United States Patent [19]

Johnston et al.

[11] **3,777,887**

[45] **Dec. 11, 1973**

[54] **APPARATUS FOR SEPARATING DRY GRANULAR MATERIAL**

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[73] Assignees: **Albert M. Clark; John C. Manning,** Bakersfield; **John G. Troster,** Atherton, Calif. ; part interest to each

[22] Filed: **May 27, 1971**

[21] Appl. No.: **147,545**

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 863,989, Oct. 6, 1969, Pat. No. 3,667,601.

[52] **U.S. Cl.** **209/474,** 209/486, 209/490, 209/499, 209/502

[51] **Int. Cl.** **B03b 3/04**

[58] **Field of Search** 209/474, 486, 490, 209/491, 502, 506, 475, 483, 260

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[57] **ABSTRACT**

Separator apparatus embodying an inclined porous deck having parallel transverse upper grooves at right angles to its direction of inclination. Granular material deposited onto the upper end of the inclined deck is assisted by low pressure air forced upwardly through the deck in moving toward the lower end of the deck, the air effecting separation between granules or particles of greater specific gravity and granules or particles of lighter specific gravity, the former dropping to the bottom of the grooves while the latter float upwardly and flow progressively from groove to groove toward the lower end of the porous deck. The downstream sides of the grooves make an acute angle with the upper face of the inclined porous deck to entrain greater specific gravity particles in the grooves.

4 Claims, 6 Drawing Figures

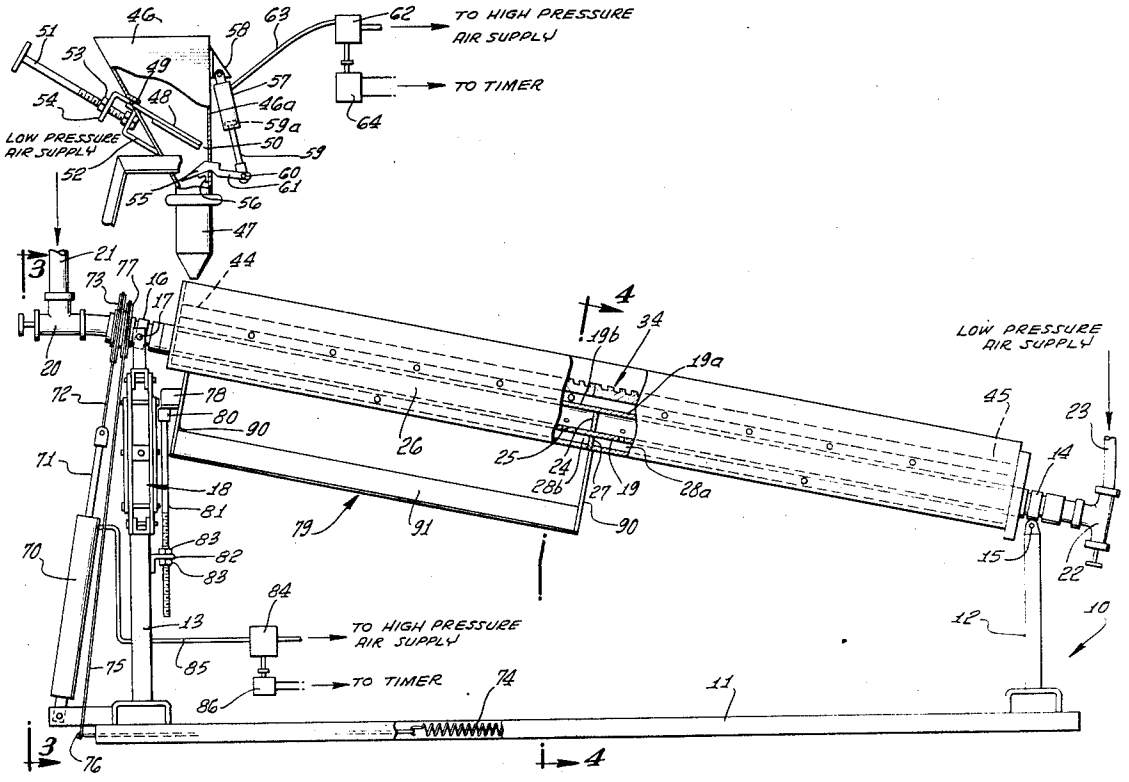
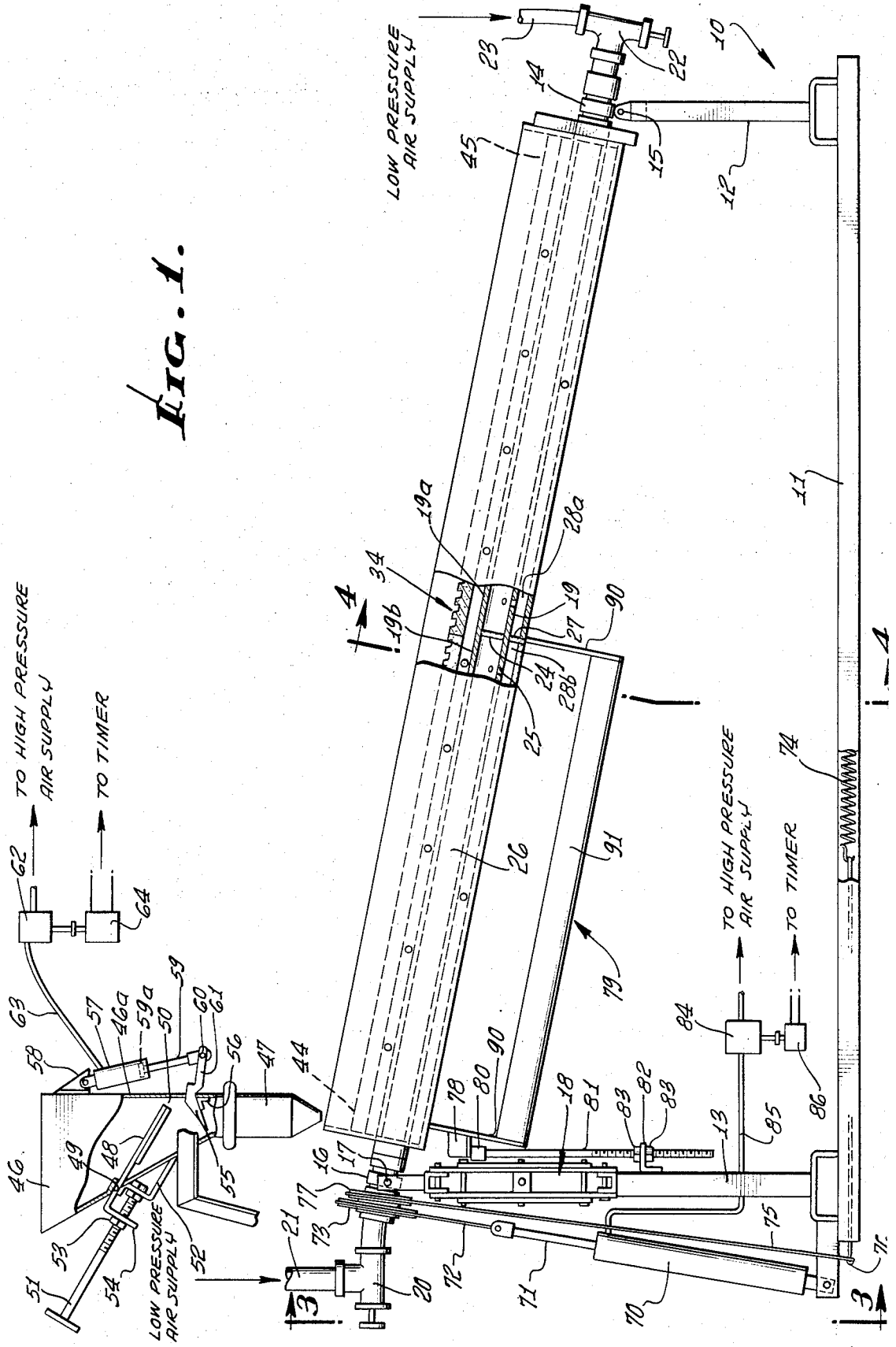


