Jan. 11, 1955 T. H. MILLIKEN, JR., ET AL 2,699,249

APPARATUS FOR HANDLING RESILIENT GRANULAR MATERIAL

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Fig. 1.

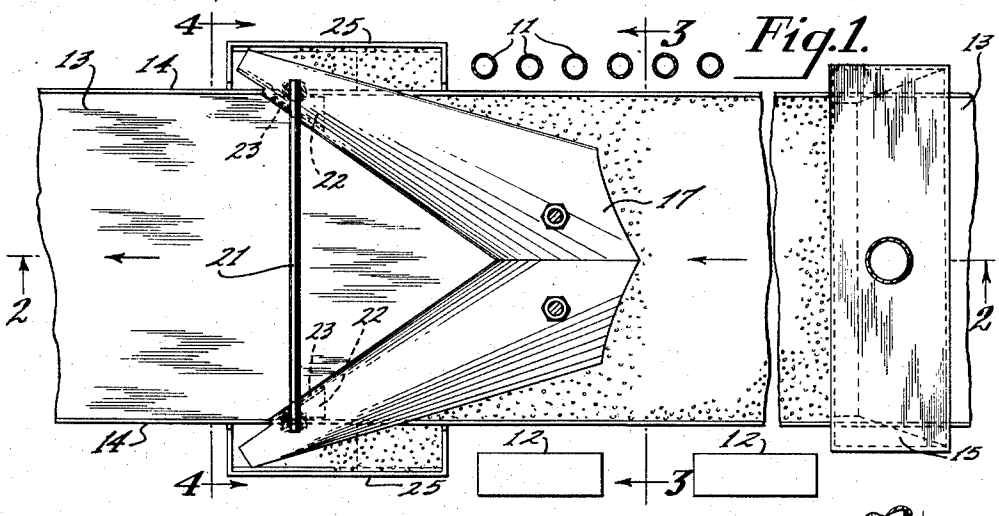


Fig. 2.

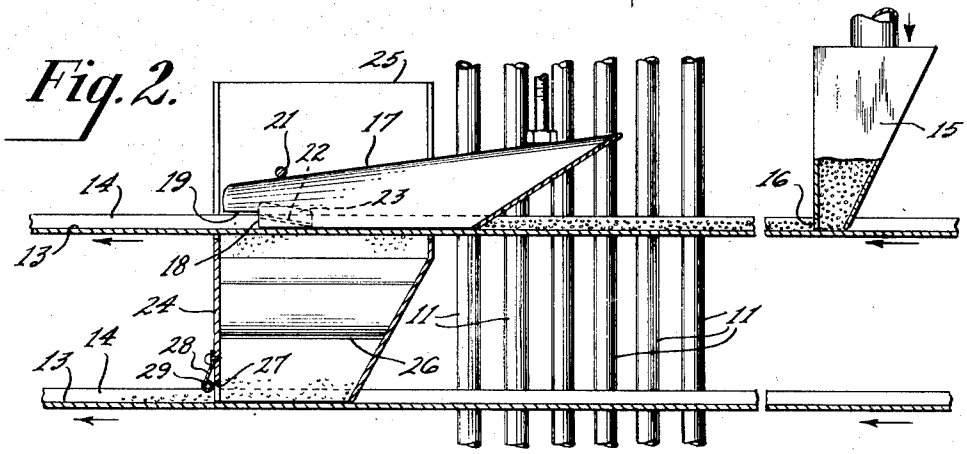


Fig. 3.

