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MULTIPLE CONDUIT SYSTEM FOR ELEVATING CONTACT MATERIAL

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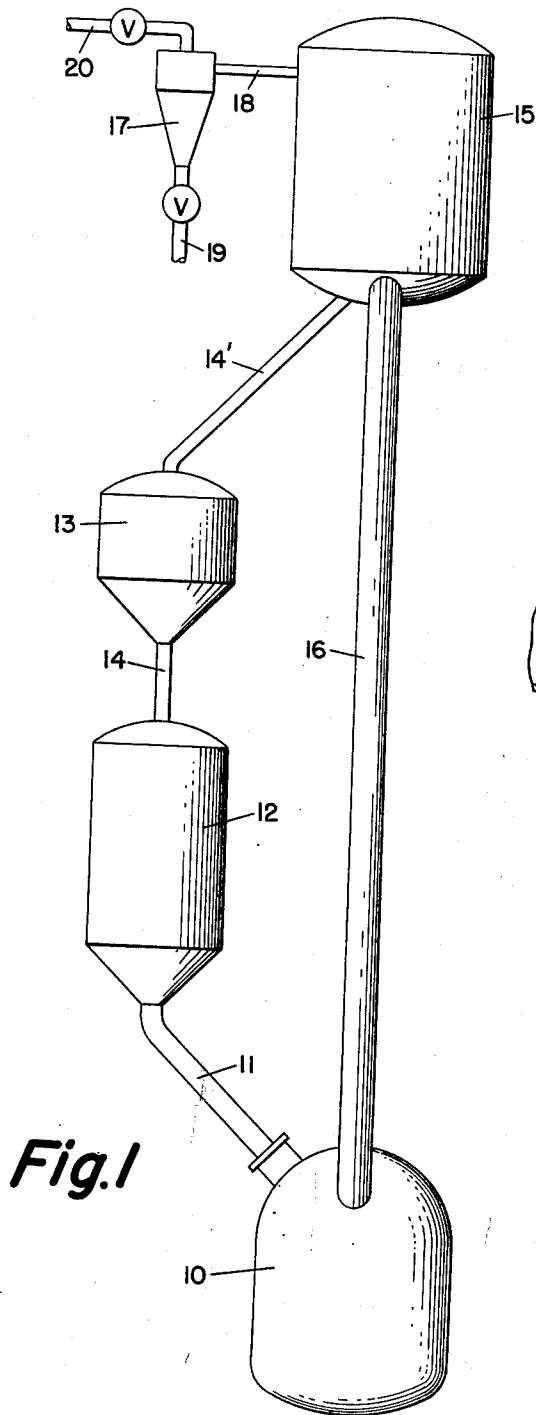


