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(71) Applicant: **AMMONIA CASALE S.A.**
Via della Posta 4
CH-6900 Lugano(CH)

(71) Applicant: **Zardi, Umberto**
Via Lucino 57
CH-6932 Breganzona (Ti)(CH)

(72) Inventor: **Zardi, Umberto**
Via Lucino 57
CH-6932 Breganzona(CH)

(74) Representative: **Incollingo, Italo**
AMMONIA CASALE S.A. Via della Posta 4
CH-6900 Lugano(CH)

(54) System to improve the mixing of reacted gases and quench gases in the heterogeneous synthesis converters.

(57) The general conditions of the thermal exchange are improved by ameliorating the mixing of reacted gases together with quench gases, in order to increase in this way the yields and to reduce the energy consumption in reactors used for heterogeneous synthesis (ammonia, methanol, etc.), consisting of an external shell, of an internal cartridge with catalytic baskets lying one above the other, at least one of mentioned baskets being crossed axially by the reaction gas, and of means to feed the quench gas between the bottom of one basket and the top of the following basket, said gas mixing being now carried out in a peripheral zone near the internal cartridge wall.

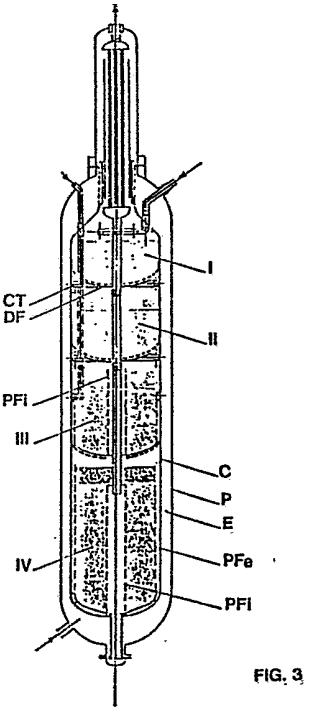

FIG. 3

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DESCRIPTION

Background of the Invention

This invention refers to a system to improve the mixing of reacted gases and quench gases and to increase the yields and to reduce the energetic consumption in the reactors for heterogeneous synthesis of ammonia and methanol in particular, consisting of: an external shell or pressure-resistant body; an internal cartridge that can form a conduct for the fresh reaction gas flow between the its external and internal wall of the mentioned shell; catalytic baskets placed one above the other; and means to feed unreacted quench gas in order to cool down the reacted gases in the zone between the bottom of the upper catalytic bed and the upper loose surface of the catalytic bed situated below, the above mentioned reaction gas axially crossing at least one of the said catalytic beds.

Prior Art

Axial reactors of the above mentioned type were widely diffused in the past and are often indicated as "Kellogg"-type reactors. These axial reactors were most often put into service during the periods when the cost of energy was very low. With today's higher energy costs it is of great importance, especially in the industrial technology for producing a basic compound as NH3, to improve the efficiency of the synthesis reactor, i.e. to increase as much as possible and at a parity of other conditions, the conversion degree of the reaction gas flow during the passage through the catalytic beds. This is valid not only for newly constructed plants in which the most advanced technology can be applied, but also for plants already in use, in which as explained above, the production costs are strongly influenced by the reactors' performances which must increase along with the rise in energy costs.

Of notable interest are all the actions or measures adapted to improve the reactors and to increase their efficiency with a consequent reduction in energy consumption.

In prior patents and patent applications, the applicants have suggested reactors of great interest with regard to the yields, operation costs and costs of putting them into production. For example, in the Swiss patent applications no. 03238/85 and no. 02100/85 in particular, an interesting modification to the axial quench-type Kellogg reactor has been proposed to transform them into radial reactors, which are able, among others, to employ smaller granular catalysts notoriously more active than the larger granular catalysts presently used in axial reactors, with consequent improvement of the reactor performances.

In the continuation of their systematic research in this field, the applicants have been successful in devising and carrying out further improvements to the assett and structure of these reactors with at least one catalytic bed which is axially crossed by the reaction gas; these improvements have proven to be very advantageous in increasing the efficiency of the mixing of the reacted and quench gases, and have thus optimized the general thermal conditions in which the reactions take place. This corresponds to a yield increase and to an energy consumption reduction.

