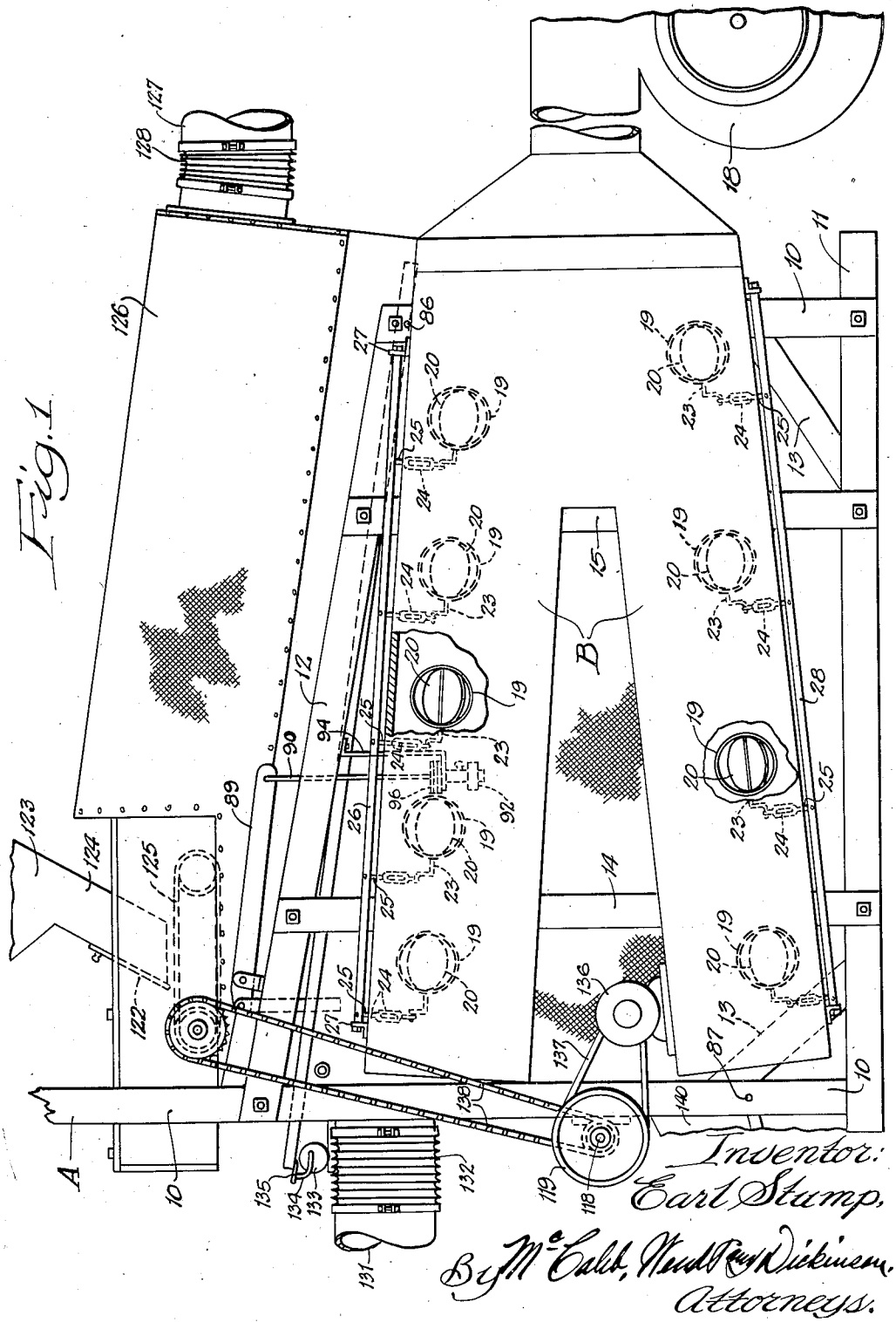
Oct. 19, 1943. E. STUMP 2,332,183

APPARATUS AND PROCESS FOR SEPARATING FINELY DIVIDED INTERMIXED MATERIALS

Filed Aug. 23, 1941 5 Sheets-Sheet 1

Fig. 1



Oct. 19, 1943. E. STUMP 2,332,183

APPARATUS AND PROCESS FOR SEPARATING FINELY DIVIDED INTERMIXED MATERIALS

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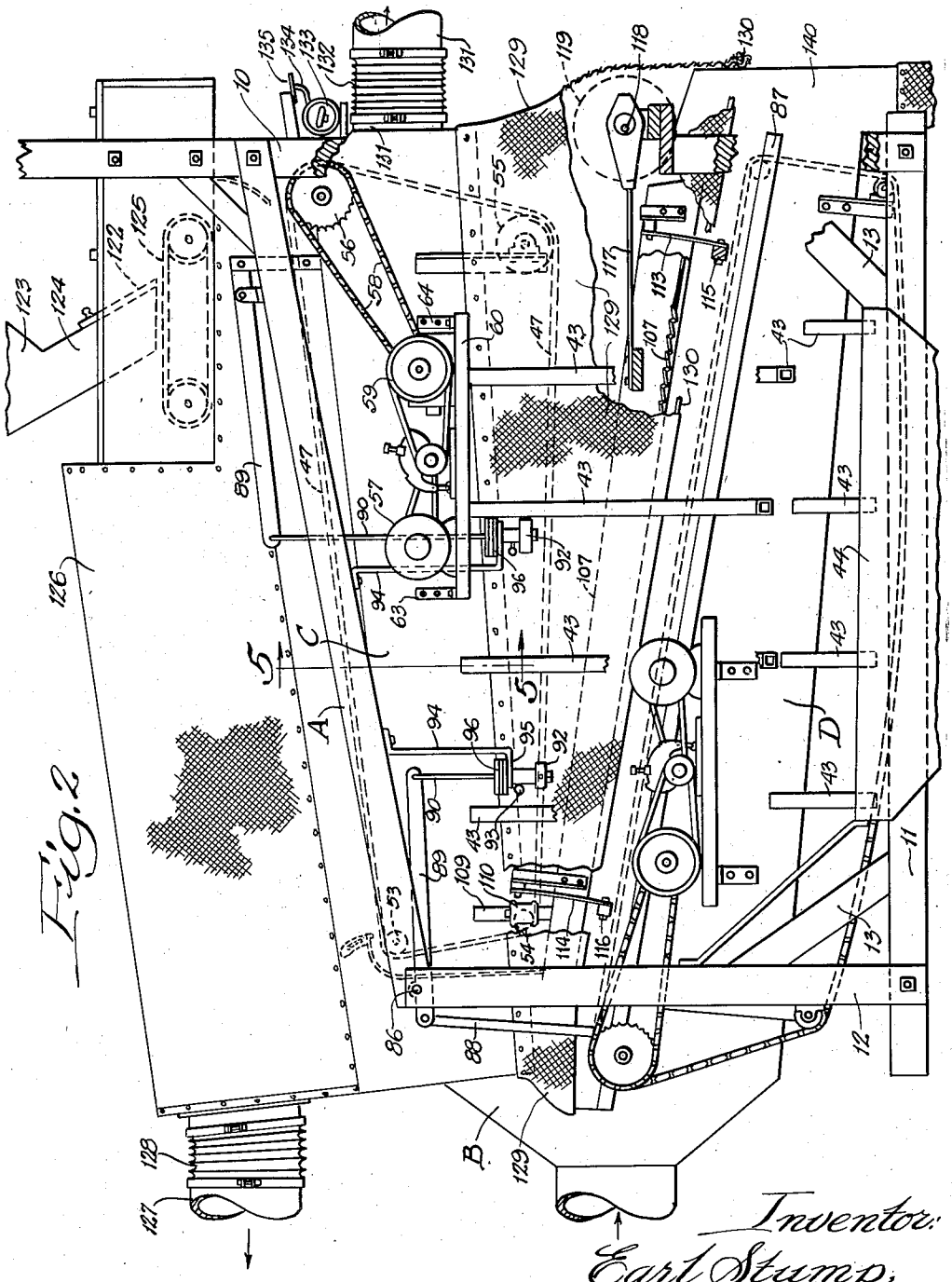


