PATENT SPECIFICATION

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COMPLETE SPECIFICATION

Improvements in Apparatus for Carrying Out Exothermic Catalytic Gas Reactions

We, BADISCHE ANILIN- & SODA-FABRIK (I.G. Farbenindustrie Aktiengesellschaft "in dissolution") a company recognised under German law, of Ludwigshafen-on-Rhine, Germany, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

For a long time an apparatus for the carrying out of exothermic catalytic gas reactions in several stages of conversion has been known, in which a plurality of catalyst layers and heat exchangers are arranged alternately one behind another in a common container. This proposal has, however, not found any introduction into industry. The heat exchangers and catalyst chambers in this apparatus have the same cross-sectional area; this is unfavourable for obtaining an optimum transfer of heat in the heat exchanger on the one hand and for obtaining the smallest possible resistance to flow in the catalyst space on the other hand. The apparatus also has the drawback that, apart from the parts of the apparatus near to the container opening, the heat exchanger elements and also the interposed catalyst chambers are difficultly accessible for repairs and for changing the catalyst.

The object of the present invention is to provide an apparatus for carrying out exothermic catalytic gas reactions in a plurality of conversion stages which is free from the said drawbacks.

According to the present invention cylindrical tubular-bundle heat exchangers for heat exchange between the reactant gases entering and the reaction product gases leaving the catalyst chambers are arranged centrally within annularly formed catalyst chambers and in the jacket of the heat exchangers, preferably adjacent the base plates of the tubular bundles, there are provided gaps or openings through which the reactant gases flow into the catalyst chambers directly or through intermediate spaces surrounding the tubular bundle in the form of a jacket, or the reaction product gases flow back into the heat exchangers. In such an arrangement, the cross-sectional areas of the heat exchangers and the catalyst chambers may be adapted to the optimum conditions in any desired ratios. It is therefore possible on the one hand to provide high speeds of flow within the heat exchanger tubes and in the spaces between the tubes and on the other hand to reduce the resistance to the flow in the catalyst mass to any desired degree by increasing the area of the annular contact chambers. The building of the heat exchangers directly in the centre of the catalyst chambers and the consequent compact construction of the whole apparatus offers the advantage that the thermal stability of the apparatus is considerably increased by the great heat capacity of the heat exchangers constructed of metallic materials on the one hand and by the smaller radiating surface on the other hand. This has the consequence that interruptions in operation or temporary reductions in the loading of the whole system may be better bridged over. A further advantage is to be seen in the fact that the reactant gases enter the catalyst chambers from the middle outwardly, whereby a uniform distribution of gas over the annular catalyst chambers is ensured.

The invention will be further described with reference to the accompanying drawings which show diagrammatically sectional elevations of three embodiments of the invention by way of example.

Referring first to Figure 1, 1, 2 and 3 are three catalyst chambers arranged consecutively and 4 and 5 are interposed centrally disposed tubular-bundle heat exchangers. The gases to be reacted enter the pipe 6 and pass first into the distributing chamber 7 and then flow sequentially through the tubes of the heat exchangers 5 and 4 and become heated thereby in heat exchange with the reaction product gases leaving the catalyst chambers 1 and 2 to the temperature necessary for the initiation of the reaction. Through openings in the wall of the gas collecting chamber 8, the preheated gases pass into the catalyst chamber 1. After the gases have been partially reacted in the catalyst in the chamber 1, with the resulting increase in temperature, they flow through the jacket-shaped intermediate space 9 and the gaps at the upper end of the jacket of the heat exchanger 4 back into the outer space of the heat exchanger 4. Here they are led in counter-current to the fresh gas flowing inside the tubes, and the most advantageous flow of the gases for the improvement of the heat exchange may be brought about in known manner by baffles. The gases then pass at reduced temperature into the catalyst chamber 2 through gaps in the jacket at the lower end of the heat exchanger 4 and in the intermediate space 10 at the top thereof. Conversion again takes place by the action of the catalyst in the catalyst chamber 2. The gases which have thereby become heated again pass through a collecting chamber 11 into the heat exchanger 5 and are cooled therein by the fresh gases flowing in the tubes; the gases, cooled to a lower temperature, then enter the top of the catalyst chamber 3 after passing through a gap at the lower end of the heat exchanger jacket and through a gap at the top of the intermediate space 12. The conversion is completed in the catalyst chamber 3. The gases leave through a collecting chamber 13 and an outlet 14. Their heat content may be used in a heat exchanger outside the catalytic reaction apparatus for heating up the fresh gas entering through the pipe 6.

