

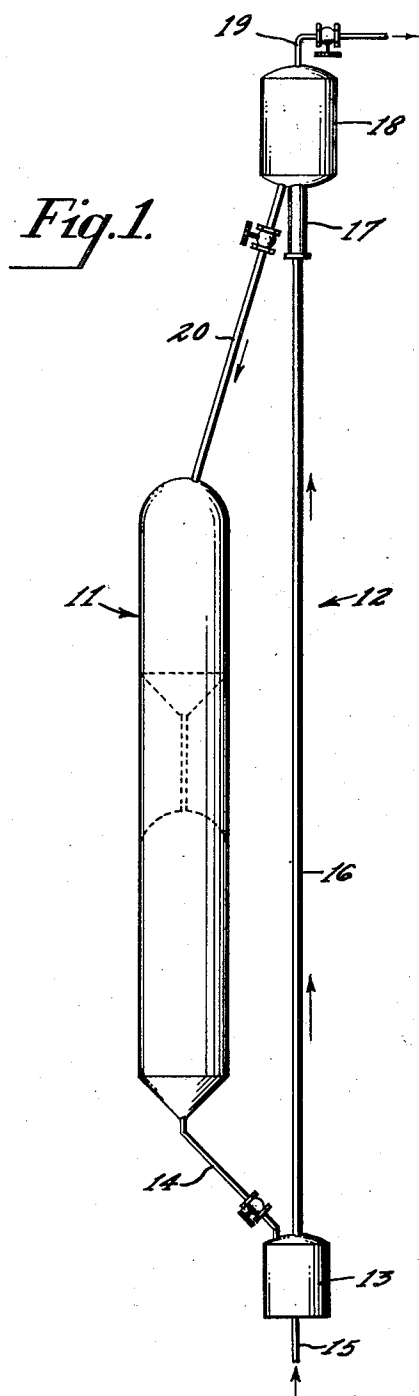
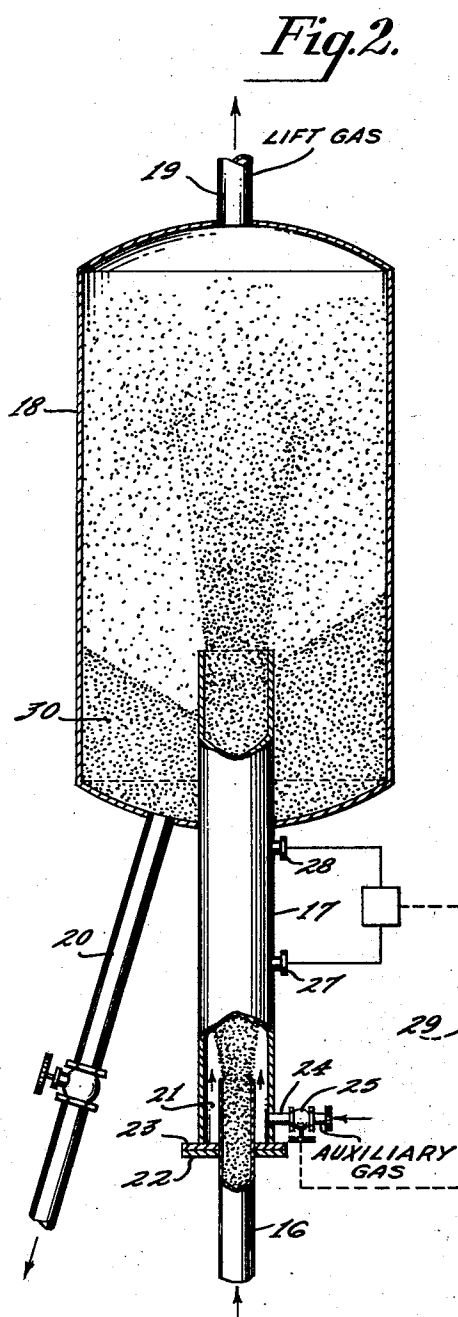
Dec. 21, 1954

J. NEWMAN

2,697,640

DISCHARGE VELOCITY CONTROL FOR PNEUMATIC LIFTS

Filed May 1, 1952



INVENTOR
Julian Newman
BY
William K. Kline
ATTORNEY

1

2,697,640

DISCHARGE VELOCITY CONTROL FOR
PNEUMATIC LIFTS

Julian Newman, Lansdowne, Pa., assignor to Houdry
Process Corporation, Wilmington, Del., a corporation
of Delaware

Application May 1, 1952, Serial No. 285,453

7 Claims. (Cl. 302—59)

This invention relates to the pneumatic elevation of granular contact material through an elongated lift pipe, particularly as applied to hydrocarbon conversions or other processes which involve a continuous circulation of granular contact material, such as beads or pellets of catalytic material, having an average particle size of about 14 mesh, or larger.

