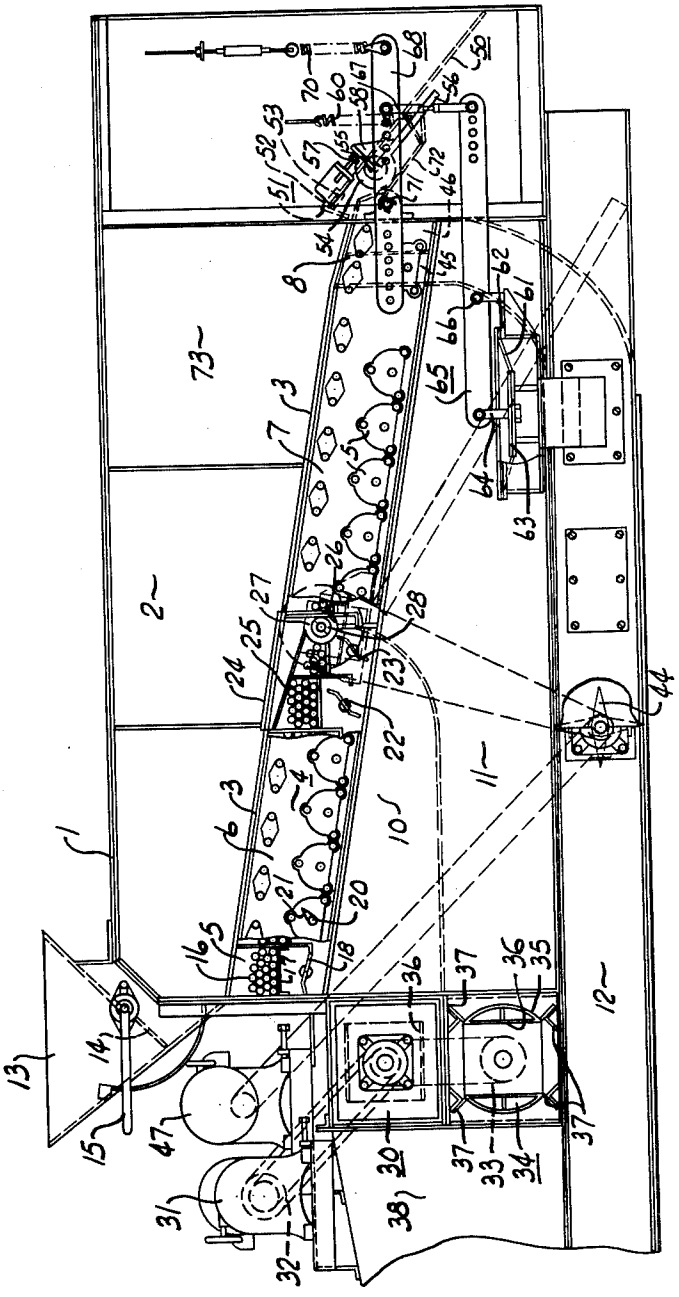
Dec. 4, 1962 D. B. BINNIX 3,066,800

METHOD AND APPARATUS FOR PNEUMATIC STRATIFICATION

Filed Jan. 14, 1960 2 Sheets-Sheet 1

Fig. 1



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METHOD AND APPARATUS FOR PNEUMATIC STRATIFICATION

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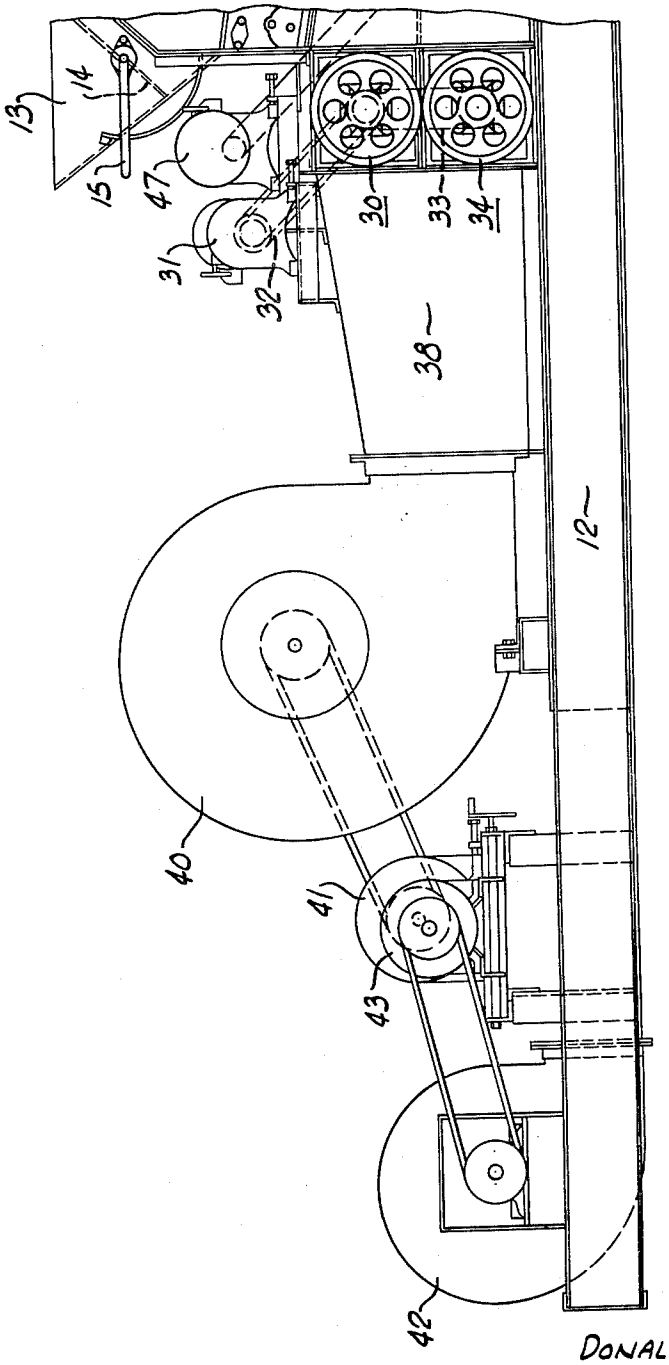


Fig. 2

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METHOD AND APPARATUS FOR PNEUMATIC STRATIFICATION

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15 Claims. (Cl. 209—475)

This invention relates generally to the separation of minerals by pneumatic stratification and more particularly to the method and apparatus for accomplishing the same.

An important object of this invention is in the dividing of the air screen into a plurality of compartments each being supplied with a source of air under pressure independently effective in stratifying the mineral along a pneumatic bed. Two or more of the compartments or zones may be supplied with air admitted thereto alternately from a common blower source or from entirely independent sources of air.

Another object is the provision of a sloping pneumatic screen for stratification of minerals which provides a large number of independent cells each independently controlled and regulated for the admission of air to and through these cells to provide a gradation of increased volume and air pressure along the sloping pneumatic screen in proportion with the heavier density of the stratified materials thereon.

Another object is the provision of veins or valves in each of the many cells along the sloping pneumatic screen to attain a uniform movement and stratification for the continuous separation of materials by pneumatic floatation.

Another object is the provision of a series of cells distributed along a pneumatic screen and which are provided with marble packs of depreciating depth in proportion to the increased stratification and weight of the pneumatically suspended bed as it moves down the sloping pneumatic screen.