Since the hot gases flow outside the tubes of the heat exchanger and the cooler gases flow inside the tubes, any strong thermal strain on the base plates of the heat exchanger and the sensitive junction points of the heat exchanger tubes is avoided and consequently a longer duration of operation of the heat exchangers in continuous operation is ensured. It has been found, however, that at high temperatures injury to the heat exchangers in continuous operation cannot entirely be avoided, even when the tubes are constructed from high quality metallic materials or are specially protected by surface treatment or by covering with protective tubes at the places where the hot gases impinge on them, so that it is occasionally necessary to change the tubes. In order to render this possible, the heat exchangers may be arranged within the apparatus so that the base plates of the heat exchangers are accessible through specially provided openings in the casing surrounding the heat exchanger.

Apparatus which has been designed with fact in mind is shown in Figure 2; 1, 2 and 3 are three consecutive catalyst chambers, 4 and 5 are centrally arranged tubular bundle heat exchangers and 6 is an external heat exchanger for the preheating of the fresh gas entering the pipe 7 by heat exchange with the reacted gases flowing through the tubes of the heat exchanger 6 and leaving at 8. The direction of flow may be seen from the arrows. Cold fresh gas may be supplied to the gases leaving the two heat exchangers 4 and 5, when desired, through the branch pipes 9 and 10, whereby a very accurate control of the temperature in the single stages of the reaction may be obtained. The branch pipe 11 renders possible a patrial cutting out of the heat exchanger 6. 12, 13, 14 and 15 are openings provided for carrying out repairs or replacements of the heat exchangers. If necessary, further catalyst chambers having centrally arranged heat exchangers may be arranged behind the catalyst chamber 3. Additional means for temperature regulation, as for example cooling jackets around the catalyst chambers, may be used.

For gas reactions in which especially high temperatures occur and in which therefore account must be taken of great wear on the heat exchanger tubes, it is advantageous to use an apparatus in which, according to a further embodiment of the invention, the tubular bundle of the heat exchanger is formed in one with the two end plates so that it may be removed as a whole from the apparatus, while the jacket with its surrounding intermediate spaces for gas forms a fixed component of the catalyst chambers. Such an arrangement may also be used with advantage when the catalyst chambers are lined with ceramic material. The jackets and the gas intermediate spaces may also be made of ceramic material so that metallic materials are to a large extent removed from the action of highly heated gases. Only the metal tubes of the heat exchanger are exposed to this action, but these are protected against overheating by the cooler gases flowing therethrough and moreover are readily accessible for repair operations by the removal of the tubular bundle.

Figure 3 shows an apparatus having a removable tubular bundle and a fixedly inbuilt jacket of ceramic material. The consecutively arranged catalyst layers 1 and 2 are arranged in a container 4 provided with a lining of ceramic material 3. The tubular bundle 5 of the heat exchanger may be withdrawn through the opening 6. 7 and 8 are parts made of metallic material and formed as compensating intermediate members which serve to seal off the gas spaces which are to be kept separate. They may also be replaced for example by sand packings. 9 are the cylindrical walls of the heat exchanger formed of ceramic material and the inner walls of the catalyst chamber. The tubular bundle is sealed at 10 into the lining 3. The gases to be reacted enter through pipe 11 into distribution chamber 12, flow through the tubes of the heat exchanger 5, pass into the top of the catalyst chamber 1, leave the same through the collecting chamber 13 and the intermediate space 14, flow downwardly around the tubes of the heat exchanger 5 in counter-current exchange with the fresh gases ascending in the tubes, and pass through the intermediate space 15 into the next catalyst chamber 2. At the end of the reaction they leave the apparatus through the collecting chamber 16, the outer annular space 17 and the outlet 18.

In any of the described arrangements, manhole flaps may be provided in the outer jackets or in the intermediate floors of the catalyst chambers for the introduction and removal of the catalyst.

Having now particularly described and ascertained the nature of our said invention and in what manner the same is to be performed, we declare that what we claim is:—

1. Apparatus for carrying exothermic catalytic gas reactions in a plurality of reaction stages with the interposition of heat exchangers for heat exchange between the reactant gases entering and the reaction product gases leaving the catalyst chambers, wherein cylindrical tubular bundle heat exchangers are provided centrally within annular catalyst chambers and openings are provided in the jackets of the heat exchangers, preferably adjacent the base plates of the tubular bundles, through which the reactant gases pass into the catalyst chambers or the reaction product gases flow back into the heat exchangers either directly or through surrounding intermediate spaces in the form of jackets.