Specifically, the invention relates to a method for reducing the discharge velocity of such contact material as it discharges from the upper end of the lift pipe into the usual disengaging vessel, in order that the contact material may be disengaged from the lift gas by complete gravitational deceleration within a minimum vertical distance and permitted to fall freely to one or more collecting points.

In such systems, the upper end portion of the lift pipe usually extends upwardly into a disengaging vessel of substantially greater cross-sectional area than that of the lift pipe, and terminates at a level therein spaced from the upper end of the vessel a distance sufficient to effect the disengagement of the solids from the gas and to minimize attrition of the particles of contact material as a result of impingement against the confining walls or other internal surfaces of the disengager and of particle-to-particle impact as the contact material falls to the bottom of the disengager or to the surfaces of collecting baffles or trays which may be provided for the purpose of minimizing the distance of free fall. A practicable disengaging height between the upper end of the lift pipe and the top of the disengager has been found to be up to about 20–25 feet.

It has been found that solids material may be pneumatically elevated through a lift pipe at velocities which, if the solids were to be discharged directly into the disengaging zone, would require a disengaging height for the solids substantially in excess of the maximum, and may be decelerated just prior to their introduction into the disengaging zone by being passed through a decelerating pipe section of increased flow area at the upper end of the lift pipe.

For this purpose, outwardly tapered decelerating pipe sections have been employed at the upper end of the lift pipe and have proved effective in reducing the discharge velocity of the solids stream by reason of the gradual increase in cross-sectional flow area of the lift path and the consequent gradual expansion of the stream of lift gas.

It has been suggested that a cylindrical decelerating pipe section of substantially greater flow area than that of the lift pipe be employed. Experience has shown, however, that to obtain any substantial deceleration the difference in diameters of the lift pipe and the decelerator pipe must not be too great, and the decelerator pipe must be of sufficient length to permit the decelerating factors to become effective before the solids leave the decelerator pipe.

Furthermore, it has been demonstrated that during its passage through the cylindrical decelerating section the stream of solids has a tendency toward non-uniform flow, accompanied by substantial recycling of the solid particles. When the annular space between the lower end of the decelerator pipe and the lift pipe is closed, such recycling causes flooding of the decelerator pipe with consequent spill-over of the solid particles into the path of the stream emerging from the upper end of the lift pipe.

Heretofore, the above-mentioned considerations im-

2

posed serious limitations on the practical velocities at which the contact material could be discharged from the lift pipe.

In accordance with the present invention the discharge velocity of the contact material from the upper end of the elongated lift pipe is maintained at a desirable maximum, and the velocity of the contact material as it actually discharges into the disengaging zone is reduced to a desirable low value, by passing the stream of contact material and lift gas from the upper end of the lift pipe into a relatively short pipe of substantially greater diameter than the diameter of the lift pipe, whose length nevertheless is sufficient to effect a substantial deceleration of the particles of contact material passing through it. The stream of lift gas and contact material thereafter discharges at a substantially reduced velocity from the decelerator pipe into the disengaging zone. In order to adjustably control the rate of such deceleration as the particles pass through the enlarged decelerator pipe, additional lift gas is introduced in relatively minor but controlled amount into the lower end of the decelerator pipe. Such additional lift gas is introduced at the lower end of the enlarged decelerator pipe in a manner to cause the additional gas to travel upwardly as an annular stream about the upper end portion of the elongated lift pipe. The additional lift gas is introduced in such amount as to combine with the primary lift gas and maintain a relatively smooth flow of contact material through the decelerator pipe. In order to maintain the desired characteristics of contact material flow, the rate of introduction of the additional gas into the decelerator pipe may be regulated as desired, such as in response to pressure changes between vertically-spaced points along the decelerator path.

For a clearer understanding of the invention, reference may be had to the following description and claims taken in connection with the accompanying drawing forming a part of this application in which:

Fig. 1 is a diagrammatic elevational view showing a cyclic hydrocarbon conversion system employing a pneumatic lift for elevating the granular contact material along the upflow portion of its path of circulation, to which lift the method and apparatus of the present invention may advantageously be applied; and

Fig. 2 is a fragmentary elevational view, in cross section, showing the decelerator and the disengager constituting the upper end of the pneumatic lift.

