July 17, 1956 R. KOLLGAARD ET AL 2,754,966

ELUTRIATION OF FINES

Filed April 11, 1951 2 Sheets-Sheet 1

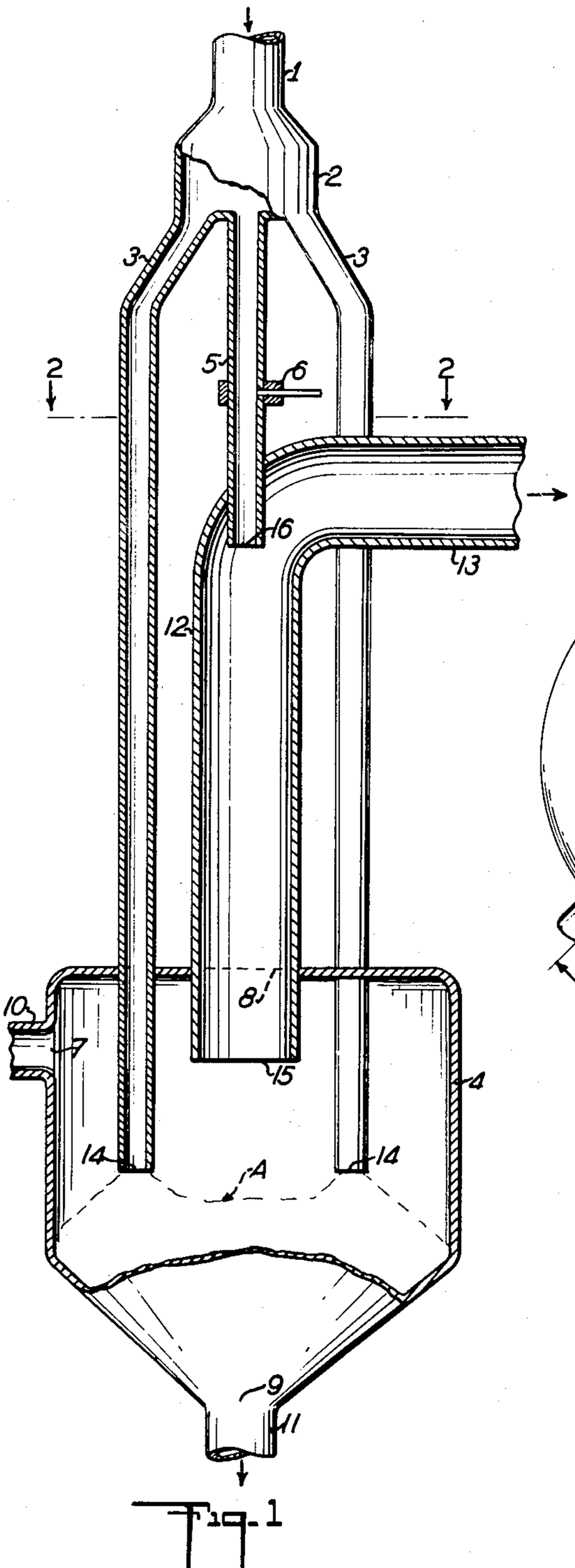