Fig. 1

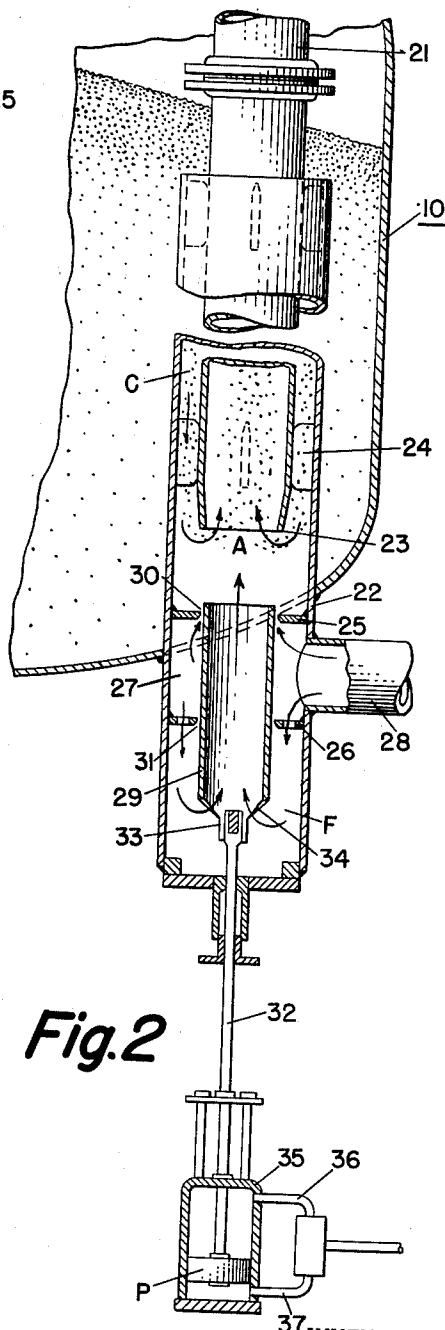


Fig. 2

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MULTIPLE CONDUIT SYSTEM FOR ELEVATING CONTACT MATERIAL

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This invention relates to a system and apparatus for moving pneumatically granular or pelleted contact material or catalyst from a lower receptacle, which receives the material in a continuous stream, upwardly into an upper receptacle. In particular the invention is directed to the method of and apparatus for regulating the ratio of gas, air or other fluid lifting medium to the contact material so that it can be conveyed from the lower receptacle to and through one or a plurality of conveying conduits to an upper chamber in a manner to reduce attrition of the material particles or pellets to a minimum.

It is well known in the art of catalytic operations, such as the cracking of heavier petroleum fractions to gasoline and other hydrocarbon processing operations, to use a catalytic or contact material in a continuous system. In such continuous systems a conversion zone is operated continuously to produce the desired product while a second zone operates continuously in regeneration. Most commercial moving catalyst systems have the conversion zone and regeneration zone in superposed relationship with the conversion zone usually above the regeneration zone so that the catalyst or contact material moves through the conversion zone to the regeneration zone by gravity and after regeneration it is carried upwardly and returned to the conversion zone to repeat the cycle of operation. To return the catalyst or contact material from the lower regenerating zone to the upper conversion zone two well known means applicable to the transportation of granular solids from one locus to another have been used, namely: by mechanical conveyors and by pneumatic conveyors, in the latter of which air, steam or flue gas produced at the refinery is readily available as the pneumatic lifting medium.

It is necessary in systems employing conversion and regeneration zones in superposed relationship to convey the catalyst or contact material continuously upwardly to a height of several hundred feet, in order that it can be delivered continuously by gravity to these zones and maintain the desired volumes of the material therein to effect optimum operation. Conveying the material upwardly by a fluid medium requires a receptacle positioned at a level below that of the lower reaction zone which is designed to effect the lifting or upward conveying operation. This lowermost receptacle is generally known in the art as an engager since the material is engaged therein by the lifting fluid to effect the lifting operation. A lift conduit has its lower end ex-

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tending into or is in communication with the engager receptacle while its upper end communicates with an upper receptacle positioned at a level above the top of the upper reaction zone or chamber. The upper receptacle is designed so that the lifting medium is separated from the catalyst or contact material and is generally known as the disengager.

The maintenance of a constant and predetermined rate of flow of lifting fluid and catalyst through the lift is a desideratum which is essential to satisfactory operation but is difficult of achievement. The ideal condition is to so regulate the velocity of the lifting fluid that the catalyst will be lifted with just sufficient force to effect its emergence from the top of the lift, so that it will drop gently down into the disengaging chamber. To the extent that a constant and predetermined rate of flow of lifting fluid and catalyst, with a force regulated as specified, is approached, attrition is greatly reduced.

But this ideal condition, it is believed, has not been reached in practical operation before my invention. Thus, there is a tendency for the lifting fluid to channel a rapid path along the axial region of the lift with relatively slow flow of catalyst along the lift wall and even some fall of catalyst from this peripheral region laterally and downward against the catalyst being projected along the axial region. This operation not only produces a departure from the ideal constant rate of flow of the catalyst from the engager to the disengager, but it gives rise to excessive frictional contact between the particles of the catalyst with resultant excessive attrition. Also, in such operation, the difference in pressure between that at the top of the lift and that at the bottom (which must remain constant if a constant velocity of flow of lifting fluid and catalyst is to be maintained), is necessarily reduced, thus increasing the velocity of flow of lifting fluid.

