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APPARATUS FOR COUNTERCURRENTLY CONTACTING A
GAS WITH A FINELY DIVIDED SOLID

2,925,330

Filed March 4, 1955

2 Sheets-Sheet 1

FIG. 1

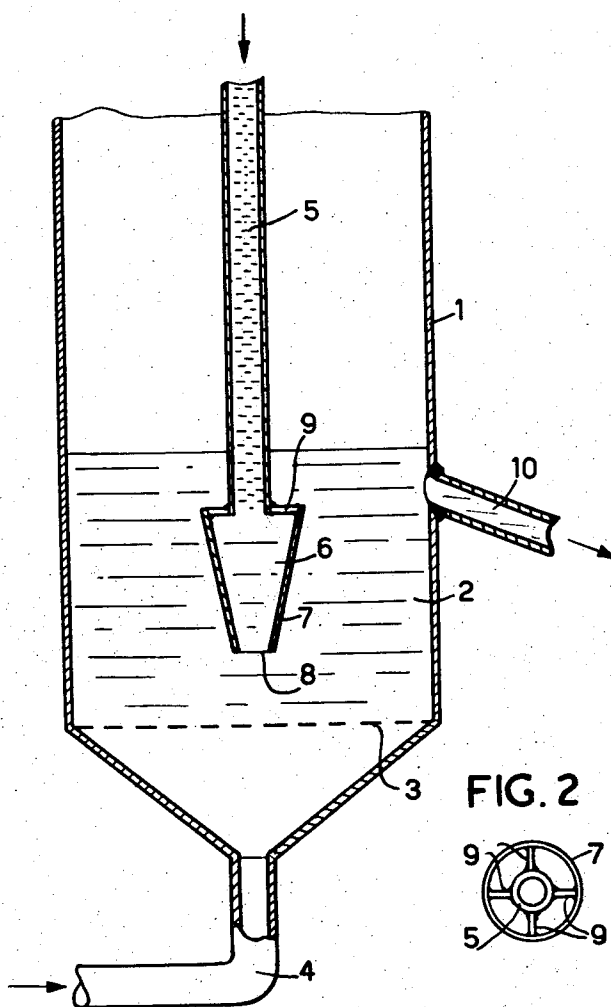


FIG. 2



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ATTORNEYS.

