

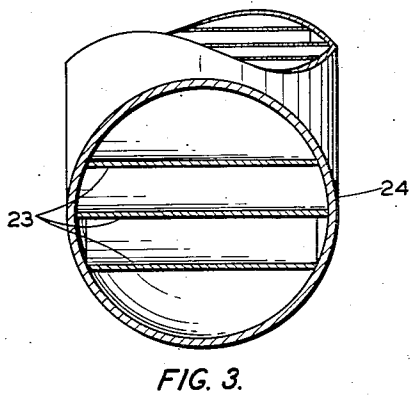
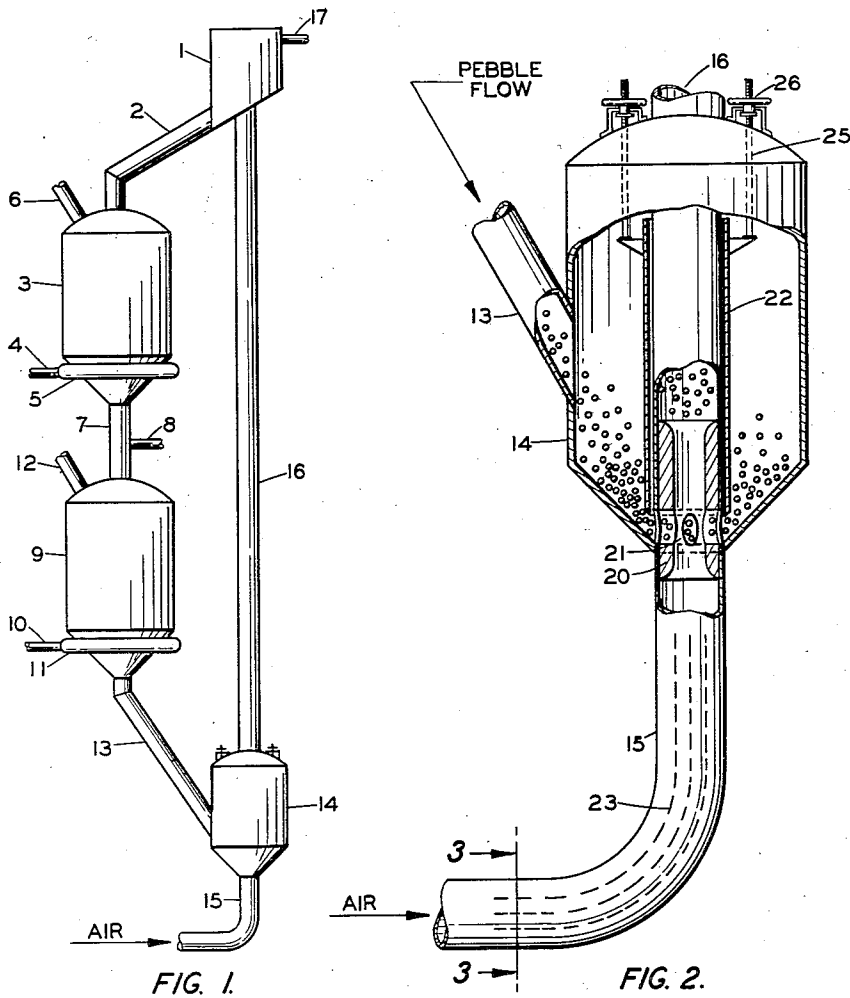
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STRAIGHTENING VANES IN PEBBLE HEATER AIR LIFT

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STRAIGHTENING VANES IN PEBBLE HEATER  
AIR LIFT

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The present invention relates to improved air lift means to prevent erosion in a pebble heater air lift.

Pebble heaters are ideally suited for endothermic reactions which require high temperatures and extremely fast heating and cooling rates, for example, thermal cracking and thermal dehydrogenation. The conventional pebble heater generally comprises two cylindrical chambers in substantially vertical alignment, with a connecting neck between the two. Refractory pebbles are introduced into the upper portion of the top chamber or heater. Here the pebbles form a moving bed flowing downwardly through the chamber countercurrently and in direct heat exchange with hot combustion gases. The pebbles are thus heated to a high temperature and then flow through the neck into the lower or reaction chamber where they give up heat to reactant gases passed countercurrently thereto. Stack gases and reaction products are removed from the upper portion of the heater and reactor respectively. The pebbles then gravitate from the base of the reactor into a suitable elevating means for recycle to the system. The pebbles are usually spheroidal, about  $\frac{1}{4}$  inch in diameter, and of ceramic or metallic composition which will withstand temperatures in the range of 3500 to 4000° F.