Fig. 1

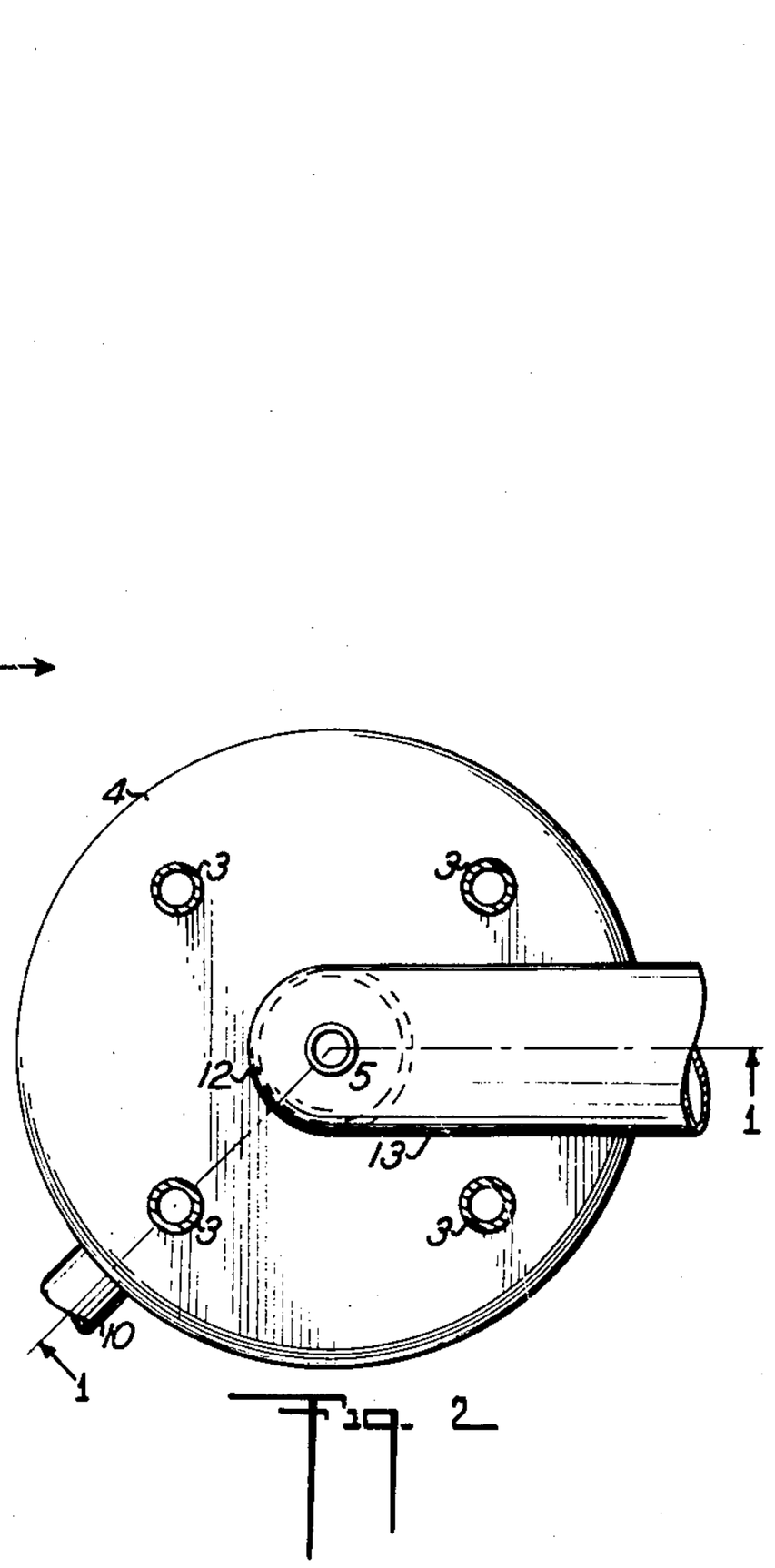

Fig. 2

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Fig. 3.