Fig. 2

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APPARATUS AND PROCESS FOR SEPARATING FINELY DIVIDED INTERMIXED MATERIALS

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Fig. 3

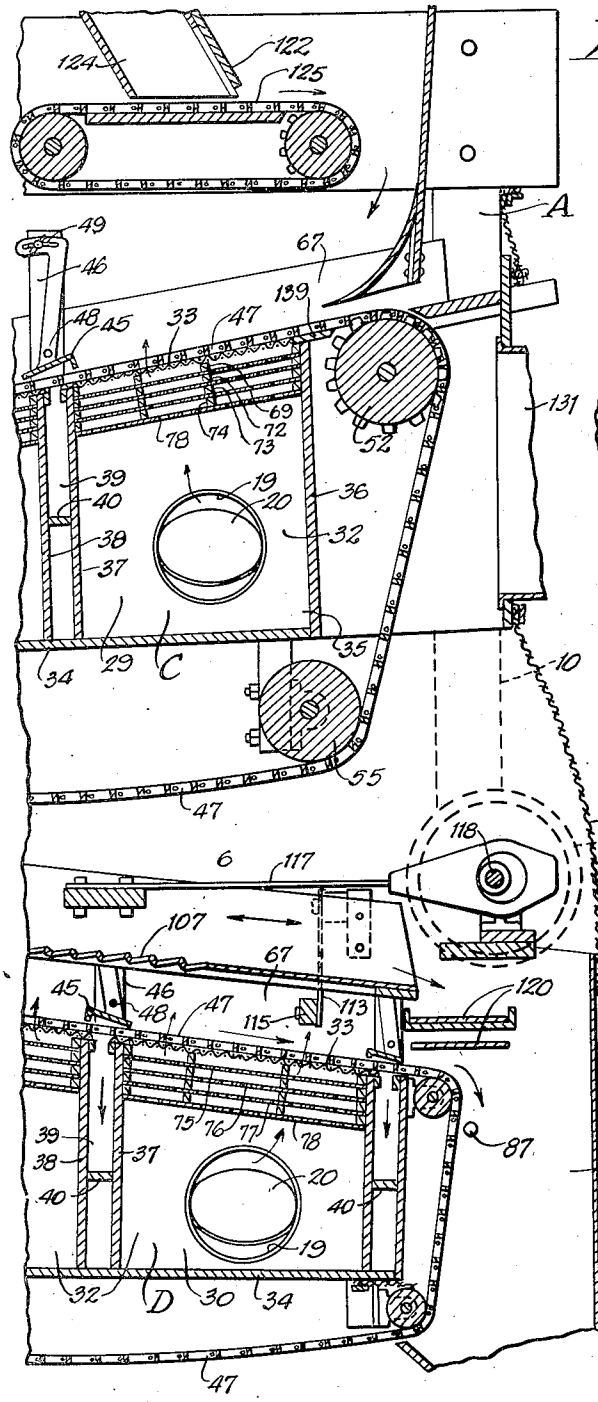


Fig. 6

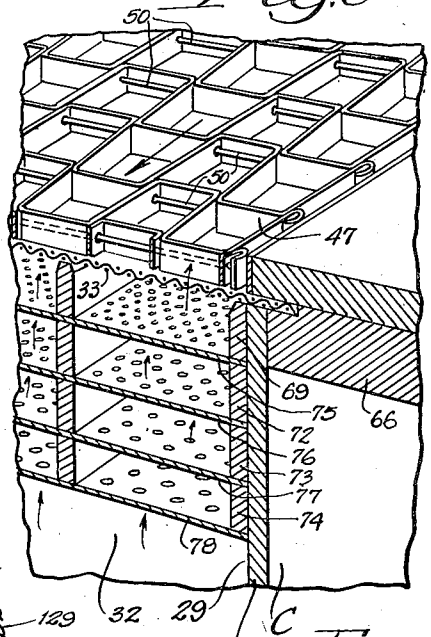
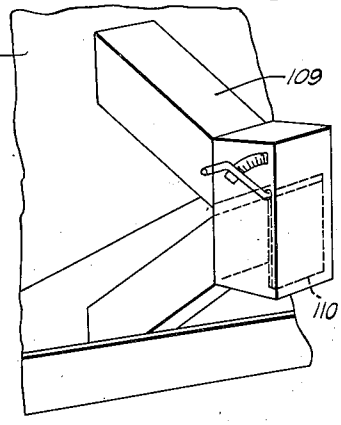


Fig. 8



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APPARATUS AND PROCESS FOR SEPARATING FINELY DIVIDED INTERMIXED MATERIALS