Referring to Fig. 1 of the drawing, the numeral 11 indicates a typical hydrocarbon conversion unit comprising a combination superimposed reactor-regenerator, such as that disclosed in an article entitled "Houdrifiow: New Design in Catalytic Cracking," appearing at page 78 of the January 13, 1949 issue of the "Oil and Gas Journal."

Since the reactor-regenerator and its associated conduits for supplying the hydrocarbon charge, air, steam, etc., and for removing the gaseous products of conversion and regeneration form no part of the present invention, a detailed description thereof is omitted for the sake of brevity.

The pneumatic lift employed in conjunction with the combination reactor-regenerator for the purpose of maintaining a continuous circulation of the granular contact material is generally indicated by the numeral 12. The lift comprises: an introduction chamber or engager 13, located laterally below the lower end of the conversion unit 11, wherein the regenerated contact material conveyor thereto through seal leg 14 is engaged by a gaseous lift medium introduced through inlet conduit 15; an elongated lift pipe 16 extending upwardly from a low point within the engager to a level adjacent the upper end of the unit 11; a decelerator pipe 17, wherein a controlled reduction of the velocity of the contact material is effected; and a disengager 18 surrounding the upper end of the decelerator pipe 17, wherein the contact material is disengaged from the lift gas, the lift gas being discharged from the upper end of the disengaging zone through outlet conduit 19, and the contact material being discharged from the lower end thereof and conveyed to the upper end of the conversion unit 11 through conduit 20, which conduit may if desired serve as a seal leg.

Referring to Fig. 2, the upper end of the lift pipe 16 extends a relatively short distance axially into the lower end of the decelerator pipe 17. The decelerator pipe is of larger diameter than the lift pipe, thereby providing an annular space 21 between the upper end of pipe 16 and the lower end of pipe 17. The lower end of annular space 21 is closed off by means of an annular plate 22 mounted on the lift pipe and secured to a flange 23 formed on the lower end of the decelerator pipe. A gas inlet conduit 24 is provided in the side wall of the decelerator pipe near its lower end, so that additional lift gas may be introduced into the lower region of the annular space 21.

The annular space 21 is of sufficient length to provide a smooth-flowing, upwardly-directed annular stream of additional lift gas rising about the periphery of the stream of contact material and lift gas discharging from the upper end of the lift pipe, as indicated by the arrows. The amount of additional lift gas so introduced is controlled by a valve 25 in the inlet conduit 24. The length of the path through the decelerator pipe 17, from the upper end of the lift pipe 16 to the discharge end of the decelerator pipe, is sufficient to effect a substantial reduction in the velocity of the contact material, so that upon discharge into the disengager vessel 18 it will require a minimum of disengaging height. That is, the required distance, between the discharge end of the decelerator pipe and the top of the disengager, for substantially complete deceleration of the particles of contact material may be held to a minimum.

Operating in accordance with the invention, the contact material is engaged within the introduction chamber or lift engager 13 by primary lift gas in an amount sufficient to elevate the contact material through lift pipe 16 at relatively high velocities. For example, by the time it reaches the upper end of the lift pipe the contact material may have been accelerated to a discharge velocity of up to about 70 ft./sec. The most practical discharge velocity from the lift pipe will of course depend to some extent upon the characteristics of the particular contact material, especially with respect to hardness.

As the lift gas and the contact material discharge into the larger decelerator pipe, there is substantially immediate expansion of the lift gas stream, with a consequent reduction in velocity. The momentum of the particles of contact material carries them a substantial distance within the decelerator pipe before there is any appreciable reduction in velocity. Beyond such point, however, the particles of contact material decelerate rapidly, so that by the time they reach the discharge end of the decelerator pipe 17 they have attained a relatively low velocity.

In order to insure that the contact material will not slug in passing through the decelerator pipe 17, additional or decelerator lift gas is introduced through conduit 24 into the annular space 21 at the lower end of the decelerator pipe. It has been observed that without the introduction of such decelerator lift gas, contact material tended to accumulate in the annular space 21. When the accumulation of particles reached a level above the discharge end of the lift pipe 16 the particles avalanched into the rising high velocity stream discharging from the lift pipe, with consequent high attrition of the particles.

Since the addition of lift gas into the decelerator pipe 17 tends to counteract the velocity reduction effect resulting from the difference in flow area between the lift pipe and the enlarged decelerator pipe, it follows that the maximum practical velocity reduction is effected when the amount of additional lift gas is held to a minimum consistent with smooth operation of the lift. It is therefore contemplated that the introduction of such additional lift gas will be in controlled amount, just sufficient to prevent undesirable slugging in the decelerator pipe.