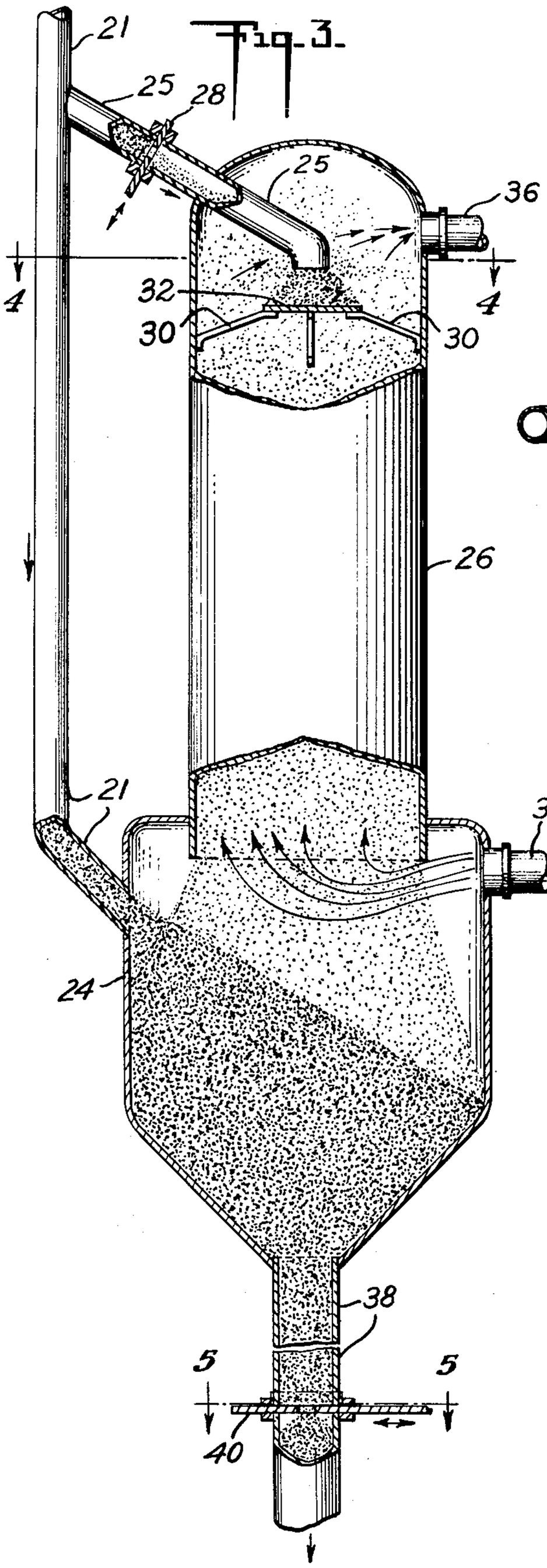


Fig. 4.

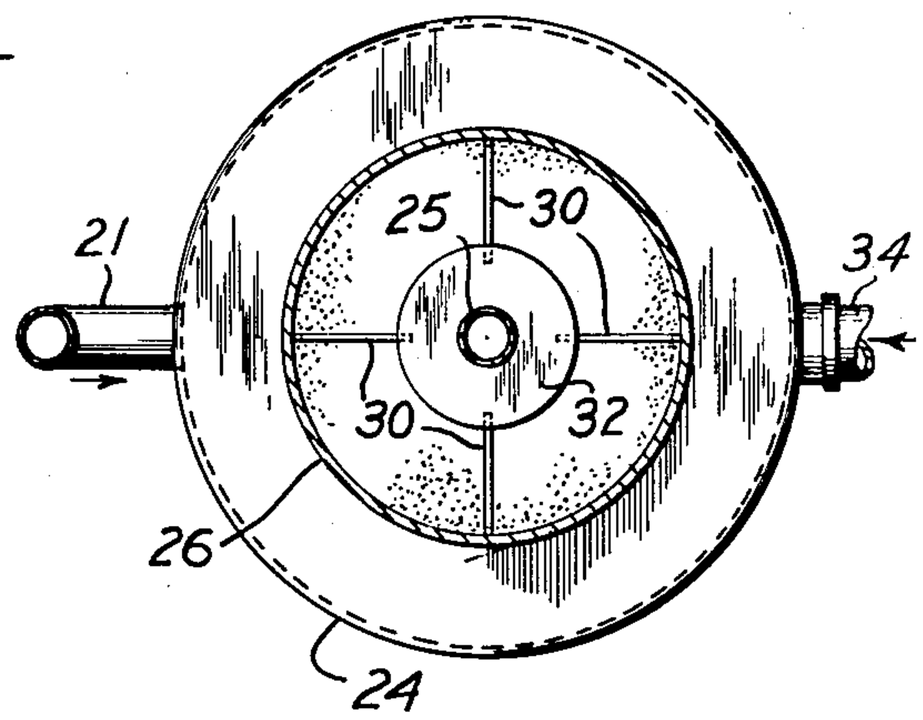
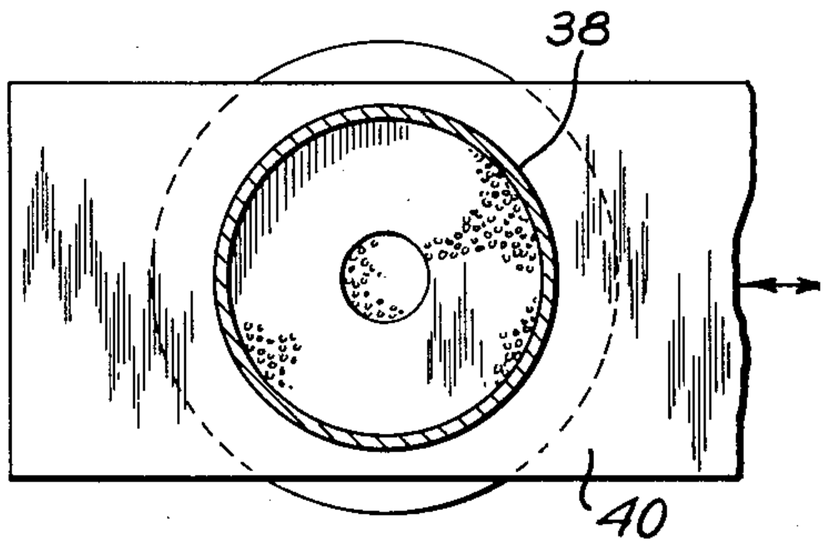