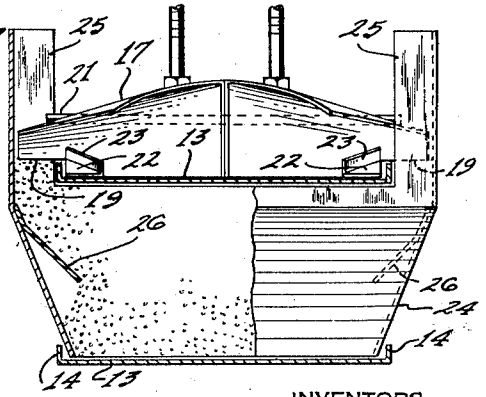
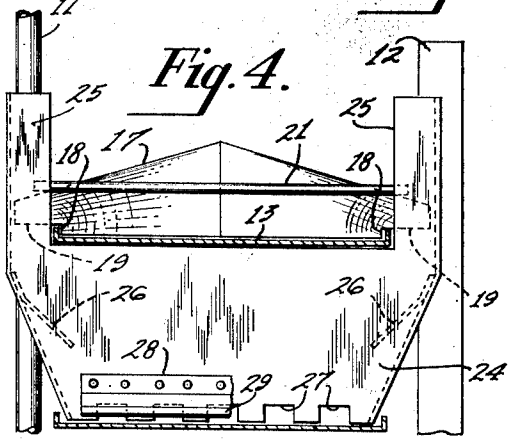


Fig. 4.



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APPARATUS FOR HANDLING RESILIENT GRANULAR MATERIAL

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8 Claims. (Cl. 198—84)

This invention relates to apparatus for handling resilient granular material while transporting the same by gravity flow between successive levels of a multi-level treating system.

The invention is particularly adapted for the transfer of resilient granular material from one horizontally-moving shallow layer supported on a moving tray or belt to a similar moving tray or belt disposed a substantial vertical distance underneath the first tray while the material is being exposed to a desired treating atmosphere, the material in transit being repeatedly turned over and spread as a shallow layer so as to expose new surfaces of the material to the treating medium, and to effect such thorough mixing of the material as will assure uniformity in the treated product.

While the invention is of broad application to various processes and apparatus for the treatment of resilient granular material, it will hereinafter be considered particularly in connection with a drying treatment, such as that which may be effected in a vertical turbo-dryer of the type described and illustrated in an article by A. Weisselberg entitled "Vertical turbodryers," starting at page 999, in the September 1938 issue of Industrial and Engineering Chemistry.

A typical turbodryer of the type referred to in the cited article may comprise a series of annular shelves or trays vertically-arranged within a large chamber or housing. Fans are mounted on a central vertical axis within the open core formed by the annular trays, and are arranged to blow radially outwardly over the exposed surfaces of the shallow layers of material spread over trays which are at the same level as the fan. The fans are vertically spaced along the central axis, each fan blowing currents of air outwardly over a group of trays to the peripheral region of the housing. The air then passes over heating elements in the peripheral region and is returned to the fan for recirculation by passing in a divided stream upwardly and inwardly over one or more trays immediately above the group and downwardly and inwardly over one or more trays immediately below the group.

The heating elements are arranged in a circumferential row within the housing, between the vertical wall of the housing and the outer limits of the series of trays or shelves, thus making possible a relatively large number of reheating cycles and permitting the temperature to be held within close limits at various levels within the dryer without resorting to temperature controls or zoning baffles.

In vertical turbodryers of the continuous transfer type, the trays are usually arranged to rotate as a unit about the central axis. The granular material is deposited on the uppermost tray, and is then leveled to a layer of substantially uniform depth. Each tray is provided with one or more transverse openings or slots which provide a path of communication for material passing from one tray to the tray next below. A wiper blade is positioned above each tray in such manner that as the tray passes under the wiper blade the granular material is swept into the opening or slot, from which the material falls freely to the surface of the tray below. During the transfer, the granular material becomes thoroughly mixed. Following its deposition in a pile on the lower tray the material is again spread into a layer of substantially uniform depth, at the same time exposing new surfaces of the material to the current of drying gas passing over the surface of the lower tray.