On the other hand conditions may arise causing more or less clogging of the lift with such resistance to upflow of the catalyst that the force of the lifting fluid is not adequate to carry the catalyst to the top of the lift. In this operation it is obvious that a back pressure will be created against the inflowing lifting fluid with resultant decrease in the velocity of flow of the lifting fluid. Either departure from the desired normal tends to aggravate the condition, causing such a departure with resultant further departure from the desired normal of rate of flow of the lifting fluid and quantity of catalyst supplied to the lift conduit.

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I have found that the conditions causing these irregularities, and especially the tendency of the lifting fluid to channel a separate path along the lift's axis, is greatly reduced by substitution, for the usual single lift conduit of wide diameter, a multiplicity of lift conduits of comparatively small diameter, all leading from the engager to one common disengager. This substitution is especially effective if the catalyst is fed to the lower ends of the respective lifts by channels separated each from the other. Such an arrangement, while it ameliorates certain of the factors that in actual operation effect a departure from the desired normal rate of flow of lifting fluid and catalyst, do not alone solve the problem. Indeed there still remains the liability of the catalyst to more or less clog the lift with resultant diminution of rate of flow of the lifting fluid and catalyst as above explained.

In the event of a departure from the desired constancy of flow of lifting fluid and catalyst, restoration of that constant flow is effected in the process embodying my invention, as hereafter described. Let it be assumed that conditions arise tending to obstruct the flow of catalyst through the lift and thus creating a back pressure operation to reduce the flow of lifting fluid. When this condition arises means are provided to automatically allow a more free flow of lifting fluid, causing it to overcome this back pressure and restore to normal. At the same time the volume of catalyst at or below the lower or admission end of the lift, that is, the thickness of the zone of catalyst against which the lifting fluid is projected, decreases; this operation continuing until the volume of catalyst in the lift is reduced to normal depth and consequent restoration of constancy of flow of lifting fluid and catalyst through the lift.

On the other hand, if the flow of lifting fluid through the lift becomes too free and rapid, thus reducing the normal difference in pressure between the upper and lower ends of the catalyst, means are provided to automatically throttle the inflow of lifting fluid; and at the same time the volume of catalyst acted upon by the lifting fluid increases, this operation continuing until the volume of catalyst in the lift is increased to normal with constant restoration of constancy of flow of lifting fluid and catalyst through the lift conduit.

It should be understood that while I have described the operation of the process on the assumption of the existence of a departure from normal rate or velocity of lifting fluid and catalyst through the lift, in the practiced operation of the process such an abnormal condition cannot to any pronounced degree usually arise, since the process functions as described upon such slight departures from the desired normal that the desideratum of maintenance of the desired constancy of flow of lifting fluid and catalyst is substantially attained.

It should also be understood that while the substitution of a plurality of small diameter lift conduits for a single lift conduit of large diameter is of substantial importance, the described features of governing the volume or rate of feed of the lifting fluid and of governing the thickness of the zone of catalyst that is in the path of the lifting fluid, are operative whether a single lift or a plurality or multiplicity of lift conduits are provided. In the latter application the devices essential to the described operation should be applied to each individual lift conduit.

While the practice of the process is not limited to the employment of particular control or regulating devices a construction and arrangement adapted to automatically perform the aforesaid process is hereinafter described, such construction and arrangement being illustrated in the accompanying drawings in which:

Figure 1 is a diagrammatic view of a system utilizing a continuously moving body of contact material.

Figure 2 is a view generally in vertical section showing the details of a lift conduit.

Figure 3 is an elevational view showing the system for controlling the supply of lifting medium and also the system for adjusting the supply of contact material to the lift conduit.

Figure 4 is a sectional view taken on the line 4-4 of Figure 3.