Fig. 5.



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ELUTRIATION OF FINES

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This invention relates to apparatus for recycling gravitating beds of solids in particle form of the type widely used in the conversion or cracking of hydrocarbons; and, more particularly, to the separation therefrom of "fines" or minute solid particles.

In recycling systems for handling a moving bed of particle form solids of the type referred to, the solids which are of granular size (for example, in the range of 4 to 16 mesh, as determined by standard Tyler screens) produce fines, or minute solid particles of considerably smaller size as the result of attrition. The presence of these fines is sometimes highly objectionable, as an accumulation thereof might effect a substantial change in the operating characteristics of the system by changing the pressure gradients existing between various regions thereof. It is therefore desirable, and in some instances absolutely essential, to remove from the moving bed of particle form solids the fines that are present therein. This removal of fines from the primary solids-recycling system is conveniently conducted by diverting a portion of the circulating solids as a side stream to an elutriating system operating to remove fines from that stream and return larger sized particles to the primary solids-recycling system.

It is among the objects of the present invention to provide an improved apparatus for elutriating fines.

Another object of the invention is to provide an elutriator operating under substantially constant conditions in a system of the type described, wherein the solid granular particles which have been freed of fines can be returned to the primary solids-recycling system at a region having a pressure substantially different from that existing in the elutriation zone.

The desired objectives are obtained in accordance with the present invention by maintaining a seal leg establishing the desired pressure differential between the elutriation zone and the region of return of the elutriated solids to the main solids circulating stream, the seal leg being maintained constant by a substantially compact bed of granular solids immediately thereabove, which bed is kept at a constant level.

The foregoing and other objects and advantages of the invention will be apparent from the following specification when considered along with the accompanying drawing in which:

Figure 1 is an elevation, partly in section, of an apparatus which has been constructed in accordance with the teachings of the present invention;

Figure 2 is an enlarged view taken along the line 2—2 of Figure 1;

Figure 3 is a view which is similar to the view of Figure 1, but illustrating a modified form of the present invention;

Figure 4 is a sectional view on the line 4—4 of Figure 3; and

Figure 5 is an enlarged view on the line 5—5 of Figure 3.