FIG. 1.


LOW PRESSURE AIR SUPPLY
TO HIGH PRESSURE AIR SUPPLY
TO TIMER
TO HIGH PRESSURE AIR SUPPLY
TO TIMER
LOW PRESSURE AIR SUPPLY
4
4
3
3

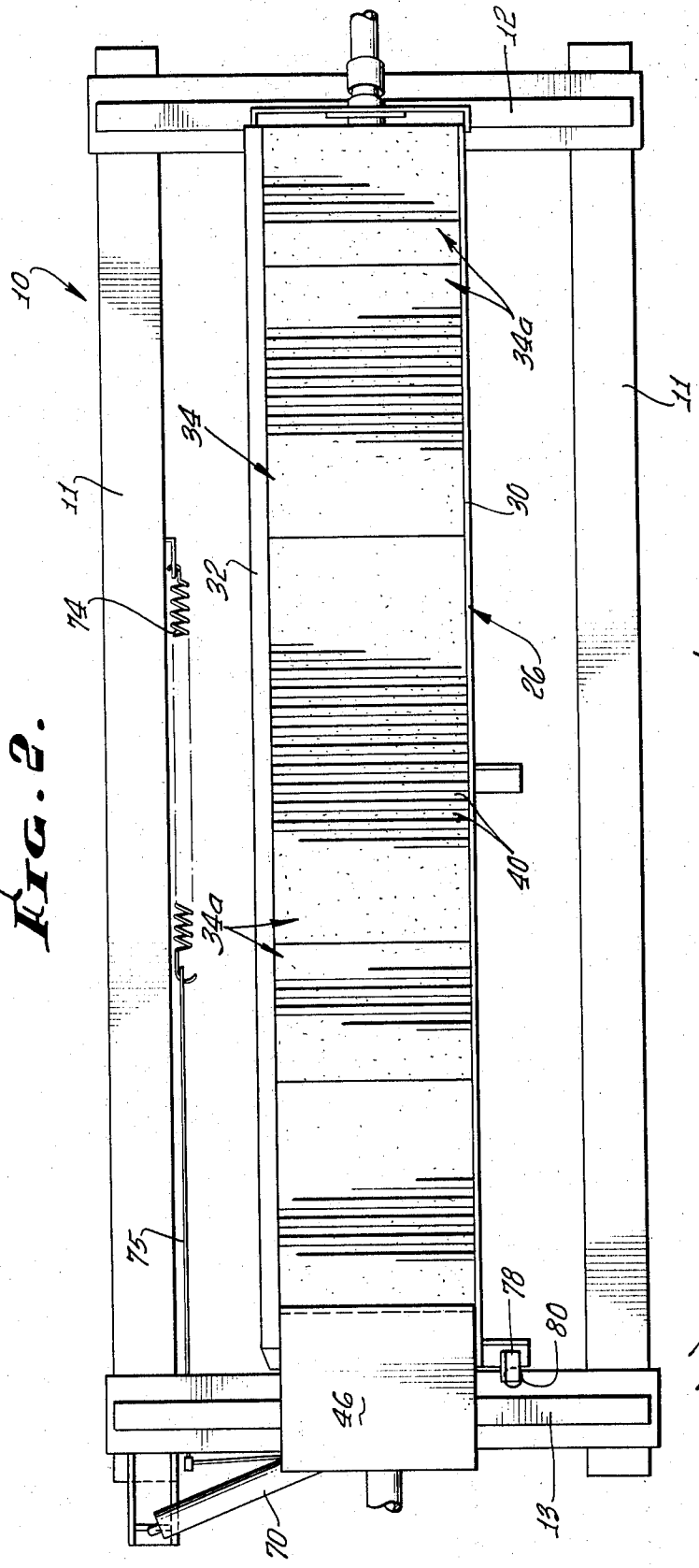


FIG. 2.

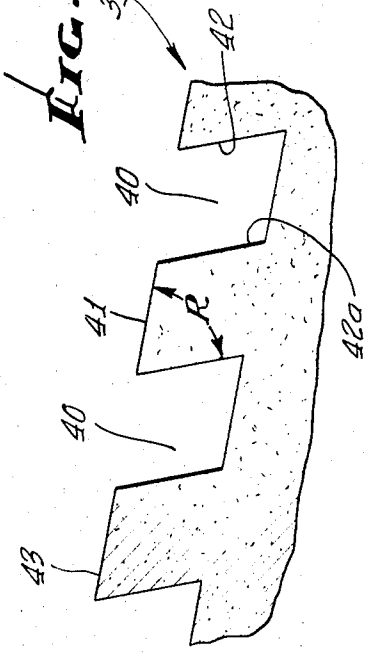


FIG. 6.

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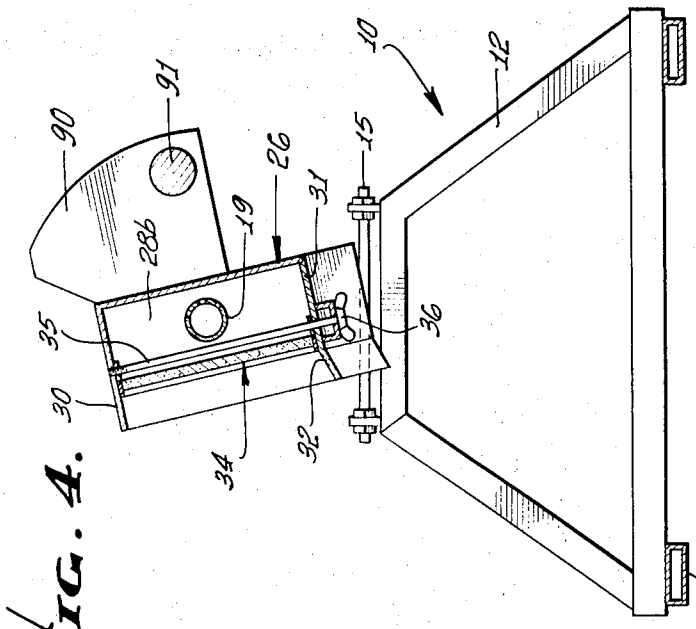


FIG. 4.

