March 25, 1952 C. L. NORTON, JR 2,590,202

MATERIAL DISCHARGE MECHANISM

Original Filed July 4, 1944 3 Sheets-Sheet 1

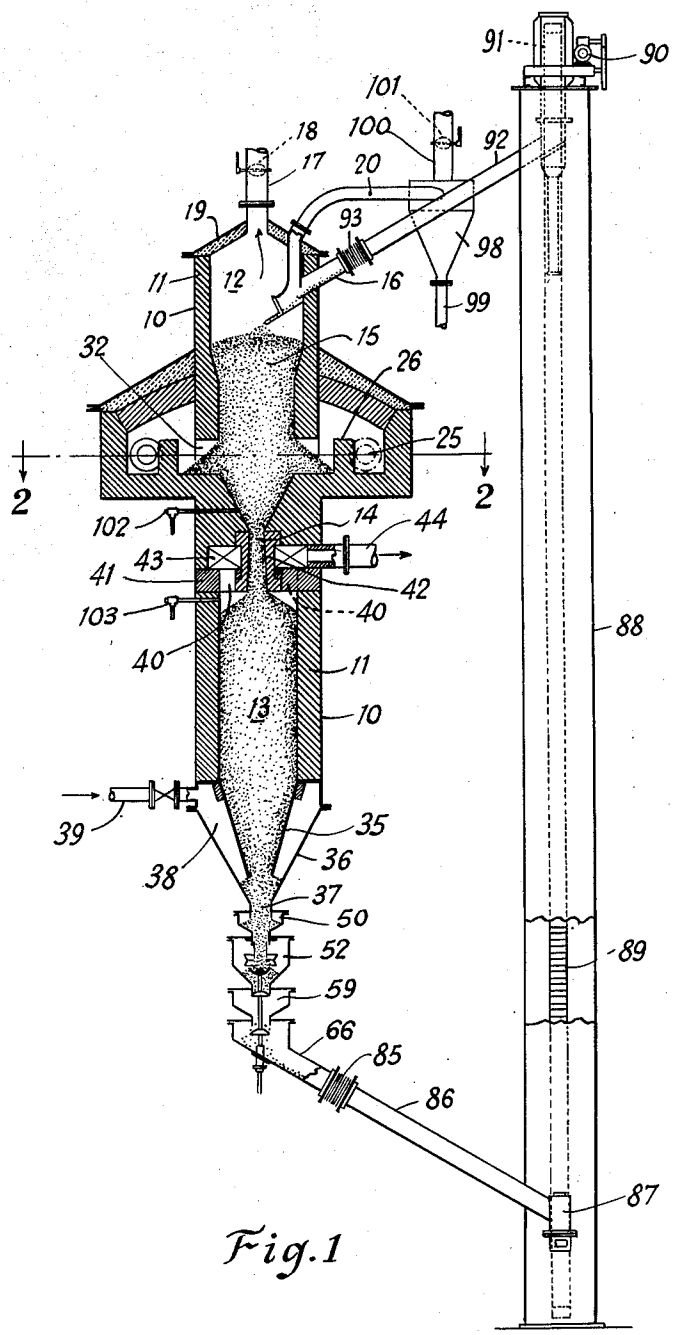


Fig. 1

INVENTOR
Charles L. Norton, Jr.
BY
ATTORNEY

