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PATENT SPECIFICATION

DRAWINGS ATTACHED

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COMPLETE SPECIFICATION

Improvements relating to Solids/fluid Contacting apparatus

5 We, BATAAFSE PETROLEUM MAATSCHAPPIJ N.V., (formerly known as N.V. De Bataafsche Petroleum Maatschappij), a company organised under the laws of The Netherlands, of 30 Carel van Bylandtlaan, The Hague, The Netherlands, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

10 The invention relates to apparatus for effecting contact between a bed of granular solids and a fluid which may be a liquid, a vapour or gas, wherein the fluid passes through both the bed and screening means adjoining the bed. Such apparatus may be used, for example, as a chemical reactor in a catalytic process, such as a catalytic desulphurization process wherein hydrocarbon vapour derived from heavy naphtha containing sulphur compounds is passed through a bed containing particulate cobalt-molybdenum catalyst to convert the sulphur compounds to hydrogen sulphide.

25 In such apparatus it is often necessary to mount a screen within the vessel near the bed of solids, either on the upstream side thereof to prevent entrained matter from being carried into the bed and/or on the downstream side to retain the solids. It has been found in practice that such screens become fouled in time, leading to reduced fluid flow rates which become so low that the unit must be shut down for cleaning, and attempts have been made to extend the on-stream life of the screens by forming them in shapes which provide for a total screen area greater than the cross sectional area of the vessel, as by giving the screen a conical shape. However, it was further found that clogging occurs also at the surface of the bed. For example, it is not feasible, without incurring at excessively high pressure drop, to use a sufficiently fine screen on the upstream side of the bed to remove all

45 entrained matter, and as a result of not using such a screen a layer is formed at the bed surface which soon significantly interferes with the entry of the fluid into the bed; or the bed surface may become clogged by the deposition of matter from impurities carried in the fluid state with the fluid stream. It has also been sought to provide screening means in the form of a layer of ceramic balls or other discrete bodies of inert solid material, and of a size several times greater than that of the particles of the bed, but in this case also it is found that the finer particles of entrained material pass through the screening layer and are deposited in the solids bed itself, leading to a high pressure drop and consequent shut-down. 50 55 60

It is the object of the invention to provide an improved apparatus for contacting a fluid with a bed of subdivided solids wherein the on-stream time is extended. 65

According to the present invention, an apparatus for effecting contact between fluid and granular solids comprises a tank; a bed of granular solids in a portion of said tank constituting a solids chamber; screening means engaging the upper horizontal surface of said bed and dividing the interior of said tank into the solids chamber and an ante-chamber, said screening means offering substantially no resistance to fluid flow through the tank and maintaining the surface of said bed in an extended form with an area at least about three times greater than the cross sectional area of said tank; and inlet and outlet means for said tank, one of which communicates with said antechamber and the other with said solids chamber for the flow of a fluid successively through said chambers and through said screening means and bed of granular solids. By this means the surface area of the bed of granular solids (specifically, for example, a catalyst bed) at which the fluid enters the body (or leaves it) is substantially extended so that 70 75 80 85

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area

any clogging which occurs at the surface is spread out over a larger area; this enables the onstream time of the apparatus to be significantly prolonged.

5 A particular form of screening means suitable for the purpose of the invention comprises a partition and a plurality of cylindrical screens connected at one end to openings in said partition and being closed at the
10 other end with screen material, having the closed ends thereof extending into the bed of solids, so that the sides and closed ends of the cylindrical screens are in contact with the solids. The partition is preferably itself
15 formed of screen material i.e. formed all over with a large number of holes or perforations; and may include a supporting frame, serving also to secure it in the tank. The partition may be slightly spaced from the surface of
20 the bed, far enough to leave room for the passage of fluid between the partition itself and the surface of the bed, since otherwise access of fluid to the bed surface would be restricted by the supporting frame, but close
25 enough for the cylindrical screens to extend over the greater part of their length into the bed of solids.

Another form of screening means suitable for the purpose of the invention is a layer of
30 discrete particles of inert material, part of which layer extends into deep depressions formed in the upper surface of the bed of granular solids so as to maintain said depressions in being in the configuration of said sur-
35 face, said depressions being of such dimensions that the surface area of the bed is at least about three times greater than the cross-sectional area of the tank and the depth of the depressions below the upper surface of the
40 bed forms the greater part of the total depth of particles of inert material. The inert bodies are preferably of an average size at least about three times greater than that of
45 the particles of granular solid and may most conveniently be in the form of ceramic balls of uniform size.