Referring to Figure 1, 10 indicates the engager which receives catalyst or contact material through line 11 from a reaction zone such as a regenerator 12 positioned below an upper reaction zone 13 which is in communication with zone 12 through line 14 and which receives contact material continuously through line 14' from a disengaging zone 15. Means for conveying the contact material from the engager 10 to the disengager 15 is shown generally at 16. Separating means such as a cyclone separator 17 is in communication with the disengager 15 through line 18 and fines are removed by the separator through line 19 while the lifting medium is removed from the separator 17 through line 20. Figure 1 does not show any details of the present invention and is provided only to show the general arrangement of a continuous system wherein catalyst or contact material is utilized in a continuously moving mass.

Referring to Figure 2 which shows details of the lift conduit arrangement of the present invention associated with the engager 10 and although only one such conduit arrangement is shown it will be understood that a plurality are contemplated in the specific adaptation of the invention. The lift conduit is indicated generally at 21 while 22 indicates an outer conduit or sleeve secured about the lower portion of the lift conduit and enclosing the inlet end 23 of the lift conduit. The sleeve 22 will be maintained fixed relative to the engager 10 and may be secured thereto as by welding. The upper open end of the sleeve 22 is provided with lugs 24 in order to maintain the sleeve rigid with respect to the lift conduit 21 and the lower portion of the sleeve 22 extends through the lower end of the engager 10. A partition plate 25 is secured within the sleeve 22 at a point a short distance below the inlet end 23 of the lift conduit and provides an upper chamber C for contact material and a lower chamber F for lifting fluid medium. It will be understood that as the contact material is returned to the engager 10 that the engager will be maintained substantially full of contact material and also that the space C between the lift conduit 21 and sleeve 22 will also be maintained constantly filled. Below the plate 25 is provided a guide ring 26 providing a space 27 with the plate 25 and a lifting fluid supply conduit 28 is in communication with the space 27 for the supply of lifting medium thereto. The guide ring 26 is apertured so that the lifting medium from the conduit 28 is directed downwardly through the apertures and then upwardly through the nozzle 29 to the inlet 23 of the lift conduit.

75 lift conduit.

The nozzle 29 is positioned in apertures 30 and 31 in plate 25 and guide ring 26 respectively. The nozzle 29 is of such a diameter as to be slidable in the apertures and a small amount of air (assuming the use of air as lifting fluid) from the supply conduit 28 may pass downwardly through the aperture 31 to the lower end of the nozzle 29 and also a small amount of air may pass through the aperture 30 to prevent any fines existing in the contact material from entering the fluid section F. Provision is made for the nozzle 29 to be adjustable toward and from the inlet 23 of the lift conduit in order to adjust the distance therebetween and vary the contact material zone A between the inlet end 23 and the upper end of nozzle 29. To this end a shaft 32 is provided having its upper end 33 secured to the lower end 34 of the nozzle and the lower portion of the shaft 32 is positioned exteriorly of the fluid section F and terminates in a piston P which is movable in cylinder 35 and the movement of the nozzle 29 is in accordance with the position of the piston P in the cylinder 35 which is regulated by the supply of a control fluid to the cylinder through lines 36 and 37 as will be described more fully in connection with Figure 3.

The volume and velocity of the lifting fluid discharged through nozzle 29, the differential pressure between the engager and the disengager, and the amount of catalyst that is propelled through the lift conduit in a given time, should be accurately controlled in order that there should be an accurate correspondence between the rate of flow of the catalyst into the engager and the rate of conveyance of the catalyst from the engager to the disengager. Under some conditions of operation it is possible to so control the rate of flow into the engager and also the differential pressure between the engager and disengager that they may be maintained in substantially exact correspondence with each other. However, under some conditions of operation neither the rate of flow of the catalyst into the engager nor the differential pressure between the engager and disengager may be constant, and it is then clear that, with a fixed distance between the discharge end of the nozzle 29 and the inlet end of the lift conduit (that is, the height of zone A), which determines the amount of catalyst that in any given time is acted upon by the propellant gas, and with a fixed pressure in the gas-supply conduit 28, this correspondence between the rate of flow of catalyst to the engager and its rate of conveyance to the disengager cannot be effected. In my present invention this problem is solved by so automatically controlling the distance between the discharge end of the nozzle 29 and the inlet end of the lift conduit, and also by so controlling the supply of the incoming lifting gas, that the rate of flow of the catalyst to the engager and its discharge therefrom to the disengager will always be in balance, while at the same time the level of catalyst in the engager 10 will remain constant. This figure in addition shows a system for controlling the supply of lifting fluid to the inlet of the lift conduit and also an arrangement for controlling the actuation of the piston P which in turn controls the distance between the inlet end 23 of the lift conduit and the upper end of nozzle 29 and hence the volume of contact material in zone A. In order to adjust the position of the nozzle 29 pressure from the lift conduit 21 is transmitted by line 40 to a remote control