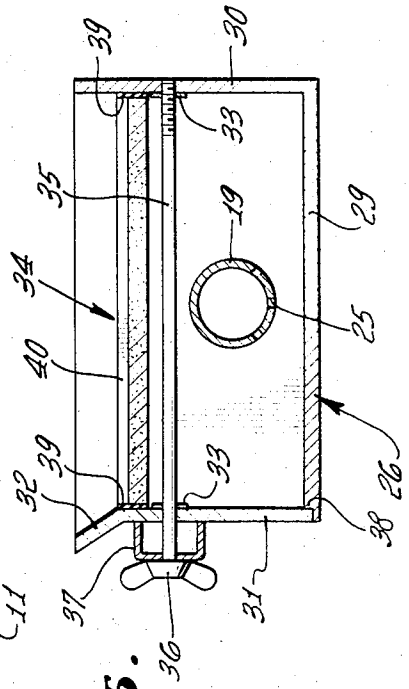


FIG. 5.

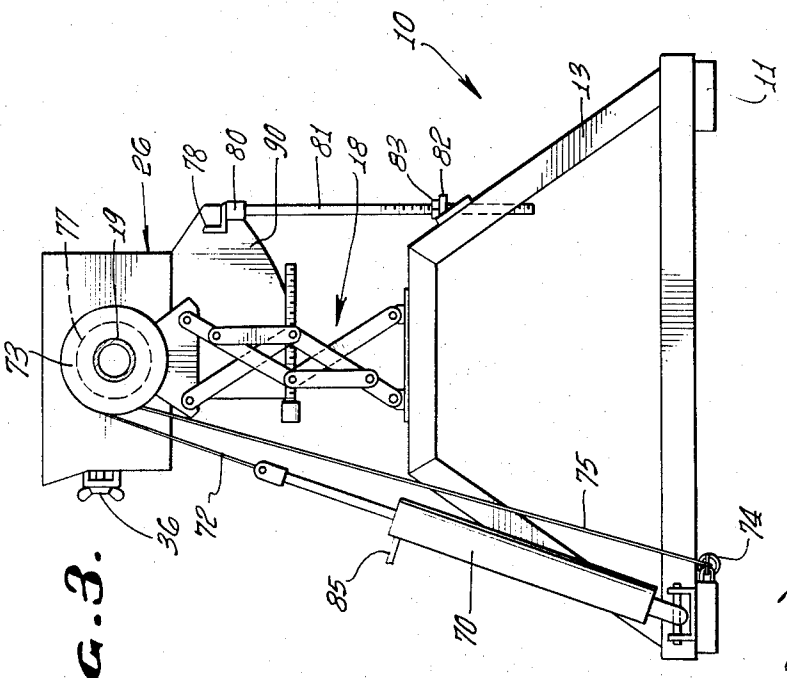


FIG. 3.

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APPARATUS FOR SEPARATING DRY GRANULAR MATERIAL

This application is a continuation-in-part of United States application Ser. No. 863,989, filed Oct. 6, 1969, for "Apparatus for the Dry Separation of Granular Materials" now Patent No. 3,667,601.

The present invention relates to separator apparatus, and more particularly to apparatus for separating granular material in a dry state.

In applicants' above-identified application, an apparatus is disclosed in which a blanket of dry material moves along a porous grooved bed while the bed is being vibrated and air forced upwardly through it to fluidize the material, the denser particles settling out and becoming trapped in the grooves while the gangue or worthless fractions of the material proceed along the bed for removal at its downstream portion. The prior apparatus is very effective in separating the material, but the necessity for vibrating the porous bed requires the various parts to be rigid and, therefore, of comparatively heavy, strong and sturdy construction. Vibrators, spring supports, vibration absorption devices, levelling devices, and other equipment, are necessarily included, which adds considerably to the complexity and cost of the equipment, as well as to the cost of maintaining it in proper working order and adjustment for optimum performance. The vibration of the bed limits the bed length that can be used, correspondingly limiting the capacity of the apparatus.

It has been found that a large percentage of the gangue or worthless sand, or other material, can be removed initially with a high recovery of the heavier values without vibrating the porous deck. With a non-vibration deck, the apparatus is much simpler since all vibrating equipment is omitted. Moreover, the framework can be lighter and, therefore, less costly. Maintenance costs are also reduced. The absence of vibration enables the porous bed or deck to be made much longer, resulting in much higher recovery of the valuable denser particles as the fluidized blanket flows along the bed.

Despite the high recovery of denser materials with the non-vibrating porous deck, it is usually desirable to employ the vibrating type of apparatus, described in the above-identified patent application, for final high purification of a mineral concentrate.

In addition to the foregoing objectives, that include simplicity, economy and greater capacity of the apparatus, a grooved porous deck is provided in which the deck has greater retentivity of the heavier particles in its grooves, particularly with the deck disposed in a downwardly inclined position with respect to the direction of travel of the material along the deck.

This invention possesses many other advantages, and has other objects which may be made more clearly apparent from a consideration of a form in which it may be embodied. This form is shown in the drawings accompanying and forming part of the present specification. It will now be described in detail, for the purpose of illustrating the general principles of the invention; but it is to be understood that such detailed description is not to be taken in a limiting sense.