Another object is the provision of a movable dam at the end of a sloping pneumatic screen for separating the dense and high specific gravity materials rejected from the separated material of less specific gravity. This object includes the provision of a cam shaft which permits the adjustment of the dam to regulate the thickness of the reject material removed as well as permitting the dam to be opened quickly for the removal of an unusually large object that is blocking the operation of the pneumatic stratifier.

Another object is the provision of a pneumatically actuated control for operating the extent of the opening of the refuse gate in accordance with the resistance to flow of air through the bed of minerals which depends upon the density of the bed due to the accumulation of the materials of high specific gravity. Thus the permeability of the air through the bed is employed to control the opening and closing of a valve that regulates the thickness of the reject material flowing from under the pneumatically suspended bed of minerals.

Another object of this invention is the provision of variable speed motors and reducers for driving pulsators and thereby effect the pneumatic suspension of the mineral bed. The speed of the motor reducers in driving the pulsators in the form of rotary valves varies the number of pulsations per minute fed to suspend the mineral bed which may be varied along the pneumatic screen in accordance with the density of the mineral bed for maintaining it uniformly in suspension.

Another object is the provision of the use of a transparent plastic on the sides of the sloping pneumatic screen to visually disclose the stratification for the purpose of permitting adjustment of the many cells along the bed

to effect the best and most economical stratification of the minerals forming the bed. The transparent plastic being affected very little by the movement of the mineral as compared to that of glass which is a harder material and is more readily scratched for this reason.