pressure transmitter 41 which is located in the plant in close proximity to the lift conduit, and air from the plant, which is termed instrument air and used for the control of various instruments, is also supplied to the pressure transmitter 41 by line 42 and the instrument air from the pressure transmitter 41 is directed by line 43 to a pressure controller 44 which is located at a remote point from the plant, for example, in the control room. From the pressure controller 44 air pressure is transmitted to a piston controller 45 by line 46. The piston controller 45 regulates the air supplied to piston cylinder 35 through the lines 36 and 37 to vary the position of the piston P and thus adjust the position of nozzle 29 with respect to inlet 23 of the lift conduit. In order to control the supply of the lifting medium to the contact material zone A an orifice plate O is positioned in the supply conduit 28 between flanges 51-52 and flow lines 53-54 leave from above and below respectively of the orifice plate to a manometer M which is enclosed in a flow transmitting cylinder 55 located in the plant. Instrument air is supplied to the flow transmitting cylinder 55 through lines 56 and 57 and in accordance with the differential pressure across the orifice plates air will be transmitted therefrom by line 58 to a flow recording cylinder 59 positioned in the control room and from which air will be directed back to the plant by line 60 for operation of a diaphragm valve 61 to control the supply of air through the conduit 28 to the contact material zone A.

The remote control pressure transmitter 41, the pressure controller 44, the piston controller 45, the flow transmitting cylinder 55 and the flow recording cylinder 59 are instruments well known in the art and readily available on the market and hence no detailed description of these elements is considered necessary for an understanding of the invention.

Figure 4 shows one pattern for arranging a plurality of lift conduits 21 and outer catalyst and air supply sleeves 22 within the engager 10.

It will be understood that the volume of contact material in compartment C of the sleeve 22 is sufficient to provide a continuous supply of material to the zone A below the inlet end 23 of the lift conduit and is also sufficient to prevent migration of the lifting medium from one air lift conduit to another when a plurality are utilized. The rate of supply of lifting medium from one conduit 28 will determine the velocity of the contact material upwardly through the lift conduit and the rate of supply of lifting fluid and the rate of supply of contact material to zone A will determine the differential pressure between the upper and lower portions of the lift conduit and provide a control system wherein attrition of the contact material is reduced to a minimum.

It is customary in elevating contact material from an engager to a disengager to make provision for exerting pressure on the bed of contact material in order to deliver it to the inlet of the elevating conduit. Although no arrangement is shown in the drawings for supplying a pressure medium such as gas, steam or air to the engager 10, it will be understood that various arrangements can be utilized for effecting this result. For example, a pressure medium could be supplied to the top of the body of contact material in the chamber 10 to exert pressure downwardly or as is usually the case when the contact ma-

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 terial is admitted at a point adjacent the top of the engager, the material acquires an angle of repose and it is advantageous to admit the pressure medium at a common level within the body of contact material in order to exert equal downward pressure.

I claim:

1. Method of elevating contact material through a plurality of confined passageways each having an inlet end in communication with a lower vessel and an outlet end in communication with an upper vessel which comprises the steps of maintaining a body of the material within the lower vessel, supplying contact material to independent contact material zones adjacent the inlet end of each passageway, simultaneously supplying a stream of lifting fluid to the bottom of each of said zones to direct the material from the zones upwardly into and through the passageways to the upper vessel and controlling the rate of supplying the contact material to said zones in accordance with the pressure conditions existing at selected loci in the passageways.

