July 11, 1933. A. O. JAEGER 1,917,716

CATALYTIC CONVERTER

Filed May 31, 1930 2 Sheets-Sheet 1

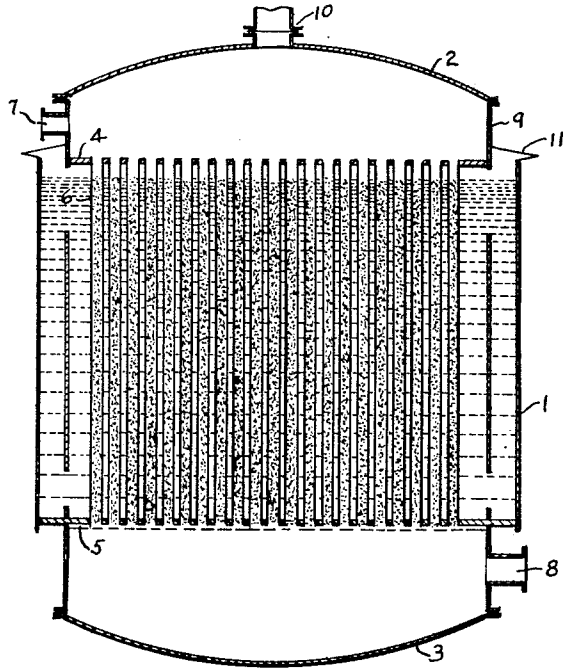


FIG. 1

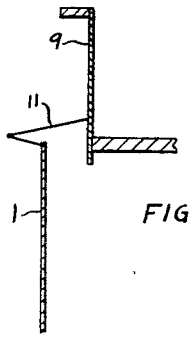


FIG 2

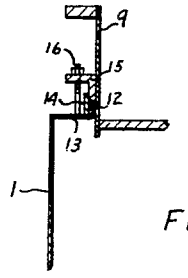


FIG 3

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CATALYTIC CONVERTER

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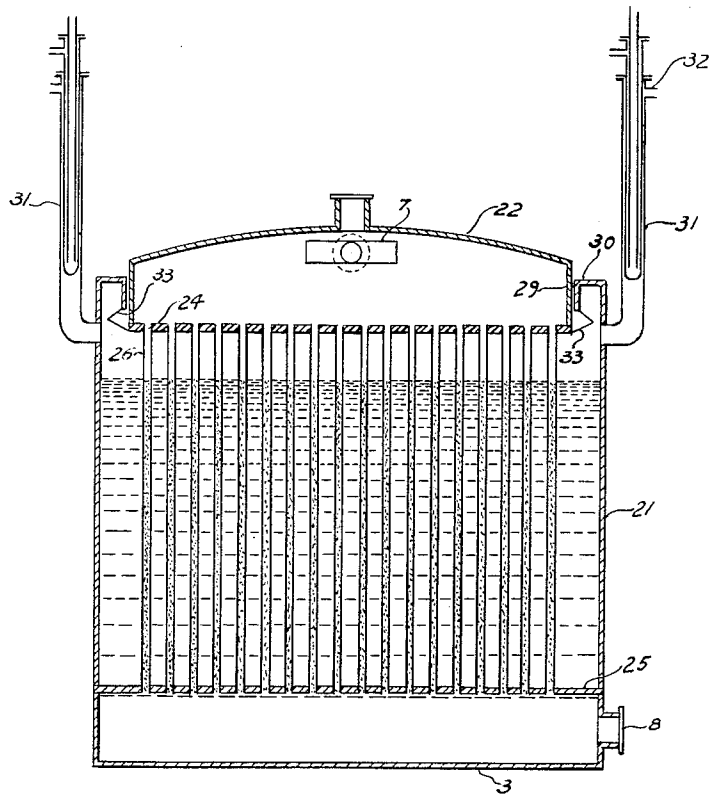


Fig. 4

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UNITED STATES PATENT OFFICE

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CATALYTIC CONVERTERS

Application filed May 31, 1930. Serial No. 458,010.

This invention relates to catalytic converters and more particularly to converters of the bath type in which the reaction temperature is controlled by means of a bath, either boiling or non-boiling, which surrounds tubes containing the catalyst and conducts away the heat generated by the reaction.

Converters of this type are usually constructed after the same fashion as a fire tube boiler; that is to say the catalyst tubes are welded or expanded into tube sheets which are rigidly fastened to the converter shell. In carrying out reactions which take place at relatively low temperatures water or salt solutions have been used as bath material, but for reactions which take place at more elevated temperatures it has been necessary to use metals, alloys or mixtures of salts in the molten state.

