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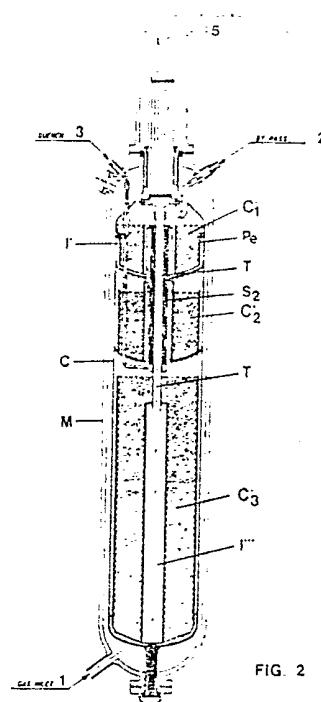
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54 Improvements to reactors for heterogeneous synthesis.

57 Improved process to convert in situ conventional reactors with four catalytic beds with axial flow and with intermediate quenching (Kellogg reactor), characterized by the fact that the third and fourth original beds are combined thus obtaining a reactor with three beds through which the synthesis gas now flows with a substantially radial flow.



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## Improvements to reactors for heterogeneous synthesis

The invention relates to a process to improve yields and reduce energy consumption in existing reactors for heterogeneous synthesis, and more particularly for the synthesis of ammonia, consisting of several catalytic beds through which synthesis gas flows axially, and cooled by feeding quench gas between beds.

The invention also includes reactors so obtained.

It is known that one of the most common reactors currently used in ammonia synthesis plants is the type with four catalytic beds through which the synthesis gas flows axially, with intermediate quenching (Kellogg).

Numerous systems have been put forward, described and adopted in order to improve yields in the above-mentioned Kellogg reactors. More particularly, according to a description in "Nitrogen", Nr. 165, January/February 1987, Topsoe convert the Kellogg 4-bed reactor into a 2-bed reactor (by joining the 1st and 2nd bed and the 2nd and 3rd bed of the original reactor), with intermediate cooling between beds by means of a heat exchanger (Fig. 1 in the article quoted). The gas flows radially.

According to the same article, Kellogg themselves convert the reactor using the space in the 1st bed, introducing heat exchangers. The second bed in the existing reactor becomes therefore the 1st bed in the new layout according to which the 3rd and 4th bed in the existing reactor are intended to operate in parallel (according to the so-called split-flow system), and a reactor is therefore obtained in which there are two reaction stages with intermediate cooling by exchanger (Fig. 8 of the above-mentioned article). The gas flow remains axial as in the original reactor. Still in the above-mentioned article in "Nitrogen", it is stated that the applicants intend to maintain the same number of beds as in the original Kellogg reactor (4 beds) and the same quenching system between beds.

The gas flow is changed from axial to axial-radial (Fig. 4 in the article).

Ammonia Casale has been the first to describe a system for the conversion in situ of Kellogg reactors thus improving performance and reducing consumption. In effect in its USA Patent No. 4755362 the Applicants show in Fig. 1A, as state of the Art, exactly the above classic Kellogg reactor with four axial beds and four intermediate quenches.

In this pioneering Patent No. US 4755362 the Applicants have maintained the same number of beds as at the start even in substantially radial reactors obtained by conversion in situ.

In Swiss Patent Application No. 02529-87-9 the

Applicants have suggested (Fig. 1) a further application of their system for modernizing a 4-bed Kellogg reactor converting it into a 3-bed reactor with quenching between the 1st and 2nd bed and cooling by means of an exchanger between the 2nd and 3rd bed. As the above-mentioned Figure shows, the 2nd bed in this layout is obtained by joining the 2nd and 3rd bed in the original reactor into a new 3-bed layout with quenching between the first and the second bed and an exchanger between the 2nd and 3rd bed. As Fig. 1 in said Swiss Patent Application shows, such Figure still being shown in this Patent Application, the 2nd (C2) and the 3rd (C3) bed were made into one with the interchanger being installed coaxially.

This solution, although offering considerable advantages when compared to the quench system, can however give rise to a less than optimal distribution of the catalyst, in the sense that the volume of catalyst installed in the second bed could result excessive.

The purpose of this invention is to supply a process and a new layout for the modified reactor which avoid the above disadvantages.

Continuing in their research the Applicants have now found surprisingly that considerable improvements can be obtained by adopting the layout described in Fig. 1 of Swiss Patent Application No. 02529/87-9, but more especially by creating the three beds by joining the 3rd and 4th bed in the original Kellogg 4-bed reactor layout.