Another object of this invention is the provision of a trap intermediate the length of the sloping pneumatic screen which will remove the initial particles of heavier density for discharge before they reach a zone of increased volume and pressure of air which would cause such particles to rise higher in the stratification of the pneumatically suspended mineral. This preliminary rejection of the parts of higher specific gravity permits the bed to have increased density or penetration requiring greater volume and higher pressures toward the end of the bed to maintain the same in pneumatic suspension.

Other objects and advantages of this invention appear hereinafter in the following description and claims.

The accompanying drawings show for the purpose of exemplification without limiting this invention or the claims thereto, certain practical embodiments illustrating the principles of this invention; wherein:

FIG. 1 is a view in side elevation showing the pneumatic stratifier comprising this invention.

FIG. 2 is a view in side elevation illustrating the blowers attached to the left end of the machine shown in FIG. 1.

Referring to FIG. 1 of the drawings the pneumatic stratifier comprises the enclosure 1 being separated in five different chambers, the material chamber 2 the bottom of which contains the sloping pneumatic screen 3, the second chamber 4 containing a series of cells 5 which separate the under side of the screen 3 in seven cells for the first section 6, for the second section 7 there are six cells 5 and in the third section 8 there are two cells. The third chamber is a pneumatic chamber 10 that supplies the air to the first section 6 of the cells 5. The fourth chamber 11 is a pneumatic chamber that supplies air to the second section 7 of the cells 5 and the fifth chamber 12 is a pneumatic chamber that supplies air to the last two cells in the section 8. Thus each of the five chambers within the enclosure 1 provides a function to increase the volume and pressure of the air downwardly along the pneumatic screen 3 to the discharge end.

Chamber 2 is supplied with a mineral such as run of the mine coal which is preferably sized from zero to three-quarter inch that is dumped in the hopper 13, the hopper gate 14 of which is adjustably positioned by the operating handle 15. The limitations of the movement of the gate 14 are shown in the drawing.

The coal proceeds down into the chamber 2 and along the screen 3 and each cell 5 under the screen is divided into two sections, the top section that contains a marble pack which consists of a pack of glass marbles 16 that diffuse the air flowing upwardly through the cell and through the screen 3 to suspend the coal and stratify the same. The marbles 16 are supported on a large screen mesh 17 and the marble pack or bed will vary in depth in the consecutive cells from the beginning of the screen to the discharge thereof. More marbles are provided in the initial cells than in the end cells because the marbles have the effect of not only diffusing the air but also diminishing the volume and pressure of the air to the screen 3 as the pack is increased in depth. Each cell also contains a manually operated vane or valve 18 pivoted on the shafts 20 and provided with an indicator such as shown at 21. The vanes or valves 18 are employed to also regulate the amount of air admitted to each cell. Thus the adjustment of the vanes or valves 18 together with the depth of the marble pack are determining factors in the amount of air that is admitted to that section of the screen 3 supplied by each particular cell 5 for deter-

ming the pneumatic suspension of the body of material such as coal.

When the run of mine coal enters this stratifier the particles of heavier specific gravity such as slate and rock and sulphur balls and the like are interspersed throughout the material but as the material is suspended by the air these heavier particles drop to the lower part of the screen; whereas the lighter coal particles stay at the top of the bed of pneumatically suspended coal. As the bed moves down the screen the heavier parts all collect at the under side of the bed close to the screen and become very dense which requires a greater volume of air and a higher pressure of air to suspend the bed which is compensated for by separating the chambers **10**, **11** and **12**.