It has been found that such transfer by free fall of granular material which is initially highly resilient, or which acquires resiliency during the drying operation, creates a serious problem. Such material has a tendency to bounce on the surface of the tray following its free fall from the tray above. The random motion of the bouncing particles causes many of them to be projected off either side of the tray and to fall to the bottom of the apparatus. Any substantial accumulation of the particles at the bottom of the dryer may interfere with the proper functioning of the apparatus and, in any event will prevent the misdirected particles from receiving the full drying treatment.

The inability of turbodryers of present design to cope with the problem of resiliency or bouncing of the particles has imposed a serious limitation on their use for the drying of hydrogel beads or pellets, such as those employed as a catalyst in hydrocarbon conversion processes. Typical of such beads or pellets are those described in U. S. Patent No. 2,384,946, issued to M. M. Marisic on September 18, 1945. The beads are discharged from the bead-forming apparatus in a wet state and must then be dried and heat treated to render them suitable for use as catalytic material. As delivered to the dryer, the beads are highly resilient, and continue to be so during the drying operation. In a system requiring free fall of the beads between successive treating levels, such resiliency causes the particles to bounce about upon the surface of the belt, tray, or other receptacle upon which the beads are deposited. Obviously, many of the beads will bounce off the receiving surface and fall to the bottom of the drying chamber.

In accordance with the present invention granular material is transferred from a horizontally-moving supported layer at an upper level to a lower level, and there reformed as a similar moving layer, by being discharged from the layer-supporting surface at the end of its run on the upper level; collected into a confined stream immediately upon discharge from said supporting surface and conveyed by gravity flow downwardly and inwardly to the lower level; discharged directly onto the layer-supporting surface at the lower level within a confined area extending a substantial lateral distance across said lower surface; conveyed forwardly on the lower supporting surface as at least one horizontally-moving stream discharging forwardly from the lower end of said confined stream; and immediately after such discharge spread laterally over the lower supporting surface and leveled to form a moving layer of substantially uniform depth. This operation is repeated as the material moves through the various levels of a multi-level system.

Where the configuration of the horizontally moving surface is such as to preclude discharge from the forward end thereof, the material may be discharged laterally from one or both sides of the moving surface.

The discharge of beads from the sides of the moving surface may be accomplished by any means suitable to cause gradual lateral movement of the material toward side of discharge adjacent the end portion of the horizontal run.

In a preferred embodiment of the invention, especially as applied to drying apparatus of the type referred to in the aforementioned article, or similar apparatus for effecting other treatment of granular material, the beads are passed by gravity flow between the various treating levels, but instead of being pushed into an opening in the bottom of the moving belt or tray by a wiper blade which is held stationary above the moving surface the beads are engaged by a plow which directs them laterally to each side of the belt or tray and pushes them off the edge. The beads falling from the sides of the moving surface are collected in stationary receptacles or bins each located between adjacent conveying levels and having inlets disposed along each side of the moving surface in a position which will enable them to receive all the beads pushed off the surface by the plow. The receptacle extends laterally across the space between adjacent trays and has sloping sides which guide the material collected from the upper moving surface inwardly to a bottom discharge outlet located directly over and closely adjacent to the lower moving surface upon which the beads

are to be deposited. The lower edge of the forward wall of the bin, that is in the direction of movement of the receiving surface, is adapted to provide a gap above the moving surface sufficient to permit the beads to be carried forward from the bin as a substantially uniform layer on the moving tray. The opening or openings at the lower forward edge of the bin outlet through which the granular material is carried by the forward movement of the tray is low enough to prevent the material from being carried forward as a layer of greater than the desired depth, and to prevent any of the particles falling freely within the receptacle from bouncing through the opening. As the material passes successively downwardly through the various levels of the apparatus it is repeatedly pushed outwardly off the sides of the tray, caught in a bin, and directed downwardly and inwardly in a confined stream to a point immediately beneath the tray where it is collected as a mass and deposited on the surface of the tray below. Although the particles may bounce during transfer by reason of their contact with each other and with the inner wall surfaces of the bin, they are contained by the confining walls of the bin during the transfer from one tray to another so that none of the particles may escape.