The gas flow is generally changed from the original axial flow into a radial or axial-radial flow in at least part of the beds.

More particularly, and as described in the above-mentioned previous Swiss Patent Application, the axial flow could be maintained in the 1st bed.

The various aspects and advantages of the invention will become more apparent from the description of the embodiment shown in Figure 2A.

Numerical references indicate the same object as those in Figure 1 of Swiss Patent Application No. 02529-87-9.

Characteristically it can now be seen (Fig. 2) that of the three beds C1, C2 and C3, the last one is obtained by combining together the 3rd and 4th bed, i.e. the last but one and the last bed in the original layout of the Kellogg axial reactor (shown by way of example in Fig. 1A of US Patent No. 4755362). In this new embodiment the layout is still the "3 beds, 1 quenching, 1 interchanger" arrangement, but with the following important differences:

- the interchanger, still in a central position, is inserted coaxially with the 1st and 2nd bed and is

fed, shell-side, by the partly reacted gas leaving the 2nd bed and tube-side by the fresh gas;

- the dimensions of the 1st and 2nd bed may remain the same as the original ones, while the original 3rd and 4th bed are combined together.

In this way the volume of catalyst will be greatest in the new third lower bed, and smallest in the first bed; this distribution results, not unsurprisingly, in a considerable improvement in reactor performance. In addition, it is conveniently carried out in situ.

### Claims

1. Process to convert in situ existing reactors for the synthesis of ammonia with four catalytic beds with an axial flow (Kellogg) characterized by the fact that the first two upper beds are converted in situ so that the gas runs through them with a radial or axial-radial flow, and the two remaining lower beds are combined into a single bed through which the gas flow is either radial or axial-radial.

2. Process according to claim 1, characterized by the fact that quenching takes place between the two upper beds.

3. Process according to the previous claims, characterized by the fact that through the two upper beds runs an exchanger to cool the gas between the second and the third catalytic bed.

4. Reactors obtained with the process according to the previous claims, comprising:

- two upper catalytic beds converted from axial-flow beds into two beds with radial or axial-radial flow said beds having intermediate quenching.

- an exchanger to cool the gas from the second bed.

- a third catalytic bed obtained by combining the original lower third and fourth beds into a single bed with a substantially radial flow.

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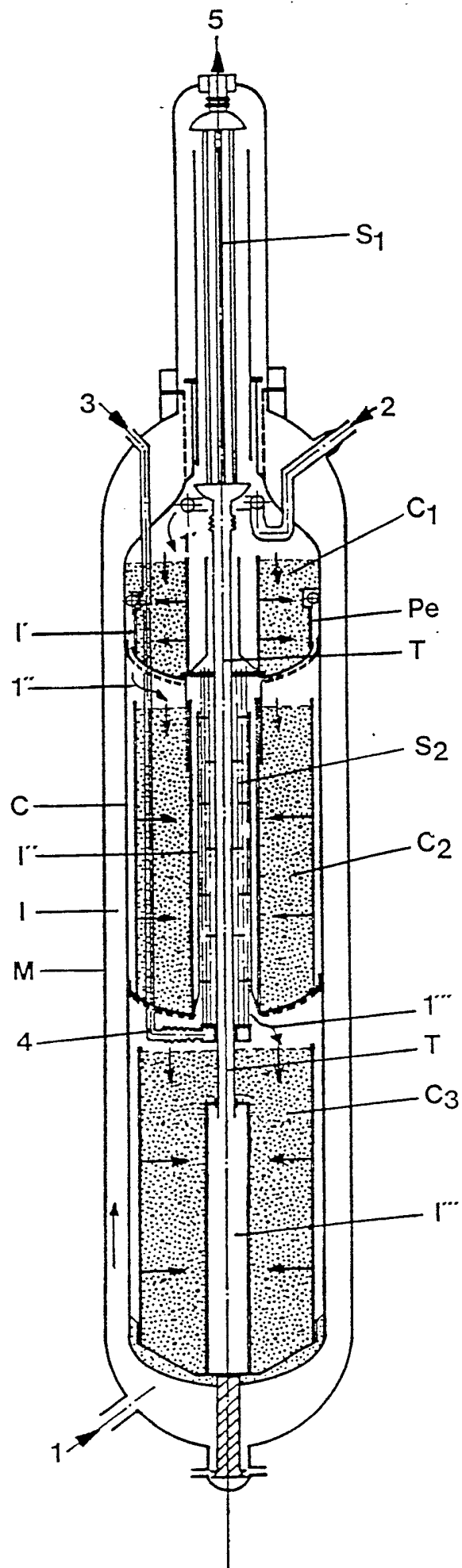