The system as specified in the introduction of claim 1 and of this Description, is characterized now by the fact that the mentioned mixing of hot reacted gases with cold quench gases takes place in a peripheral zone near the internal cartridge wall.

The reactor, according to the invention, is now characterized by: a toroidal collector with quench gas outlet near the periphery of the internal cartridge wall and by a double bottom underneath the lower portion of the catalytic bed's grid, for the conveying of the hot reacted gases exiting from the above mentioned bed to the peripheral quench gas outlet zone.

The various aspects and advantages of the invention will better appear from the following description of the preferred, but not limitative embodiments represented in the drawings in which:

- Fig. 1 is a view of a schematic and partial, longitudinal section of an already known type of axial reactor (for example a "Kellogg"-type reactor);

- Fig. 2 is a view of a schematic section on an enlarged scale of a sole portion of the reactor underneath the bottom of a catalytic bed according to this invention;

- Fig. 3 is a view of a longitudinal, schematic section of a reactor including the improvement on at least one catalytic bed according to this invention, and the modification of at least another catalytic bed according to the above patent applications.

Even if the observations that follow are generally valid, reference is made in particular to the "Kellogg" axial-type quench reactors which have three or four adiabatic beds.

Fig. 1 represents a typical silhouette of one of these conventional reactors consisting of a pressure shell P, a cartridge C of an internal diameter Dc, a channel for the flow of fresh gases up to the heat exchanger S, four catalytic beds I, II, III and IV which are each connected to a quench gas adductor Q2, Q3, and Q4 respectively, and terminate (for example) with a toroidal collector CTi.

The gas to be reacted is introduced into the bottom of the reactor through the feed opening A and flows upwards (arrow F1) in the airspace E existing between the pressure vessel P and the internals or cartridge C containing the catalyst K. After the pre-heating in the top-exchanger S to the reaction temperature (at the expense of the reacted gas), the fresh preheated gas passes through the first catalytic bed I.

At the exit of the first bed I, the gas is cooled down by fresh quench gas Q2, and is passed through the second bed II and so on through the other following beds.
The temperature control takes place between the bed (Li) and the next one (Li+1) through the mixing of the hot gas Gcu exiting the bed Li and an unreacted gas current Qi, having a temperature lower than that of the reacted gas.
In particular, given the notable reactor dimensions, the bottom grid GRi containing the catalyst K in each bed Li is of

an elictic type, in such a way as to increase the mechanical resistance. The gas exiting from the bottom of the elictic grid GRi is collected and conveyed to the center of a special diaphram DAi and here it is mixed with the cold gas Qi distributed appropriately by each toroidal collector CTi. The gas mixed in this fashion then enters into the following layer at the desired temperature.
The mixing of the gas in this way is repeated for all the other catalytic layers (III, IV, etc.).

It clearly appears that the particular quench system now described requires a notable free volume (unoccupied by the catalyst) and that the useful volume of the reactor (i.e. the volume occupied by the catalyst), is penalized, and that the bed yields are penalized by the poor mixing efficiency of the reacted gas with the quench gas.

It has now been found that it is possible to overcome these inconveniences by providing a different quench system as represented on an enlarged scale and in connection to the bottom of a sole bed Li in Fig. 2.

According to the invention, the toroidal collector CTi (quench ring) is now transferred from the central zone Zc (Fig. 1) to that of the peripheral zone ZPi (fig. 2) preferably and critically in correspondence to the extrados DESi of the elictic grid GEi (i.e., in the most peripheral zones utilized until now), and the hot reacted gas is returned to the outside through an appropriate double bottom DFi. It is thus possible to increase the available space for the catalyst and therefore the total quantity of it to be inserted in the reactor (in a four-bed reactor, the quantity gained is four times the amount recuperated in each bed). This gain is surprisingly accompanied by the fact that the admixing of the hot reacted gas Gcu with the quench gas Qi is now extremely efficient; in fact, it has been ascertained that this mixing is particularly favoured in the restricted peripheral zone Zc (with respect to that which took place in the ample central passage zones Zc).