For a clearer understanding of the invention reference may be had to the accompanying drawings forming a part of this application, in which:

Fig. 1 is a fragmentary plan view of a plow and transfer device associated with a moving tray;

Fig. 2 is an elevation view, in section, taken along the line 2—2 of Fig. 1;

Fig. 3 is a front view of the plow and transfer device viewed in the direction indicated by the arrows associated with line 3—3 of Fig. 1; and

Fig. 4 is a rear view of the same in the direction indicated by the arrows associated with line 4—4 of Fig. 1.

Referring to the drawing, a portion of a granular material treating system has been diagrammatically shown, the system comprising a multiplicity of vertically-arranged moving trays or belts, each conveying a shallow layer of granular material, such as hydrogel beads or pellets. For the purpose of illustrating the invention only two trays have been shown, but it is to be understood that the apparatus may comprise a considerable number of vertically-spaced trays, each moving in the same horizontal direction, or alternately arranged so that adjacent trays move in opposite directions. The trays may, for example, be of annular shape and be supported one above the other on a drum or other supporting structure which rotates as a single unit about the vertical axis of the trays, as shown in the aforementioned article, or they may be arranged to move in straight horizontal paths as separate endless conveyors, with the direction of movement being reversed at alternate levels. In the present description the apparatus will be considered as being employed for the drying of catalyst beads or pellets of the type referred to in the aforementioned patents. The trays will be considered as moving in a straight line between a row of vertical extending heating pipes **11** arranged as a coil at one side of the trays, and a vertical tier of fans or blowers **12** arranged at the opposite side of the trays and adapted to blow continuous streams of drying gas horizontally across spaced groups of trays. The drying gas, after passing across the trays of one group and picking up moisture from the granular material thereon, circulates around the tubes of the heating coil and returns to the opposite side of the apparatus by passing over the tray or trays above and below the aforementioned groups, thus providing continuous paths of circulation for each fan or blower.

The trays **13** are relatively wide, and are turned upwardly at each side, as at **14**, or are otherwise adapted to retain a shallow layer of beads on the surface of the tray. Instead of the upturned sides **14**, for example, longitudinal surface grooves or ridges may be provided adjacent the sides of the tray, so that the shallow layer of granular material spreading outwardly over the tray will be sufficiently restrained from lateral movement beyond the grooves or ridges to prevent beads from falling off the sides of the tray. Both of the trays **13** in the embodiment illustrated are moving in the same horizontal direction, as indicated by the arrows. For the sake of clarity, the illustration is to a certain degree diagrammatic in that the positional relationship of the moving trays and of the bead transfer devices is shown, without inclusion of the supporting means which combine the same into a unitary structure. The apparatus illustrated may be considered as a fragmentary portion of a large unit comprising a multiplicity of vertically-arranged trays, the whole being contained within a suitable housing, not shown, having an inlet and an outlet for the gaseous material which is to be circulated around the trays by the blowers.

Catalyst beads are introduced into a hopper **15** supported above the uppermost of trays **13** and having a lower discharge outlet extending laterally across and closely adjacent to the surface of the tray. The forward lower edge of the hopper is at a higher elevation than the remaining edges in order to provide a gap **16** between the raised edge and the surface of the tray through which the beads may flow or be carried forward on the surface of the tray in the direction of its travel. The height of gap or discharge opening **16** is such as to deposit a layer of beads of the desired depth across the entire surface of the moving tray, the layer of beads being confined along the sides of the tray by the upturned edges **14**, or by other suitable means, such as a ridge or a groove extending longitudinally along the surface of the tray adjacent its side edges. If desired, the gap may be made adjustable in known manner so that the depth of the layer may be varied. Or, a separate levelling member may be placed above the surface of the tray to engage and level the beads after their discharge through the opening **16**.