March 25, 1952 C. L. NORTON, JR 2,590,202

MATERIAL DISCHARGE MECHANISM

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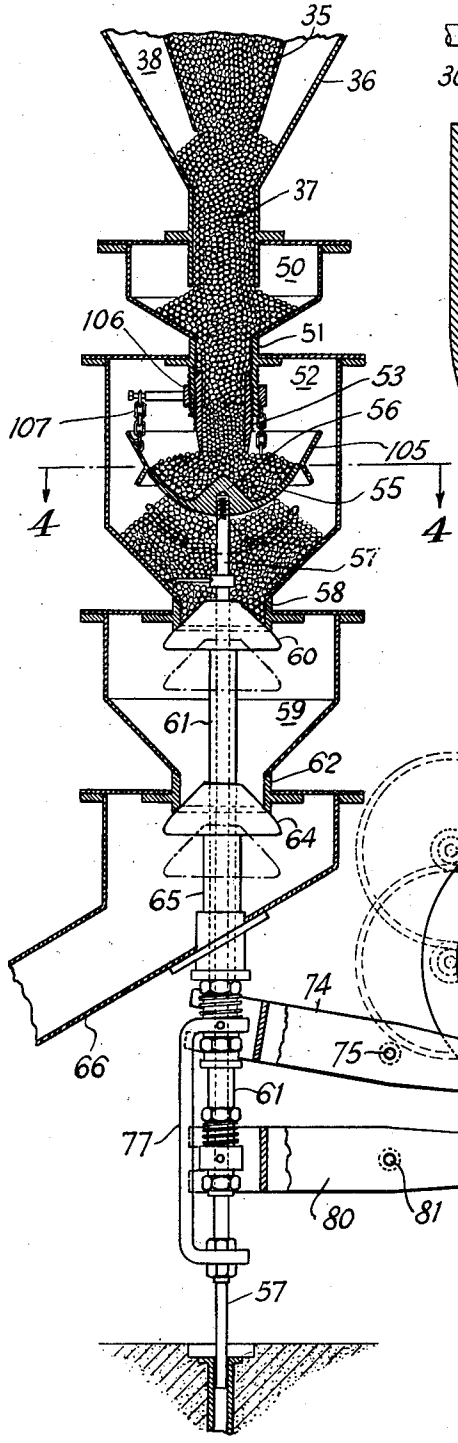
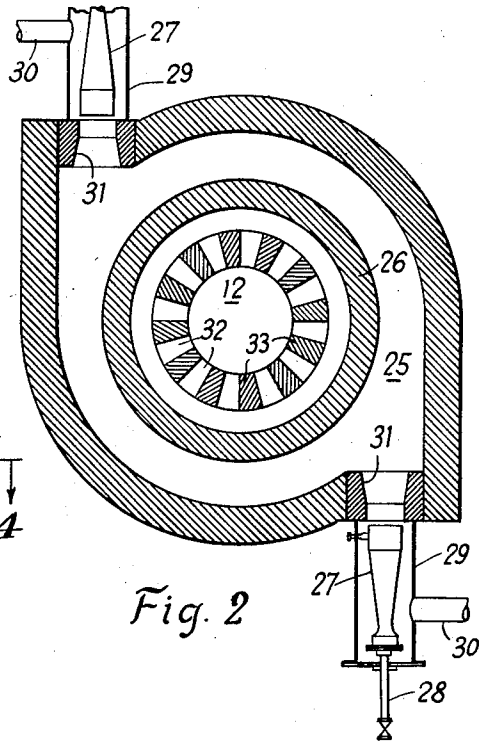