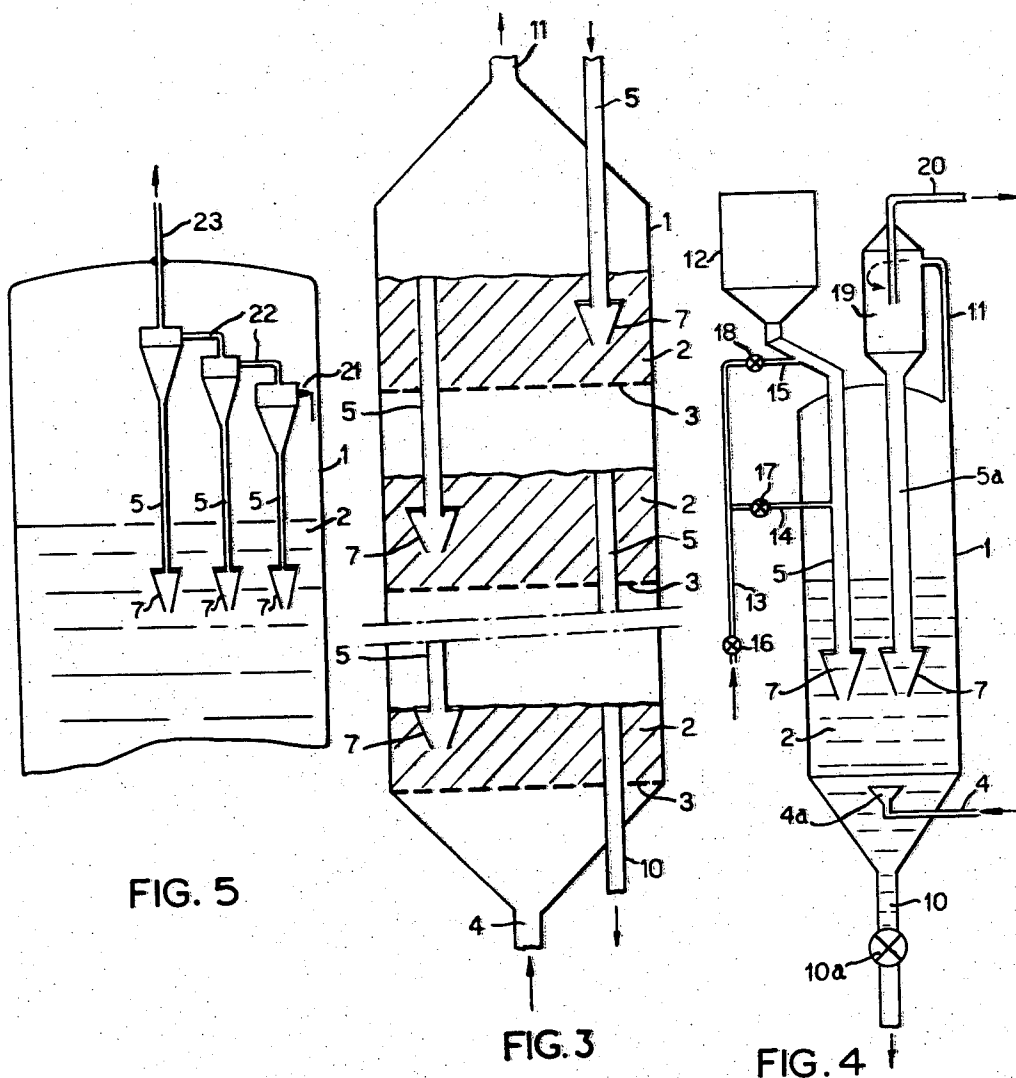
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APPARATUS FOR COUNTERCURRENTLY CONTACTING A GAS WITH A FINELY DIVIDED SOLID

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2 Claims. (Cl. 23—288)

The present invention is concerned with novel means for facilitating the feed of a finely divided solid material into a space in a direction opposed to a gas flow therein.

It is sometimes necessary in industrial and other processes to supply a finely divided solid material into a chamber or other space in opposition to a gas flow therein. By way of example, mention may be made of procedures involving reactions between gases and finely divided solid material in the fluidized state where fresh solid must be periodically or continuously supplied to the fluidized solid bed. The customary procedure in such cases is to supply the solid material downwards through a feed pipe, the lower end of which opens into the fluidized bed. With such an arrangement, however, the gas employed for maintaining the fluidized state tends to pass upwardly into the feed pipe thus interfering with the feed of the solid material.

It has now been found that this interference with the feed may be eliminated or at least minimized by means of a suitably designed sleeve or shroud positioned about the discharge end of the feed pipe in the manner more specifically described below. Accordingly, the principal object of the invention is a provide novel means for avoiding interference with the feeding of finely divided solids into a reaction zone or the equivalent in a direction opposed to a gas flow therein. Other objects will also be hereinafter apparent.

Broadly stated, the invention involves providing the feed pipe with a tapered sleeve open at both ends, the inner end of said sleeve being positioned about the solids discharge end of said feed pipe and being larger in cross-sectional area than the discharge end of said feed pipe thereby providing passage means between said pipe and said sleeve for the discharge of gas entering said sleeve, said sleeve extending outwardly from the discharge end of said feed pipe to enclose the path of solids discharged therefrom and being tapered towards the direction of solids discharge so as to terminate in an end having a cross-sectional area no greater than the discharge end of said pipe.

In other words, the present invention provides a device for facilitating the feed of a finely divided solid material into a space in a direction opposed to a gas flow therein, said device comprising a feed pipe and a shroud in the form of an open-ended tapering sleeve, on the end of which has a larger cross-sectional area, and the other end of which is equal to, or less than the cross-sectional area of the discharge end of the feed pipe. Additionally, the sleeve is so positioned with respect to the pipe that a space is left between the pipe and the sleeve wall through which gas may rise from within the shroud. The shape and positioning of the sleeve is also such that when the feed pipe is vertical and leads into a rising current of gas and finely divided solid material is fed downwards through the pipe, solid material leaving the discharge end of the pipe is directed through the shroud or sleeve in the direction of its taper

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and gas which rises against but does not actually enter the shroud through its narrower end is deflected outwards to ascend clear of the discharge aperture.