As the material is carried forward by the tray its exposed surface is swept by a current of drying gas, such as air, moving from the blower side of the apparatus to the heating coil side of the apparatus, or vice versa, depending upon whether the tray is located in the outgoing or return stream of circulating gas.

After the layer of beads has been carried forward the desired distance at the uppermost level of the dryer, the beads are engaged by a stationary plow **17** suitably supported from the rigid framework of the apparatus. The plow comprises two conical, or substantially conical, segments intersecting at their broader ends to form the forward end of the plow, the narrow ends being located at the rear of the plow and extending outwardly beyond the sides of the moving tray. The position of the conical segments is such that the line of intersection at the front of the plow is a straight line, sloping upwardly and forwardly of the plow in a vertical plane extending through the longitudinal center line of the tray. The lower edges of the conical segments engage the upper surface of the moving tray, so that as the tray passes under the stationary plow the beads are deflected by the forward edge of the plow to either side of the tray, and are gradually forced by the pressure of the following beads upwardly over the upturned sides **14** of the tray. The lower edge of each conical segment is stepped at the rear end, the riser portion **18** of the step being substantially in sliding engagement with the inner vertical surface of the upturned side **14**. The horizontal portion of the step extends rearwardly and outwardly over the upturned side of the tray, terminating a substantial distance laterally of the moving tray. The conical segments of the plow are joined by any suitable means along the forward line of intersection, such as by brazing, welding, etc. and rigidity is provided in the structure by a horizontal bar **21** extending across the V-shaped gap formed between the conical segments at the back-end of the plow. The ends of bar **21** are secured in any suitable manner to the upper surface of each conical segment at points adjacent the back end.

In order to prevent beads from being wedged between the forwardly facing surfaces of the plow and the inner side surfaces of the upturned portions **14** of the tray, a small deflector **22**, in the form of a triangular member sloping upwardly from the surface of the tray toward the rear of the plow, is provided so that the beads may be scooped from the surface of the tray and pushed upwardly on an inclined triangular plane surface, the upper edge of which extends at least to the top of the upturned portion **14** of the tray. The triangular deflector member **22** has an upturned flange **23**, by which it is secured to the outer surface of the conical segment. The beads are thus pushed outwardly by the conical portion of the plow to the edge of the tray and are then lifted from the surface of the tray and passed over the side by the deflector elements **22**.

The beads dropping off each side of the tray are caught by a receptacle or bin **24** which extends laterally across the space between the trays. The bin **24** is substantially wider than the trays and its side portions extend upwardly a substantial distance above the upper tray. The upwardly extended side portions **25** are turned inwardly toward the tray along each vertical edge, the innermost vertical edges terminating adjacent the upturned sides of the tray. The side portions **25** extend longitudinally along the sides of the tray a distance sufficient to assure that all the particles pushed off the tray by the plow will be deposited within the bin. The bin **24** converges inwardly on three sides toward its lower end, the back-side of the bin being vertical. The sides of the bin slope inwardly sufficiently to clear the upturned edges of the lower tray. The bottom of the bin is open and discharges the gravitating beads onto the surface of the lower moving tray in a manner similar to that provided by the hopper **15**. The bin **24** is provided with sloping baffles **26** which guide the gravitating beads toward the central portions of the bin, so that they may be deposited in a central region on the surface of the lower tray. The falling beads deposited on the moving tray spread out over the surface of the tray and are carried by the movement of the tray toward the rear wall of the bin **24**. The lower edge of the rear wall is provided with cut-out portions **27** spaced across the width of the tray. The cut-out portions **27** provide openings through which the beads may be carried out of the bin **24**. In passing through the cut-out portions or openings **27**, the beads are leveled by a curtain or flap **28** which extends the width of the bin and is attached along its upper edge, in any siutable manner to the rear wall of the bin. In the illustrated embodiment, the curtain **28** is a non-rigid, fabric-like material provided with a hem along its lower edge, through which is inserted a metal rod **29**. If desired, however, a single hinged rigid flap may be provided in place of the fabric-like curtain, or hinged flaps individual to each opening may be provided. The lower edge of the curtain or flap **28** serves to level the beads as they pass through the openings **27**, so that a layer of substantially uniform depth is deposited on the lowermost tray.