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Fig. 4

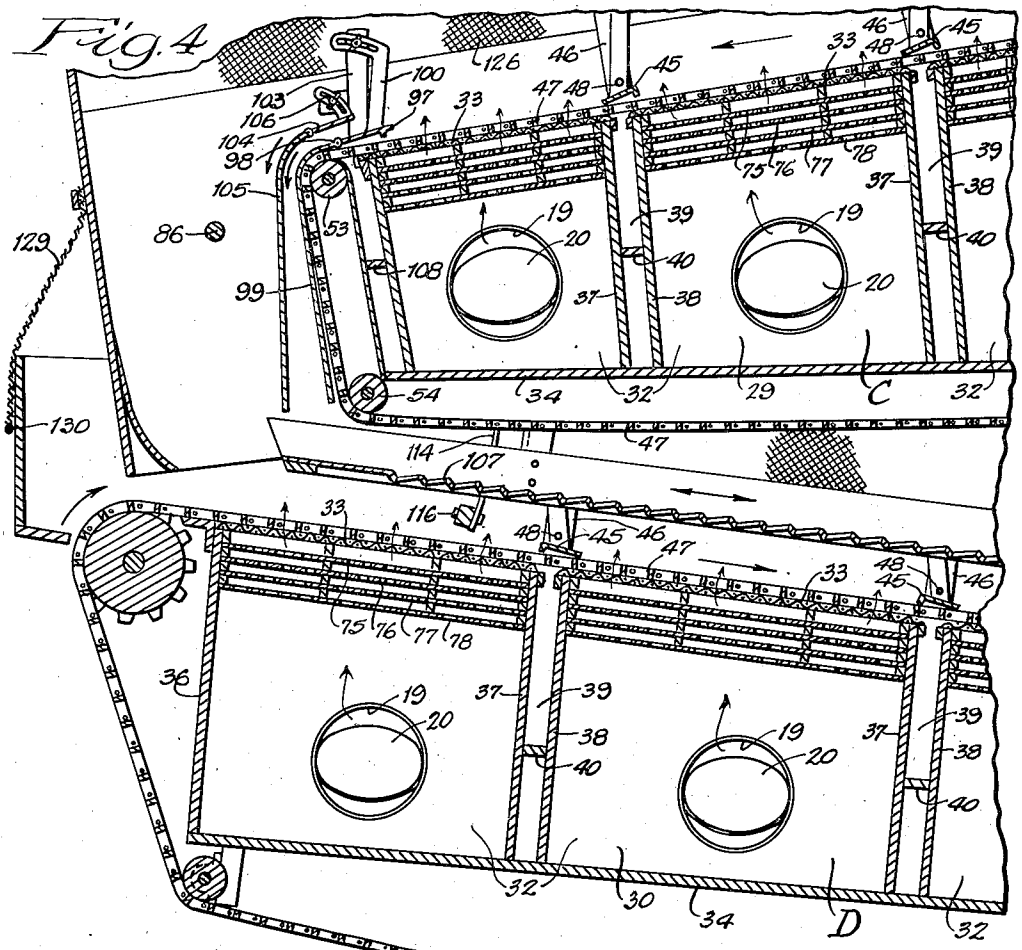


Fig. 5

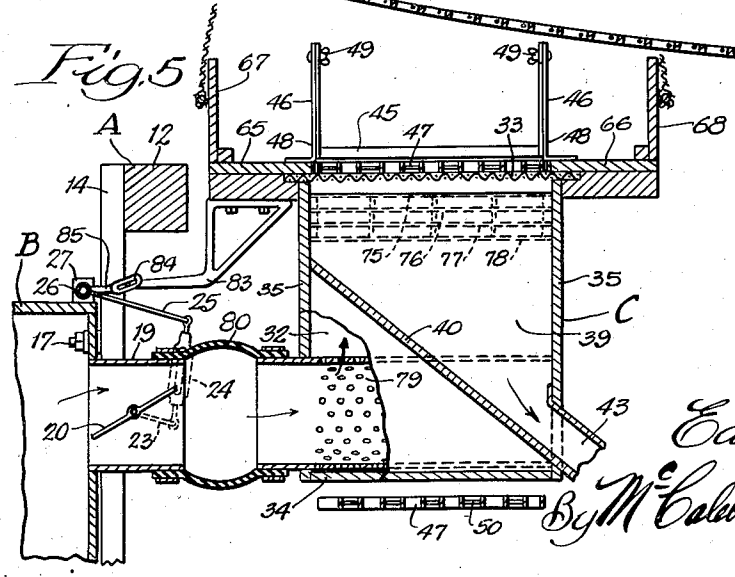
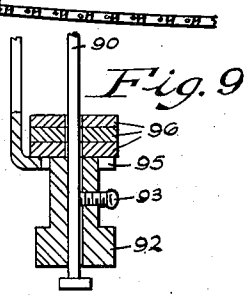


Fig. 9



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APPARATUS AND PROCESS FOR SEPARATING FINELY DIVIDED INTERMIXED MATERIALS

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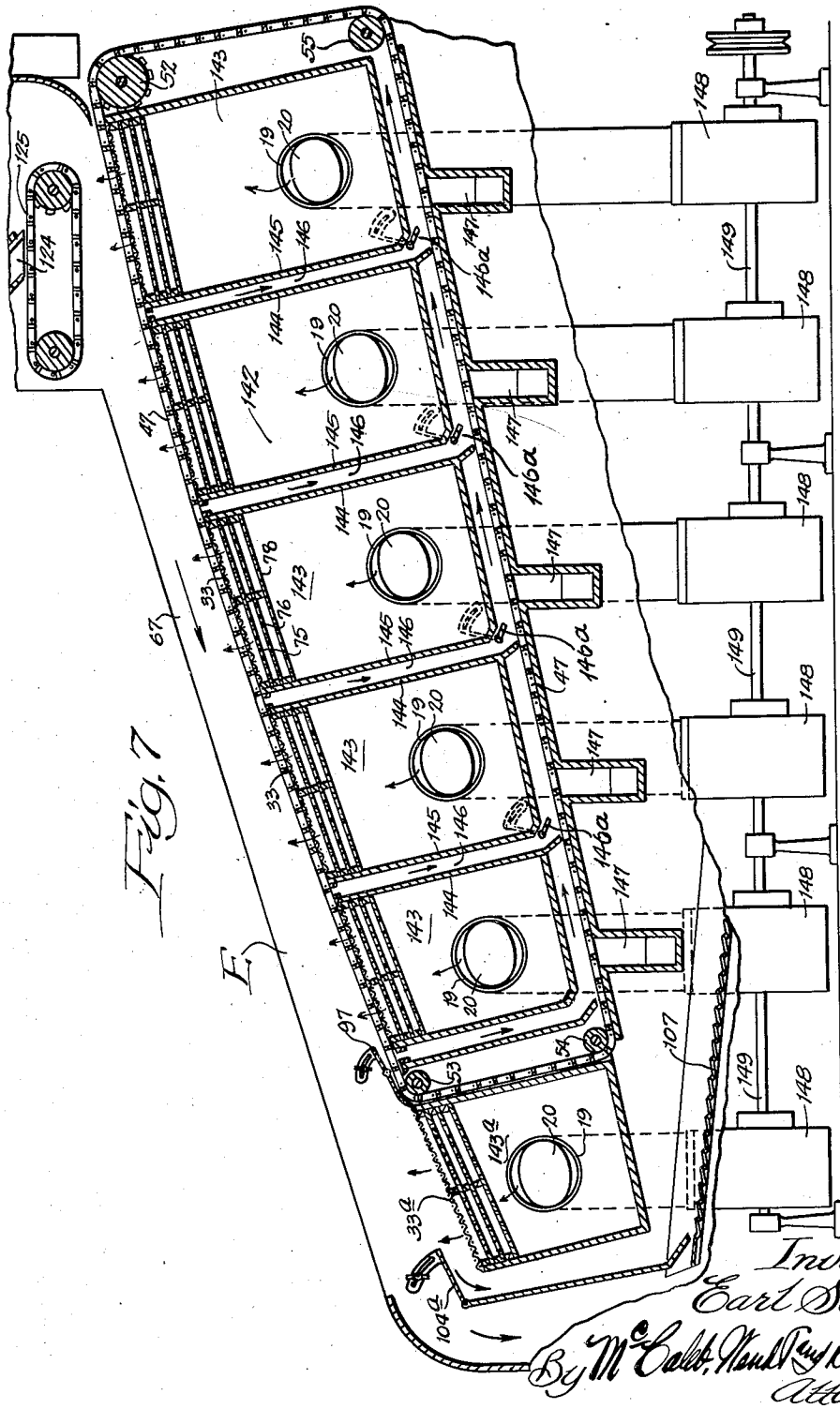


Fig. 7

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UNITED STATES PATENT OFFICE

2,332,183

APPARATUS AND PROCESS FOR SEPARATING FINELY DIVIDED INTERMIXED MATERIALS

Earl Stump, Harvey, Ill.

Application August 23, 1941, Serial No. 408,048

16 Claims. (Cl. 209—474)

My invention relates to the cleaning and grading of coal. It contemplates more specifically improvements in coal cleaning and processing for use principally with raw coal of intermixed finely divided particles of varying sizes below a predetermined maximum; for example, from approximately three-eighths of an inch in diameter down to and including the most finely pulverized particles.

Such coal is used largely in industrial operations, as for instance marine and locomotive boilers, cement burning, ore roasting, and in large central heating stations, since its heat liberation per cubic foot of combustion space can far exceed that of other types of coal. Such coal usually is purchased under specification contract by plants having laboratory testing facilities, and, therefore, the sulphur and ash content as affected by impurities present must be controlled within close limits.

In my Patent No. Re. 21,682, issued December 31, 1940, I have developed a raw coal cleaner suitable for the processing of such finer sizes of coal by the use of pulsating air currents, and without the need of a supplemental flotation medium, such as sand or heavy liquid as has been used in prior coal cleaning processes.

An important feature of my present invention is the ability to control separation of strata developed by the processing and at various stages of operation.

An important feature of my improved mechanism and process is its ability to develop, and to operate with, an underlying bed of impure particles by separation of such particles from the material in process.

The movement of impurities through, and their discharge from, my cleaner and grader is fully and easily controlled and regulated separately from the control of the flow, and progressive stratification and division or separation, of the coal particles.

My invention transforms a bed of small mixed raw coal particles having heavier rock-like particles intermixed therewith into a liquid-like mass without the addition of any extraneous liquid or solid medium, and, by means of a directed air flow in a part only of the mass, produces an effect of greater buoyancy on the lighter coal particles subjected to the air flow action without increasing the specific gravity of the remainder of the mass. This action hastens the separation of impure or rock particles from the coal.

My invention is readily adapted for installation in existing buildings without specific precautions against heavy vibration since the only vibrating part required is of relatively small weight and may be reduced in magnitude or entirely omitted without affecting other and important operating characteristics.