Referring more particularly to the drawings, the numeral 1 designates an inlet conduit through which a stream of solids constituting a portion of the solids in the primary solids-recycling system is charged to the elutriator. The solids may come from a chute at or near the top of a mechanical solids-elevator or from a gas lift disengaging chamber. This solids inlet conduit 1 is superposed on, and communicates with, a distribution chamber 2 which is adapted to receive a substantially compact column of particle form solids ranging in size from "fines" (or minute solid particles) to granular solids having considerably larger dimensions as, for example, in the range of about 4 to 16 mesh (as determined by standard Tyler screens).

The bottom of the distribution chamber 2 communicates with a plurality of downwardly extending elongate downcomers 3. The lower ends of the elongate downcomers 3 communicate with the top of, and extend into, a collection chamber 4.

A vertically disposed solids feed conduit 5 communicates with the central portion of the bottom of the distribution chamber 2, is provided with a control valve 6, and terminates short of the collection chamber 4 in a manner, and for a purpose, which will be later described.

The side-wall and top of the collection chamber 4 are provided with gas inlet and gas outlet ports, as at 7 and 8, respectively, while its bottom is provided with an outlet port 9 for solids. Gas is supplied to the gas inlet port 7 through a pipe 10, while solids are conducted from the solids outlet port 9 through a conduit 11 which may discharge the solids into any convenient region of the primary solids-recycling system, as into a kiln or into a gas lift supply hopper.

A vertically disposed cylindrical gas outlet conduit 12 communicates with the gas outlet port 8 in the top of the collection chamber 4, and discharges into a gas-solids separator, such as a cyclone (not shown), as by means of an angular extension 13.

An important feature of the apparatus of the present invention resides in the termination of the elongate downcomers 3 at a point 14 which is in spaced relationship with respect to the bottom of the collection chamber 4; while the lower end of the cylindrical gas outlet conduit 12 may either terminate at the top of the collection chamber 4 or extend slightly downwardly thereinto, so long as it remains spaced above point 14, as indicated at 15.

Referring to Figure 1 which, it will be noted, is taken on the line 1—1 of Figure 2, the solids feed conduit 5 extends concentrically downward into the cylindrical gas outlet conduit 12, as through the upper wall of its junction with its right-angular extension 13, and terminates at a point 16 within the vertical conduit 12.

According to the foregoing construction and arrangement, the axis of the gas outlet conduit 12 is wholly within the path of solids which are discharged through the lower end 16 of the vertically disposed solids feed conduit 5.

In operation:

The particle form solids employed in a conventional solids-recycling system, as exemplified by a hydrocarbon cracking system, are permitted to flow by gravity through the reacting apparatus and, upon reaching the lowest point in the system, are customarily elevated by a mechanical elevator or a gas lift to the top of the system, from which point the solids recommence their cyclic movement. A portion of the circulating solids is withdrawn as a side stream from any convenient high point in the gravitating portion of the primary solids-recycling system and, after passage through an elutriator, is returned (partially freed of fines) to a lower point in the gravitating portion of the system.

The solids withdrawn from the primary solids-recycling

system are conducted in a substantially compact gravitating column of fines and granular particles through the solids inlet conduit **1** to the distribution chamber **2**. A portion of these solids will then pass through the solids feed conduit **5**, while the remainder gravitates through the elongate downcomers **3**. The solids discharging from the lower ends **14** of the downcomers **3** form, in collection chamber **4**, a constant-level gravitating bed whose surface A is disposed below the elutriating gas inlet port **7** and also below the lower end **15** of the gas outlet conduit **12**.

An inert or compatible elutriating gas is passed through the gas inlet port **7** into the collection chamber **4**, from which it flows upwardly through the gas outlet conduit **12** and out of its right-angular extension **13** which may, if desired, be connected to a cyclone separator (not shown) for the removal of the fines from the elutriating gas prior to the venting of this gas to the atmosphere.