In a dryer comprising a considerable number of tray levels, the beads which have been carried the desired distance on the second tray are again engaged by a similar plow, and are transferred to another moving tray immediately below. Such transfer of beads from tray to tray continues until the lowermost tray of the dryer has been reached, from which latter tray they may be discharged into a conveyor which directs or transports them out of the dryer.

The plow and collector bin is adapted for use with various types of moving trays or belts. In a turbo-dryer of the type described in the aforementioned article, all the plows and collector bins may be arranged in a vertical tier at one side of the rotating drum.

Alternatively the moving surfaces may comprise endless belts at each level having a straight horizontal run with the return run immediately below. In such arrangement, alternate belts may rotate in opposite directions, so that the beads are carried at successive levels back and forth through a horizontally elongated housing. For such operation, plows and bins are alternately placed at opposite ends of the belt conveyors. The beads that are discharged from the sides of the endless belt into the extended side portions **25** of bins **24** are conveyed downwardly therein as a confined stream past the return run of the belt to the upper surface of the next lower endless belt.

A furher modification of the endless belt arrangement may be obtained by providing a single endless belt arranged to travel back and forth and downwardly over a succession of vertically aligned rollers from the top to the bottom of the housing. In such arrangement, the belt is preferably reversible, that is, both surfaces are adapted to contain a layer of beads thereon. The belt may be so adapted by providing grooves or ridges on both the upper and the lower surfaces adjacent each side of the belt.

It is to be understood that the invention is not limited to the specific form illustrated in the drawing and specifically described herein. It is contemplated that various modifications of the apparatus may be made without departing from the invention.

The invention may be carried out by any suitable means which will serve to discharge the granular material from one or both sides of the upper moving surface, such as a belt or tray, and which will convey the discharged material as a fined stream to the lower moving surface in such manner as to deposit the material onto lower moving surface as a static or compact moving layer. The gravitating material may be guided to the lower surface as a sliding stream confined only at the bottom and sides, in which case the transfer must be effected without causing the particles to bounce as a result of severe impact with each other or with the confining surfaces. Or, the particles may be transferred by free fall, with attendant bouncing of the particles, provided the falling stream is totally confined so as to prevent any of the particles from bouncing off the apparatus. Furthermore, it is not essential that the granular material be deflected from the surface of the belt or tray by a physical obstruction, such as a wiper blade or plow. If desired, the particles may be deflected gradually to the side of the moving surface by a relatively high-velocity stream of gaseous material, which may be a gase employed in the treating step, or any other gas which is inert with respect to the material. Another possible method of operation, especially where the granular material is conveyed on the surface of a flexible endless belt, is to forcibly twist or bend the moving surface near the final portion of the desired horizontal run, so that the granular material, such as spherical beads, may roll or slide off the side of the moving surface. After the particles have been discharged from such moving surface the latter may be caused to reassume its normal shape.

It is further contemplated that, in certain arrangements where the material is conveyed on the surface of an endless belt that passes downwardly around a roller at the end of each horizontal run, the material may be caused to discharged off the end of the moving belt in the direction of belt movement, rather than off either side, and may be caught and conveyed as a confined stream downwardly to the surface of the next lower moving belt, or to the next lower horizontal run of the same moving belt.

Obviously many modifications and variations of the invention as hereinbefore set forth may be made without departing from the spirit and scope thereof, and therefore only such limitations should be imposed as are indicated in the appended claims.