In earlier systems requiring the elevation of such granular material, mechanical means, such as bucket elevators, were commonly employed. More recently these have been replaced by pneumatic means comprising an elongated vertical lift pipe associated with a lift hopper at its lower end and a disengaging chamber at its upper end. The pebbles gravitate from the reactor into the lift hopper wherein they are entrained in a stream of lift gas and blown through the lift pipe to the disengaging chamber. Here the pebbles are disengaged from the lift gas and returned to the downflow path. Pneumatic lift systems employing both a single lift pipe and multiple lift pipes are in commercial use.

One of the problems in elevating pebbles by pneumatic means is erosion of the air lift pipe by the pebbles, especially adjacent those points where the pebbles must undergo a change of direction while being rapidly accelerated. This erosion is presumably caused by turbulence and zigzag flow within the rising stream of pebbles, causing the latter to strike the walls of the lift pipe. The flow characteristics of the pebbles being conveyed upwardly along the lift path are determined to a considerable extent by the manner in which they are introduced into the lift path. It is known that the deviation of the pebbles from straight line flow can be minimized if the pebbles are initially accelerated upward through one or more narrow pipes discharging at their upper ends into the lower end of a comparatively large diameter lift pipe. See, for example, U. S. 2,645,442.

The same effect may be obtained by using a single large diameter conduit as the lift pipe and providing it with a constrictive liner or insert through which the pebbles enter the pipe. Since the velocity of the lift gas is in-

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creased in passing through the constrictive insert it gives initial acceleration to the pebbles entering at this point. The use of a single constrictive pipe obviously has the advantage of simplicity over a plurality of narrow pipes extending into one large pipe. Its disadvantage is that unless modified it results in severe pitting of the insert by the pebbles immediately above the point where they enter the air lift. In addition, the conduit walls become eroded upstream from the liner and require periodic welding to build them up to their original thickness. This requires periodically shutting down the entire unit, replacing the liner, and performing the necessary welding. In addition, considerable breakage of the pebbles accompanies the erosion of the side walls.

The source of most of this erosion is an unavoidable deviation in the straight line flow of the lift gas at a point beneath the pebble engaging pot. For practical reasons it is necessary that the liner element be positioned near the surface of the ground; e. g., it must be low enough to permit the pebbles to gravitate into it from the reactor, hence, cannot be raised without raising the entire unit. Since the lift gas must necessarily come from a source external to the pebble engaging pot it is obviously necessary for the gas conduit from this source to bend from the horizontal to the vertical in order to enter the base of the pebble engaging pot. This change in direction sets up swirling and turbulence in the lift gas downstream from the bend or elbow. The comparatively short length of pipe between the bend and the pebble engaging portion of the pot is insufficient to eliminate this turbulence. Hence, when this turbulent gas picks up the pebbles entering the lift pipe it hurls some of them against the walls of the liner and the downstream conduit, causing the erosion described above.

Since it is obviously impossible to eliminate this bend except by bringing the lift gas straight up out of the ground, it is necessary to somehow eliminate the turbulence caused by the bend. The first attempt consisted of placing straightening vanes in the elbow. It was found, however, that this did not solve the problem and that the liner continued to be severely eroded and pitted by the pebbles. Although the art pertaining to straightening vanes indicates that they should not be adjacent a restriction in the line, it was decided to lengthen the vanes to extend almost to the liner. The result was surprising; the lengthened vanes substantially reduced erosion in the liner and adjacent conduit.

Accordingly, the purpose of the invention is to reduce erosion in a pebble heater air lift conduit. A more specific object is to reduce the turbulence in a pebble heater air lift caused by the combination of a bend in the air lift conduit and a constriction in the conduit adjacent thereto. A further object is to reduce the time lost in replacing constrictive liners in an air lift conduit. Another object is to reduce pebble breakage in an air lift conduit.

