Dec. 28, 1965 H. H. STOTLER ETAL 3,226,204

BAFFLED REACTOR

Filed Jan. 4, 1962

FIG. 1

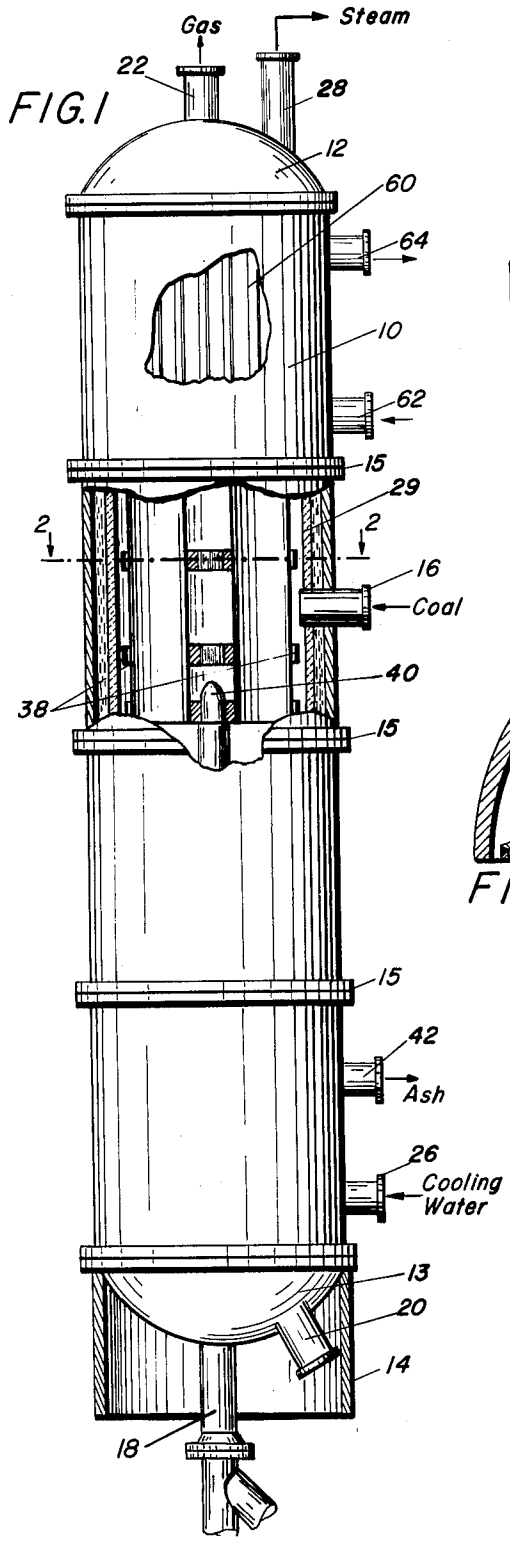
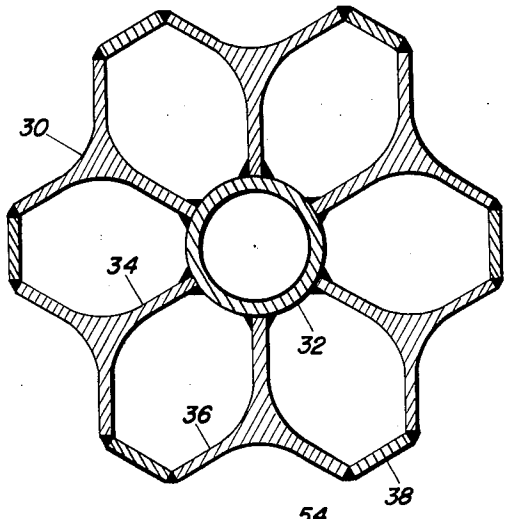