2. Apparatus as claimed in claim 1 in which the base plates of the heat exchangers are accessible through openings in the casing surrounding the heat exchanger.

3. Apparatus as claimed in claim 1 or 2 in which the tubular bundle of the heat exchanger is removable and the jacket and the gas intermediate spaces are fixed components of the catalyst chambers.

4. Apparatus for carrying out exothermic catalytic gas reactions substantially as herein described with reference to Figures 1, 2 or 3 of the accompanying drawings.

Dated this 10th day of November, 1949.
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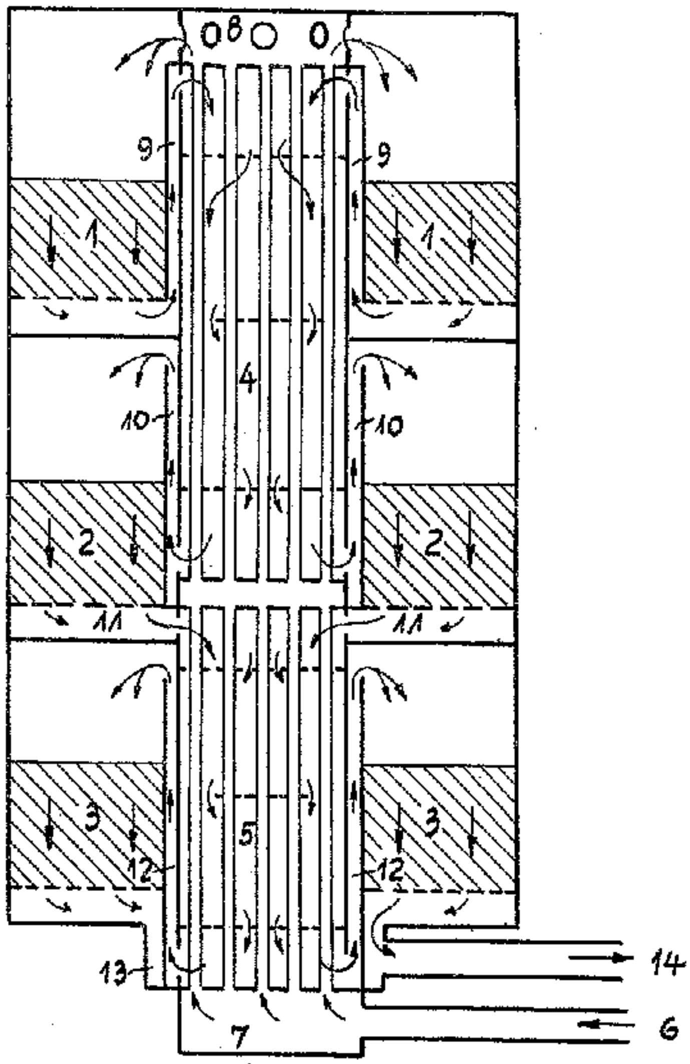
Fig. 1



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SHEET 2

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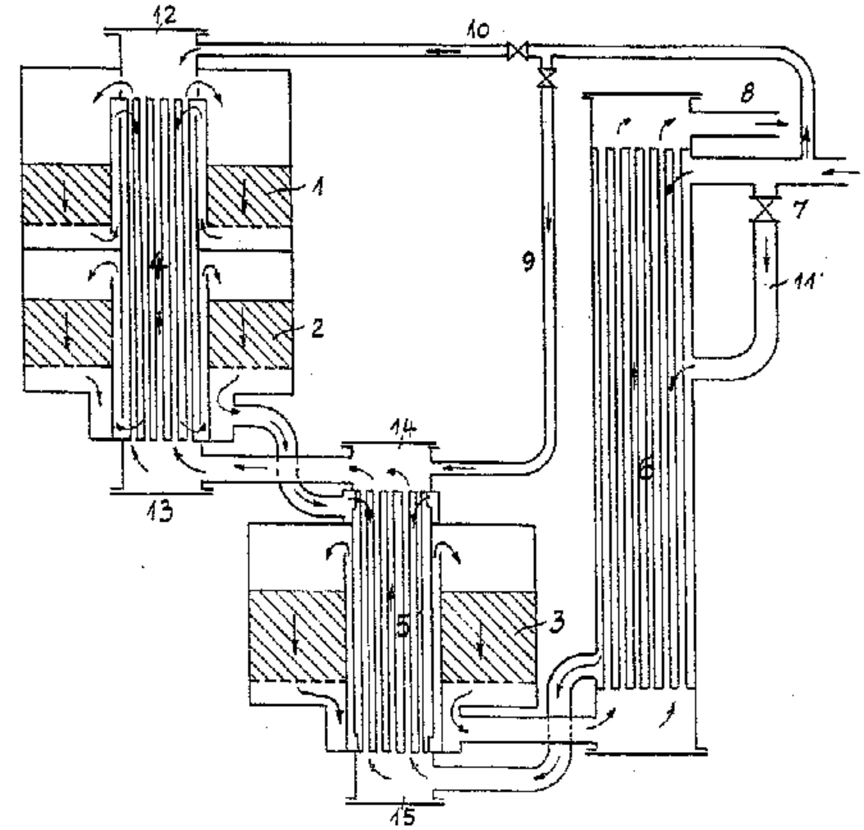
Fig. 2



