PATENT SPECIFICATION

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COMPLETE SPECIFICATION

Improvements in or relating to Apparatus for Performing Chemical Reactions

We, METALLGESELLSCHAFT AKTIENGESELLSCHAFT, a Corporation organised under the Laws of Germany, of 45, Bockenheimer Anlage, Frankfurt-on-the-Main, 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:—

This invention relates to apparatus for performing chemical reactions.

For many chemical reactions exact adherence to a certain temperature is an indispensable condition to extensive conversion of the originating substances and, above all, to uniform production of a certain product, while avoiding undesirable side reactions. This applies particularly, for example, to the synthesis of hydrocarbons, alcohols, and the like, from mixtures of carbon monoxide and hydrogen.

It has been found essential to the performance of, in particular, catalytic reactions that the reaction chamber filled with catalyst should be kept at a temperature which must be exactly maintained and that, for this reason, the reaction chamber itself should have the smallest possible width, in order that the whole of the catalyst mass, including those portions not in direct contact with the walls of the reaction chamber, may be kept reliably at the temperature of the walls. This is of particular importance when such reactions, for example exothermic reactions, have to be carried out under pressure for the purpose of increasing the rate of reaction, since in such case a very considerable evolution of heat within the catalyst mass must be expected.

It has now been ascertained that these requirements may best be complied with by making the reaction chamber containing the catalyst in the shape of a spiral, for example by making it of sheets wound spirally over one another, after the style of known heat exchangers, in such a way that these sheets alternately form a spiral chamber to serve as reaction chamber and, therebetween, a chamber-like passage for the cooling or heating medium. In this way reaction chambers only a few millimetres in width can be evolved, in which a uniform temperature can be dependably maintained even in the case of the most intense heat effect of the reactions.

The present invention accordingly provides in a heat exchanger consisting of spiral plates which constitute the walls of one or more spiral channels or conduits, the arrangement of a catalyst within said spiral channels and of heating or cooling channels between the channels containing the catalyst.

In the apparatus of the present invention heat conductors are preferably provided in the reaction chamber. Such heat conductors may for example be sieve or grid-shaped fixtures or the like, having good heat conductive properties. Alternatively, substances may be added to the catalysts which are adapted to increase the thermal conductivity thereof.

At the same time the pressure stresses of the walls of the reaction chamber can easily be controlled in such an apparatus, since in the case of a closed spiral, i.e. for example, when the outer end of the chamber wall is welded on to the adjacent inner chamber wall, such stresses will almost be those of a cylindrical tube in the walls of which principally only uniform tensile stressing occurs. An apparatus of this type is consequently also practicable, without difficulty, for working under high pressures. Furthermore, warping of the chamber walls, for example through thermal expansion of iron, is precluded for the same reason, since the spiral wall is able to expand uniformly.

In order to avoid excessive pressure stressing of the chamber walls, devices are furthermore provided, in the case of higher working pressures, to keep the pressures in the reaction and cooling chambers automatically at a certain level, or to effect a pressure compensation in the event of a permissible pressure difference between the reaction chamber and the cooling chamber being exceeded.

The catalyst mass may be accommodated in the reaction chambers either in granular form or in the form of a liquid.

However, in order to avoid differences in temperature inside the reaction chamber under all circumstances, the catalyst may also be provided solely on the walls of the reaction chamber, with good transmission of heat to the walls. Depending on the nature of the catalyst to be employed, such a coating may be applied to the walls in liquid form or else, for example, be produced by evaporation or crystallisation from a solution. In special cases, when using a metallic catalyst, the latter may be applied to the walls by electro deposition or ionic exchange.

The apparatus of the present invention is utilisable both for reactions progressing exothermally and for those progressing endothermally. A certain temperature is most simply maintained by employing as cooling or heating medium liquids, or vapours thereof, which boil, or condense, under the desired reaction conditions (pressure and temperature). In the case of higher working temperatures, for example, diphenyl and mercury are suitable as cooling and heating media.

In this case the cooling or heating medium is preferably circulated through the cooling passages in liquid or vapour form with the aid of a pump. In the case of an endothermic reaction the vapour condensing on the walls of the contact chamber is constantly freshly generated in a vapour generator. In the case of an intensely exothermic reaction, the vapour formed from the liquid cooling medium may, under certain circumstances, be utilised for the generation of energy, or, in the case of steam, be utilised for the production of hydrogen containing gases, for example in water gas plants.