FIG. 2



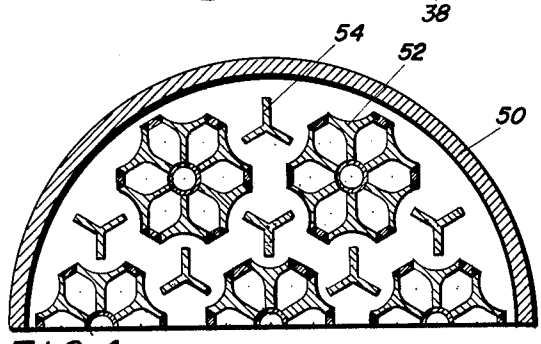


FIG. 4

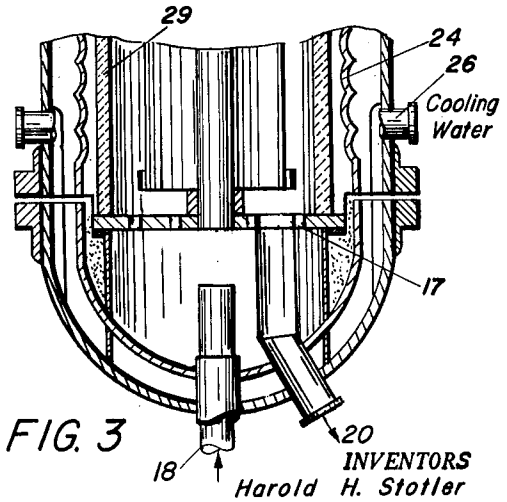


FIG. 3

INVENTORS
Harold H. Stotler
George B. Farkas
Percival C. Keith

BY Nathaniel Ely
Attorney

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BAFFLED REACTOR

Harold H. Stotler, Westfield, N.J., George B. Farkas, Jackson Heights, N.Y., and Percival Cleveland Keith, Peapack, N.J., assignors to Hydrocarbon Research, Inc., New York, N.Y., a corporation of New Jersey

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7 Claims. (Cl. 23—284)

This invention relates to improvements in reactors of the type which are primarily adapted for carrying out high temperature and high pressure gaseous reactions in the presence of a fluidized bed of particulate solids. It is an improvement on the invention disclosed in the patent of Keith, 2,995,426, of August 8, 1961.

The efforts to fluidize relatively fine powders such as iron oxide or coal with gases at high temperatures and high pressures, as for the purpose of reduction and gasification, has developed some unusual problems of maintaining uniform fluidity, avoiding rat-houling of gases, avoiding the formation of bubbles that cause objectionable tremors, avoiding the formation of ash clinkers and obtaining a uniform gas-solids contact.

While it was known that partitioning the mobilized layer with substantially vertical surfaces was effective in certain cases as, for example, when the fluidized bed did not exceed about five feet in depth and was usually about one foot in depth, it was only after subsequent studies of the problem that it was found possible to maintain unusually good gas-solid contact in beds of at least eight feet in depth. As commercial practice required the deeper beds, this became of substantial importance.

The foregoing Keith patent is based on the discovery that in a fluidized bed of this type (such as the gasification of coal fines or the reduction of iron oxides fines) fluidity at elevated temperatures and pressures can be maintained when the extended surface in the fluidized reaction zone, including the area of the walls of the reaction zone, is in the range of from four to twelve square feet for each cubic foot of the fluidized bed.

In the gasification of coal it has been found that powdered coal is somewhat easier to fluidize than iron oxide powder and that the extended surface can be reduced to four square feet for each cubic foot of fluidized bed which has the advantage of reducing capital expenditure.

In accordance with our invention, we have found that the geometry and construction of such baffles, within such extended surface limitation, must be such as to prevent any accidental accumulation of fines and to permit the necessary free flow of particles which tend to move laterally as well as vertically in a fluidized bed.

More specifically, it is the object of our invention to provide a reactor for high temperature, high pressure fluidized reactions which is of a commercial size in diameter and height and having an internal baffling which is adapted to maintain a gas-solids contact comparable to small laboratory scale results.

Another object of our invention is to provide a baffle structure for a fluidized reaction which structure has sufficient mechanical strength to maintain its shape at temperatures in the order of 1800° F. and which gives an extended surface, together with the wall area, of from four to twelve square feet of surface for each cubic foot of bed and permits completely free movement of the fluidized particles in their customary flow paths.