The invention can best be illustrated by the accompanying drawings wherein Figure 1 is a schematic view of the pebble heater apparatus, Figure 2 is a view of the lower end of the air lift showing a section of the engaging pot and the connections thereto, and Figure 3 is a cross-section of the vanes in the elbow.

Referring to Figure 1, pebbles are supplied from disengaging pot 1 through leg 2 to the top of pebble heater 3. Gaseous heating fluid enters the base of heater 3 through conduit 4 and header 5. This fluid passes countercurrently up through the moving bed of pebbles, heating them by direct heat exchange, and is vented at outlet 6. A throat 7 connects the base of heater 3 to the top of reactor 9. Inlet conduit 8 serves to admit seal gas to throat 7 to prevent passage of vapors from one vessel to the other. The heated pebbles are thus passed into reac-

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for 9 wherein they are contacted with feedstock vapors introduced through conduit 10 and header 11. Gaseous reaction products are withdrawn at 12 and the pebbles gravitate through outlet leg 13 into engaging pot 14. Lift gas introduced to the base of pot 14 through inlet line 15 carries the pebbles up through lift pipe 16 to disengaging pot 1 wherein gas and pebbles are separated, gas being vented at 17 and the pebbles returned through leg 2 to the pebble heater.

Referring to Figure 2, air lift conduit 16 is provided with a fixed cylindrical insert or liner 20, provided with orifices 21. Surrounding a portion of insert 20 and conduit 16 is sleeve 22, adjustable vertically through rods 25 and hand wheels 26 so as to vary the respective size of the orifices 21. This, of course, varies the rate of flow of pebbles through the orifices into the insert 20. The means for moving the sleeve is described in greater detail in Serial No. 399,329, same assignee, and hence is not detailed here. Vanes 23 extend through elbow 24 to a point just short of the entrance of insert 20. As shown in Figure 3, these vanes extend completely across conduit 15, providing a series of separate parallel passages to eliminate turbulence and swirling. Preferably, three vanes are used and are spaced so as to divide the pipe into compartments of equal volume for equal lengths of vanes. Stated another way, the cross sectional area of the pipe is divided into four sections by the three vanes (Figure 3) and these four sections are of equal area. However, the invention is not limited to vanes of the type illustrated; a bundle of small tubes fastened in the pipe also forms a convenient straightening vane installation. For best results the vanes should extend to within  $\frac{1}{2}$ -5 inches of the base of the liner and preferably from 2-4 inches. The ends of the liner should taper gradually so as to blend into the conduit wall, thus substantially preventing swirling and turbulence at this point.

Exemplifying an actual lift operation in accordance with the present invention is the following data based on a pebble heater unit using  $\frac{3}{8}$ " alumina pebbles having a bulk density of 125 lbs./cu. ft. and employing an air lift with straightening vanes in the elbow only.

|                                                            |             |                |
|------------------------------------------------------------|-------------|----------------|
| Lift pipe height.....                                      | feet.....   | 76             |
| Lift pipe internal diameter.....                           | inches..... | 9.56           |
| Length of liner.....                                       | feet.....   | 4-5            |
| Internal diameter of liner.....                            | inches..... | 7.625          |
| Number of vanes.....                                       |             | 3              |
| Thickness of vanes.....                                    | inch.....   | $\frac{1}{8}$  |
| Distance between base of liner and upper end of vanes..... | inches..... | 20-22          |
| Distance from ports to top of liner.....                   | inches..... | 24             |
| Approximate air volume through lift                        |             |                |
| cu. ft./hr.....                                            |             | 99,000-105,000 |
| Air temperature.....                                       | ° F.....    | 900            |

The above-described air lift was operated for 4 months and was then examined for erosion. It was found that at a point about 1 foot above the base of the liner a groove  $\frac{1}{2}$  inch deep and 3 to 4 inches wide had been worn half way around the interior of the liner. This groove was on the same side as the long radius of the bend (i. e., the hole was on the east side of the riser and the air flow from the west) indicating that the baffles had been ineffective in straightening the flow of air into the liner. A groove of this size is serious because it tends to trap pebbles rolling up the liner wall, thus accelerating the gouging action of the pebbles and increasing the turbulence of the air stream past that point. In addition, it was found that the outer pipe was eroded above the liner to such an extent as to require welding in several places. Hence, it was necessary to replace the liner and do the necessary welding.