It has been found possible by means of the present invention to obtain an undisturbed feed of finely divided solid into an opposing gas flow. The gas entering the sleeve through its narrower end spreads over an increasing cross-sectional area as it rises in the expanding passage through the shroud, and escapes at the wider end thereof, there being little, if any, tendency for the gas to ascend through the feed pipe.

The feed rate of the solid substance, which depends on the feed pressure, may be influenced by the dimensions of the sleeve. In general, it has been found that the feed rate increases as the size of the wider end of the shroud is increased. The size of the narrower end of the shroud may also be varied. When using relatively wide feed pipes, it is preferred to make the narrower end of the sleeve smaller, e.g., half the cross-section of the feed pipe.

The device of the invention may be used with various kinds of feed pipes and stand pipes. It is particularly well suited for use in feeding finely divided solids into a fluidized bed where a reaction is carried out in the fluidized state. By way of illustration, mention may be made of processes in which a finely divided solid substance, such as catalyst, is brought into countercurrent contact with gases or vapors by passing the solid particles through a reaction vessel which comprises a number of superimposed compartments partitioned off by perforated plates on each of which a mass of the finely divided solid substance is kept in the fluidized state by upward flow of the gas through the perforated plates. With such an arrangement, the flow of fluidized solid from one fluidized bed to the next takes place from top to bottom of the vessel by means of feed or discharge pipes extending downwardly from one compartment to the next. The position of the top of each discharge pipe in a particular compartment determines the level of fluidized solids therein while the bottom of each discharge pipe extends below the level of fluidized solids in the next lower compartment. The performance of apparatus and procedures of this type can be considerably improved by using the discharge pipe modified to include the tapered sleeve of the invention. One advantage which has been noted is that if gas bubbles should form in a fluidized bed, such bubbles are eliminated since, on entering the sleeve or shroud, they become distributed over an increasingly wide cross-sectional area and get mixed up with the solid substance issuing from the feed pipe.

In order that the invention may be more readily understood, reference is hereinafter made, by way of example, to the various embodiments of the invention as illustrated diagrammatically in the accompanying drawings wherein like parts are designated by corresponding reference numerals and:

Figure 1 is a sectional elevation of one form of gas-solids contact apparatus including the novel feed means of the invention;

Figure 2 is a plan view of the feed means shown in Figure 1;

Figure 3 is a sectional elevation of a reaction column including a plurality of feed devices according to the invention; and

Figures 4 and 5 are sectional elevations of other types for apparatus for contacting gases and solids including the present feed means.

Referring more specifically to the drawings, the apparatus shown in Figure 1 comprises a vessel 1 in which a bed 2 of finely divided solid substance is kept in the fluidized state on a grid 3 by means of a gas supplied through the

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pipe 4. The solid substance is supplied to the bed through the feed pipe 5 and discharged through the pipe 10. The lower end of feed pipe 5 empties into the space 6 which is formed by a shroud 7, the latter being in the form of a tapered open-ended sleeve. The opening 8 at the narrow end of the shroud is of substantially the same diameter as the diameter of the pipe 5. As shown, shroud 7 is connected to the feed pipe by means of the radial connecting arms 9 (see particularly Figure 2). However, it will be appreciated that the shroud may be held in position in some other suitable manner, e.g., by means of arms joined to the wall of the vessel 1 or to the grid 3.

The solid material descending through pipe 5 empties into space 6 and is directed through the shroud 7 in the direction of its taper. Some gas rises into the shroud through the aperture 8 and this gas becomes distributed over an increasingly large cross-sectional area as it ascends through the shroud. For the most part, the gas which enters the shroud escapes therefrom through the area defined by the walls of the shroud and feed pipe 5 and the radial arms 9. Gas rising against the outside of the shroud wall is deflected outwardly and ascends clear of the feed pipe.