Referring to the drawings:

FIG. 1 is a side elevational view, with portions in section, of an apparatus embodying the invention;

FIG. 2 is a top plan view of the apparatus shown in FIG. 1;

FIG. 3 is an end elevation of the apparatus taken along the line 3—3 on FIG. 1;

FIG. 4 is a cross-section taken along the line 4—4 on FIG. 1, illustrating the deck of the apparatus tilted to a dumping position;

FIG. 5 is an enlarged cross-section through the deck of the apparatus; and

FIG. 6 is an enlarged fragmentary section through the porous bed of the apparatus.

The apparatus disclosed in the drawings includes a frame structure **10** having a base **11**, longitudinally spaced vertical standards or supports **12, 13** secured to and extending upwardly therefrom. The upper portion of the rear standard or support **13** is vertically adjustable, while the forward standard **12** may be of a fixed height. This latter standard is secured to a forward bearing support **14** by a pivot pin **15**, a rear bearing support **16** being secured by means of a pivot **17** to the upper end of a toggle type of jack **18**, of known construction, such as used in raising and lowering portions of vehicular trucks, the lower portion of such jack being secured to the fixed rear standard **13**. Rotatably mounted in the bearings **14, 16** is a heavy pipe **19** that extends longitudinally beyond each bearing. The rearward end of the pipe **19** is connected through a suitable valve **20** to tubing **21** through which low pressure air can be fed, the forward end of the pipe also being secured to a valve **22** connected to a tubing or conduit **23** through which low pressure air can be supplied to the pipe. The pipe has an intermediate traverse wall or closure **24** therein, separating it into forward and rearward sections **19*a***, **19*b***, the lower portions of each section being provided with perforations **25** through which air is fed into an air chamber or plenum **26** through which the pipe extends, the plenum also being separated by an intermediate wall **27** into forward and rearward chamber portions **28*a***, **28*b***. The plenum is suitably affixed to the pipe **19** for movement therewith as a result of arcuate movement of the pipe **19** in its supporting bearings **14, 16.**

The plenum includes a bottom wall **29** and a first side wall **30** extending upwardly therefrom. A second removable side wall **31** extends upwardly from the bottom of the plenum, with its upper end portion **32** tapering or flaring outwardly. Parallel mounting strips **33** are suitably secured to the inner faces of the side walls **30, 31** intermediate their vertical heights and on which a permeable deck **34** is supported, these strips being preferably narrow so as to avoid substantial impairment of the vertical flow of air from the plenum upwardly through the permeable deck or bed. The bed **34** is clamped between the side walls **30, 31** by means of longitudinally spaced tie rods **35** that extend transversely across the plenum, the tie rods extending through the strips **33**, with one end of each tie rod being suitably secured to one of the side walls **30** and the other end portion extending through the removable side wall **31**, a wing nut **36** being threaded on the outer portion of each tie rod and engaging a suitable clamp member **37** that bears against the outer face of the movable side wall **31.** Tightening of the wing nuts **36** will retain the lower end of the movable side wall **31** against a recessed shoulder **38** in the bottom wall **29** and cause the upper portion of the movable side wall to engage one side of the deck **34**, holding the other side of the deck

against the other side wall **30.** Thus, plurality permeable bed **34** rests upon the supporting strips **33** and is clamped between the side walls.

The deck or bed preferably comprises a pluraltiy of individual plates **34** that abut each other, being clamped between and against the side walls **30, 31.** The sides of these plates preferably have thin sponge rubber strips **39** clamped between the deck sides and the side walls **30, 31** to prevent air leakage from the plenum **26** upwardly between the side walls and the deck. Partial loosening of the wing nuts **36** allows replacement and exchange of one or more plates **34***a*, which may have become damaged during operation of the apparatus, thereby obviating the necessity for replacing the entire deck, as in previous devices.

The permeable deck **34,** which, for example, may be made of a material marketed by Ferro Corporation of Cleveland, Ohio, under the trademark "Filtros," has a plurality of transverse grooves **40** in its upper face disposed perpendicular to the direction in which the granular material flows longitudinally along the bed, as described hereinbelow. The grooves are parallel to each other, their width and depth and separation from one another being determined to provide the most effective recovery of the valuable heavier particles from the material flowing downwardly along the deck. A typical groove arrangement is one in which the width of each groove is about one-quarter of an inch, the depth of the groove also being a quarter of an inch, with the lands **41** between adjacent grooves having a width of about one-quarter of an inch. The side walls **42, 42***a* of each groove are inclined to the upper face **43** of the deck, the downstream side **42** of each groove making an acute angle R with the upper deck face in order to provide greater retentivity of the heavier particles of material in the grooves that settle thereinto while low pressure air is travelling upwardly through the porous deck, the air fluidizing the dry granular material flowing downwardly along the inclined deck, the upper or rear end **44** of which is at a substantially higher elevation than the forward or lower end **45.**