Since it is essential, in order to control the temperature effectively, that the width of the reaction chamber should be very small and uniform over the whole length, it is of particular advantage to restrict the distance between the chamber walls, for example by ribs or wart-like raised portions on the sheets, and thus to prevent variation of the width of the chamber under the influence of heat or of the pressure applied to the walls of the chamber. Inserted cross-pieces are also suitable for this purpose.

A particularly convenient embodiment of the apparatus comprises closing the spiral reaction chambers, which are open on one side, by a common, pressure resistant, arched cover, while the cooling or heating chambers, which are open on either side, are closed against the outside by an identical cover. In order to regulate the circulation in the heating or cooling chambers, the latter are closed by a further flat lid, which is fitted inside the pressure chamber.

Depending on the resistance of the chamber filling, the reaction gases move through the reaction chamber in the direction of the axis of the spirals or along the spirals themselves.

In the case of larger apparatus, it is particularly convenient to accommodate the spiral body of the reaction and cooling chambers in a pressure-resistant container of its own. In this case a plurality of spiral bodies may be simultaneously accommodated in one cylindrical container. For this purpose only the outer container needs to be made pressure resistant, while the spiral chambers may have thin walls, provided that the cooling chamber and the reaction chamber are under approximately the same pressures. When such containers are cylindrical, reactions which require particularly high pressures and involve intense heating effects may be performed with the apparatus.

In order more clearly to understand the invention, reference is made to the accompanying drawings, which illustrate diagrammatically and by way of example, several embodiments thereof and in which:—

Figs. 1 and 2 are a vertical section and plan respectively of one embodiment; and

Fig. 3 is a vertical section through a second embodiment.

Fig. 1 shows an apparatus in which the spiral chamber walls themselves close the apparatus against the outside. The middle piece 1 consists of spirally wound sheets which jointly form the reaction chambers 2 and the cooling chambers 3, the chamber walls being alternately joined at the top and bottom in such a way that the cooling chambers are open on one side (for example at the top) and the reaction chambers are open at the other side (for example at the bottom). The middle piece comprising the spirals is furnished at top and bottom with a flange on to which the arched, pressure-resistant lids 4 and 5 are screwed. The spiral passages are closed within the lid by flat cover plates 6 and 7, which are preferably screwed on to the spiral body. The lid 4 contains an inlet pipe connection 8 for the cooling medium which is introduced, for example, through holes 9 in the cover plate 6 into the spirals, and passes out again through the aperture 10 and the length of piping 11 through the pipe connection 12. The inlet pipe connection 13 for the reaction gases is provided in similar manner on the lid 5, said reaction gases entering the reaction chamber through the holes 14 in the cover plate 7 and passing out through the aperture 15, the length of piping 16 and the

pipe connection 17, together with the reaction products.

In Fig. 2 the cover plate 6 is shown with the apertures 9 and 10 for the entry and withdrawal of the cooling medium. It also shows in broken lines the path of the spiral passages.

In the apparatus shown in Fig. 3, the spiral chambers are accommodated in an independent pressure-resistant container. In the container 18, with flanged-on lid 19, is mounted the spiral body 20. The latter is covered at top and bottom by the cover plates 21. The reaction gases and cooling medium enter and leave through the pipe connections 23.

With the aid of the apparatus of the present invention it is possible to perform chemical reactions which involve intense heating effects, while accurately maintaining given temperatures. In particular, such reactions, which are otherwise difficult to control, may also be carried out under considerable pressures with the aid of the said apparatus, and thus the yields may be considerably increased, referred to the unit of volume. The reaction may thus further be made to approach as closely as possible the theoretically possible maximum.

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. In a heat exchanger consisting of spiral plates which constitute the walls of one or more spiral channels or conduits, the arrangement of a catalyst within said spiral channels and of heating or cooling channels between the channels containing the catalyst.

2. Apparatus as claimed in claim 1, in which there are provided inside the reaction chamber, heat conductors, for example sieve or grid-shaped fixtures or the like, possessing good heat conductive properties, or in which substances are added to the catalyst which increase the thermal conductivity thereof.

3. Apparatus as claimed in claim 1, having a catalytically active coating on the inner walls of the reaction chambers.

4. Apparatus as claimed in any of claims 1 to 3, in which regulating means are provided which automatically regulate the pressure in the reaction and cooling chambers.