Fig. 2



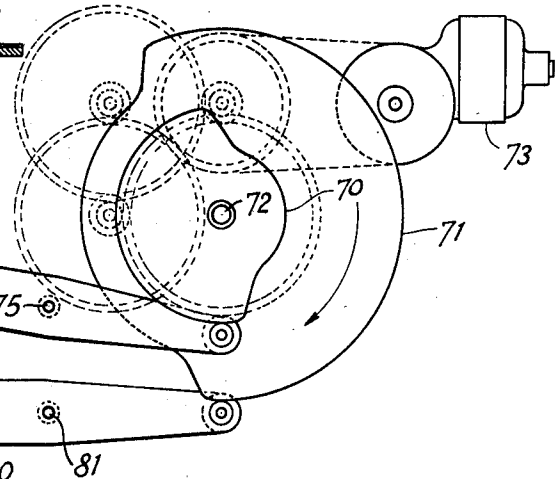


Fig. 3

INVENTOR.
Charles L. Norton, Jr.
BY
J. P. Moran
ATTORNEY

March 25, 1952 C. L. NORTON, JR 2,590,202

MATERIAL DISCHARGE MECHANISM

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Fig. 4

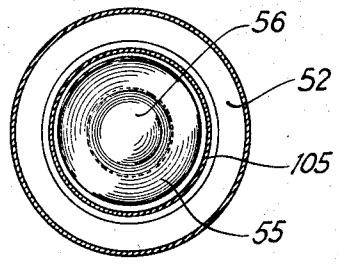
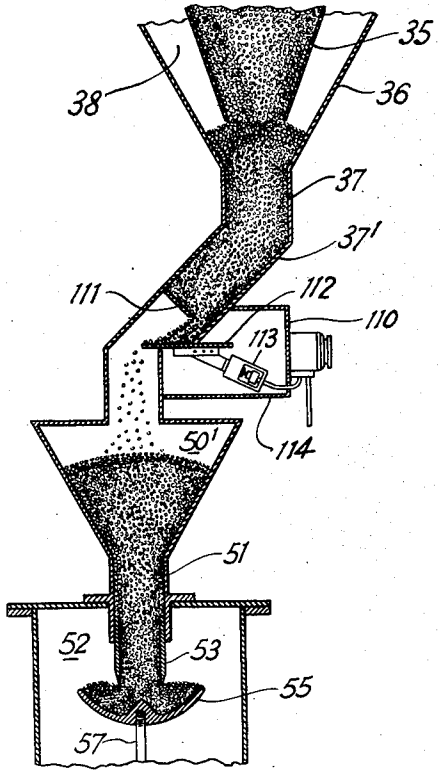


Fig. 5



INVENTOR
Charles L. Norton, Jr.
BY
ATTORNEY

Patented Mar. 25, 1952

2,590,202

UNITED STATES PATENT OFFICE

2,590,202

MATERIAL DISCHARGE MECHANISM

Charles L. Norton, Jr., New York, N. Y., assignor to The Babcock & Wilcox Company, Rockleigh, N. J., a corporation of New Jersey

Original application July 4, 1944, Serial No. 543,441. Divided and this application October 29, 1945, Serial No. 625,239

9 Claims. (Cl. 214—17)

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My present invention relates in general to the construction and operation of solid material discharge mechanisms, and more particularly, to mechanisms of this character designed for operation with a material receptacle under a positive pressure and adapted to maintain a gas seal at the discharge end of the receptacle.

The general object of my invention is the provision of an improved mechanism for controlling the discharge of a fluent mass of solid material from a chamber or receptacle under a positive pressure, while maintaining an effective gas seal at the discharge end of the chamber or receptacle. A further and more specific object is the provision of an improved mechanism for controlling the discharge of a fluent mass of solid material from a chamber under a positive pressure which insures a continuous discharge of the solid material while maintaining an effective gas seal at the discharge end of the chamber.

The various features of novelty which characterize my invention are pointed out with particularity in the claims annexed to and forming a part of this specification. For a better understanding of the invention, its operating advantages and specific objects attained by its use, reference should be had to the accompanying drawings and descriptive matter in which I have illustrated and described preferred embodiments of my invention.

Of the drawings:

Fig. 1 is an elevation, partly in section, of a fluid heater unit incorporating discharge mechanism constructed in accordance with my invention;

Fig. 2 is a horizontal section taken on the line 2—2 of Fig. 1;

Fig. 3 is an enlarged sectional elevation of the material discharge mechanism shown in Fig. 1;

Fig. 4 is a horizontal section taken on the line 4—4 of Fig. 3; and

Fig. 5 is a partly diagrammatic sectional elevation of a modified form of solid material discharge mechanism.

My invention is illustrated as used in a fluid heater of the character disclosed in my prior application Serial No. 543,441, filed July 4, 1944, now Patent No. 2,520,164, August 29, 1950, of which this application is a division. The fluid heater illustrated in Figs. 1 and 2 has a vertically elongated fluid tight metal casing 10 of circular cross-section lined with an annular wall of suitable high temperature refractory material 11. The fluid heater interior is divided into an upper chamber 12 and a lower chamber 13 connected

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by a vertically elongated uninterrupted throat passage 14 of substantially reduced cross-section. The chambers 12 and 13 and throat 14 are normally filled to the levels indicated with a continuous fluent mass or column of refractory heat transfer material 15 of a character hereinafter described.