As the bed reaches the cells **22** and **23**, a special screen is provided as indicated at **24** over these cells and which permits the entry of $-3/16''$ reject off the bottom of the suspended coal bed moving thereunder. These rejects are the heavy particles initially separated out from the bed and have not had a sufficient time to become too dense and therefore are more readily removed through the screen **24** from whence it drops on the lower screen **25** and is conveyed to the transverse pipe **26** through the opening **27** and is conveyed laterally by the screw **28**. If these $-3/16''$ rejects were permitted to be conveyed further along the pneumatically suspended bed of coal the increased air pressure from this point on would have the tendency of sending these ten mesh rejects higher in the pneumatically suspended coal bed and thus create a condition where it would be difficult to insure the removal of a high percentage of the $-3/16''$ rejects at the end of the bed. The separation is therefore improved by this intermediate draw-off of the $-3/16''$ rejects before the air volume and pressure become too high to cause these rejects to intermingle with the coal. It will be noted that the cells **22** and **23** are at the end of the air chamber **10** which is the first chamber of the system. The chamber **10** is supplied with air through the rotary valve **30** which is driven by the variable speed rotor **31** and reducer mechanism through a chain **32**. A second chain **33** drives the lower rotary valve **34**. The rotary valves **30** and **34** are the same and have spherical plug members as indicated at **35** with a central passageway **36**. The spherical portions of the plug **35** of the valve cooperate with the adjustable port members **37** of which there are four. It will be noted in the drawings that the same motor driving the two rotary valves **30** and **34** control the movement of air therethrough at 180° out of phase from each other as the port **36** of the upper valve plug is shown in a horizontal position while the port **36** of the lower valve plug is shown in a vertical position. In other words, while the valve **30** has its passage **36** so as to let the maximum amount of air from the chamber **38** to the chamber **10** as shown, the valve **34** closes and prevents any pasasge of air from the chamber **38** to the chamber **11**. Thus upon the rotation of both of the valves **30** and **34** the air supplied to the cells **5** is pulsated according to the revolutions per minute of the rotary valves and since these valves are operated simultaneously but at 180° out of phase with each other, the pulsation of air in pneumatically suspending the initial portion of the coal bed is also 180° out of phase than the second portion which is indicated by that portion of the pneumatically suspended coal over the cell **7** fed by the chamber **11**. These pulsations not only aid in the suspension of the bed but provides a movement that allows the particles making up the coal bed to arrange themselves in stratification throughout the depth of the bed in accordance with the specific gravity of each of the particles. Thus not only the size and depth of the marbles in the marble pack **16** but also the adjustment of the valves or vanes **18** function to pneumatically suspend the coal bed but the number of air pulsations created by the rotary valves **30** and **34** likewise have an effect in the pneumatic

suspension of the coal bed that permits the particles of different specific gravity to reach their own level within the bed. This too is further affected by the size and the number of cells pulsated by each of the valves. One thus has many variables which may be adjusted to provide an improved pneumatic suspension of the coal bed.

The chamber **38** as shown in FIG. 2 is supplied with air from the fan indicated at **40** which is in turn driven by a motor **41**. The chamber **12** in turn is supplied with air from the fan **42** driven by the motor **43**. The motors **41** and **43** are likewise variable in speed so as to permit a change in the volume of air produced over a given time which is a sixth factor in the control of the supply of air to pneumatically suspend the bed of coal which is thus caused to move down the sloping screen **3** due to gravity and because of this pneumatic pulsating suspension.

The chamber **12** is provided with the rotary valve member **44** which is a single bladed valve that imparts two pulsations per revolution from the chamber **12** to the end cells **45** and **46**. The valve **44** is driven by means of the variable speed motor and reducer **47** and this motor is also employed to drive the screw conveyor **28** as shown.

Thus not only each of the consecutive cells **5** all the way down the screen **3** provide for the passage of an increased volume of air progressively down the screen but the last two cells require a considerably greater amount of air than the cells in the chamber **7** because the bed of coal by this time is substantially all properly stratified with the heavy specific gravity rejects lying along the bottom portion of the bed being substantially uniform in depth and the air supplied through the cells **45** and **46** of the chamber **8** must be materially greater in volume to pulsate the bed at this position for which reason the chamber **8** is supplied with air from an independent source.

At the end of the chamber **2** a discharge chute **50** which is rather steep in its inclination has a lip or dam **51** at its upper end. This dam has upper and lower projections **52** and **53** that fit on the top and bottom of the chute **50** which permit the dam member **51** to be removable and changed for different types of run of the mine coal. It will be noted that the bottom edge of the dam is spaced from the screen **3** and this spacing permits the flow of the reject material from the under side of the stratified bed; whereas the coal will flow over the top of the dam **51** and pass down the chute **50** cleaned of all of its reject. The chute **50** rests on the cam **54** which is mounted on the shaft **55** rotated by the hand lever **56**. Thus different positions of the lever **56** will cause the cam **54** to vary the heighth of the chute **50** and thus the opening between the bottom edge of the dam **51** and the screen. A stop **57** prevents the member **58** on the shaft **55** to limit the movement of the lever and the spring **60** is attached to the lever **56** to maintain the movable abutment **58** against the stop **57** and thus at all times maintain a constant opening between the bottom of the dam **51** and the screen **3**. If for some reason a large chunk of material descends in the pneumatically suspended bed and tends to clog this opening under the dam one need only to depress the lever **56** and the cam **54** will raise the chute **50** and the dam to permit the large piece that is blocking the dam to pass therethrough to reject. The mere release of the handle **56** causes the spring **60** to move into its fixed position against the stop **57**.