The solids which pass downwardly through the solids feed conduit **5** are discharged from the lower end **16** thereof in a free-falling stream which terminates at the surface A of the gravitating bed in the collection chamber **4**. The elutriating gas is admitted to the collection chamber **4** in such quantities that the velocity of its upward flow through the gas outlet conduit **12** will be sufficient to lift only the fines which are present in the stream of falling solids, whereupon the larger granular solids fall into the gravitating bed in the collection chamber **4**, while the fines are impelled upwardly through the gas outlet conduit **12** and its right-angular extension **13** by the elutriating gas.

The solids in the gravitating bed in the collection chamber **4** pass through the solids outlet port **9** and are returned through the solids outlet conduit **11** to the primary recycling system at a point below the elutriator. Since the region, in the primary recycling system, to which the partially elutriated solids are returned, is usually maintained at pressures which are substantially different from those existing in the elutriator, the solids outlet conduit will act as a pressure seal therebetween. This seal leg is maintained substantially constant by reason of the fact that the downcomers **3** provide a moving bed within the elutriator having a substantially constant level, whereby the elutriation of fines from a stream of solids is effected under substantially constant operating conditions.

As before stated, in Figures 3, 4 and 5, there is disclosed a modified form of the apparatus of the present invention. According to this modification, there is provided an inlet conduit **21** through which a stream of solids constituting a portion of the solids in the primary solids-recycling system is charged to the elutriator. The lower end of this inlet conduit **21** communicates with a collection chamber **24** which may be identical in size and shape with the collection chamber **4** of Figures 1 and 2.

A branch feed pipe **25** is connected to, and communicates with, the upper portion of the inlet conduit **21** and communicates with the upper portion of a cylindrical vessel **26** which is superposed upon the collection chamber **24**. In order to regulate the flow of solids through the branch feed pipe **25**, a conventional orifice plate **28** is provided, as shown.

The cylindrical vessel **26** is of smaller diameter than the collection chamber **24**; and adjacent its upper end, it is provided with a plurality of spaced and upwardly converging supporting elements **30**, which, between them, support a centrally disposed target plate **32**. The upper portion of the collection chamber **24** is provided with a gas inlet **34**, while the upper end of the cylindrical vessel **26** is provided with a gas outlet **36**.

Solids are conducted from the collection chamber **24** through a conduit **38** which may discharge into any convenient region of the primary solids-recycling system, as into a kiln or into a gas lift supply hopper. In order to control the flow of solids through the conduit **38**, an

orifice plate **40** is provided, the same being similar in construction and function to the aforementioned orifice plate **28**, but providing an orifice of larger size.

It will be understood by those skilled in the art that the solids outlet conduit **11** of Figure 1 may be supplied with an orifice plate similar to the orifice plate **40**, or, in lieu thereof, a smaller conduit may be used.

The operation of the modified embodiment is similar in principle to that of the embodiment previously described. The freely falling solids passing through the vessel **26** are traversed by the countercurrently moving gas admitted through inlet **34**, which gas suspends the fines and removes the same through the outlet **36**, while the coarse particles drop on the bed in collection chamber **24**.

According to the foregoing, the apparatus of the present invention provides for completely contacting a stream of solids with a countercurrently flowing elutriating gas, whereby a substantially complete removal of fines from the stream of solids is effected under substantially constant operating conditions, while the elutriated solids are returned to a region in the primary solids-recycling system which has a substantially different pressure than that existing in the elutriator.

While there have been shown and described herein certain specific embodiments of the present invention, it will be readily understood that the invention is not to be limited exactly thereto, since various modifications may be made without departing from the scope of the invention as defined in the appended claims.