A heat transfer material inlet pipe 16 is connected to the upper part of the chamber 12 and a heating gas outlet pipe 17, controlled by a valve 18, opens centrally into the conical top 19 of the chamber. The material inlet pipe 16 discharges into the lower portion of an auxiliary heating gas outlet pipe 20, which opens into the chamber 12. A substantially annular combustion chamber 25 is formed by an enlarged section of the casing 10 around the lower part of the chamber 12. As shown in Figs. 1 and 2, the inner side of the combustion chamber is formed by an annular bridge wall 26 extending upwardly for part of the height of the chamber and over which flow the heating gases generated by the combustion of any suitable fuel in the surrounding combustion space. As shown, premixed air and gas burner nozzles 27 are arranged at diametrically opposite points and substantially tangential to the combustion chamber 25. Each nozzle 27 is supplied by a valve controlled fuel pipe 28 and an air casing 29 to which a secondary air supply pipe 30 is connected. The ignited mixture of fuel and air discharges through a burner block 31 into the combustion chamber 25 under a positive pressure, with the heating gases generated flowing over the top of the bridge wall 26 and through a circular series of gas inlet ports 32 formed between firebrick 33 and opening into the lower part of the chamber 12. The chamber 12 is formed with an inverted conical bottom section extending from the lower end of the ports 32 to the top of the throat passage 14.

The lower chamber 13 is shown as of substantially uniform circular cross-section from its upper end to a point spaced from its lower end, the lower end portion of the chamber being downwardly tapered and defined by an inverted frusto conical metal screen 35. The lower part of the casing 10 surrounding the screen 35 is downwardly tapered in a cone 36, having a bottom discharge opening 37 which is spaced below the open lower end of the screen 35 to permit any heat transfer material passing through the screen to reach the outlet 37. The parts 35 and 36 cooperate to define an annular fluid inlet chamber 38 to which one or more valve controlled fluid supply pipes 39 are connected for the ad-

mission of a fluid to be heated under a positive pressure. The upper end of the lower chamber 13 is a flat firebrick arch in which a multiplicity of radial outlet slots 40 are formed in firebrick 41. An annular fluid outlet duct 43 surrounds the tile 42 and into which open the outlet slots 40. One or more fluid discharge pipes 44 are connected to the duct 43.

Fluid heating apparatus of this type are frequently referred to as "pebble" heaters, although a wide range of heat transfer materials other than pebbles can be used therein. Such materials may be ceramic refractories or corrosion resistant alloys and alloy steels, in small pieces of regular or irregular shape, such as sized grog, pebbles or crystals of mullite, silicon carbide, alumina, or other refractories. Substantially spherical pellets of uniform shape and size and formed of a mixture of calcined Georgia kaolin, raw Georgia kaolin and a binder, fired to 2850–3000° F. have been successfully used. The pellets are made of a diameter small enough to minimize thermal shocks and impact stresses, and to provide a large amount of heat transfer surface, and yet large enough to withstand the desired gas velocities through the pellet mass without lifting. Pellet diameters ½" and $\frac{5}{16}$" have been found suitable.