My invention is capable of adaptation readily to clean and grade, or to clean only, different kinds of coal with widely varying cleaning characteristics, and permits of easy and ready check and adjustment of the progress of operations in various stages of the process, so as to produce a coal having desired characteristics.

An important feature of my invention includes the accurate balancing of parts controlling such factors as feed rate, incline slope, and the establishment of adjusted maximum and minimum bed weights, all of which are affected by variations in the class and condition of the raw fuel supply, and the provision of means for automatically correcting the conditions causing such changes.

Other objects and advantages of my invention will be apparent from the following description and the accompanying drawings.

Referring to the drawings, of which there are five sheets;

Fig. 1 is a view in side elevation of an apparatus embodying my invention, portions of a hopper and air duct being broken away;

Fig. 2 is an elevational view showing the opposite side of the apparatus from that illustrated in Fig. 1, parts being broken away to show operative features of the apparatus;

Fig. 3 is an enlarged fragmentary longitudinal sectional view taken on a substantially median plane and showing the right hand portion of the apparatus as it appears in Fig. 2;

Fig. 4 is a sectional view similar to that of Fig. 3 showing the left hand portion of the apparatus as it appears in Fig. 2;

Fig. 5 is an enlarged fragmentary section taken on the plane of the line 5—5 of Fig. 2;

Fig. 6 is a further enlarged fragmentary view in perspective of a portion of the structure illustrated in Fig. 5,

Fig. 7 is a somewhat diagrammatic view partly in side elevation and partly in longitudinal vertical section of a modified type of apparatus embodying the invention;

Fig. 8 is an enlarged view in perspective showing a lowermost discharge chute with an adjustable gate for returning the tailings to a shaker screen or optionally directing them to discharge; and

Fig. 9 is an enlarged sectional view of a counterweight adjustably mounted on a rod to control

the position of an upper pivotally mounted separating unit.

Referring to the drawings in detail, a frame A may be of timbers rigidly connected to each other, although no great strength is required of the frame due to the absence of heavy vibration which is characteristic of most screening and separating mechanisms.

The frame includes corner uprights 10, base stringers 11 and top beams 12. Diagonal corner bracing members 13 are provided, as illustrated in Fig. 2, and on one side, illustrated in Fig. 1, a pair of vertical plenum support members 14 and 15 are mounted to extend between the bottom stringer 11 and top beam 12.

A Y-shaped plenum chamber B is secured to the support members 14 and 15, as by bolts 17 (Fig. 5), with the transverse median plane of the plenum chamber substantially horizontal. The throat of the Y is connected to a suitable power driven blower 18 (Fig. 1) to receive a supply of air under pressure.

A plurality of outlet ducts 19 are mounted in the inner wall of each branch of the plenum chamber, five of such openings being provided in the upper branch, and four in the lower. A damper 20 is mounted pivotally in each of the ducts 19, and is secured to a lever arm 23, the outer end of which is connected, by an adjustable link 24, to an arm 25 secured to a shaft 26. The shaft 26 is pivoted in suitable bearings 27, such as ball bearing pillow blocks, mounted on the upper branch of the plenum chamber, and is of sufficient length to permit attachment to all of the dampers in the branch. A similar shaft 28 is mounted on the lower branch of the plenum chamber and is connected in a similar manner to each of the dampers in the lower branch. The dampers of each branch of the plenum thus are connected to a common shaft so that all of the dampers of each branch may operate in unison, but those of different branches may operate independently of each other.

A pair of flotation separation units C and D are mounted in the frame A. The upper unit C is constructed with an elongated box-like casing 29, and the lower unit D has a generally similar casing 30. Each of the casings 29 and 30 is divided transversely into a plurality of air chambers 32, each of the chambers being decked over as by means of a wire mesh 33 or other suitable air pervious material to provide for a diffused, controlled flow of air upwardly therethrough. The top decks 33 of the adjacent chambers of each unit are arranged to be substantially continuous with each other, although not necessarily in the same plane.

The units C and D are mounted one above the other with their longitudinal axes disposed in vertically diverging planes, preferably at angles substantially corresponding to those of the two branches of the plenum chamber, and with one of the units disposed laterally adjacent to each plenum branch.

The structural details of the two flotation units C and D is best illustrated in Figs. 3 to 6 inclusive. A number of the structural features of both the upper and lower units C and D are similar to each other, and therefore the particular description of such features will be directed to those of the upper unit C only.

The body of the unit C comprising the box-like casing 29 has an imperforate bottom 34 and side walls 35. An imperforate end wall 36 is mounted across the upper end of the casing 29, see Fig. 3.

A plurality of double walled partitions are mounted transversely of the casing 29, each of the partitions comprising a pair of walls 37 and 38 spaced apart to enclose a narrow vertical passage 39 to receive and discharge refuse such as rock and other impurities separated from the coal during the operation of the apparatus. Each of the refuse discharge passages is provided with a sloping bottom member 40 which directs the refuse material laterally into spouts 43 through which it flows by gravity into a refuse receiving hopper 44.

The chambers 32 formed in the casing 29 by the double walled partitions comprise air pressure chambers whereby air under pressure is forced upwardly through the pervious top decks 33 to provide the flotation characteristics to the bed of coal and other particles necessary for the operation of my flotation coal cleaning and sizing apparatus.

The wire mesh 33 or other material comprising the top decks of the chambers 32 is omitted from the areas over the refuse passages 39 to provide slotted openings through which may drop the refuse removed during operation.

A dam or gate 45 is mounted over each of the refuse discharge slots 39 with the exception of the lowermost one in the upper unit C. This lowermost slot may be provided with a special material separating arrangement to be described later herein.

The dams 45, best shown in Figs. 3 and 4, are mounted between pairs of brackets 46, located one on each side of an open mesh conveyor belt 47. Each of the dams is pivotally connected to the brackets, as at 48 and has slotted adjustable connection therewith as at 49.

Finely divided coal and other particles, under the action of the upwardly flowing air stream, together with the gravity induced stream flow of the material, assume the physical characteristics of a liquid, and will flow by gravity and rise under head in all respects similarly to such liquid. The height and angle of the dams 45 therefore has a critical separating action on the stream flow and provides for close and accurate control of the separating features of the apparatus.

The conveyor belt 47 is here illustrated as being composed of narrow strips of metal reversely bent and pivotally connected together by means of pivot wires 50 as best illustrated in Fig. 6. The belt 47 is mounted to slide on the screened top decks 33 of the chambers 32, and has driven connection with a toothed roller 52 mounted beyond the upper end wall 36 of the casing 29. The belt also passes around idler rollers 53, 54 and 55, as illustrated in Figs. 3 and 4.

The drive roller 52 (Fig. 2) has a sprocket 56 connected to an electric motor 57 through a drive chain 58 and a suitable speed reducer 59. The speed reducer is of the variable type and may be arranged, for the processing of ordinary raw coal, to permit a variation in speed of the belt 47 in the range between four and twenty-six inches per minute, which speeds may be increased or decreased beyond these limits if the coal being processed is exceptionally clean or exceptionally dirty. Both the motor 57 and speed reducer 59 are mounted on a support 60 which is secured by brackets 63 and 64 to the side wall of the casing 29.

Wings 65 and 66 extend laterally from each

side of the upper edge of the casing 29. Coal deposited on these wings during operation of the apparatus will build up to an angle dependent at least partly on the limiting angle of slip of such deposit. Side boards 67 and 68 extend upwardly from the outer edge of each of the wings.

The coal deposited on these wings is substantially static, that is, it does not flow by gravity along with the fluid-like mass of the main stream which is subjected to pneumatic stratifying and fluidizing action. In fact these wing deposits soon become impacted into caked fillets, which may remain undisturbed throughout the useful life of the machine, unless earlier removed in cleaning.