The dry granular material to be separated is dropped down onto the rear end **44** of the inclined deck **34.** This material is conducted from a suitable source into a hopper or feed bin **46** suitably supported by the framework above the deck **44** and plenum **19.** The material drops from the feed bin and through a bin chute **47** onto the upper rear end **44** of the deck, the flow of material from the feed bin into the chute and onto the rear end of the deck being controlled by a gate **48** extending across the feed bin or hopper, this gate being inclined in a downward and forward direction and being slidable through a slot **49** in the hopper. The opening or gap **50** between the forward end of the gate and the opposed forward wall of the hopper or bin is controlled by a handle **51** rotatably mounted in a bracket **52** suitably secured to the rear portion of the hopper **46** and threaded within a nut **53** attached to a flange **54** suitably secured to the gate **48.** Rotation of the handle **51** in one direction or the other will effect corresponding sliding of the gate **48** within the hopper to determine the size of the opening or gap **50** between the end of the gate and the hopper wall, and, thereby, the rate of downward feed or dropping of the granular material through the bin chute **47** and onto the rear portion **44** of the permeable deck.

At intervals, the flow of material from the feed bin or hopper **46** onto the deck is to be stopped or prevented. This action is effected by a check gate **55** in the hopper disposed below the flow gate **48.** This check gate has a hinged connection **56** with the hopper and normally extends downwardly along the forward wall **46***a* of the hopper to permit the material to pass from the hopper downwardly onto the porous deck. When the discharge end of the hopper is to be closed by the check gate **55,** air is fed into the head end of the cylinder **57** that has a pivotal connection with a bracket **58** secured to the hopper **46,** the air driving a piston **59***a* and piston rod **59** downwardly of the cylinder, which has a pivotal connection **60** with an arm **61** affixed to the check gate **55** and extending outwardly of the hopper. Normally, in the absence of air under pressure fed into the head end of the cylinder, the weight of the check gate **55** swings it downwardly into an ineffective position to force the piston rod **59** and piston **59***a* upwardly in the cylinder. However, when air from a suitable air supply under the control of a solenoid operated valve **62** is allowed to pass into the cylinder through a suitable tube or hose **63,** the gate **55** is swung upwardly in the hopper to a position closing its discharge end. The valve **62** controlling the air supply is operated by a solenoid **64** electrically connected to a suitable timer switch (not shown). When the solenoid is energized, it shifts the valve **62** to permit air to flow to the cylinder **57,** and, when deenergized, it will position the valve to shut off the air supply and open the line **63,** leading to the cylinder, to atmosphere, permitting exhaust of air from the cylinder and the dropping downwardly of the valve **55** to open position.

As described more particularly hereinbelow, low pressure air passes through the pipe **19** and its perforations **25** into the air chamber sections **28***a*, **28***b*, then flowing upwardly around the pipe and through the porous bed **34,** causing fluidizing of the material dumped upon the upper end of the bed and its downward progression over the grooved bed, the heavier valuable particles settling into the grooves **40** and being retained therein. A suitable supply of granular material is deposited on the upper end **44** of the permeable bed **34,** as permitted by the valve mechanism **55.** The apparatus operates to effect separation of the granular material as it flows downwardly along the inclined bed for a predetermined period, whereupon valve **55** is closed and the material on the bed is dumped into a suitable trough structure (not shown), or the like, disposed at one side of the pivoted structure, the trough arrangement, by way of example, being as disclosed in the above-identified patent application.

Pivoting of the apparatus to dump the material on the bed is effected by air under pressure entering the rod end of a cylinder **70** suitably secured at its lower end to the frame **10** of the apparatus, such air acting upon a piston and rod mechanism **71** to move the latter downwardly in the cylinder, the upper end of the rod being connected to a cable **72** wound around a grooved pulley **73** fixed to the pipe **19** at the rear end of the apparatus. Downward pulling of the cable **72** by the piston and rod device **71** causes partial rotation of the pulley, which, for example, may be through an arc of about 135°, to shift the entire plenum from a horizontal position, dumping the material on the permeable bed **34** onto the trough (not shown, but referred to above), the flaring side portion **32** of the plenum unit **26** facili-

tating such dumping. As the plenum unit and pipe are rotated by the pulley **73**, a return spring **74** is tensioned, such return spring, for example, being disposed at the base **11** of the frame, one end being secured to such base and the other end being secured to a cable **75** that passes around a guide **76** and upwardly around a second grooved pulley **77** suitably affixed to the pipe. The bleeding of compresed air from the tilting cylinder **70**, after the dumping operation has been completed, will permit the tension spring **74** to act through its cable **75** and pulley **77** to pivot the plenum back to its initial horizontal position, as determined by engagement of a suitable stop **78** mounted on a plenum counterblaance mechanism **79** with the upper end of a companion stationary stop member **80** affixed to a vertical rod **81** having a lower threaded end extending through a bracket **82** suitably secured to the rear standard **13**, the stop rod **81** being adjustable as a result of upper and lower nuts **83**, threaded on the threaded rod portion, engaging upper and lower sides of the bracket **82**. It is evident that the position of the upper end **80** of the stop can be determined by suitable threaded positioning of the nuts **83** on the threaded portion of the rod **81**.