To this end I may provide automatic means for controlling valve 25 in accordance with changes in flow within the decelerator pipe. For example, such control means may comprise a differential pressure controller 26, diagrammatically illustrated in Fig. 2, connected between pressure taps 27 and 28 located at spaced points along the side of the decelerator pipe. Differential pressure controller 26 is connected to valve 25 by conduit 29 and is arranged to provide an increase in the flow of additional or decelerator gas whenever there is an appreciable increase in pressure between pressure points 27 and 28, such as would occur when the contact material begins to

slug. Such increase in decelerator gas flow should be sufficient to clear the decelerator pipe and restore the desired smooth flow of contact material. It has been found that, in any case, there will be a net reduction in the discharge velocity of the contact material.

At the substantially reduced velocity, the particles discharge upwardly from the decelerator pipe 17 as an unconfined stream, and thereafter decelerate by force of gravity. The particles then fall freely to the lower region of the disengager 18, where they may be retained as a compact moving bed 30 to provide a surge capacity for the system, or where they may be drawn off immediately. In either case, the particles are passed as a continuous stream through conduit 20 to the upper end of the unit 11.

The present invention is especially advantageous in those instances where, by reason of the consequent lower pressure drop through the lift pipe for a given mass flow rate, it is desired to operate at high maximum attained velocity within the lift pipe.

In present practice, it is a basic concept of pneumatic lift operation that the rate of solids flow through the system is best controlled at the lower end of the lift pipe, the manner of introduction and the amount of lift gas introduced being controlling factors. Velocity reduction at the upper end of the lift in accordance with this invention is consistent with such concept.

When operating at a high discharge velocity from the lift pipe, that is, a high maximum attained velocity, a straight cylindrical decelerator pipe section requires a relatively short vertical distance to achieve the desired velocity reduction. Any tendency toward slugging or recycling of the solid particles while passing through the decelerator section is overcome by the introduction of the auxiliary gas at the base of the decelerator pipe. Such gas is introduced primarily for the purpose of maintaining a smooth flow through the decelerator.

The need for such auxiliary gas introduction was demonstrated in an experiment with a 12-inch diameter lift pipe, fitted with a 20-inch diameter decelerator pipe. The discharge end of the latter was located 20 feet above the discharge end of the lift pipe. A series of catalyst runs were made under various conditions, and the height of rise of the discharged catalyst within the disengager was determined. Initially, the catalyst was elevated without the use of decelerator air. In those operations it was found that the annulus between the 12-inch and the 20-inch pipes rapidly filled with catalyst. The level of this catalyst tended to build up as a compact bed in the 20-inch pipe to more than one foot above the top of the 12-inch pipe. When catalyst built up in this fashion, additional catalyst falling back on top of this bed from the upper region of the disengager would slide intermittently into the rising high-velocity catalyst stream. A continuous heavy recycle of catalyst was also observed adjacent the wall surfaces of the decelerator pipe at a level about one third of the distance along the decelerator path. The introduction of decelerator air eliminated the catalyst build-up in the decelerator pipe, and increasing amounts of the additional decelerator air decreased the amount and density of recycling in the decelerator pipe.

This is not to say, however, that such auxiliary decelerator gas does not effect some measure of control upon the solids' height of rise. For example, in an air lift comprising a 12-inch diameter lift pipe topped by a 20-inch diameter cylindrical decelerator pipe forming a 20-foot extension of the confined lift path, it was demonstrated experimentally that with a lift engager air rate of about 3000 cu. ft./min. and a constant decelerator rate of about 1000 cu. ft./min. a reduction of 100 cu. ft./min. in the engager air rate reduced the solids' height of rise by about four feet; whereas, with the same initial air rates, incremental reductions of 500 cu. ft./min. in the decelerator air rate reduced the solids' height of rise by $\frac{1}{2}$ to $1\frac{1}{2}$ feet for each increment.

In a further experiment, with a 12-inch diameter lift pipe discharging solids at about 35 ft./sec. into a disengager vessel having a disengaging distance of 20 ft. between its upper end and the discharge end of the lift pipe, it was observed that a substantial portion of the solids forcefully impinged against the upper end of the vessel. When a 20-inch diameter-20-foot decelerator pipe was installed and operated in accordance with the invention, that is, with auxiliary gas introduction suffi-

5

cient only to achieve a smooth solids flow, the height of rise of the particles decreased to about 13-14 feet, which is within the practicable range of disengaging height.

While decelerator air rates in excess of 25% of the lift engager air rate do not have an appreciable effect on the height of rise when the lift stream is expanded from a 12" diameter lift path to a 20" diameter decelerator path, it is believed that a smaller differential between the respective flow path areas will show a substantially greater effect for the decelerator air. Accordingly, in cases where it is not desired to control the height of rise by adjustment of the lift engager air rate, the decelerator air rate may be made the controlling factor by providing a smaller flow path expansion in passing from the lift pipe into the decelerator pipe.