We claim:

1. In a system for contacting fluids with moving granular solids continuously circulating as a body through said system, the method of removing fines from said circulating body of solids which comprises continuously withdrawing a fraction of the solids from said circulating body as a compact moving stream, splitting said fraction into two separate portions, continuously introducing one of said portions as an extension of said compact moving stream into a confined zone and depositing the same directly onto the surface of a compact moving bed of accumulated solids maintained at the bottom of said zone, withdrawing solids from the bottom of said bed and passing the same downwardly as an elongated compact moving column, discharging solids from the lower end of said column at a controlled rate effective to maintain the solids comprising said stream, said bed and said column as a continuous compact moving mass, introducing the other of said portions of solids as a free-falling stream into the upper region of said zone at a controlled rate which is less than the rate of solids discharge from the lower end of said column, passing a stream of gas within said zone countercurrently through said free-falling stream of solids at a velocity effective to suspend said fines while permitting the larger-size solids to be deposited on the exposed surface of said bed, and discharging the mixture of gas and suspended fines at the upper end of said zone, the combined length of the compact mass of solids comprising said bed and said column being sufficient to maintain a constant pressure seal between said zone and the zone receiving the discharge of solids from said column.

2. The method in accordance with claim 1 wherein said column of solids is discharged into a region having a pressure substantially different from the pressure in said elutriation zone.

3. The method in accordance with claim 1 wherein said system comprises a hydrocarbon conversion unit and said compact column of solids is discharged into the kiln of such system.

4. The method in accordance with claim 1 wherein said system comprises a gas-lift and said column of solids is discharged into the gas-lift supply hopper.

5. In a system for contacting fluids with moving granular solids continuously circulated as a body through said system, apparatus for removing fines from said body of

granular solids comprising an elongated upright vessel having a relatively narrow upper section in open communication at its lower end with the upper end of a wider lower section, a solids supply pipe extending downwardly from a location above said vessel and being branched at a level which will permit gravitational flow of solids to the upper end of said vessel, one of the branch pipes being in open communication with the upper region of said upper section and being adapted to introduce therein a free-falling stream of solids, and the remaining one or more of said branch pipes being in open communication with said lower section at an intermediate level therein, an elongated solids discharge conduit at the bottom of said vessel, means at the lower end of said conduit for controlling the flow of solids therefrom in order to maintain a rate of solids discharge lower than the maximum possible rate of supply of solids to said supply pipe, but higher than the rate of solids flow from said first-mentioned branch pipe, thereby maintaining a compact moving bed of solids in the bottom of said lower section and spaced from said upper section, said bed being replenished at least in part by solids discharging as a compact moving stream from said remaining one or more branch pipes, gas inlet means in said lower section discharging at a level above the surface of said bed, and gas outlet means at the upper end of said upper section.

6. Apparatus according to claim 5 wherein said branch pipe for introducing a free-falling stream of solids into the upper region of said upper section is provided with flow control means.

7. In a process wherein a body of granular solids is continuously passed through a solids-recycling system, with resultant production of fines, and wherein a fractional portion of said body is withdrawn from said system, is contacted with gas in an elutriating zone for the removal of said fines and is thereafter returned to said system at a separate location which is maintained at a pressure substantially different from the pressure within said elutriating zone, the steps which comprise: passing the fines-free portion of withdrawn solids by force of gravity from said elutriating zone to a confined collecting zone therebelow and depositing the same by free fall upon the surface of a compact moving bed of solids maintained within said collecting zone, said collecting zone and said elutriating zone being in such constant open communication as to provide substantially unrestricted gaseous flow therebetween; introducing an additional fractional portion of said body of solids as a compact moving stream directly to the surface of said bed so as to maintain said bed at a constant level; and passing the combined fractional portions of withdrawn solids from said bed to said separate location as an elongated compact moving column adapted to provide a seal leg sufficient to maintain the desired differential pressure between said location and said elutriating and collecting zones.

8. The method according to claim 7 wherein said first-mentioned fractional portion of solids and said additional fractional portion of solids are withdrawn from said system as a common compact moving stream.

9. The method according to claim 7 wherein the rate of solids introduction into said elutriating zone and the rate of solids discharge from said collecting zone are constant, said rate of discharge being greater than said rate of introduction thereby maintaining said constant bed level by continuous flow of said additional portion of solids onto the surface of said bed.