The side wings here are shown as horizontal in transverse section, since such mounting is simple, and provides suitable support for the deposits which build up thereon. It would, of course, be practicable to mount these wings at other angles to the horizontal if desired, without adversely affecting the operation of the apparatus, the main consideration being to provide a gradual widening of the space above the conveyor 47 so as to dissipate the air currents and reduce their velocities as they pass upward.

The deck screen 33 is supported by a grill 69 mounted immediately beneath it, and a plurality of other generally similar grills 72, 73 and 74 are provided to support, respectively, perforated diffusion plates 75, 76 and 77. An additional perforated plate 78 is shown mounted beneath the lowermost grill 74. These perforated plates may have a total open area of approximately 11%, and the sizes of the perforations in the plates may decrease in size and increase in number progressively from the bottom upward. However, the percentage of open area in the different plates may be varied within comparatively wide limits with consequent controlled variation of the air stream characteristics. This arrangement provides for proper diffusion of the air stream prior to the formation of a diffusion deck within the cells of the conveyor, as will be brought out later in the specification, and prevents jet action through the flotation bed of material being processed. The widening of the cross sectional area of the bed above the conveyor belt, accomplished by the provision of the wings 65 and 66, also aids materially in the stratification of the material, since lateral diffusion of the emerging air reduces the air content of the flotation bed and thus, since the amount of air in this upper portion of the stream is lessened proportionately to the mass, the particles, though actually lighter than those in the lower part of the stream, are closer together, thereby effecting a gradual increase in density and specific gravity of the body of the stream as it approaches the top.

An air inlet duct 79 is provided into each of the air chambers 32. These ducts may constitute perforated pipes extending entirely across the chambers 32 as illustrated in Fig. 5, only the portions within the chambers being perforated. These pipes or ducts are substantially in alignment with the ducts 19 of the plenum chamber and are connected to the ducts 19 by flexible sleeves 80.

A damper operating bracket 83 is mounted near the upper end of each of the units C and D as illustrated in Fig. 5. The bracket is provided with a pivoted, slotted connection 84 to a lever arm 85 secured to the shaft 26. A similar connection, not illustrated, may be provided between the upper end of the lower unit D and the shaft 28 controlling the action of the dampers 20 in the lower branch of the plenum chamber. This interconnection between the flotation unit and the dampers in the plenum branch associated therewith operates the dampers to provide an increased air flow upon a lowering of the upper end of the units, caused by the presence of damp or especially rocky and therefore heavier raw coal on the unit to assist in suspending and opening up the mass to impart the desired liquid-like characteristics thereto. Conversely, a lighter load on the unit will cause a reduction in air flow properly to maintain the liquid-like character of the bed.

In order to permit such movement of the units C or D under variations in weight of the bed of material in process the upper unit C is pivotally mounted adjacent its lower end on a rod 86 while the lower unit D is pivoted adjacent its lower end on a rod 87. The upper end of each of the units C and D may be supported by a lever and counterweight arrangement as illustrated in Fig. 2. In order to avoid torsional stresses on the units a counterweight preferably is provided on each side of each of the upper and lower units. Since these counterweight arrangements are in general similar, that provided for the upper end of the lower unit D only will be described in detail.

A link 88 is connected from the unit D to a lever arm 89 which is illustrated as being pivotally mounted on the pivot rod 86. A weight supporting rod 90 is mounted pivotally in the opposite end of the lever 89 from that to which the link 88 is connected and has a weight 92 adjustably secured to its lower end. The position of the weight 92 on the rod 90 may be adjusted lengthwise of the rod by means of a set screw 93 which is threaded into the weight 92 and the inner end of which is adapted to engage the rod 90. A bracket 94 having a bifurcated and perpendicularly offset foot portion 95 extends downwardly from the frame member 12, the forked lower end being adapted to receive the body of the weight 92 between its bifurcations. A supplemental weight 96 is mounted slidably on the rod 90 to rest on the weight 92, and is adapted to be supported by the forked lower end 95 of the bracket 94 on a predetermined lowering of the rod 90 and its connected weight 92 through the action of the lever arm 89 caused by variations in the weight of the supported load of the material in process in the unit. The supplemental weight 96 is illustrated as being composed of a plurality of individual weight members which may be similar to the weights provided for an ordinary beam-type scale to permit variation of the supplemental loading characteristics. This arrangement permits very accurate adjustments to be made throughout the entire working range of the apparatus.

The strata separating arrangement for the lower end of the upper run is best illustrated in Fig. 4. A dam 97 is pivoted at its rear edge, as at 98, to an apron 99, which overlies the conveyor belt 47 as it passes over the idler roller 53, and etxends downwardly to a point adjacent the lower idler roller 54. An arm 100 is secured to each end of the dam 97 and has adjustable slotted connection at its upper end with a bracket 103. A separating or skimmer plate 104 is mounted over the dam 97 and is spaced upwardly therefrom. The upstream edge of the plate 104 is offset in a downstream direction from the upstream edge of the dam 97, so that the upstream

edge of the plate 104 will be shielded by the dam 97 and will be located in a zone free from upward air currents. The plate 104 is hinged at its lower end to an apron 105 and is provided with an adjustable connection 106 for varying the height of its upstream edge. The apron 105 is mounted substantially vertically above the upper or inlet end of a shaker screen 107 so that material separated from the downwardly flowing stream of material in process and passing over the apron 105 will be discharged beyond the upper end of the shaker screen 107 onto the top deck of the lower unit D, while the material separated and passing between the aprons 99 and 105 will be discharged onto the shaker screen 107.

Any material passing below the dam 97 will, of course, be discharged into the lowermost refuse chute and will be deflected laterally by a sloping bottom plate 108 and through a spout 109 to a point exteriorly of the casing 29. A manually operated tilting gate 110, as shown in Fig. 2, is provided at the discharge end of the spout 109 whereby the material from this spout optionally may be returned onto the shaker screen 107 or permitted to discharge into the refuse hopper 44.

The shaker screen is mounted for longitudinal reiprocation on spring arms 113 and 114, supported on transverse mounting members 115 and 116, respectively. A reciprocating drive for the screen 107 comprises a connecting rod 117 which has eccentric connection with a shaft 118 connected to a suitable motor 136 through a driven pulley 119, Fig. 1. The shaker screen 107 is arranged to be actuated simultaneously with the raw coal feed to separate out any finer particles which may come down from the upper unit C with the larger particles of coal which pass between the dam 97 and the plate 104.

A lateral take-off conveyor belt 120 may be mounted to receive the material discharged from the lower end of the shaker screen 107 and convey this material laterally beyond the apparatus to a suitable hopper or receptacle not shown. If such separation of the larger particles is not required, the conveyor belt 120 may be omitted and the shaker screen may be permitted to discharge its contents directly into the material discharged from the lower end of the lower unit D.

A feed arrangement for the raw coal may comprise a hopper 123 from whence a chute 124 is arranged to discharge onto a conveyor belt 125. A chop gate 122 is mounted on the chute 124 to regulate the discharge rate of coal from the hopper.

A hood 126 is provided of suitable dust-tight cloth over the upper unit C and a duct 127 is connected from this dust hood to a suitable evacuating blower, not illustrated. A flexible connection 128 is provided between the duct 127 and the end of the hood to permit free tilting of the upper unit C about its pivotal axis 86 through the operation of the weight controlled counterbalance.

A dustproof cloth shield 129 also may be secured to the marginal lower edge of the casing 29 and arranged to overlap the top of the lower unit D. This dust shield is provided with metal rods 130 inserted in its hemmed lower edges to retain the shield in overlapping, substantially dust-tight, relation with the lower unit D. Other similar dust shields may be employed as required to maintain the apparatus dust-tight within desired limits.

An evacuating duct 131 is in open communication with the space between the upper and lower units, as best illustrated in Fig. 3, and is provided with a flexible connection 132 to permit free tilting operation of the upper unit C under the action of the counterbalancing arrangement previously described.