The high pressure air supply to the tilting cylinder **70** passes through a suitable valve **84** and through a tube **85** leading to the rod end of the cylinder. The opening and closing of this valve and bleeding of air from the cylinder is determined by a solenoid **86** that controls operation of the valve, this solenoid also extending to a suitable electrically operated timer (not shown) which controls the passage of current to the solenoid.

The counterbalance mechanism **79** is provided to facilitate pivotal movement of the entire deck assembly **26, 34** during its movement between its horizontal position and its dumping position. As shown, the counterbalance mechanism includes longitudinally spaced end members **90** affixed to the bottom of the plenum **26**, a counterbalance bar **91** extending between and being suitably secured to the transverse or end members.

In the operation of the apparatus, the slope of the deck **34** is predetermined and is set through appropriate adjustment of the toggle jack **18** at the rear end of the apparatus. At the commencement of a cycle of operation of the apparatus, the deck assembly is in its fully upright position, the flow control valve **55** being in its open position and the material flowing from the feed bin **46** and through the bin chute **47** onto the upper end **44** of the permeable deck. Air under a suitable pressure passes through both low pressure air supply pipes **21, 23** and through the open valves **20, 22** into the mounting pipe **19**, the air flowing into the plenum **26** and then moving upwardly through the permeable bed **34**, the air flow through the bed fluidizing the dry material and causing it to flow from the rear portion of the bed toward its forward portion **45**, the particles of greater specific gravity settling out into the grooves **40** and becoming trapped therein, the gangue material at the forward end of the bed passing therefrom onto a suitable conveyor belt (not shown) for transport to a point of discharge. Air at slightly different pressures may be applied to the upper (rear) and lower (forward) portions of the deck, since the upper part of the deck becomes filled with heavy grains of material before the lower half and may require slightly more air flow to keep the ore fluidized for progressive downward movement along the bed. Each valve **20, 21** may be suitably adjusted to provide the desired air pressure and air flow for any given ore that is being concentrated, and to provide different degrees of pressure, if required, passing into the rear and forward portions of the plenum.

As pointed out above, the lower face **42** of each deck groove **40** is not vertical, but slopes downwardly with respect to the upper face **41** of the deck or bed in the direction of ore travel. This enables the smaller and lighter mineral grains, which are not totally freed from the gangue, to remain in the grooves **40** since they cannot climb the downstream side **42** of each groove and move into the next groove. These lighter grains are close to the density of the valuable minerals to be recovered, and they should likewise be recoverd, if at all possible. It is found that substantial additional recoveries of valuable minerals is achieved through slanting the forward or downstream faces **42** of the grooves in the manner described. By way of example, by inclining the permeable bed **34** 15° to the horizontal, and with the inclined lower groove faces **42**, it is found that the valuable lighter minerals are incapable of scaling the downstream faces **42** of the grooves and will be trapped therein. Grooves **40** making an angle of 70° to the upper face, which is 20° from the perpendicular to the upper face **41** of the bed, effect satisfactory performance of the apparatus, although such angle can be varied from the specific figure given, ranging from about 10° to about 45° from the perpendicular to the upper face of the porous deck. The net effect of the slanting grooves **40** is to retain the heavy values of material better, increasing recovery and purity of the concentrate.

The deck assembly is dumped periodically, under the control of a timer (not shown). Prior to tilting of the deck assembly, the ore feed is shut off a few seconds by the timer, causing the solenoid **64** to actuate the valve **62** and effect closing of the ore flow control valve **55**. This short period allows the ore blanket to run off the forward end **45** of the deck **34** for disposal. With the flow control valve **55** closed, the timer effects opening of the high pressure air supply valve **84** to the tilting or dumping cylinder **70**, which is then actuated to tilt the deck assembly and dump the material entrapped within its grooves **40**, wehreupon the air supply is shut off and vented from the cylinder **70**, allowing the spring **74** to return the deck assembly to its initial position. At this time, the timer appropriately actuates the high pressure air supply valve **62** leading to the feed bin cylinder **57**, venting the latter and allowing the flow control valve **55** to reopen to permit the ore or other material in the feed bin **46** to again drop onto the upper end **44** of the porous deck. The entire interruption of ore feed caused by the dumping procedure, from the time the flow control valve **55** is first closed to the time of its reopening, may typically range from about 8 to 12 seconds, depending upon the extent of inclination or slope of the porous deck **34**. The ore concentrating period may, for example, be about 4 minutes, the entire cycle time being variable depending upon the richness of the ore, that is, the percentage of the feed material to be recovered. The richer the ore, the shorter will be the cycle time so as to avoid losing valuable minerals to the tailings. Because of the relatively short period required for effecting the entire dumping operation, the apparatus is actually operating in the performance of its concentrating operation about 96 percent of the time.