FIG. 1

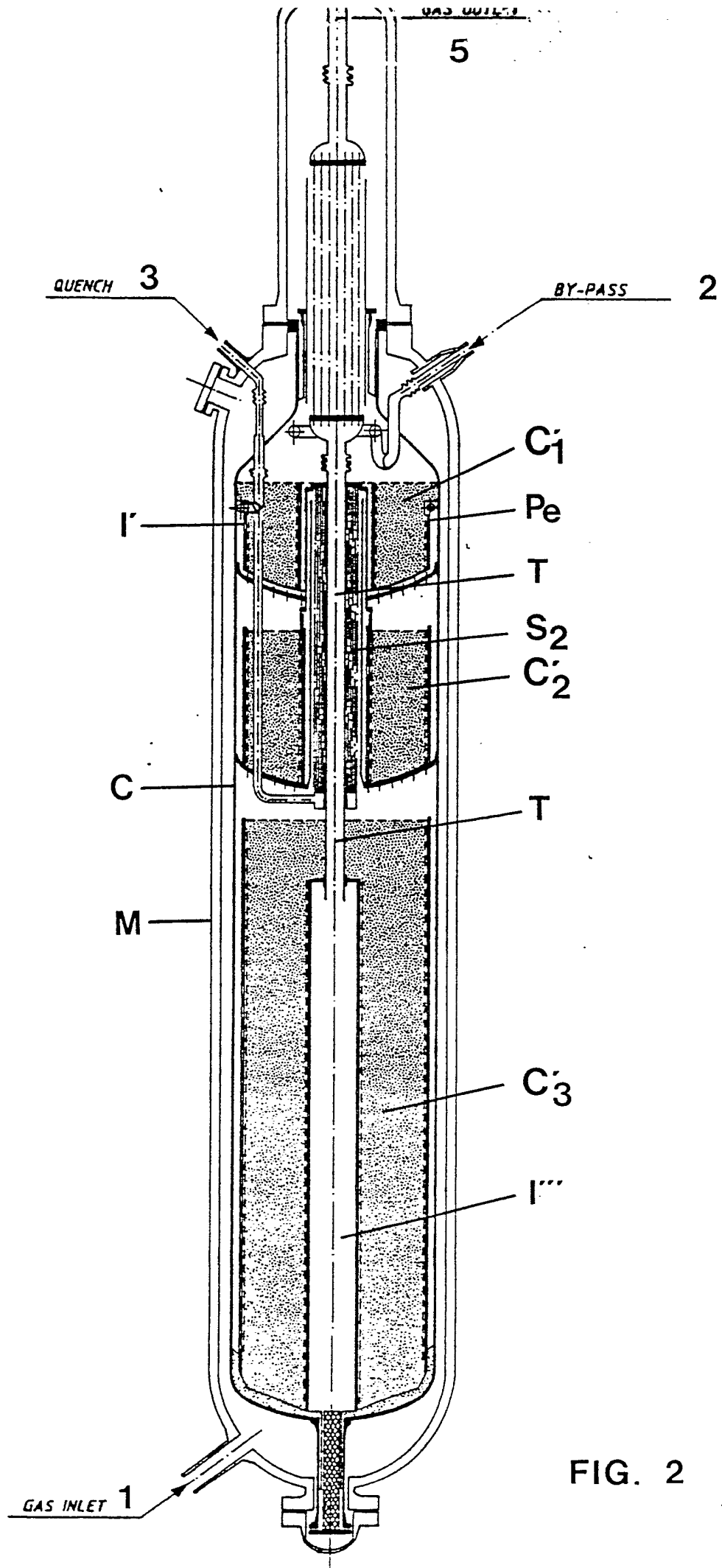


FIG. 2



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DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
D, P, X	EP-A-297474 (AMMONIA CASALE) * the whole document *	1, 2, 4	C01C1/04 B01J8/04
A	FR-A-2343699 (HALDOR TOPSOE) * claims 1, 7; figure 2 *	3	
A	EP-A-272448 (UHDE)		
D, A	EP-A-202454 (AMMONIA CASALE)		
D, A	Nitrogen, vol 165, jan/febr. 1987 p.27-31; "Revamping of ammonia converters".		
			TECHNICAL FIELDS SEARCHED (Int. Cl.5)
			C01C B01J
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 10 APRIL 1990	Examiner ZALM W. E.
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone V : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention F : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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