2. In the conveyance of solid particles from a lower vessel to an upper vessel through a conduit in which particles of solid material are continuously supplied to the lower vessel and in which a zone of such material is maintained adjacent the lower inlet end of the conduit and in which a stream of conveying fluid is directed to the lower end of said zone of material, the process of maintaining a substantially constant rate and velocity of flow of material into said conduit by varying the depth of material within said zone in accordance with any variation of pressure within said conduit.

3. In the conveyance of solid particles from a lower vessel to an upper vessel through a conduit, in which particles of solid material are continuously supplied to the lower vessel and in which a restricted zone of such material is maintained adjacent the lower inlet end of the conduit and in which a stream of lifting fluid under pressure is directed upward against said zone of material, the process of maintaining a substantially predetermined rate and velocity of flow of material through said conduit which comprises, upon occurrence of any variation of such rate and velocity of flow and consequent rise or fall of fluid pressure in said conduit, controlling by such pressure the volume of material against which said stream of lifting fluid is directed to thereby change the rate of flow of material into said conduit and thus re-establish the predetermined rate and velocity of flow of material through said conduit.

4. Method of elevating contact material through a confined passageway having an inlet end in communication with a lower vessel and an outlet end in communication with an upper vessel, which comprises the steps of maintaining a zone of contact material adjacent the inlet end of said passageway, supplying a stream of lifting fluid to the bottom of said zone at a predetermined rate of flow to direct the material from the zone upwardly into and through the passageway to the upper vessel, and varying the depth of the zone of contact material by varying the distance between the inlet end of said passageway and the point of discharge of said stream of lifting fluid into said zone in accordance with the pressure existing at a selected locus in said passageway.

5. In the conveyance of solid particles from one vessel to another through a conduit, in which

particles of solid material are continuously supplied to the first vessel and in which a restricted zone of such material is maintained adjacent the inlet end of the conduit and in which a stream of conveying fluid under pressure is directed through a supply conduit and thence through a nozzle against said material and toward the inlet end of the conduit, the process of regulating the rate of conveyance of the material from said zone to the conveying conduit by moving said nozzle toward and from the inlet to said conveying conduit and varying the position of said nozzle in accordance with the pressure existing at a selected locus in said conveying conduit.

6. Method of elevating contact material through a confined passageway having an inlet end in communication with a lower vessel and an outlet end in communication with an upper vessel, which comprises the steps of maintaining a zone of contact material adjacent the inlet end of said passageway, supplying through a fluid supply conduit a stream of lifting fluid to the bottom of said zone to direct the material from the same upwardly into said passageway, maintaining a predetermined rate of supply of lifting fluid to said zone by measuring the pressure differential ahead of and beyond a locus in said supply conduit and throttling ahead of said locus the flow of fluid through said conduit in accordance with said pressure differential.

7. Method of elevating contact material through a confined passageway having an inlet end communicating with a lower vessel and an outlet end communicating with an upper vessel, which comprises maintaining a zone of contact material in said lower vessel adjacent the inlet end of said passageway, flowing through a supply conduit a stream of conveying fluid and directing it upward into said zone of contact material to force the material in said zone up into and through said passageway, increasing or decreasing the freedom of flow of the conveying fluid through said conduit to said zone in accordance with the rise or fall of the differences in pressure between the upper and lower ends of said passageway, and simultaneously varying the volume of catalyst against which the conveying fluid is projected to force the catalyst into such passageway, thereby maintaining a substantially constant rate of flow of conveying fluid and catalyst through said passageway.