The vanes were then lengthened about 18 inches so as to extend to within 2-4 inches of the base of the liner. The unit was then operated for 6 months, shut down, and the air lift reexamined. It was found that the erosion of the liner and adjacent conduit walls was negligible;

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furthermore, it was completely uniform instead of being concentrated at certain points as in the previous run. The extent of erosion was not serious enough to require replacement of the liner or welding of the conduit.

In the operation of a commercial unit of this type, it is expected that it will be necessary to shut down temporarily every 6 months for examination and repair of equipment. Since the use of extended straightening vanes permits operation of the pebble engaging portion of the unit for 6 months, the vanes obviously eliminate premature shutdowns from this source. It was considered surprising that the extension of the vanes would give the effect it does since the knowledge on this subject would indicate the contrary. For example, the use of flow meters presents an analogous situation. In measuring the rate of flow of fluids through a conduit it is common practice to insert a standard restrictive orifice in the line and to measure the pressure drop across this orifice. To eliminate the effect of turbulence caused by this restriction, the ideal location of the orifice is in a long straight run of pipe with no change of direction closer than 10 pipe diameters to the upstream side of the orifice. When this length of straight pipe is not available, as when a bend precedes the opening to the orifice, it is common practice to insert straightening vanes in the pipe between the bend and the orifice. However, the rule in this case is that the straightening vanes must be inserted at least 6 pipe diameters upstream of the orifice. See, e. g., The Chemical Engineering Handbook, 3d ed. (1950) p. 1285. This rule is based on the fact that when the fluid emerges from the ends of the vanes into the relatively quiescent surrounding fluid, a certain amount of swirling results. Hence, a sufficient length of straight pipe must be provided to smooth out the fluid stream until straight line flow is attained. Applying this rule to applicant's air lift where the distance between the bend and the orifice is much less than 6 pipe diameters, one would conclude that this space should be left clear. The discovery that the extension of the straightening vanes from the elbow into this space would reduce the normal turbulence at the vane outlets was unexpected.

Obviously certain modifications of the invention described may be made without departing from the spirit and scope thereof and the embodiments shown should be considered as illustrative rather than limiting.

We claim:

1. An improved air lift for solid particles comprising in combination a closed upright elongated shell; inlet means for said particles in the upper portion of said shell; particle entrainment means extending through said shell and comprising a conduit extending vertically through said shell, a liner within that portion of the conduit which is within the shell, and aligned orifices in said conduit and liner to permit entry of particles from said shell into said conduit; a bend in said conduit at a point below said shell, means for admitting a lift fluid into the lower end of said conduit for flow through said bend and shell, whereby particles passing through said orifices are entrained in said fluid and blown upwardly through said conduit; and a plurality of straightening vanes in said conduit extending from within said bend to a point just below the base of said liner, whereby the turbulence imparted to the gas stream in passing through the bend is substantially eliminated and the particles are entrained by a vertical straight line flow of gas, thus reducing erosion of the liner and particles.

2. An improved pebble air lift comprising: a pebble engaging vessel; a pebble disengaging vessel superimposed above said engaging vessel; an air lift conduit extending from a point below said engaging vessel through said vessel and terminating within said disengaging vessel; a plurality of ports in the portion of the conduit which is within the engaging vessel, whereby pebbles are enabled to pass from said vessel into said conduit; a bend in that portion of the conduit below the engaging vessel; means

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for admitting a lift gas to the lower end of said conduit for flow through said bend and vessels, whereby pebbles in the lower vessel are entrained in said lift gas and thus elevated to the upper vessel; and a plurality of straightening vanes in said conduit extending from within the bend to a point just below said ports, whereby the turbulence in the gas caused by passage through said bend is substantially eliminated before the gas entrains the pebbles, thus reducing erosion between the entrained pebbles and the conduit walls.