In accordance with my invention, the downward flow of heat transfer material through the upper chamber 12, throat 14, and lower chamber 13, is controlled by a pressure-tight feeder receiving material from the pellet outlet 37, while maintaining a fluid seal on the lower end of the chamber 13. The outlet pipe 37 opens into a small fluid tight expansion chamber 50 constructed to provide a space above the pellets at their normal angle of repose therein. The expansion chamber 50 has a bottom outlet pipe 51 provided with an adjustable sleeve extension 53 having a sharp-edged lower end determining the effective position of the outlet in a subjacent valve chamber 52. The feeder mechanism is constructed to provide a periodic discharge of a small amount of pellets from the lower end of the sleeve 53. The mechanism for this purpose comprises a valve member 55 in the chamber 52 having a concave upper surface, preferably in the form of a bowl or cup having an inner central conical portion 56. The cone 56 acts to deflect the pellets outwardly on the valve member and facilitates its movement upwardly and the discharge of pellets therefrom. The cup valve member 55 is vertically movable by means of a rod 57 between an upper position shown in full lines in Fig. 3 at which the normal angle of repose of the pellets on the upper surface of the valve member is greater than the angle formed between the outer periphery of the valve member and the lower end of the sleeve 53, so that the pellets do not tend to flow over the periphery of the valve member when the latter is in its upper position, and a lower position indicated in broken lines at which the angle between the periphery of the valve member and the bottom of the sleeve will be greater than the angle of repose of the pellets on the valve member, so that a gravity flow of the pellets over the periphery of the valve member can take place when the valve is moved to this position. The flow of pellets is thus dammed when the cup shaped valve member 55 is moved to its upper position without requiring any contact between the valve member and the lower end of the sleeve 53 which might tend to crush pellets therebetween.

The valve chamber 52 has a central valve controlled bottom outlet 58 opening into a third chamber 59. The passage of pellets from the chamber 52 through the outlet 58 into the chamber 59 is controlled by a vertically movable bell valve member 60 slidable relative to the rod 57 in the chamber 59 and mounted on a hollow rod 61 surrounding the rod 57. The valve 60 is timed to open after the cup valve member 55 reaches its upper position and stops the pellet flow from the lower end of the sleeve 53. The downward movement of the valve 60 permits the pellets accumulated in the bottom of the chamber 52 to drop into the chamber 59 which has a discharge opening 62 concentric with the opening 58 and closed by a bell valve member 64 similar to the valve member 60. The valve 64 surrounds and is movable relative to the operating rods 57 and 61 and is mounted on a third hollow rod 65 surrounding the rods 57 and 61. The opening of the valve member 64 permits the pellets to drop into an inclined discharge pipe 66. The valve 64 is normally closed when the valve 60 is open and vice versa to minimize fluid leakage from and thus preserve the fluid pressure conditions in the chamber 13. The described valve parts are coaxially arranged with the operating rods extending through a guide bearing in the discharge pipe 66.

The cup valve member 55 and bell valves 60 and 64 are intermittently operated to effect a fluid seal at all times on the lower end of the chamber 13. The operating mechanism for this purpose consists of a pair of cam members 70 and 71 rotated by a shaft 72 through suitable gearing and a belt drive from an electric motor 73. A lever 74 is pivotally mounted at 75 and arranged with one end in contact with the periphery of the cam member 70. The opposite end of the lever 74 has a forked pivot connection with the lower end of the hollow valve rod 65 and a bracket 77 connects the same also to the innermost valve rod 57. With this arrangement movement of the lever 74 will cause simultaneous raising and lowering movements of the cup valve 55 and bell valve 64. The bell valve member 60 is alternately raised and lowered by a second lever 80 pivotally mounted at 81 with one end in contact with the periphery of the cam member 71. The opposite end of the lever 80 has a forked pivot connection with the lower end of the hollow rod 61. The cam members 70 and 71 have their cam surfaces shaped and relatively arranged on the shaft 72 to effect a cyclic movement of the cup valve 55 and bell valves 60 and 64. With the arrangement of the parts shown in Fig. 3, the cup member 55 and bell valves 60 and 64 are in their upper positions, the cup member having just been raised to its upper position to dam the pellet flow from the chamber 50 and the valve 64 closed after having delivered pellets from the chamber 59 to the pipe 66. The pellets previously discharged while the valve 55 is in its lower position accumulate in the bottom of the chamber 52 and the valve 60 is about to open to allow this pellet accumulation to drop into the chamber 59, the bottom outlet of which is now closed by the valve 64. The pellets drop into the chamber 59 and the valve 60 is then moved to its top closing position, after which the cup member 55 and valve 64 are simultaneously moved to their lower positions. The opening movement of the valve 64 permits the pellets in the chamber 59 to drop into the discharge pipe 66, while the descent of the cup member permits a new batch of pellets to flow over its periphery and accumu-

late on the bottom of the chamber 52. The parts are proportioned and timed to minimize the possibility of any pellets becoming jammed between the valves 60 and 64 and their respective seats, while the cup member 55 is arranged so that it does not actually seat on any surface. Any upward movement of the column of pellets in the sleeve 53 during the rising movement of the cup member 55 is absorbed in the expansion chamber 50 by the movement of the pellets into the available space therein.