The apparatus shown in Figure 3 comprises a reaction column 1 which is divided into a number of super-imposed compartments by perforated plates or grids 3. On each plate 3, a mass 2 of finely divided solid substance is kept in the fluidized state by an upward flow of gas which is admitted through the inlet 4 and passes upwardly from one compartment to the next through the plate perforations. The gas leaves the column at the top through the gas outlet 11.

The solid substance is fed into the column through the uppermost feed pipe 5 so that it enters the top compartment to form the fluidized bed therein. The solid thereafter flows through the column by means of the other feed pipes 5, each of which leads from one fluidized bed to the adjacent bed directly below. Thus the solid flows countercurrently with respect to the gas, from one fluidized bed to another and from the top of the column to the bottom where it is eventually discharged through the solids discharge pipe 10. The level of the fluidized solids in each bed is regulated by positioning the top or inlet of the feed pipe which leads therefrom into the next bed.

As shown, each of the feed pipes 5 has associated therewith a conical shroud 7 similar to that illustrated in Figure 1. The arrangement of Figure 3 has the advantage that when a reaction is to be commenced and gas is first supplied to the column through the gas inlet 4, flow of gas upwardly through any of the pipes 5 ceases just as soon as solid substance commences to flow through that particular pipe. Consequently, the reaction column can be started more easily.

Referring now to Figure 4, the apparatus shown therein comprises a reaction vessel 1 in which a mass 2 of solid substance is kept in the fluidized state by means of an ascending current of gas supplied through the pipe 4 and the distributor 4a.

The solid substance is supplied from a hopper 12 through the feed pipe 5. The solid substance is kept flowing in feed pipe 5 by supplying small amounts of auxiliary gas through the pipes 13, 14 and 15, the latter being provided with control valves 16, 17 and 18, respectively. Solid substance is discharged from vessel 1 through the

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pipe 10 which is provided with a control valve 10a. The gas rising in the vessel from the fluidized bed passes by way of gas discharge pipe 11 into a dust collector 19 in which entrained solid particles are separated and returned to the fluidized bed 2 through the feed pipe 5a. The gas, freed of solid particles, leaves the separator 19 through the pipe 20.

Each of the feed pipes 5 and 5a has associated therewith a conical shroud 7 similar to that shown in the apparatus of Figures 1 and 3.

Figure 5 shows part of the upper portion of a reaction vessel 1 in which a bed 2 of solid substance is maintained in the fluidized state by a rising current of gas. Gas discharged from the reactor enters the pipe 21, successively passes through three cyclone separators connected by pipes 22 and is then discharged through pipe 23. Solid particles separated from the gas are returned to the fluidized bed 2 from each separator through a feed pipe 5 having a tapered shroud 7 similar to that shown in Figures 1, 3 and 4.

It will be appreciated that various modifications may be made in the invention as described herein. Hence, the scope of the invention is not to be considered as limited by the foregoing description and should instead be determined by the appended claims wherein—

I claim:

1. In an apparatus of the type described having means for containing a bed of solid particles, means for flowing a gas upwardly into said bed to maintain the same in a fluidized state, means for discharging solid particles from the fluidized bed and a feed pipe having a discharge opening in its lower end for feeding solid particles downwardly into the fluidized bed in opposition to the flow of gas, the improvement comprising shroud means disposed adjacent the lower end of said feed pipe within the fluidized bed for facilitating the feed of solid particles into the fluidized bed in opposition to the flow of gas, said shroud means including a sleeve having a lower opening below the discharge opening of said feed tube in unobstructed communication with the fluidized bed whereby the gas and particles in the fluidized bed can pass freely through the opening, said lower sleeve opening having a cross-sectional area from approximately one-half to approximately equal the cross-sectional area of said feed pipe discharge opening, the upper end of said sleeve having a periphery larger than the periphery of the lower end of said feed tube and being disposed relative to the latter to define passage means between said feed pipe and said sleeve for the discharge of gas entering the lower opening of said sleeve, the exterior surface of said sleeve being shaped to deflect outwardly the rising gas adjacent said lower opening which does not enter the same so that it does not enter the discharge opening of the feed pipe.

2. Apparatus according to claim 1 including means fixed said sleeve to said feed pipe, said fixing means including radial arms extending between said pipe and said sleeve.

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