A particular object of our invention is to provide a baffle having Y-shaped baffle elements for a fluidized reactor in which the baffle itself is laterally open to particle flow but vertically continuous to maintain fluidity of solid particles.

Further objects and advantages of our invention will appear from the following description of preferred forms of embodiment thereof when taken with the drawings attached which are illustrative thereof and in which:

FIG. 1 is an elevation, with parts in section of a reactor for high temperature fluidized reactions.

FIG. 2 is a horizontal cross section taken on the line 2—2 of FIG. 1.

FIG. 3 is a vertical cross section through the lower part of FIG. 1 showing the detail of mounting of the baffle.

FIG. 4 is a schematic horizontal section of a modified form of reactor having a multiplicity of baffles.

The reactor **10** of FIG. 1 comprises a cylindrical vessel having a dished top **12** and bottom **13**. Conveniently, the reactor **10** is supported on a cylindrical extension or skirt **14** projecting below the bottom **13** and its associated elements. Such an extension **14** is usually provided with access openings (not shown) and is of sufficient height to give the desired headroom under the reactor.

The shell of the reactor **10** may conveniently be divided into a plurality of sections as suggested by the flange elements **15** to subdivide the reactor into a plurality of reaction stages or zones. However, for the purposes herein, the reactor **10** may be considered to have a vertically continuous internal chamber to form a vertically continuous fluidized bed. On a commercial scale, this would be a bed of from five to fifty feet in height when fluidized and usually would have a diameter of from one to ten feet.

Finely divided solids may be introduced to this chamber in any desired manner as through the side inlet **16** and they will rest on the perforated bottom plate **17** except, of course, when the gases maintain the bed in a fluidized or suspended condition. The fluidizing gases such as oxygen and steam enter as through gas inlet **18** below the bottom plate **17** as shown in FIG. 3 so that the gas passing up through the perforated plate **17** will be uniformly distributed across the bottom of the reactor. Solids may be drained from the system at **20**.

As is well known in the fluidizing art, the velocity of the gas can be regulated to maintain either a dense phase or a disperse phase fluidized bed. This is a function of the particle size and density as well as the velocity and density of the gas. Usually, an expansion is desired which is sufficient to assure complete gas contact with the particles without serious carryover. The reactant effluent discharges from the upper part of the reactor as through outlet **22**.

The reactor shown herein is adapted to be water-cooled and thus has an inner wall lining **24** forming a chamber to which water is suitably introduced as at **26** with the steam removed as at **28**. A brick lining **29** is also customarily used on high temperature coal gasification operations.

With commercial size reactors as defined, we find it necessary in order to maintain fluidization to use internal baffles which, as generally indicated at **30** in FIG. 2, are hereinafter described. It is to be pointed out that the area of the extended surface of these baffles together with the inner exposed wall of the reactor is of the order of four to twelve square feet per cubic foot of bed.

As shown in FIG. 2, the baffle **30** has a central core **32** from which webs or blades **34** extend radially forming baffle elements. These elements **34** are generally of Y shape in cross section with their outer branches **36** suitably secured to the outer branches of adjacent elements through cleats or filler plates **38**. This thus tends to form a wheel shaped assembly one or more of which will extend over the entire cross section of the reaction zone depending on its size.

The respective blade or web portions are also relatively

thin as compared to length to avoid any hold-up of solids. For effective strength, the thickness is usually a small part of the total length.

Referring again to FIG. 1, it will be seen that the central core **32** is preferably a series of vertically spaced discontinuous collars which thus do not impair horizontal intermixing of the particulate solids. Similarly, the cleats or filler plates **38** are also discontinuous and vertically spaced and merely maintain the desired spacing of the extended branch portions. Usually, we prefer to make the baffle sections **30** in several pieces, suitably mounted one on the other as with a bayonet type joint indicated at **40** in FIG. 1.

In a commercial construction for coal gasification, the baffle members **30** are chrome castings adapted to be operated under temperatures in the order of 1800° F.