The apparatus is comparatively simple, since it is movable only during the dumping operation. The air

flowing through the static porous deck **34**, coupled with the inclination of the deck, causes the material to flow from the upper end **44** of the deck to its lower end **45**. Accordingly, it is evident that the motivating factors in producing flow of ore down along the bed are the vertical air stream flowing upwardly through the porous bed **34** and gravity. The entire deck assembly is moved only during the dumping cycle. Thus, complex auxiliary equipment is avoided, as in prior devices, and yet a high degree of recovery is effected. Moreover, the capacity of the apparatus is much greater than in prior devices, since the relative immobility of the deck **34** enables it to be made much longer and, therefore, capable of operating over a longer period during each cycle in effecting the settling of the heavy particles into the grooves **40**.

By way of example, a 1 foot by 6 foot porous deck has been found to be capable of handling from about 15 to more than 50 tons of ore in a 24-hour day, depending on grain size and the difference of density between the gangue and the heavy mineral "values." This capacity increases the greater the density difference and the larger the grain size. Thus, coarse gold can be run at somewhat more than 50 tons per day per deck, while the light ores, such as malachite in fine grain size, would reduce the effective recovery capacity to 15 tons per day.

A typical cycle of operation is as follows:

a. An electrical timer impulse results in opening of the ore feed valve **55**.

b. After a predetermined time for the low pressure air to fluidize the ore and effect a deposit of the heavier values in the grooves **40**, the timer and the air cylinder **57** operate the feed valve **55** to a closed position.

c. After about 5 seconds (which is adjustable for each ore) for the ore blanket to flow off the lower end **45** of the deck **34** sufficiently, the timer opens the air valve **84** to the tilting cylinder **70** to effect dumping of the concentrate and the middlings into a suitable trough or other receiver.

d. After about 2 seconds, the timer actuates the valve **84** to vent the tilting cylinder **70**, allowing the spring **74** to return the deck **34** to its laterally horizontal position.

e. Immediately upon the return of the deck to the horizontal position, the timer operates the air valve **62** to vent the cylinder **57** and allow the ore feed valve **55** to open.

We claim:

1. In apparatus for separating intermixed materials of different specific gravities: a supporting structure; a plenum; a perforate pipe passing through said plenum; means mounting said pipe on said supporting structure; a porous deck mounted in said plenum and having spaced parallel grooves in its upper surface extending from the rearward portion of said deck to the forward portion of said deck; means for depositing the materials on the rearward portion of said deck; and means for conducting a gaseous medium into said pipe for discharge into said plenum and upward passage through said deck to effect fluidizing of the materials and their progression across said grooves from the rearward portion of said deck to the forward portion of said deck; said mounting means pivotally carrying said pipe on said supporting structure to enable said pipe, plenum and deck to be tilted between a normal position in which said grooves face upwardly and a tilted position in which the material of said grooves can be dumped from said deck.

2. In apparatus as defined in claim **1**; said deck, pipe and plenum being held in a stationary position while the materials are being fluidized.

3. In apparatus for separating intermixed materials of different specific gravities: a supporting structure; a plenum; a perforate pipe passing through said plenum; means mounting said pipe on said suporring structure; a porous deck mounted in said plenum and having spaced parallel grooves in its upper surface extending from the rearward portion of said deck to the forward portion of said deck; means for depositing the materials on the rearward portion of said deck; and means for conducting a gaseous medium into said pipe for discharge into said plenum and upward passage through said deck to effect fluidizing of the materials and their progression across said grooves from the rearward portion of said deck to the forward portion of said deck; said mounting means normally supporting said pipe, plenum and deck in a stationary position inclined to the horizontal downwardly from the rear portion of said deck to the forward portion of said deck; said mounting means pivotally carrying said pipe on said supporting structure to enable said pipe, plenum and deck to be tilted between its normal stationary position in which said grooves face upwardly and a tilted position in which the material in said grooves can be dumped from said deck.

4. In apparatus as defined in claim **3**; said parallel grooves having downstream sides disposed at an acute angle to the upper face of said deck.

* * * * *

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,777,887 Dated December 11, 1973

Inventor(s) NORRIS JOHNSTON, ET. AL.

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 3, line 1, "plurality" should read -- the -- .

Signed and sealed this 16th day of July 1974.

(SEAL)
Attest:

McCOY M. GIBSON, JR.
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents

FORM PO-1050 (10-69)

USCOMM-DC 60376-P69
* U.S. GOVERNMENT PRINTING OFFICE : 1969 O—366-334.