The air chamber has exposed thereto a servomotor of pneumatic type containing a flexible diaphragm **61** which is fastened between the annular rings **62** and the center of the diaphragm is provided with the plates **63** which permit it to be attached by the link **64** to the lever **65**. The lever **65** is fulcrumed at **66** and its other end is provided with the link **67** that connects to the second lever **68** of the system. The link **67** may be adjusted

along the levers 65 and 68 to provide for different weights of the reject material. The end of the lever 68 is supported by the spring 70 and its intermediate portion is fulcrumed as indicated at 71. This fulcrum can be changed in its positions along the lever 68 by means of the many holes provided. Thus the lever 68 is adjustable relative to the lever 65 as well as the link 67.

The fulcrum 71 of the lever 68 carries the refuse gate 72 which receives all the refuse that flows under the dam 51. The refuse is held on the gate by reason of the lever system and is opened only when the air effective on the diaphragm 61 is of sufficient pressure which indicates that it is having a very difficult time pneumatically suspending the bed of coal just above the dam 51. As the reject strata in the coal bed on the screen 3 becomes very dense, the pressure in the chamber 12 increases. This dense material is of course a measurement of the weight of the reject and since the high density creates an increased pressure on the diaphragm 61 the lever 65 will be rotated clockwise and pull the lever 68 against the tension of the spring 70 and will open the gate 72 and allow more or less reject to flow from the end of the screen 3.

The pulsating air pressure in the chamber 12 is effective to vibrate the lever system in the period of the pulsations of air which vibration makes the lever system sensitive to slight variations in pressure and the gate 72 is thereby maintained open to the proper amount for the exist of the reject at a speed correlated with the density of the reject in the last portion of the screen. In this manner a very high degree of accuracy is maintained in the separation of reject from the coal by this gaseous suspension stratifier.

The sides 73 of the chamber 2 may be made of a clear plastic when the stratifier is employed for the separation of rejects from coal. Such plastic side walls may be made of methyl methacrylate and will last a considerable length of time which is rather difficult to understand as one would think that such a material would become scratched by the coal and other particles traveling therethrough. However, the methyl methacrylate is found to stand up far better than that of glass which is much harder and it permits the operator to frequently view the stratification of the reject in the pneumatically suspended pulsating coal bed. It is believed that the plastic is lubricated by the coal and does not set up a charge that will hold the dust particles which permits the bed to be readily observed through plastic rather than through glass.

I claim:

1. The method of cleaning minerals which comprises the steps of suspending a downwardly sloping mineral bed by applying a pulsating pneumatic pressure upwardly therethrough for the full length of the bed to move it downwardly, providing a gradation of increased pneumatic pressure along the downwardly sloping bed to stratify and maintain the suspended particles stratified according to their specific gravity, separating the stratified layers at the end of the bed as the sloping bed continues to move and controlling the separation of the stratified layers in accordance with the variations of the pulsating pneumatic pressure suspending the last portion of the bed.

2. A machine for pneumatically stratifying a mineral bed which comprises a downwardly sloping screen, a plurality of divisible sections disposed in series along the under side of the sloping screen, dividing means to independently isolate a plurality of sections under the screen, means for supplying pulsating pneumatic pressures in each of said divisible sections, partition means for dividing the last portion of the screen to be independent of the previous portions of the screen, independent means for supplying pneumatic pulsations to said last portion of the screen, and movable gate means for independently discharging the separated stratified particles of heavier specific gravity from the stratified bed and control means for operating said gate means to vary the discharge of the heavier particles from the stratified bed in accordance with the pressure of the pneumatic impulses due to the permeability of the last portion of the bed.

3. A gaseous suspension stratifying machine comprising a chamber, a sloping screen in said chamber, a plurality of independent marble packed cells under said sloping screen for directing the flow of gases upwardly therethrough, partition means below said cells for separating the supply of gases to sections of said cells, means for controlling the supply of pulsating gaseous pressures to said cells to suspend a bed of minerals on said screen and stratify the same according to the specific gravity of the minerals, means for controlling the gradation of the pulsating gaseous pressures supplied to said partition means to aid in effecting the increased gradation in the pressures suspending the bed down the sloping screen, a stratification separator means at the discharge end of said screen, a gate to receive the separated particles of heavier specific gravity, and a servomotor connected to actuate said gate, said servomotor of the pneumatic type actuated by the pressure pulsations due to the permeability of that portion of the bed before said separator means.