Operation in accordance with the present invention permits the use of relatively high discharge velocities in the lift pipe, and effectively reduces the velocity of the catalyst stream before it discharges into the disengaging zone. The substantial reduction in height of rise effected by the decelerator pipe permits a reduction in the height of the disengager vessel, thereby producing substantial savings in the cost of materials and construction.

The invention provides additional operational advantages, especially when starting up a unit. For example, before catalyst circulation is started, enough decelerator air is turned on to insure that catalyst will not slug in the decelerator pipe. When catalyst circulation is established, the decelerator air may be cut back to obtain the desired exit velocity for catalyst leaving the decelerator, which exit velocity may be determined by means of a height of rise determination in the disengager.

While the invention may be practiced to advantage through a relatively wide range to size differences in the cross-sectional flow areas of the lift pipe and the decelerator pipe, for most practical purposes the flow area of the decelerator pipe will be in the range of $1\frac{1}{2}$ to $2\frac{1}{2}$ times the flow area of the lift pipe.

With respect to the decelerator pipe, its most practical size will be found when the ratio of length to diameter is in the range of between 7 to 1 and 18 to 1.

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 pneumatic lift system for circulating granular material including an elongated vertical lift pipe and a disengaging chamber at the upper end of said lift pipe, the combination therewith of a secondary elongated lift pipe, a relatively short decelerator pipe of greater cross-sectional flow area than said lift pipe and forming an upper longitudinal extension of the latter, the upper end portion of said lift pipe extending a distance axially into the lower end portion of said decelerator pipe and the upper end portion of said decelerator pipe extending a distance into said disengaging chamber, means for closing the lower end of the annular space formed between said lift pipe and said decelerator pipe, and means for introducing controlled amounts of lift gas into the lower region of said annular space.

2. Apparatus as defined in claim 1, including means for controlling the amount of said lift gas introduced

6

into the lower region of said annular space in accordance with a differential pressure between vertically-spaced points along the lift path formed by said decelerator pipe.

3. In a pneumatic lift system for circulating granular material including an elongated vertical lift pipe and a disengaging chamber at the upper end of said lift pipe, the combination therewith of a relatively short decelerator pipe of greater cross-sectional flow area than said lift pipe and forming an upper longitudinal extension thereof, the upper end portion of said lift pipe extending a distance axially into the lower end portion of said decelerator pipe to form an annular space therebetween, and the upper end portion of said decelerator pipe extending a distance into said disengaging chamber to provide a disengaged granular material collecting space at the bottom thereof, means for closing the lower end of said annular space formed between said lift pipe and said decelerator pipe, and controllable means for introducing lift gas into said annular space at a distance from its upper end sufficient to assure a smooth upward flow of said lift gas about the discharge end of said lift pipe.

4. In a pneumatic lift system for circulating granular material including an elongated vertical lift pipe and a disengaging chamber at the upper end of said lift pipe, the combination therewith of a relatively short decelerator pipe of greater cross-sectional flow area than said lift pipe and forming an upper longitudinal extension thereof, the upper end portion of said lift pipe extending a distance axially into the lower end portion of said decelerator pipe to form an annular space therebetween, and the upper end portion of said decelerator pipe extending a distance into said disengaging chamber to provide a disengaged granular material collecting space at the bottom thereof, means for closing the lower end of said annular space formed between said lift pipe and said decelerator pipe, and controllable means for introducing from within said annular space an upwardly-directed smooth-flowing annular stream of lift gas about the upper periphery of said lift pipe.

5. Apparatus as defined in claim 4, including means for controlling the amount of said lift gas comprising said annular stream in accordance with a differential pressure between vertically-spaced points along the enlarged extended portion of said lift pipe formed by said decelerator pipe.

6. Apparatus as defined in claim 4, characterized in that the cross-sectional flow area of said decelerator pipe is in the range $1\frac{1}{2}$ to $2\frac{1}{2}$ times the cross-sectional flow area of said lift pipe.

7. Apparatus as defined in claim 4, characterized in that the ratio of length to diameter of said decelerator pipe is in the range of about 7/1 to 18/1.

References Cited in the file of this patent

UNITED STATES PATENTS

Number	Name	Date
2,435,927	Manning	Feb. 10, 1948
2,460,546	Stephanoff	Feb. 1, 1949

FOREIGN PATENTS

Number	Country	Date
258,524	Italy	Dec. 8, 1925