To insure that no pellets will be accidentally displaced and fall over the edge of the valve member 55 when the latter is in its upper or flow damming position, an annular shroud or shield 105 may be arranged to contact with the peripheral edge of the valve member in that position. The shroud is preferably of oppositely flaring vertical cross-section with its minimum diameter portion of the same diameter as the valve member peripheral edge, to avoid binding of the parts. The depending outlet 51 serves as a support for a vertically adjustable ring 106 connected by flexible supporting chains 107 to the shroud member 105. As the valve member moves upwardly it enters the lower flared section of the shroud, and contacts therewith in its upper position. If any pellets should be caught between these parts, the flexible support of the shroud permits it to be moved upwardly by the valve member.

The discharge pipe 66 is connected through an expansion joint 85 to a second inclined pipe 86 leading to a box 87 at the foot of an elevator casing 88. The box 87 opens into the elevator casing and is provided with openings through which pellets can be added or taken from the system. The elevator casing 88 is of welded gas tight construction, and encloses an elevator 89, indicated as being the slow speed continuous bucket type having overlapping buckets which are partly filled with pellets at the normal rate of pellet circulation. The elevator is driven by an electric motor 90 having a drive connection with the elevator headshaft. The buckets empty into a vertical discharge pipe 91 which has its lower end opening into an inclined pipe 92, connected through an expansion joint 93 to the inlet pipe 16. With this arrangement a substantially continuous circulation of the heat transfer material is maintained externally of the fluid heater between the bottom discharge opening 37 and the top inlet pipe 16, so that the mass or column of heat transfer material within the chambers 12 and 13 and throat 14 will descend at a predetermined rate.

To avoid contamination of the outgoing fluids by any dust and pellet fragments formed during the circulation of the pellets, the heat transfer material entering through the inlet pipe 16 is preferably subjected to a scavenging effect by a controllable portion of the heating gases leaving the chamber 12 through the auxiliary gas outlet conduit 20. The pipe 20 extends externally to a cyclone separator 98 having a bottom outlet 99 for separated solid material and a vent pipe 109 controlled by a valve 101 for discharge of the gases.

In the normal operation of the described apparatus the heating gases generated in the combustion chamber 25 enter the chamber 12 through the interstices of the pellets in the gas inlets 32 under a predetermined pressure, and are substantially uniformly distributed throughout the horizontal area of the adjacent portion of the mass of refractory heat transfer material. The heating gases flow upwardly through the mass in intimate contact with the descending heat transfer material which reaches its maximum temperature at the level of the heating gas inlets. The heat transfer material continues its descent through the throat passage 14 into the chamber 13. The fluid to be heated, such as air, steam, or other gas or vapor, enters as a predetermined temperature and pressure through the supply pipe 39 and inlet chamber 38 and flows through the annular screen 35 into the lower end of the heat transfer material in the chamber 13, passing upwardly through the interstices in the material in intimate counterflow contact with the descending pellets. The entering gas is at a relatively low temperature to insure a low discharge temperature for the pellets which will provide a high thermal efficiency, lessen thermal shock on the pellets, and permit safe handling of the pellets by the pressure-tight feeder and elevator. The fluid to be heated reaches its maximum temperature at the top of the chamber 13 flowing out through the slots 40, duct 43 and discharge pipe 44. Mixing of the fluid atmospheres in the chambers 12 and 13 can be avoided by maintaining predetermined relative pressures in the two chambers to provide a zero fluid flow through the throat 14. Pressure taps 102 and 103 are indicated for measuring the pressure differential across the throat, and variations in this condition from a predetermined standard are utilized to control the position of the valves 18 and 101 and thereby the gaseous pressure in the chamber 12 to control the relative pressures in the two chambers. The return of the pellets through the feeder and elevator to the inlet pipe 16 has been previously described.