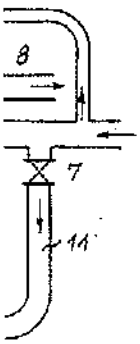


Fig. 3

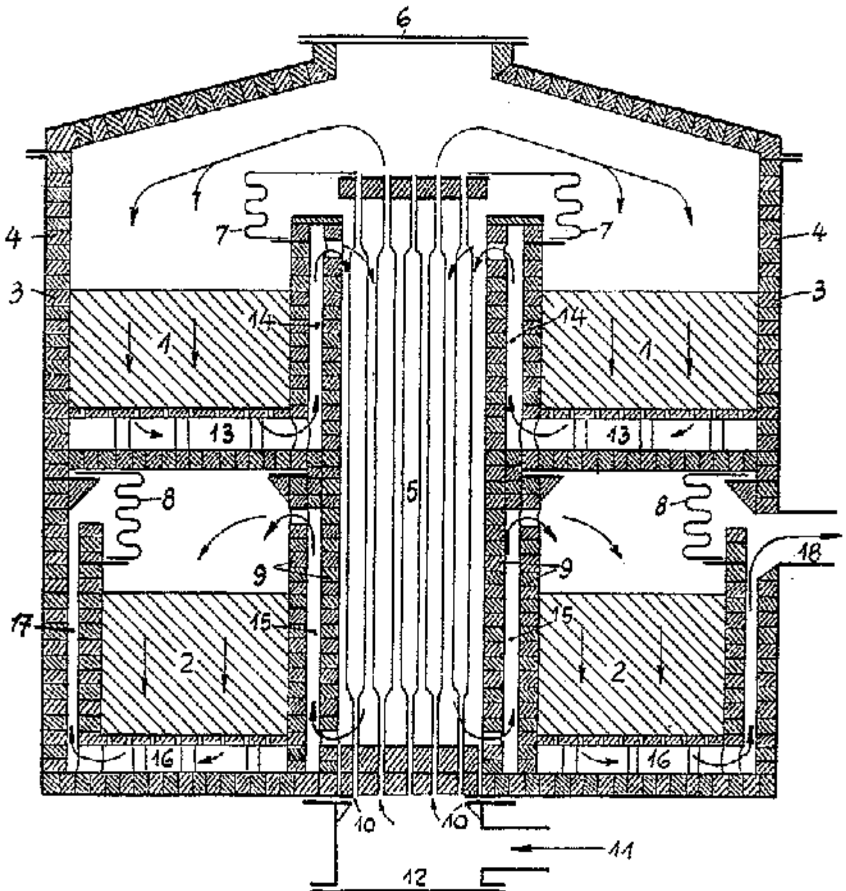


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Fig. 2

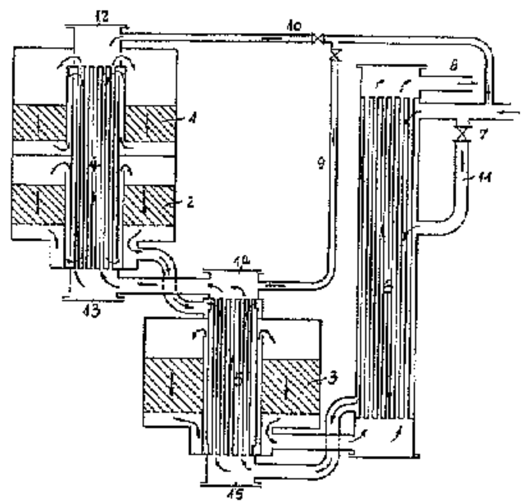

Fig. 3