The invention also includes a method of setting up an apparatus having screening means of the kind last mentioned, said method
50 comprising insertion into the surface of a bed of granular solids contained in a tank a plurality of tubes, filling the tubes with discrete particles of inert material, adding further granular solids round the outsides of the
55 tubes and then withdrawing the tubes, and, before or after the withdrawal of the tubes, adding a layer of the discrete particles to cover the whole surface of the body of granular solids.

60 The invention will be described with reference to the accompanying drawings showing three preferred embodiments, wherein:—

Figure 1 is a vertical sectional view through a vessel constructed in accordance with the
65 invention,

Figure 2 is a transverse sectional view, taken on the line 2—2 of Figure 1;

Figure 3 is an enlarged sectional view of one cylindrical screen and a part of the deck-screen and framework, taken on the line 3—3
70 of Figure 2;

Figure 4 is a plan view of Figure 3;

Figure 5 is a view corresponding to a portion of Figure 3 showing a modified shape
75 of the cylindrical screen; and

Figure 6 and 7 are vertical sections similar to Figure 1 showing two stages in the setting up of a third embodiment of the invention.

Referring to Figures 1—4 of the drawing, 80 the apparatus includes a tank 10 having a separate dome 11 fitted with a flanged nozzle 12 for connection to a supply pipe. A false bottom 13, including a framework and a perforated plate, supports a loose bed of granular material 14. The space 15 beneath the
85 false bottom communicates with a discharge nozzle 16. The tank may include one or more manways, such as is shown at 17, closed by a plate 18.

The tank contains near the top a transverse partition 19 which divides the tank into a lower solids-chamber 20, containing the afore-
90 mentioned bed of solids, and an antechamber 21. The partition 19 consists of a metallic deck screen 24 formed of woven wires and stiffened by a framework of structural angle
95 bars 22, which are supported by a ring 23 welded to the inside of the tank, the framework 22 being secured to the screen 24 by bolts and washers 25.

A plurality of holes are formed in the deck screen 24 to each of which is fastened
100 a pendant, cylindrical screen 26. As is shown in Figures 3 and 4, each screen 26 has a cylindrical side 27 carrying a flat bottom 28 and a rim 29, all made of metallic woven
105 wire screen, and joined to one another by soldering or brazing. The baskets extend down through the openings in the deck screen with the rims 29 resting on the deck screen
110 and secured thereto by bolts and washers 30.

It will be noted from Figure 1 that the upper level of the bed 14 is spaced beneath
115 the partition by a short distance which is less than the heights of the pendant screens, and that the latter therefore extend into the bed, so that the solid particles are in contact not only with the bottom 28 but also with the side
120 27.

When used, for example, as a chemical catalytic reactor to convert sulphur compounds such as thiophenes into hydrogen sulphide, the
125 solids 14 are small catalyst particles containing, as active constituents cobalt and molybdenum, such as pellets of the same size, for example 3/16 in., 1/12 in. or 1/6 in. A hydrocarbon vapor, such as heavy naphtha containing the said sulphur compounds, is ad-
130 mitted through the nozzle 12 into the ante-



particles

chamber 21 and passes through the deck screen 24 and the several pendant screens 26 into the bed 14. The converted vaporous mixture of hydrocarbons and hydrogen sulphide is discharged through the nozzle 16. The screens intercept most of the scale and other foreign bodies which would otherwise foul the bed. By arranging the screens as shown much of the scale is able to collect at the bottoms of the pendant screens, leaving the sides unclogged. However, the action of the screens is imperfect and small solids are carried through the screens into the bed. By engaging the pendant screens in the bed these entrained solids are distributed over a greater boundary area of the bed, and the bed can be operated for an extended period without shut-down for cleaning.

By way of example, a reactor 6.5 feet in diameter applied to the service and with the catalyst described in the preceding paragraph had to be cleaned on an average of about every three months when provided with a deck screen of stainless steel, square mesh, 8 meshes per inch, but without the pendant screens. When the reactor was modified to provide thirty-nine pendant screens, as shown in Figures 1-4, each 16 inches deep and 5-7/8 inches in diameter and made of like screen stock, the onstream time between cleaning was prolonged to 18 months.