An automatic feed cut-off switch 133 has a spring biased arm 134 positioned to be engaged by a plate 135 secured to the upper unit C. The switch 133 is connected in series with such motor drives on the mechanism as are required such as the motor 136. The motor 136 is connected through a belt 137 and chain 138 to the feed belt 125. The switch 134 is adjusted so that when the weight of the uper unit C is sufficient to raise the supplementary weight 96 from its position on the forked bracket 94 the switch 134 will be opened, thereby stopping the motor 136, and the supply of raw coal will be shut off until the unit has cleared itself sufficiently to again permit the counterweight to raise the unit to close the switch 134. Thus when an occasional run of wet or other heavy coal is encountered the mechanism will automatically control the supply to an amount which can be processed satisfactorily.

The operation of the apparatus is as follows: A supply of raw coal first is placed in the hopper 123 and permitted to flow down the chute 124. This raw coal is of indiscriminately mixed sizes below a predetermined maximum as for instance three-eighths of an inch. Such raw coal is produced by preceding screenings or separating operation whereby the larger lump sizes of coal are removed and separated into their respective grades.

Assuming that the supply of raw coal to be separated and cleaned is one with which the operator is not familiar, the machine may be adjusted initially for a screening operation which would handle a relatively dirty and finely divided coal product. Thereafter, several adjustments, hereafter to be described, may be made to adapt the mechanism for the proper cleaning and grading of the particular type and quality of coal being processed. Once the machine is adjusted, no further adjustments are necessary as long as that same class of raw coal is being processed.

The various phases of operation will be discussed in sequence in accordance with the flow of the coal and other material downwardly through the machine.

The feed-belt 125 as illustrated in Fig. 3, feeds the coal to the right and discharges it downwardly onto the conveyor belt 47. The rate of delivery of the raw coal is controlled by variation in the speed of the feed belt 125 and in the height to which the chop-gate 122 is raised. All of the various drive mechanisms are energized, including that to the blower 18, the evacuating blower (not illustrated) connected to the ducts 127, and 131, the motor drives to the two main conveyor belts. The motor 136 also is energized to operate the shaker screen 107 and the feed belt 125. If the lateral takeoff belt 120 is employed, as illustrated in Fig. 3, to remove the material from the shaker screen laterally beyond the machine, this lateral takeoff belt 120 also is operated.

The indiscriminately mixed mass of raw coal, and its contained impurities, in sizes from the maximum (as determined by such previous screening operations as it may have received and which, for the purpose of the present description, may be assumed to be ⅝ inch) on down-

wardly to the most finely pulverized particles, is received on the conveyor belt **47**, and is supported by the screened top **33** of the first air chamber. The upwardly flowing air stream, diffused by its passage through the perforated plates **75** to **78**, inclusive, passes upwardly through the mass of coal in a bubbling-like manner and imparts to the coal bed the physical characteristics of a liquid. The screen **33** is of minimum resistance to air flow and has as its principal function to support the deck of impure particles which accrue in the cells of the mechanically actuated conveyor belt as explained in the following paragraphs.

Each opening in the conveyor belt **47** is surrounded by a substantially vertical wall, which prevents lateral diffusion of the air stream, and tends to support the lighter or pure coal particles of the stream entirely above the surface of the conveyor belt. The physical reason for this phenomenon lies in the fact that as the air stream passes through the cells of the conveyor belt, the walls of the openings in the conveyor prevent lateral diffusion of the air stream. Thus a larger quantity of air actually is entrained in the material within the belt openings and separates these particles more widely from each other, thereby lowering the specific gravity of the resultant mass. In addition to this pure flotation characteristic the confinement of the air flow within the openings of the conveyor induces an upward particle-supporting air flow. Therefore only the heaviest particles constituting impurities are able to remain in the walled openings or cells within the conveyor belt, all of the pure, or substantially pure coal particles being supported by the air flow above the plane of the top surface of the conveyor belt **47**.

The cells in the conveyor confine the heavier particles of refuse, which settle by gravity into them, the force of the air currents being regulated to be less than that required to support such heavier impure particles and restrain these heavier particles from stream-flow across the inclined support screen. The cells thus gradually fill with the refuse particles to form a diffusion bed or deck which increases in thickness, due to such accretion of refuse particles therein, as the belt moves across each air chamber. The deck thus formed reaches a maximum or desired thickness just above each refuse discharge chute **39**.

This arrangement provides a mechanically progressed and controlled resistance deck which builds up from the refuse particles of the material being processed. Since the speed of the conveyor belt is adjustable within broad limits, the depth of the deck thus formed and the rate of refuse discharge can be accurately and positively controlled for coals of widely varying characteristics. The deck characteristics can be varied at will to suit the requirements of each type of coal being processed by changing the conveyor speed and the air flow through each compartment.

The initial open character of the deck at the upper end of an air chamber insures full unimpeded aerating and separating action at this stage of operation, thereby producing more active agitation and speeding the separation of heavier particles. The building up of the deck by the accretion of refuse particles causes a gradual reduction in air flow and increase of diffusion, and thereby causes a proper stratification of the material being processed at the zones of separation, such as the dams, lower end separating plates, and refuse discharge slots of the structures illustrated.

As the stream of coal particles, together with some impurities constituting principally smaller and only partly impure particles, reaches the first dam **45**, see Fig. 3, the stream-flow and pressure-head characteristic of the liquid-like mass cause it to flow over the dam **45**, while the mechanically controlled slowly moving conveyor belt **47** carries the entrained heavier impure particles beneath the dam, where they drop into the refuse passages and are deflected laterally by the sloping bottom **40**, and descend, through the spout **43**, into the refuse hopper **44**.

As the liquid-like stream of particles flows downwardly over the conveyor belt **47**, being supported above it by the air stream passing upwardly through the conveyor belt, the smaller particles of heavier impurities and those of only slightly lesser weight, such as particles which are part coal and part rock, will gradually stratify, and their separation within required degrees can be accomplished by individual adjustment of the successive dams **45**, and by individual adjustment of the dampers opening into the air chambers **32**.

Simultaneous adjustment of all the dampers connected to either of the shafts **26** or **28** may be accomplished by adjusting the adjusted heights of the upper ends of the units C or D. This may be accomplished by adjusting the position of the weights **92** lengthwise of the rod **90** by means of the set screws **93**. Individual adjustment of the dampers may be accomplished by means of the turnbuckles **24** associated with each of the dampers.

The stratification of the various classes of particles comprising the stream, progresses as the material moves downwardly along the conveyor belt **47**. As the flow of particles reaches the dam **97** at the lower end of the unit C, many of the heavier impurities will have been removed, and from this point on the action constitutes principally a separation of the various grades or sizes of coal within the stream. Since the specific gravities of the purer coal particles is substantially the same, and their specific gravity varies in the stream only in proportion to the amount of the air which is mixed therewith, the lowermost dam **97** and the plate **104** may be adjusted to divide the stream into its various strata. Some refuse, or refuse mixed with some coal particles termed "middlings," will still be present in the conveyor cells at this point, and such refuse or middlings will pass beneath the dam **97**. The larger coal particles will pass over the dam **97**, but below the plate **104**, and the still more finely pulverized particles will pass over the plate **104** and will be discharged beyond the shaker screen **107**. The particles which pass over the dam **97** and below the plate **104**, will be discharged onto the shaker screen **107**. The longitudinal reciprocating action of the screen **107** jogs the particles downwardly by successive agitative steps, and screens out finer particles which may remain in the coal in this stratum, discharging the larger particles at the bottom end of the screen, as illustrated in Fig. 3.

As the material reaches the lower end of the lower conveyor belt, it is discharged into a spout **140**, which in turn is arranged to discharge into a suitable hopper (not illustrated) or otherwise as desired.