A traditional "Kellogg" reactor, appropriately modified according to this invention, can be charged with at least 10% more catalyst, which amounts to an appreciable conversion increase.

Fig. 3 represents a Kellogg reactor modified according to this invention, in which the first I and second bed II are axial (not transformed), whereas the remaining two beds have been transformed as per the applicants' earlier patent applications (transformation of beds III and IV as beds with axial flow into beds with radial gas flow).

Obviously, it is possible to have one axial bed and three remaining radial beds (1 + 3), or two axial beds and two radial beds as indicated in Fig. 3 (2 + 2), or three axial beds and one radial bed (3 + 1).

CLAIMS

1. A system to improve the mixing of reacted gases and quench gases and to increase in this way the yields and to reduce the energetic consumption of reactors for the heterogeneous synthesis particularly of ammonia and methanol, consisting of an external shell or pressure-resistant body, of an internal cartridge, of catalytic baskets lying one above the other, and of means to feed unreacted quench gas in order to cool down the reacted gas into the zone between the bottom of the upper catalytic bed and the loose upper surface of the catalytic bed situated directly below it, the above mentioned reaction gas flowing axially through at least one of the stated catalytic beds, characterized by the fact that the mixing of the reacted gas and the quench gas takes place in a peripheral zone very close to the internal wall of the cartridge.

2. A system, according to claim 1, characterized by the fact that the diameter of the toroidal collector which feeds the quench gas and is transferred to the periferical zone, is slightly smaller than the one in the cartridge and that the hot reacted gases exiting from the bottom of the catalytic bed are forced to flow towards the peripheral zone of the quench gas outlet.

3. Reactors for the heterogeneous synthesis particularly of ammonia and methanol, consisting of an external shell or pressure-resistant body, of an internal cartridge, of catalytic baskets placed one above the other, and of means to feed unreacted quench gas in order to cool down the reacted gas in the zone between the bottom of the upper catalytic bed and the free upper surface of the catalytic bed situated directly below, the above mentioned reaction gas flowing axially through at least one of the two catalytic beds, characterized by: one toroidal collector with quench gas outlet near to the periphery of the internal cartridge wall and by a double bottom below the lower portion of the grill of the catalytic bed, for conveying of hot reacted gases exiting from the mentioned bed towards the peripheral zone of quench gas outlet.

4. Reactors, according to claim 3, characterized by the fact that they have a grid with an elictic bottom and a quench gas feed collector with a peripheral outlet in the extrados of the mentioned elictic grid.

5. Reactors, according to claim 4, characterized by at least one catalytic bed which is axially crossed by the reaction gas and which has a peripheral gas quench adductor preferably in the extrados of the elictic grid; and by at least one catalytic bed which is crossed in a substantially radial direction by the reaction gas and is possibly fed by quench gas.