Figure 5 shows a modification wherein the screens 26a are conical in shape.

Figures 6 and 7 show an intermediate and final stage in the setting up of an apparatus employing a layer of ceramic balls as the screening means. In Figure 6 the tank 10 has its dome 11 removed and is part-filled with a bed of loose granular material 14. Into the surface of the bed are inserted a number of tubes 31 which are then filled with ceramic balls 32. The tank 10 is then filled with further granular material up to the level 33 indicated by a dotted line. Thereafter the tubes are withdrawn, leaving the balls 32 in position as shown in Figure 7, and a further layer of balls 34 is added before the dome 11 is replaced. Alternatively, the tubes may be withdrawn after addition of the layer of balls 32.

By way of example, a reactor 5.3 feet in diameter, employed for the purpose and with a catalyst as described above, can be set up by the use of 28 tubes each about 3 feet long and 3 inches in diameter, the ceramic balls employed being of the same size and about 1/2 inch in diameter. By this means, the on-stream time between cleaning was prolonged from six months (in a reactor having a screen consisting only of a 33 inch layer of ceramic balls) to eighteen months. If desired, the ceramic balls could have been of the same size and about 1 inch in diameter.

WHAT WE CLAIM IS:—

1. Apparatus for effecting contact between fluid and granular solids, comprising a tank; a

bed of granular solids in a portion of said tank constituting a solids chamber; screening means engaging the upper horizontal surface of said bed and dividing the interior of said tank into the solids chamber and an antechamber, said screening means offering substantially no resistance to fluid flow through the tank and maintaining the surface of said bed in an extended form with an area at least about three times greater than the cross sectional area of said tank; and inlet and outlet means for said tank, one of which communicates with said antechamber and the other with said solids chamber for the flow of a fluid successively through said chambers and through said screening means and bed of granular solids.

2. An apparatus according to claim 1, comprising, as the screening means, a partition and a plurality of cylindrical screens connected at one end to openings in said partition and being closed at the other end with screen material, having the closed ends thereof extending into the bed of solids.

3. Apparatus according to claim 2, wherein the partition is so spaced from the surface of the bed as to allow passage of fluid between the partition and the surface of the bed but is close enough for the cylindrical screens to extend over the greater part of their length into said bed.

4. Apparatus according to claim 2 or 3, comprising a supporting frame for the partition, said partition being formed of screen material.

5. Apparatus according to claim 1, comprising, as the screening means, a layer of discrete particles of inert material, part of which layer extends into deep depressions formed in the upper surface of the bed of granular solids so as to maintain said depressions in being in the configuration of said surface, said depressions being of such dimensions that the surface area of the bed is at least about three times greater than the cross-sectional area of the tank, and the depth of the depressions below the upper surface of the bed forms the greater part of the total depth of particles of inert material.

6. Apparatus according to claim 5, wherein the particles of inert material are of an average size at least about three times greater than the particles of granular solid.

7. Apparatus according to claim 6, wherein the particles of inert material are ceramic spheres.

8. Apparatus according to any one of the preceding claims, wherein the screening means are disposed in the upper part of the tank, dividing the interior thereof into a larger and lower solids chamber and a smaller and upper antechamber.

9. Apparatus according to any of the preceding claims, wherein the granular solids are catalyst particles.

chamber 21 and passes through the deck screen 24 and the several pendant screens 26 into the bed 14. The converted vaporous mixture of hydrocarbons and hydrogen sulphide is discharged through the nozzle 16. The screens intercept most of the scale and other foreign bodies which would otherwise foul the bed. By arranging the screens as shown much of the scale is able to collect at the bottoms of the pendant screens, leaving the sides unclogged. However, the action of the screens is imperfect and small solids are carried through the screens into the bed. By engaging the pendant screens in the bed these entrained solids are distributed over a greater boundary area of the bed, and the bed can be operated for an extended period without shut-down for cleaning.