5. Apparatus as claimed in any of claims 1 to 4, which is provided with overflow valves which connect the reaction chambers and the cooling chambers in such a way that the pressure in the two chambers is kept approximately equal.

6. Apparatus as claimed in any of the preceding claims, characterised by the use of sheets having ribs or wart-shaped raised portions or of inserted cross-pieces, which ensure a uniform distance between the walls of the channels.

7. Apparatus as claimed in any of the preceding claims, comprising arched, pressure resistant covers, which close on one side the spiral of the reaction chambers and, on the other side, the spiral of the cooling and heating chamber, and also by covers taking no pressure and restricting the flow of the gases and of the cooling or heating medium to the spiral chambers.

8. Apparatus as claimed in any of the preceding claims, in which the spirals of the reaction and cooling or heating passages are accommodated in a pressure resistant, preferably cylindrical container.

9. The apparatus for performing chemical reactions, constructed, arranged and adapted to operate substantially as described with reference to the accompanying drawings.

10. Method of making the apparatus as claimed in claim 3, in which the catalytically active coating is applied by evaporation or crystallisation from a solution.

11. Method of making the apparatus as claimed in claim 3, in which the catalytically active coating is applied by electro deposition or ionic exchange.

12. A method of operating the apparatus claimed in any of claims 1 to 9, in which liquids, or mixtures of liquids, which boil or condense at the desired reaction conditions (pressure and temperature), are employed as heating or cooling media.

13. A method of operating the apparatus as claimed in any of claims 1 to 9, in which the heating or cooling medium is recycled through the contact apparatus.

Dated this 20th day of May, 1938.

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Fig. 1

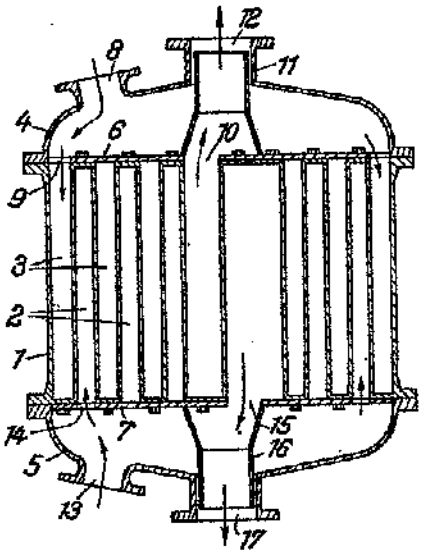


Fig. 2

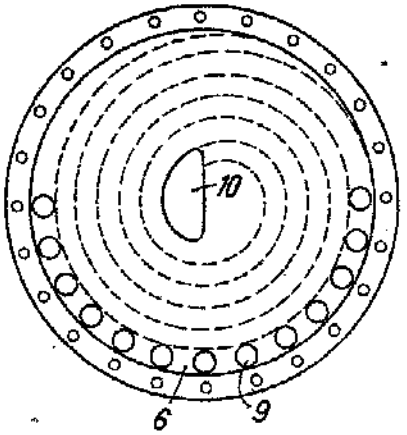
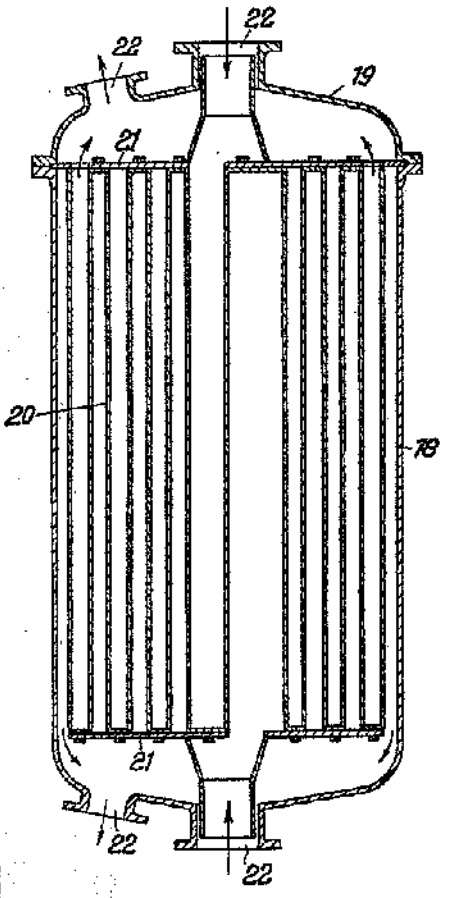


Fig. 3



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