The invention is particularly suitable for the gasification of coal in silt form for the production of hydrogen. In such case, coal fines usually smaller than 10 mesh are pre-treated as for drying and then blown into a coal feed bin which is adapted to discharge by gravity into a coal hopper. By inert gas means, the powdered coal is then transferred by dense phase transport into the reactor **10** through line **16**.

The reactor **10** for a commercial gasification of coal fines would have a fluid bed of about ten feet in diameter and forty feet deep with a fluidized density of 20 lb./cu. ft. (a settled bed of similar material is about 20 feet high with a settled density of 35–40 lbs./cu. ft.).

Gasification of an anthracite coal fines containing 20% ash with preheated steam and oxygen in a fluidized reactor as described herein operating at 450 p.s.i.g. and 1700° to 1800° F. will yield a product gas containing approximately 37.3% CO, 53.1% H_2 and 9.6% CH_4. The product is produced at a rate of 16,500 s.c.f.h. per square foot of reactor. This type reactor enables safe operation under pressure thereby resulting in production rates several times higher than can be achieved otherwise.

The amount of ash in the coal will vary within wide limits but we find that we can easily remove the ash as through side discharge line **42**. These ashes will be suitably cooled in a well known manner. The minimum superficial velocity of gas as above mentioned will prevent the internal formation of clinkers.

In the gasification of coal, as well as in certain other reactions, we find it especially desirable to partially cool the effluent gases to reduce the carryover of solid particles. As shown in FIG. 1, this may be accomplished with a typical internal heat exchanger **60** to which water may be fed at **62** and from which the steam is removed at **64**.

In certain tests that we have observed, we find that a reduction of temperature from about 1700° F. to about 700° F. reduces the solids carryover to about one sixth of that at the higher temperature.

In a fluidization operation such as coal gasification, it is very important that there be no place for a hang up of ash or agglomeration of coal particles. It will be noted that the webs **34** of the baffle are not only widely spaced to avoid any sharp corners or notches, but they are welded with fillets to give the exposed cross section of the baffle a very free flowing aspect. Furthermore, with the vertically spaced collars **32** and filler plates **38**, there is a complete freedom of the fluidized particles to move laterally as well as downwardly.

In FIG. 4 we have illustrated a reactor indicated at **50** with a series of baffles **52** and supplemental individual webs or blades **54**. For uniform fluidization throughout the cross section of very large reactors, it is desirable to adjust the baffle surface to obtain, as much as reasonably possible, a uniform spacing between baffles and conform to the ratio of four to twelve square feet per cubic foot of bed as hereinbefore referred to. In such case, supplementary open Y baffle elements, such as shown at **54**, may be provided. These will be held in fixed position by suitable means, not shown. These supplementary elements may, of course, be heat exchange tubes if excessive heat is to be added or removed from the fluidized bed.

From a commercial standpoint, the economic production of hydrogen from coal is an important use of the hereinabove described reactor. However, this type reactor can be advantageously used in (1) the reduction of iron ores with hydrogen and/or carbon monoxide; (2) the gasification of carbon formed from the cracking of petroleum oils to produce hydrogen and carbon monoxide; (3) the hydrocracking of petroleum oils; (4) the hydrogenation of coal with hydrogen to produce a fuel gas of reasonable B.t.u. value; (5) or any other process in which intimate contact of gases and solids are desired in a fluidized bed and where the mechanical strength of the reactor internals are limited due to the temperature level of operation; (6) or any process in which localized heat is generated in one or more sections of the fluidized bed and it is desired to distribute this heat uniformly throughout the fluidized bed.

In such cases the solids may be reactants such as coal fines or iron ore (iron oxides) to be reduced, or the solids may be typical catalysts as for hydrodesulfurization or hydrocracking or the solids may of course be inert contact surfaces. In each case, it is contemplated that they will have the typical fineness characteristic of the particular process and in each case, adapted to be fluidized by the flowing gas.