10. The method according to claim 7 wherein said elutriating zone and said collecting zone are adjacent superimposed zones having open communication therebetween.

11. The method according to claim 10 in which said collecting zone comprises a lower expanded extension of said elutriating zone.

12. In a process wherein a body of granular solids is continuously passed through a solids-recycling system,

with resultant production of fines, and wherein a fractional portion of said body is withdrawn from said system, is contacted with gas in an elutriating zone for the removal of said fines and is thereafter returned to said system at a separate location which is maintained at a pressure substantially different from the pressure within said elutriating zone, the steps which comprise: passing the substantially fines-free portion of withdrawn solids by force of gravity from said elutriating zone to a confined collecting zone therebelow and depositing the same by free fall upon the surface of a compact moving bed of solids maintained within said collecting zone, said collecting zone and said elutriating zone being in open communication with substantially unrestricted gaseous flow therebetween; introducing an additional fractional portion of said body of solids as a compact moving stream to the surface of said bed thereby maintaining said bed at a substantially constant level; and withdrawing solids from said bed as a confined compact stream of sufficient length to provide a seal leg capable of maintaining the desired differential pressure between said separate location and said elutriating and collecting zones.

13. In apparatus for continuously circulating a body of granular solids including means arranged to provide a downflow path through which said body gravitates and an elutriating chamber adapted to contact a free-falling stream of said solids with a countercurrently flowing stream of gas for the removal of fines produced by such circulation, said downflow path having an upper region from which a fractional portion of said body is withdrawn by gravity flow to provide said free-falling stream and a lower region, maintained at a pressure substantially different from the pressure within said elutriating chamber, to which elutriated solids are returned by gravity flow, the combination of: a collecting chamber below said elutriating chamber adapted to contain a compact moving bed of solids, said chambers being so connected and arranged as to provide constant open communication and unrestricted passage of elutriated solids therebetween with free fall of said solids onto the surface of said bed; means for controlling the rate of flow of withdrawn solids into said elutriating zone; means for passing solids as an elongated compact moving column from said bed to said lower region of said downflow path; means for controlling the flow of solids from the bottom of said column into said lower region; and means for introducing additional withdrawn solids as a compact moving stream directly onto the surface of said bed so as to maintain said bed at a substantially constant level, said means for passing solids from said bed to said lower region of said downflow path being of such length that said compact moving column provides a seal leg between said elutriating chamber and said lower region.

14. Apparatus as in claim 13 in which said collecting chamber is larger than said elutriating chamber and extends around and below the lower end portion of said elutriating chamber, and including means for introducing said stream of gas into the upper region of said collecting chamber above the surface of said bed and out of contact with said free-falling stream of solids.

15. In apparatus for continuously circulating a body of granular solids including means arranged to provide a downflow path through which said body gravitates and an elutriating chamber adapted to contact a free-falling stream of said solids with a countercurrently flowing stream of gas for the removal of fines produced by such circulation, said downflow path having an upper region from which a fractional portion of said body is withdrawn by gravity flow to provide said free-falling stream and a lower region, maintained at a pressure substantially different from the pressure within said elutriating chamber, to which elutriated solids are returned by gravity flow, the combination of: a collecting chamber below said elutriating chamber adapted to contain a compact moving bed of solids, said chambers being so connected

and arranged as to provide constant open communication and unrestricted passage of elutriated solids therebetween with free fall of said solids onto the surface of said bed; means for controlling the rate of flow of withdrawn solids into said elutriating zone; means for withdrawing solids from the bottom of said collecting chamber adapted to provide an elongated compact moving column of solids of sufficient length to form a seal leg capable of maintaining the desired differential between said lower region of said downflow path and said collecting and elutriating chambers; means for controlling the flow of solids from said compact moving column to said lower region of said downflow path; and means for introducing additional solids withdrawn from said upper region of said downflow path as a compact moving stream discharging directly onto the surface of said bed to thereby maintain said

bed at a substantially constant level within said collecting chamber.

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