8. Method of elevating contact material through a confined passageway having an inlet end communicating with a lower vessel and an outlet end communicating with an upper vessel, which comprises maintaining a zone of contact material in said lower vessel adjacent the inlet end of said passageway, flowing through a supply conduit a stream of conveying fluid and directing it upward into said zone of contact material to force the material in said zone up into and through said passageway, so varying the supply of conveying fluid as to maintain a substantially constant pressure of conveying fluid so directed upward into said zone notwithstanding any variation in pressure in, and rate of flow of contact material through, said passageway, and varying the rate at which contact material is forced from said zone into said passageway in accordance with variation in pressure existing at a selected locus in said passageway.

9. Apparatus for elevating contact material from a lower chamber containing a body of the material to an upper chamber which comprises an elevating conduit having its lower inlet end

extending through the top of said lower chamber to be positioned therewithin and its upper outlet end extending into the upper chamber, a sleeve positioned about the lower portion of said elevating conduit, said sleeve having its upper end open and disposed within the body of material with its lower end disposed below the lower end of the elevating conduit providing with the inlet end of said conduit a space for contact material, a lifting fluid nozzle communicating through the lower end of the sleeve with said space for conveyance of contact material upwardly from the space, said lifting fluid nozzle being movable toward and from the inlet end of the elevating conduit to increase or decrease the vertical thickness of said space, and means for supplying lifting fluid for passage upwardly through said nozzle to force contact material from said space into and through the elevating conduit to the upper chamber.

10. Apparatus as in claim 9 further characterized by the provision of a plurality of the elevating conduits spaced in a pattern within said lower chamber.

11. Apparatus as in claim 9 further characterized by driving means for said nozzle and control means between the elevating conduit and said driving means for regulating the position of the outlet end of said nozzle with respect to the inlet end of the elevating conduit in accordance with pressure conditions existing in the upper portion of the elevating conduit.

12. Apparatus as in claim 9 further characterized by driving means for said nozzle and control means between the elevating conduit and said driving means for regulating the position of the outlet end of said nozzle with respect to the inlet end of the elevating conduit in accordance with pressure conditions existing in the upper portion of the elevating conduit and other control means connected with the lifting fluid supply means for varying the supply of lifting fluid to said contact material zone in accordance with the position of the outlet end of said nozzle relative to the inlet end of the elevating conduit.

13. Apparatus for elevating contact material from a lower chamber containing a body of the material to an upper chamber which comprises a multiplicity of elevating conduits each having its lower inlet end extending through the top of said lower chamber to be positioned therewithin and its upper outlet end extending into the upper chamber, a sleeve positioned about the lower portion of each of said conduits, each sleeve having its upper end open and disposed within the body of material with its lower end

disposed below the lower end of the corresponding elevating conduit providing with the inlet end of the conduits a space for contact material, a lifting fluid nozzle communicating through the lower end of each sleeve with each space for conveyance of contact material upwardly from each space, each of said lifting fluid nozzles being movable toward and from the inlet end of each elevating conduit in accordance with pressure conditions existing in each conduit to increase or decrease the vertical thickness of each of said spaces, and means for supplying lifting fluid for passage upwardly through each nozzle to force contact material from each space into and through the elevating conduits to the upper chamber.

14. Apparatus for elevating contact material from a lower chamber containing a body of the material to an upper chamber which comprises a multiplicity of elevating conduits each having its lower inlet end extending through the top of said lower chamber to be positioned therewithin and its upper outlet end extending into the upper chamber, a sleeve positioned about the lower portion of each conduit, each sleeve having its upper end open and disposed within the body of material with its lower end disposed below the lower end of the corresponding elevating conduit, a partition across each sleeve dividing it into an upper contact material space and a lower lifting fluid space, a lifting fluid nozzle mounted in an aperture in each partition and being adapted for receiving lifting fluid from said lower fluid spaces for conveyance of contact material upwardly from the upper contact material spaces, said lifting fluid nozzles being movable toward and from the inlet ends of the elevating conduits to increase or decrease the vertical thickness of said contact material spaces, and means for supplying lifting fluid to the lower spaces for passage upwardly through said nozzles to force contact material from said upper spaces and through the elevating conduits to the upper chamber.

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