While the feeder valve operating mechanism described is normally operated to complete a cycle in a relatively few seconds, and thus provide a substantially continuous discharge of pellets from the outlet 37 and downward movement of the pellet column in the chambers 12 and 13, the high rate of heat transfer in the chamber 13 in conjunction with the periodic dwell of the pellets in the chamber even with the rapid cycle of feeder operation described will result in a slight variation in the heated fluid outlet temperature. While such temperature variation may be negligible for most uses of the invention, in some cases a uniform final temperature of the heated fluid may be important.

A continuous discharge of pellets from the outlet 37 while maintaining the feeder under pressure is provided by the modified feeder mechanism shown in Fig. 5. In this construction the outlet pipe 37 has an inclined lower section 37' in which a vibrating feeder unit 110 is incorporated. The flow area of the inclined pipe section 37' is reduced by a plate 111 therein restricting the pellet flow to one side of the pipe section below which a horizontally extending vibrating plate 112 is located. The vibrating plate is supported and actuated by an electrically operated vibrator unit 113 in a fluid tight casing 114. The vibrating plate 112 extends into the pipe 37' for a distance sufficient to cause the pellet stream to assume an angle of repose thereon and stop the pellet flow when the plate 112 is stationary. In operation the pellets continuously discharge from the inner end of the plate 112 at a rate depending upon the vibrating frequency and drop into an expansion chamber 50' having a volumetric capacity sufficient to provide an expansion space above the

normal level of pellets therein. The pellets periodically discharge from the chamber 50' through the outlet pipe 51 and feeder mechanism previously described. With this feeder construction, the pellet column will continuously descend through the chambers 12 and 13 at a controllable rate.

I claim:

1. A material discharge mechanism for a receptacle containing a fluent mass of solid material which comprises a chamber having a solid material inlet and a lower solid material outlet, a valve member in said chamber, and means for moving said valve member in a timed cycle relative to said inlet between a solid material damming upper position spaced below said inlet and in which the angle of slope of a line between the periphery of said inlet and the periphery of said valve member is less than the normal angle of repose of said material on the upper surface of said valve member and a spaced lower material discharging position in which said angle of slope between said peripheries is greater than said normal angle of repose of the material.

2. A material discharge mechanism for a receptacle containing a fluent mass of solid material which comprises a chamber having a solid material inlet and a lower solid material outlet, a valve member in said chamber having a concave upper surface, an annular shield flexibly mounted between said solid material inlet and outlet, the minimum diameter of said shield being substantially the same as the peripheral edge of said valve member, and means for moving said valve member relative to said inlet between an upper position in normal contact with said shield and in which the angle of slope of a line between the periphery of said inlet and the periphery of said valve member is less than the normal angle of repose of said material on the upper surface of said valve member and a lower position in which said angle of slope between said peripheries is greater than said normal angle of repose of the material.

3. A material discharge mechanism for a receptacle containing a fluent mass of solid material under a positive pressure which comprises a valve chamber having a solid material inlet in its top and a solid material outlet in its bottom, a valve member in said valve chamber having a cup-shaped upper surface and a central conical projection in axial alignment with said inlet, means for moving said valve member relative to said inlet between an upper position spaced below said inlet and in which the angle of slope of a line between the periphery of said inlet and the periphery of said valve member is less than the normal angle of repose of said material on the upper surface of said valve member and a lower position in which said angle of slope between said peripheries is greater than said normal angle of repose of the material, and a closed expansion chamber between said receptacle and said valve chamber and arranged to receive material moved upwardly on the upward movement of said valve member.