During the progress of the cleaning operation, the operator will constantly check the refuse ma-

terial discharged by each of the spouts **43**, and also the spout **109**, subjecting these samples to visual inspection, as well as flotation tests, and residual ash tests, in liquids of known specific gravities, to insure that the proper cleaning and separating operations are being performed.

Although but two flotation units have been illustrated and described, it will be apparent to those familiar with the art that other additional units of generally similar character may be added or interposed with the units illustrated. Such additional units will prolong the cleaning period and thus may increase the ultimate purity of the product and permit a substantial increase in the maximum size of particles in the raw coal supply.

A modified form of my invention is illustrated in Fig. 7. In this form the successive screened tops of the individual air chambers are disposed at a gradually increasing slope from the horizontal so that as the stream of particles progresses downwardly through the machine, the rate of stream flow will be increased under the influence of gravity.

The mechanism illustrated in Fig. 7 is somewhat schematic in that some of the actual structural and operating features are not illustrated. Such details, however, will be understood when taken in conjunction with the description of the apparatus illustrated in Figs. 1 to 6 inclusive.

In the construction of Fig. 7, a unit E has a box-like casing **142** divided into a plurality of individual air chambers **143** by a plurality of double walled partitions comprising walls **144** and **145** spaced apart to provide refuse discharge passages **146** therebetween. These discharge passages extend entirely through the casing and discharge their contents onto the lower run of the conveyor belt which is arranged to pass over a succession of refuse discharge chutes **147** which discharge the refuse either onto a conveyor belt (not shown) or into a hopper as illustrated in Fig. 2. An adjustable refuse control gate **146***a* is provided at the lower end of each of the chutes **146** to control the rate of refuse discharge from the chutes. The chutes **146** are maintained full of refuse in the operation of the apparatus and the discharge rate is controlled to maintain the proper depth of diffusion deck within the cells of the conveyor. With this arrangement no dams are required over the refuse discharge chutes to control the rate of refuse discharge and a portion of the deck material may be carried over from one compartment to the next within the cells.

Each of the air chambers **143** is individually floored and is provided with a plurality of perforated diffusing plates, supporting grilles and wire mesh tops similar to those of the apparatus illustrated in Figs. 1 to 6 inclusive. Such similar parts are designated by the same reference numerals employed in the first six figures of the drawings.

A lower end dam **97** may be provided at the lower end of the first part of the unit E. The material passing beneath the dam **97** is discharged onto the lower run of the conveyor belt while that flowing over the dam **97** passes onto a screened top **33***a* of a supplemental air chamber **143***a*. Here the substantially pure coal particles which pass over the dam **97** are subjected to a further stratifying action without the presence of the conveyor belt. This permits instant lateral diffusion of the air currents as they pass above the screen **33***a* and assists in the stratification of the fine particles present. A dividing plate **104***a* may be adjusted to divide the stream, and to remove from its upper stratum the finer particles of coal, which may be discharged into a suitable hopper or otherwise disposed of as required.

It will be noted in the structure illustrated in Fig. 7 that an individual blower **148** is provided for each of the air chambers **143**, the blowers in the illustrated embodiment being arranged for driving by means of a common drive shaft **149**. This arrangement permits for a more closely controlled and positive air supply to each of the air chambers since the flow of air to any of the chambers is not affected by variations in resistance in the other chambers as may be the case in the structure of Figs. 1 to 6.

While I have illustrated and described a preferred embodiment of my invention, many modifications may be made without departing from the spirit of my invention, and I do not wish to be limited to the precise details of construction set forth, but desire to avail myself of all changes within the scope of the appended claims.

Having thus described my invention, what I claim as new and desire to secure by Letters Patent of the United States is:

1. Apparatus for separating finely divided intermixed particles comprising an inclined air pervious support, said support having a plurality of transversely disposed refuse discharge slots therein, means for feeding a supply of material for separation onto the support, air supply means directing a flow of air upwardly through the support, diffusing means interposed between the air supply means and the support, air control means mounted between the air supply means and the support, a cover adjustably mounted over each slot in said support to divide vertically superposed strata in the bed of material and to direct a lower stratum thereof into said refuse discharge slots and to pass an upper stratum over the cover, and an open conveyor travelling along the support between it and the cover.

2. Apparatus for separating finely divided intermixed particles comprising an inclined air pervious support, means for feeding a supply of material for separation onto the support, air supply means directing a diffused flow of air upwardly through the material bed to impart liquid-like physical characteristics thereto, to cause a flow of said material under gravity over the inclined support, a conveyor having a multiplicity of walled openings immediately overlying the pervious support and slidable thereon, a plurality of dams mounted over the conveyor, transversely of the gravity flow, and means below the dams for removal of particles contained within the walled conveyor openings.

3. Apparatus for separating finely divided intermixed particles comprising an inclined air pervious support, means for feeding a supply of material for separation onto the support, air supply means directing a diffused flow of air upwardly through the material bed to import liquid-like physical characteristics thereto, to cause a flow of said material under gravity over the inclined support, and means overlying the pervious support and defining a honeycomb-like multiplicity of relatively small horizontally and transversely spaced vertically walled enclosures of height at least a substantial fraction of their longitudinal and transverse dimensions to restrain upward air currents passing through the pervious member against lateral diffusion, and means for intermittently clearing the pervious

support from below part only of the walled enclosures and simultaneously stopping the upward air flow through such cleared enclosures to discharge particles therefrom.

4. Apparatus for separating finely divided intermixed particles comprising an inclined air pervious support, means for feeding a supply of material for separation onto the support, a movable member overlying the pervious support and having a plurality of walled openings throughout its area, air supply means directing a diffused flow of air upwardly through the pervious support, through the openings in the movable member and through the material bed, an enclosure over the pervious support of greater width than the pervious support for diffusion of air after passing through the openings in the movable member, the air passing through the openings in the movable member being restrained from diffusion by the walls of the openings to provide additional particle supporting action other than relative specific gravity whereby only relatively heavier particles are retained in the openings.

5. Apparatus for separating finely divided intermixed particles, comprising an inclined air pervious support, means for feeding a supply of material for separation onto the support, an air pervious celled structure overlying the support, the lower ends of the cells in said structure being closed by the support, means for moving the celled structure over the support successively to free the cells from the support, power driven air supply means mounted to direct air flow upwardly through the support and the celled structure to produce a liquid-like bed having stream flow characteristics, and a dam mounted over the cellular member at an area where the cells are free from the support to produce a gravity flow head in a stream-flow of material to separate particles of different specific gravities.

6. Apparatus for separating finely divided intermixed particles, comprising an inclined air pervious support, means for feeding a supply of material for separation onto the support, an air pervious celled structure overlying the support, the lower ends of the cells in said structure being closed by the support, means for moving the celled structure over the support successively to free the cells from the support, power driven air supply means mounted to direct air flow upwardly through the support and the celled structure to produce a liquid-like bed having stream flow characteristics, a dam mounted over the cellular member at an area where the cells are free from the support to produce a gravity flow head in a stream-flow of material to separate particles of different specific gravities, and a divider plate mounted at the lower end of the inclined support, the plate being mounted in a plane substantially parallel to the incline slope of the support, the plate being adjustably mounted to control the elevation of its upstream edge for dividing an upper from a lower portion of the stream flow.

7. Apparatus for separating finely divided intermixed particles, comprising an inclined air pervious support, means for feeding a supply of material for separation onto the support, an air pervious celled structure overlying the support, the lower ends of the cells in said structure being closed by the support, means for moving the celled structure over the support successively to free the cells from the support, power driven air supply means mounted to direct air flow upwardly through the support and the celled structure to produce a liquid having stream flow characteristics, a dam mounted over the cellular member at an area where the cells are free from the support to produce a gravity flow head in a stream-flow of material to separate particles of different specific gravities, a divider plate mounted at the lower end of the inclined support, the plate being mounted in a plane substantially parallel to the incline slope of the support, the plate being adjustably mounted to control the elevation of its upstream edge for dividing an upper from a lower portion of the stream flow, and a second divider plate adjustably mounted over the first and having its upstream edge located somewhat downstream from that of the first plate, and a separator associated with said plates adapted to maintain separated material divided from the stream by the plates.