What is claimed is:

1. In a system for treating granular material, in which said material is conveyed horizontally as a layer on a plurality of moving support members arranged at spaced levels in a vertical tier within a treating chamber and adapted along each longitudinal edge thereof to laterally confine said layer, and is transferred by gravity flow between successive levels, the combination therewith of means for continuously depositing a uniform layer of said material on the uppermost support member at the beginning of its horizontal run, a plow rigidly supported above said moving support member near the end of its horizontal run and adapted to engage and deflect said material toward at least one side of said support member, inclined deflector means affixed to the rear end of said plow adapted to engage said material at the surface of said moving support member and to elevate the same during the terminal period of its lateral displacement at least to the uppermost level of its lateral confinement, whereby said material may be discharged over the side of said support member, a collector bin supported between adjacent moving support members adapted to receive all material discharged from the upper support member and to convey the same to the surface of the lower support member, said bin having an open bottom contiguous to a portion of said lower support member extending substantially the full width thereof, the forward wall of said bin being recessed along its lower edge to provide at least one opening through which said material may be carried by said lower moving support member, and means adjacent said opening for spreading and leveling material conveyed therethrough to form a substantially uniform layer of said material upon said lower support member.

2. In a material handling system wherein granular material is transported horizontally as a supported layer at a plurality of spaced superimposed levels and is transferred by gravity flow between successive levels, the combination of a horizontally moving support member for said layer at each of said levels, means coextensive with the longitudinal edges of said moving support member for laterally confining said layer, a stationary deflector

supported above each moving support member near the end of its horizontal run and in such close proximity to its surface as to deflect all said granular material laterally to at least one side of said moving support member, the rearward portion of said deflector being inclined so as to engage the granular material being conveyed near the side edge of the moving member and to deflect said material upwardly to a level at which continued lateral deflection causes its discharge over said means for laterally confining said layer, a collector bin supported between adjacent moving support members and having an open bottom arranged to discharge collected granular material as a laterally confined stream directly onto the surface of the lower moving member over an area extending substantially the full width thereof, said bin having a side portion extended outwardly and upwardly to a location along the side of the upper moving member and arranged to collect and guide the flow of all the discharged granular material into said bin, outlet means along the forward lower edge of said collector bin for discharging conveyed granular material, and means associated with said outlet means for spreading said conveyed granular material to form a supported uniform layer of predetermined maximum depth.

3. Apparatus as defined in claim 2 including means within said collector bin adapted to intercept freely falling particles of said granular material at an intermediate level therein and deflect the same inwardly toward the central region of said collector bin.

4. Apparatus as defined in claim 2 in which said outlet means extends substantially the full width of said collector bin and comprises at least one recessed portion formed along said forward lower edge, and in which said means for spreading said conveyed granular material to form a supported uniform layer comprises a forwardly movable curtain member joined along its upper edge to the forward face of said collector bin and depending in front of said recessed portion, the lower edge of said curtain being disposed at a level adapted to provide said predetermined maximum depth of granular material.

5. Apparatus as defined in claim 2 in which said moving support member is rigid and tray-like, and said means for laterally confining said layer comprises turned-up edge portions along the sides of said tray-like moving support member.

6. Apparatus as defined in claim 5 in which said stationary deflector comprises a wedge-shaped plow supported directly above and closely adjacent to said moving support member and adapted to deflect said granular material to the sides of said support member, and inclined members attached to the rear side portions of said plow and sloping upwardly from said support member in the direction of its movement, said inclined members being adapted to engage and raise said deflected granular material to the upper edges of said turned-up edge portions.

7. Apparatus as defined in claim 6 in which the sides of said plow curve upwardly and outwardly from their lowermost edges and have extended rear portions which overhang and project outwardly beyond the turned-up edge portions of said support member to the sides of the upwardly-extended portions of said collector bin.

8. Apparatus as defined in claim 2 in which said collector bin and its upwardly extending side portion form a circumferentially complete enclosure throughout the full path of downward travel of said granular material between said supported moving layers.

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