4. A material discharge mechanism for a receptacle containing a fluent mass of solid material under a positive pressure which comprises an upper valve chamber having a solid material inlet and a lower solid material outlet and opening into a lower chamber having a solid material outlet in its bottom, a valve member in said upper chamber having a material receiving surface, means for moving said valve member relative to said inlet between an upper position spaced below said inlet and in which the angle of slope of a line between the periphery of said inlet and the periphery of said valve member is less than the normal angle of repose of said material on the material receiving surface of said valve member and a lower position in which said angle of slope between said peripheries is greater than said normal angle of repose of the solid material, whereby an intermittent flow of solid material from said inlet into said upper chamber can be effected, a closed expansion chamber between said receptacle and said upper valve chamber and arranged to receive material moved upwardly on the upward movement of said valve member, a second valve member arranged to control the material outlet from said upper chamber, a third valve member arranged to control the outlet from said lower chamber, and valve operating mechanism arranged to operate said valve members.

5. A material discharge mechanism for a receptacle containing a fluent mass of solid material under a positive pressure which comprises an upper valve chamber having a solid material inlet in its top and a solid material outlet in its bottom and opening into a lower chamber having a solid material outlet in its bottom, a valve member in said upper chamber having a concave upper surface and in axial alignment with said inlet, means for moving said valve member relative to said inlet between an upper position spaced below said inlet and in which the angle of slope of a line between the periphery of said inlet and the periphery of said valve member is less than the normal angle of repose of said material on the upper surface of said valve member and a lower position in which said angle of slope between said peripheries is greater than said normal angle of repose of the solid material, whereby a periodic flow of solid material from said inlet into said upper chamber is effected, a closed expansion chamber between said receptacle and said upper valve chamber and arranged to receive material moved upwardly on the upward movement of said valve member, a second valve member arranged to control the solid material outlet from said upper chamber, a third valve member arranged to control the solid material outlet from said lower chamber, and valve operating mechanism having timing mechanism arranged to simultaneously raise and lower said first named valve member and said third valve member and to alternately raise and lower said second valve member.

6. A material discharge mechanism for a receptacle containing a fluent mass of solid material comprising means forming a solid material outlet from said receptacle, a movable valve member having a concave upper surface spaced below said outlet in the path of said material discharging therefrom and in a position symmetrically spaced from said outlet in which the angle of slope of a line between the periphery of said outlet and the periphery of said valve member is less than the normal angle of repose of said material on the upper surface of said valve member, whereby the flow of solid material from said outlet is dammed, and means for bodily moving said valve member to a spaced second position in which said angle of slope between the periphery of said outlet and the periphery of said valve member is greater than the normal angle of repose of said material on the upper surface of said valve member, said angle being regulated to control the discharge rate of fluent solid material from said receptacle.

7. A material discharge mechanism for a receptacle containing a fluent mass of solid material comprising means forming a solid material outlet from said receptacle, a movable valve member coaxially arranged with respect to and having a peripheral configuration similar to said outlet, the upper surface of said valve being spaced below said outlet in the path of said material discharging therefrom and in a position in which the angle between the periphery of said outlet and the periphery of said valve member is less than the normal angle of repose of said material on the upper surface of said valve member, whereby the flow of solid material from said outlet is dammed, a shroud ring flexibly supported in radially spaced encircling relationship to said solid material outlet and contacting the periphery of said valve member when the member is in a material flow damming position, and means for moving said valve member out of peripheral contact with said shroud ring to cause the discharge of solid material over the periphery thereof.

8. A material discharge mechanism according to claim 1 wherein a vibrating member is positioned adjacent the solid material inlet to said valve chamber to cause a continuous discharge of solid material from said receptacle.

9. A material discharge mechanism according to claim 8 wherein said vibrating member is electrically operated to cause a continuous discharge of solid material therefrom when vibrated and is positioned to dam the flow of solid material when stationary.

CHARLES L. NORTON, JR.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
791,352	Marcus	May 30, 1905
802,176	Sheldon	Oct. 17, 1905
1,080,602	Stokes	Dec. 9, 1913
1,382,371	McClimon et al.	June 21, 1921
1,433,109	Brown	Oct. 24, 1922
1,652,250	Morrow	Dec. 13, 1927
1,863,871	Packwood	June 21, 1932
2,227,706	Conner	Jan. 7, 1941

FOREIGN PATENTS

Number	Country	Date
466,192	Germany	Oct. 3, 1928
560,041	Germany	Sept. 28, 1932