8. Apparatus for separating finely divided intermixed particles comprising a pair of elongated casings, an air pervious top deck on each of said casings, the decks sloping in a direction lengthwise of the casings, one of said casings having its lower end positioned to discharge onto the high end of the deck of the other, each of the decks having a plurality of narrow gap openings transversely thereof, feed means mounted to discharge material for separation onto the high end of one of the decks, a dam over each of the gaps, conveyor means having a multiplicity of openings throughout mounted to slide over the decks and beneath the dams, controlled power drive means associated with the conveyor, and controlled air supply means mounted to supply a flow of air upwardly through the pervious decks and the conveyor means and adapted to bubble through material on the decks and produce liquid-like characteristics in said material causing a stream flow thereof over the inclined decks, said dams separating particles of different specific gravities, the heavier of said particles being carried beneath the dams to said gaps by the conveyor means and the lighter particles flowing stream-like over the dams.

9. Apparatus for separating material of finely divided intermixed particles comprising a pair of elongated units divided into a plurality of air chambers, an air pervious top deck on each of the chambers the top decks of successive chambers in the same unit being substantially continuing and inclined from the horizontal, the units being superposed one above the other and of opposite slopes, the low end of the upper unit being positioned to discharge onto the high end of the lower unit, air supply means to each of the chambers to force air up through the pervious top decks and adapted to bubble through a bed of finely divided particles thereon to produce liquid-like characteristics therein, and a gravity flow of said material, a plurality of discharge chutes at spaced intervals throughout the length of said units, dams mounted over said discharge chutes, and means mounted between the dams and the chutes and movable independently of the gravity flow of said particles to move a lowermost stratum of said particles beneath the dams and into the discharge chutes.

10. Apparatus for separating material of finely divided intermixed particles comprising a pair of elongated units divided into a plurality of air chambers, an air pervious top deck on each of the chambers the top decks of successive chambers in the same unit being substantially continuing and inclined from the horizontal, the

units being superposed one above the other and of opposite slopes, the lower end of the upper unit being positioned to discharge on the high end of the lower unit, air supply means to each of the chambers to force air up through the pervious top decks and adapted to bubble through a bed of finely divided particles thereon to produce liquid-like characteristics therein, and a gravity flow of said material, said air supply means including a pressure blower, a Y shaped plenum chamber having its throat connected to the blower, the branches of the Y being positioned, selectively, alongside each of said units, a plurality of ducts connecting said branches to said air chambers, air control means associated with each of said chambers to control the air flow therethrough, a plurality of discharge chutes at spaced intervals throughout the length of said units, dams mounted over said discharge chutes, and means mounted between the dams and the chutes and movable at a speed independently of the gravity flow of said particles to move a lowermost stratum of said particles beneath the dams and into the discharge chutes.

11. Apparatus for separating material of finely divided intermixed particles comprising a pair of elongated units divided into a plurality of air chambers, an air pervious top deck on each of the chambers the top decks of successive chambers in the same unit being substantially continuing and inclined from the horizontal, the units being superposed one above the other and of opposite slopes, the low end of the upper unit being positioned to discharge on the high end of the lower unit, the upper unit at least being pivoted in an axis transversely of its slope, a counterbalance associated with said unit to maintain said unit at a predetermined slope with a predetermined loading of the counterbalance by the material in process, air supply means to each of the chambers to force air up through the pervious top decks and adapted to bubble through a bed of material thereon, to produce liquid-like characteristics therein, and a gravity flow of said material, air control means associated with the air supply to each air chamber, means operatively connecting the air control means to the unit to increase the air flow on a heavier displaced condition of the counterbalance and to decrease the air flow on a lightened condition thereof, a plurality of discharge chutes at spaced intervals throughout the length of said units, dams mounted over said discharge chutes, and means mounted between the dams and the chutes and movable at a speed independently of the gravity flow of said particles to move a lowermost stratum of said particles beneath the dams and into the discharge chutes.

12. Apparatus for separating finely divided intermixed particles, comprising an inclined air pervious support, means for feeding a supply of material for separation onto the support, air supply means directing a diffused flow of air upwardly through the material bed to impart liquid-like physical characteristics thereto, to cause a flow of said material under gravity over the inclined support, a cellular conveyor mounted on the pervious support and movable differentially from the gravity flow stream, the pervious member having a plurality of discharge gates therein below the conveyor, and a plate mounted above the conveyor over each of the gates, each of the plates being adjustable with respect to the height of its forward edge above the conveyor to control diversion of stratified material by weight and size into the conveyor cells and through the gates.

13. Apparatus for separating finely divided intermixed particles, comprising an inclined air pervious support, means for feeding a supply of material for separation onto the support, air supply means directing a diffused flow of air upwardly through the material bed to impart liquid-like physical characteristics thereto, to cause a flow of said material under gravity over the inclined support, a cellular conveyor mounted on the pervious support and movable differentially from the gravity flow stream, and a pair of separator plates mounted at the lower end of the pervious support, each of the plates having an edge thereof adapted to enter transversely a stream of material flowing by gravity over the pervious support, the plates being offset vertically from each other, the lower plate having its entering edge upstream from that of the upper plate to shield the upper plate from the air stream whereby the lower plate divides off a lower stratum of the stream of material while in a liquid-like condition from air flow through the stream, and the upper plate divides off an upper stratum while the stream is in an at least partially settled condition.

14. A method of separating material of finely divided intermixed particles which consists in feeding a supply of such material onto a sloping air pervious support, blowing a gaseous medium upwardly through the support to produce a liquid-like flow in the material, shielding an intermediate portion of the material within a predetermined zone from the support and the air flow, moving a lowermost stratum of the material positively and at a rate different from that of the stream flow thereof into the shielded zone, and removing such material to discharge from the shielded zone.

15. Apparatus for separating finely divided intermixed particles comprising an elongated casing, an air pervious deck on said casing, the deck sloping in a direction lengthwise of the casing, the deck having a narrow gap opening transversely thereof intermediately of its length, feed means mounted to discharge material for separation onto the higher end of the deck, a dam mounted over the gap, conveyor means mounted to slide over the deck and beneath the dam, controlled power drive means associated with the conveyor, and controlled air supply means mounted to supply a flow of air upwardly through the pervious deck and the conveyor means, and adapted to bubble through the material supported on the decks, thereby to produce liquid-like characteristics in said material causing a stream flow thereof over the inclined deck and over the dam, the material in the conveyor passing beneath the dam being shielded by said dam from the air flow and from the remainder of the stream material above the dam, the material in the conveyor beneath the dams passing by gravity into the gap opening beneath the dam.

16. Apparatus for separating finely divided intermixed particles of different specific gravities comprising an inclined air pervious support having a gap of predetermined width transversely thereof intermediately of the length of said support, means for feeding a supply of such particles onto the higher end of the support, controlled air supply means directing a flow of air upwardly through the support to impart liquid-like characteristics to material on the support, a dam overlying the gap in the support, a conveyor

having a multiplicity of cell-like openings therethrough closely overlying the support and the gap, and passing beneath the dam, to restrain the stream flow of particles immediately above the support, said cell-like openings being sufficiently small to restrict the lateral diffusion of air currents passing upwardly therethrough, and power means for slowly moving the conveyor longitudinally of the support at a controlled rate of speed, sufficiently slow that the heavier particles separated from the supply form an increasing accretive gathering in each of the cells of the conveyor gradually thereby to increase the diffusion and reduce the velocity of the air currents passing upwardly through the cells of the conveyor as the cells approach the shielded gap, at least a portion of the particles so gathered falling from the cells by gravity into the gap beneath the dam.

EARL STUMP.