4. The structure of claim 3 which also includes a transparent wall from the side of the chamber to visually expose the suspension of the particles making up the mineral bed.

5. The structure of claim 3 which also includes means for varying the volume of the supply of the gases to the machine for controlling the suspension of the particles making up the mineral bed.

6. The method of cleaning minerals which comprises the steps of suspending a downwardly sloping mineral bed by applying a pulsating pneumatic pressure upwardly therethrough for the full length of the bed to move it downwardly, providing a gradation of increased pneumatic pressure along the downwardly sloping bed to stratify and maintain the suspended particles stratified according to their specific gravity, damming the strata of suspended particles of heavier specific gravity, catching the lowermost portion of the dammed strata, releasing the caught strata in controlled pulsating movements, and controlling the pulsating releasing movements by the pneumatic impulses due to the permeability of that portion of the bed before separation.

7. The method of cleaning minerals which consists in the steps of suspending a downwardly sloping mineral bed by applying a pulsating pneumatic pressure upwardly therethrough for its full length of the bed to move it downwardly, providing a gradation of increased pneumatic pressure along the downwardly sloping bed to stratify and maintain the suspended particles stratified according to their specific gravity, dividing the supply of the pneumatic pressure into a series of zones along the bed, and supplying an independent pneumatic pressure in the last zone along the bed from an independent source of supply.

8. The method of claim 7 characterized by the step of supplying the pulsating pressures of alternate phase relation in adjacent zones at the upper portion of the downwardly sloping bed from a single source of supply.

9. The method of claim 7 characterized by the step of controlling the movement of separated particles of heavier specific gravity by the increased pneumatic pressure in only the last zone at the lower end of the downwardly sloping bed due to its increased resistance to the passage of air through the unseparated particles of heavier specific gravity in this last zone.

10. A machine for stratifying a mineral bed with pneumatic pressure which consists of a downwardly sloping screen, a stratification separator means at the discharge end of said screen, a continuous series of vertically open cells of uniform size and independent of each other and

dividing the whole of the under side of the screen, means in each cell to vary the volume of the pneumatic current under pressure passing upwardly through each cell on an increased gradient down said screen, a plurality of chambers each connected to supply a plurality of said cells forming independent zones along the bed, a rotary valve for controlling the flow of pneumatic current to each chamber to induce pulsations in the pneumatic current supplied under pressure, and means to supply independent pneumatic pressure from an independent source to at least the last of said chambers.

11. The structure of claim 10 characterized in that each of said cells includes a marble pack.

12. The structure of claim 10 characterized by means to operate said rotary valves to supply adjacent chambers alternately with pneumatic current under pressure.

13. The structure of claim 10 characterized by a variable speed motor for actuating said rotary valvular means in effecting proper gradation of pneumatic pressure down the sloping screen.

14. The structure of claim 10 characterized in that the lowermost and last independent zone is supplied from a single and independent chamber controlled by an independent pneumatic pressure to aid in controlling the separation where the greatest accumulation of material of heaviest specific gravity occurs just prior to separation.

15. A machine for stratifying a mineral bed with pneumatic pressure which consists of downwardly sloping screen, a stratification separator means at the discharge end of said screen, a continuous series of vertically open cells of uniform size and independent of each other and dividing the whole of the under side of the screen,

means in each cell to vary the volume of the pneumatic current under pressure passing upwardly through each cell on an increased gradient down said screen, a plurality of chambers each connected to supply a plurality of said cells, a rotary valve for controlling the flow of pneumatic current to each chamber to induce pulsations in the pneumatic current supplied under pressure, means to operate said rotary valves to supply the adjacent chambers alternately with pneumatic current under pressure, said means for separating the stratified material includes a movably mounted dam of variable depth disposed at the end of said bed, means for varying the movement of said dam to change the opening for passing particles of heavier specific gravity from the bottom of the stratified bed, an externally operable handle to vary said means, and spring means to bias said handle to maintain said dam at a set opening.

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CERTIFICATE OF CORRECTION

Patent No. 3,066,800 December 4, 1962

Donald B. Binnix

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 8, line 17, after "set opening." insert the following claim:

> 16. The method of claim 7 characterized by the step of alternating the phase relation of the applied pneumatic pulsating pressure in selected adjacent zones to produce alternate pulsations to the mineral bed.

in the heading to the printed specification, line 7, for "15 Claims." read -- 16 Claims. --.

Signed and sealed this 11th day of June 1963.

(SEAL)
Attest:
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Attesting Officer

DAVID L. LADD
Commissioner of Patents