3. An apparatus for elevating heat exchange pebbles from a lower vessel containing a body of said pebbles to an upper vessel which comprises: an elevating conduit extending from within said upper vessel through said lower vessel to a point below and to one side thereof; a plurality of inlet ports in said conduit to receive pebbles from the lower vessel; a bend in said conduit below said lower vessel; means for supplying a lift gas to the lower end of said conduit to entrain the pebbles passing through said ports and convey them into the upper vessel; a restrictive insert in that portion of the conduit containing the inlet ports; a plurality of ports in said insert in alignment with those in the conduit and a plurality of straightening vanes in said conduit extending from within said bend to a point just below the base of said insert, whereby the turbulence set up in the lift gas on passing through said bend is substantially eliminated before the gas enters the insert.

4. In a hydrocarbon conversion system comprising a pebble heater, a reactor, a pebble engaging chamber, means for passing pebbles in a moving bed through said heater and reactor to said engaging chamber, and a pebble disengaging chamber superimposed above said engaging chamber and heater, in combination: elevating means for recycling pebbles from said engaging chamber to said disengaging chamber for return to the heater and reactor, said elevating means comprising an air lift conduit extending from a point below said engaging chamber through said chamber and into the disengaging chamber and containing a plurality of inlet ports for the admission of pebbles thereto from said engaging chamber; a restrictive tubular liner within that portion of the conduit which is surrounded by the engaging chamber; a plurality of ports in said liner in alignment with the ports in said conduit; an elbow in said conduit at a point below said engaging chamber, means for admitting a lift gas into said elbow for passage through said engaging and disengaging chambers, whereby pebbles entering the conduit through said ports are entrained in said lift gas and conveyed upwardly therein to said disengaging chamber; and a plurality of straightening vanes in said conduit extending from within said elbow to a point within  $\frac{1}{2}$  to 5 inches of the base of said liner, whereby the turbulence imparted to the lift gas in passing through the elbow is eliminated before it reaches the liner.

5. Apparatus of claim 4 wherein the straightening vanes are parallel to each other and the cross sectional areas of conduit bounded by said vanes are equal.

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6. Apparatus of claim 4 wherein the ends of the tubular liner are tapered to meet the walls of the conduit, whereby the creation of turbulence in the lift gas at this point is minimized.

7. Apparatus of claim 4 wherein the distance between the elbow and the liner is less than 6 conduit diameters.

8. An improved pebble heater air lift comprising: a first closed vessel; a second closed vessel superimposed above said first vessel; a vertical conduit connecting said vessels, said conduit extending through said first vessel from a point therebelow and terminating within said second vessel; a plurality of orifices in that portion of the conduit within the first vessel, whereby pebbles contained within said first vessel are enabled to enter the conduit; means for admitting lift gas through said conduit for flow upwardly therethrough whereby pebbles passing through said orifices are entrained therein; means for accelerating the flow of lift gases past said orifices; a bend within said conduit at a point below the first vessel, whereby turbulence is unavoidably imparted to the lift gas in its passage to said first vessel; and a plurality of vanes in said conduit extending from within said bend to a point just below said orifices for substantially restoring straight line flow to the lift gas before it reaches said orifices.

9. An improved pebble heater air lift comprising: a first closed vessel; a second closed vessel superimposed above said first vessel; a vertical conduit connecting said vessels, said conduit extending through said first vessel from a point therebelow and terminating within said second vessel; a plurality of orifices in that portion of the conduit within the first vessel, whereby pebbles contained within said first vessel are enabled to enter the conduit; means for admitting a lift gas through said conduit for flow upwardly therethrough whereby pebbles passing through said orifices are entrained therein; a constrictive tubular liner within said conduit, said liner covering the inner wall of the conduit adjacent said orifices, and having a plurality of similar orifices in alignment with those in the conduit so that said pebbles pass through both to enter the conduit; a bend within said conduit at a point below the first vessel, whereby turbulence is unavoidably imparted to the lift gas in its passage to said first vessel; and means for substantially restoring straight line flow to the lift gas before it reaches said orifices.

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