By way of example, a reactor 6.5 feet in diameter applied to the service and with the catalyst described in the preceding paragraph had to be cleaned on an average of about every three months when provided with a deck screen of stainless steel, square mesh, 8 meshes per inch, but without the pendant screens. When the reactor was modified to provide thirty-nine pendant screens, as shown in Figures 1-4, each 16 inches deep and 5-7/8 inches in diameter and made of like screen stock, the onstream time between cleaning was prolonged to 18 months.

Figure 5 shows a modification wherein the screens 26a are conical in shape.

Figures 6 and 7 show an intermediate and final stage in the setting up of an apparatus employing a layer of ceramic balls as the screening means. In Figure 6 the tank 10 has its dome 11 removed and is part-filled with a bed of loose granular material 14. Into the surface of the bed are inserted a number of tubes 31 which are then filled with ceramic balls 32. The tank 10 is then filled with further granular material up to the level 33 indicated by a dotted line. Thereafter the tubes are withdrawn, leaving the balls 32 in position as shown in Figure 7, and a further layer of balls 34 is added before the dome 11 is replaced. Alternatively, the tubes may be withdrawn after addition of the layer of balls 32.

By way of example, a reactor 5.3 feet in diameter, employed for the purpose and with a catalyst as described above, can be set up by the use of 28 tubes each about 3 feet long and 3 inches in diameter, the ceramic balls employed being of the same size and about 1/2 inch in diameter. By this means, the on-stream time between cleaning was prolonged from six months (in a reactor having a screen consisting only of a 33-inch layer of ceramic balls) to eighteen months. If desired, the ceramic balls could have been of the same size and about 1 inch in diameter.

WHAT WE CLAIM IS:—

1. Apparatus for effecting contact between fluid and granular solids, comprising a tank; a

bed of granular solids in a portion of said tank constituting a solids chamber; screening means engaging the upper horizontal surface of said bed and dividing the interior of said tank into the solids chamber and an antechamber, said screening means offering substantially no resistance to fluid flow through the tank and maintaining the surface of said bed in an extended form with an area at least about three times greater than the cross sectional area of said tank; and inlet and outlet means for said tank, one of which communicates with said antechamber and the other with said solids chamber for the flow of a fluid successively through said chambers and through said screening means and bed of granular solids.

2. An apparatus according to claim 1, comprising, as the screening means, a partition and a plurality of cylindrical screens connected at one end to openings in said partition and being closed at the other end with screen material, having the closed ends thereof extending into the bed of solids.

3. Apparatus according to claim 2, wherein the partition is so spaced from the surface of the bed as to allow passage of fluid between the partition and the surface of the bed but is close enough for the cylindrical screens to extend over the greater part of their length into said bed.

4. Apparatus according to claim 2 or 3, comprising a supporting frame for the partition, said partition being formed of screen material.

5. Apparatus according to claim 1, comprising, as the screening means, a layer of discrete particles of inert material, part of which layer extends into deep depressions formed in the upper surface of the bed of granular solids so as to maintain said depressions in being in the configuration of said surface, said depressions being of such dimensions that the surface area of the bed is at least about three times greater than the cross-sectional area of the tank, and the depth of the depressions below the upper surface of the bed forms the greater part of the total depth of particles of inert material.

6. Apparatus according to claim 5, wherein the particles of inert material are of an average size at least about three times greater than the particles of granular solid.

7. Apparatus according to claim 6, wherein the particles of inert material are ceramic spheres.

8. Apparatus according to any one of the preceding claims, wherein the screening means are disposed in the upper part of the tank, dividing the interior thereof into a larger and lower solids chamber and a smaller and upper antechamber.

9. Apparatus according to any of the preceding claims, wherein the granular solids are catalyst particles.



10. A method of setting up an apparatus according to claim 6 or 7, said method comprising inserting into the upper surface of a bed of granular solids contained in a tank a plurality of pipes, filling said pipes with discrete particles of inert material, filling said tank around said pipes with further granular solids and then withdrawing said pipes, and, before or after withdrawing said pipes, adding a layer of the discrete particles completely covering said further granular solids.

11. Apparatus for effecting contact between a fluid and granular solids, set up by the method claimed in claim 10.

12. Apparatus for effecting contact between a fluid and granular solids substantially as described with reference to Figures 1—4, Figure 5 or Figure 7 of the accompanying drawings.

13. Apparatus for effecting contact between a fluid and granular solids, substantially as described.

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