In the reduction of iron ore nearly pure hydrogen is preferred as the reducing gas, temperatures of reduction are above 800° F. and pressures are usually in the order of 200–450 p.s.i.g. as generally set forth in Keith Patent 2,900,246.

Our invention is conceived to be of general application although primarily adapted to high temperature, high pressure fluidized reactors. In view of the various modifications of the invention which will occur to those skilled in the art upon consideration of the foregoing disclosure without departing from the spirit or scope thereof, only such limitations should be imposed as are indicated by the appended claims.

We claim:

1. A reactor for a fluidized high temperature reaction between a gas and a bed of solids which comprises an elongated vertical cylindrical chamber having a fluid bed with a height of from five to fifty feet, said chamber having a support for said bed, means to introduce the solids above said support, means to introduce a gasiform stream substantially uniformly upwardly through said bed at a velocity to fluidize the particles of said bed, and means to maintain a substantially uniform fluidity to said bed including at least one vertically extending baffle member, said member having a plurality of continuous laterally extended blade portions extending throughout the reaction zone, said blade portions having a minimum horizontal surface with reference to the length and width thereof whereby the solids are free to move vertically and laterally with respect to said baffle member, said blade portions extending substantially radially from the baffle member and being of substantially Y shaped with the line of attachment of one blade portion to the baffle member being spaced from the line of attachment of the adjacent blade portion to avoid any sharp corners, the tips of adjacent Y portions being stabilized with respect to each other, said blade portions tending to maintain the uniformity of flow of the gas stream through the reactor, and means to remove the gas stream from the upper part of the reactor.

2. The reactor of claim **1** wherein the area of said baffle member together with the area of the inner surface of the reactor in the fluidized solids zone is in the range of four to twelve square feet per cubic foot of the net volume of the zone unoccupied by said baffle.

3. The reactor of claim **1** having a plurality of baffles in a transverse cross section.

4. An elongated reactor adapted to carry out a process for the gasification of a solid carbonaceous material in comminuted form wherein a gas is passed upwardly through a vertical bed of said material, said reactor comprising a substantially cylindrical vertical shell, means for supporting said bed in said shell, said means establishing a reaction zone in said shell occupied by at least five feet of depth of said material, means to introduce said material to said reaction zone above said bed supporting means to form a bed thereon, a baffle member having integrally formed generally vertically extending blade portions disposed within said shell and above said bed supporting means with the vertical surfaces of the blade portions distributed substantially uniformly throughout the reaction zone of said shell, said vertical blade portions being spaced from adjacent vertical blade portions to permit free vertical and substantially free horizontal flow of solids, said baffle member having a horizontal cross section consisting of a hollow core formed of spaced collars, the laterally extended blade portions being of generally Y shape the bases of which are joined to the collars, the outer extensions of the blade portions being of such reach as to nearly engage each other and tying means to stabilize the extremities of the adjacent blade portions, the area of the extended surface of said baffle member together with the area of the inner surface of said shell in said reaction zone being in the range of four to twelve square feet per cubic foot of the net volume of said zone, means for introducing said gas as a plurality of separate streams into the bottom portion of said bed, said extended surfaces of said baffle member tending to maintain uniformly distributed upward flow of said gases, and means for withdrawing a gasiform stream from said reactor.

5. A vertical skeleton baffle for a fluidized reactor comprising an assembly of laterally extended blade portions, said blade portions being Y shaped in horizontal cross section and substantially straight in length (vertical dimension) and curved in horizontal cross section, vertically spaced members anchoring the inner edges of the blades with respect to each other thereby forming radially extending elements, vertically spaced members anchoring the outer tips of said blades with respect to each other, said blades being relatively thin as compared to length.

6. A baffle as claimed in claim 5 in which said vertically spaced inner anchor members are hollow collars.

7. A vertical skeleton baffle element of Y shaped cross section having a vertical length normal to the cross section many times the extent of any portion of the Y shape and being relatively thin as compared to length.

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MORRIS O. WOLK, *Primary Examiner.*

MAURICE A. BRINDISI, *Examiner.*