6. A system for reactors substantially as described and shown.

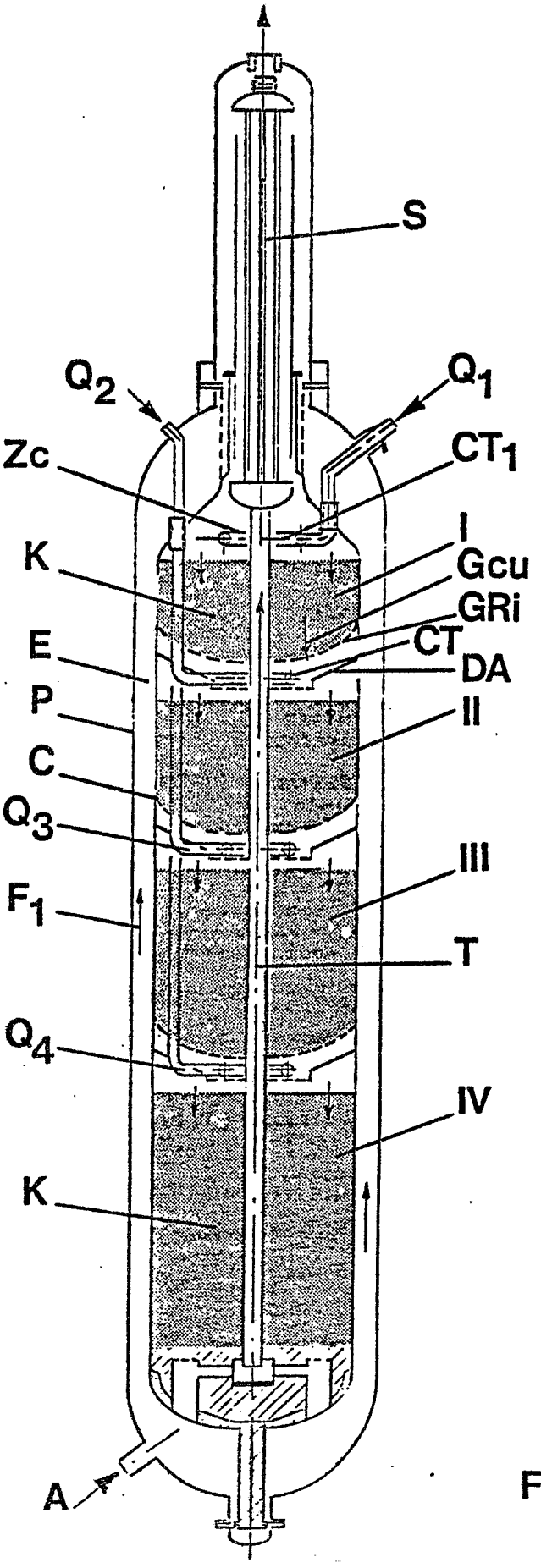

FIG. 1

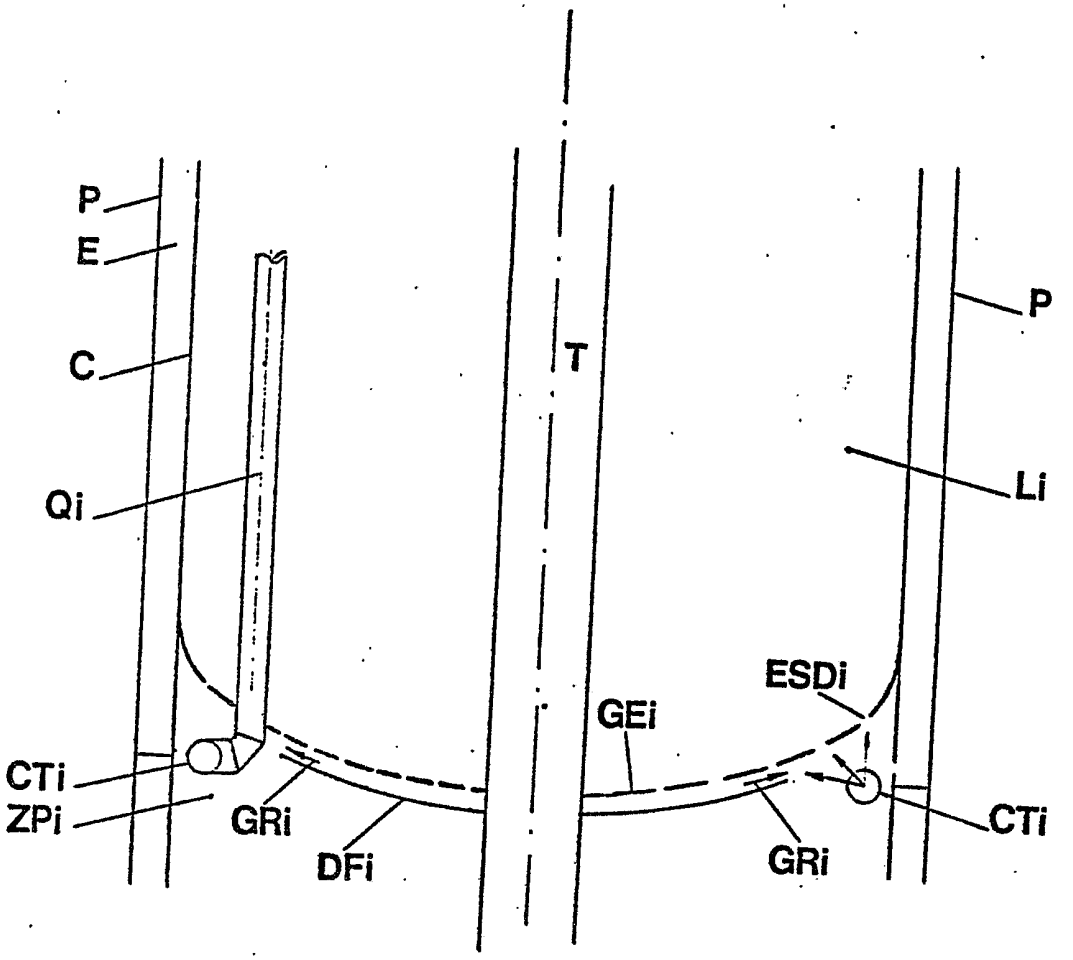

FIG. 2

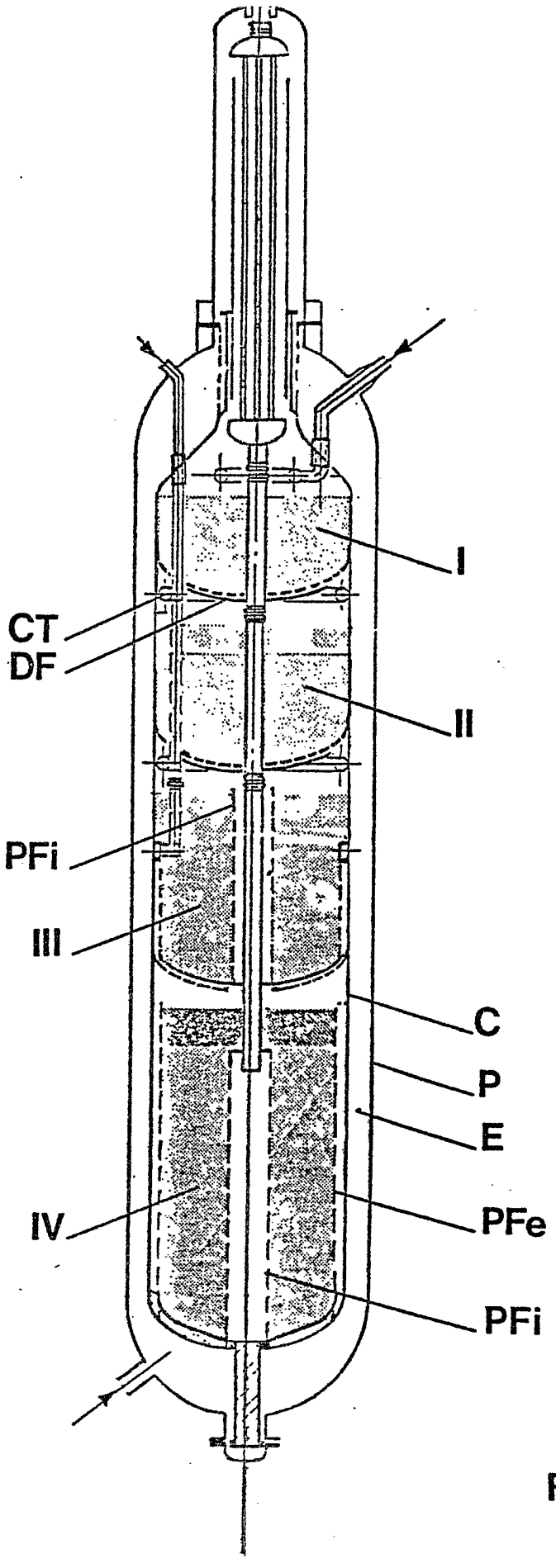

FIG. 3