In the development of converters of the type described for high temperature reactions, and even for reactions that take place at comparatively low temperatures, much difficulty has been experienced in preventing the leaks that result from warping of the tubes and tubesheets. This warping is mainly the result of the unequal longitudinal expansion of the shell and tubes and the enormous stresses resulting, since in the ordinary boiler type construction there has been no means of compensating for this movement. It has been the custom to use extremely heavy tubesheets and both welding and expansion of the tubes, which has added greatly to the cost of the apparatus but has not entirely solved the problem.

I have now found that this difficulty can be overcome by providing the converter with a floating upper tubesheet, that is to say one in which the weight of the tubes, the upper tubesheet, and the upper superstructure of the converter rests entirely on the lower tubesheet. Any movement due to expansion or contraction is taken up by flexible connections between the superstructure and the converter shell. In this way the converter is made gas-tight and permits the use of mercury, mercury alloys, salt solutions and molten salt mixtures which would be oxidized in contact with the air or which would give off poisonous or irritating vapors in operation. By this construction converters either of the boiling or non-boiling bath type, or of the combined boiling and non-boiling bath type can be developed having all the advantages of those of the prior art with the added advantage that the tendency to warp is entirely overcome.

Converters constructed according to the present invention are applicable to the most varied types of catalytic reactions, such as oxidations of organic compounds to intermediate products, for example the oxidation of benzole to maleic acid, toluol and the various substituted toluols to the corresponding aldehydes and acids, naphthalene to phthalic anhydride, anthracene to anthraquinone, acenaphthene to naphthalic anhydride, fluorene to fluorenone and the like; reactions in which an undesired impurity is burned out such as the purification of crude anthracene, crude naphthalene or coal tar ammonia and oxidations of mixtures of organic compounds with or without catalytic purification. Reductions and hydrogenations, such as the reduction of nitrobenzene to aniline, aldehydes and ketones to alcohols, hydrocarbons such as naphthalene to tetraline and decaline, phthalic anhydride to phthalide and the like; and splitting reactions such as the production of benzoic acid from phthalic anhydride can also be carried out. The apparatus is also suitable for inorganic reactions, such as the oxidation of sulfur dioxide to sulfur trioxide, the oxidation of ammonia to oxides of nitrogen, and the production of hydrocyanic acid from carbon monoxide and ammonia.

In the accompanying drawings representative types of converter have been illustrated to which the features of the present invention have been applied. It is to be understood that the specific know features of these converters do not in themselves form any part of the present invention and that in its broad aspects the invention can be applied to any converter of the boiling or non-boiling bath type, although certain advantages are to be obtained by the combination of the flexible

construction with known features of the converters shown and are included in the invention in its more specific aspects.

In the drawings:

Fig. 1 is a vertical section through a bath converter of the non-boiling or sensible heat type to which the flexible tubesheet construction has been applied;

Fig. 2 is a detail of the flexible connections shown in Fig. 1;

Fig. 3 is a detail of a slightly modified form of connection that can be used under suitable conditions; and

Fig. 4 is a vertical section through a converter of the boiling bath type.

Referring to Fig. 1, the converter in its usual form consists of a converter shell 1, provided with top and bottom pieces 2 and 3 and upper and lower tubesheees 4 and 5 between which extend catalyst tubes 6, the shell being provided with an outlet 8 at the lower portion thereof. The lower tubesheet 5 is set into the converter shell in the usual manner, but the upper tubesheet 4 is welded to a circular flange 9 in which the inlet 7 is provided and to which is fastened the top piece 2, provided with the safety flange 10. The entire superstructure, consisting of the upper tubesheel 4, the flange 9 and the top piece 2, is carried by the tubes 6 so that any expansion or contraction of the tubes results only in a raising or lowering of the superstructure. In order to provide a closed bath chamber, which is necessary where oxidizable bath material is to be used or where it is desired to effect the temperature control by a boiling bath, the converter shell 1 is extended upwardly around the flange 9, and the connection between the two surfaces is effected by a thin, pleated flange 11 of a flexible metal such as highly tempered steel or bronze or the like. This connection may consist of as many pleats or folds as may be found desirable in practice, only one such fold being shown on the drawings. The inner edge of the pleated ring is welded or otherwise suitably fastened to the circular flange 9 while the outer edge is fastened to the converter shell 1, thus affording a flexible and at the same time a gas-tight joint. In boiling bath converters where gas pressures considerably higher than atmospheric are encountered, it is sometimes desirable to reenforce these welds by turning up the edges of the metal and surrounding the connections by metallic bands which are shrunk on or otherwise suitably fastened. Such reenforcements, however, are not usually necessary in ordinary practice since the development of the modern alloy baths, which control the catalyst temperatures irrespective of pressure by adjustment of the composition of the alloy, have practically done away with the use of high pressures on a boiling bath.

It is to be understood that the invention is not limited to the use of the pleated rings 11, but on the contrary any suitable type of connection may be used. Another type of connection which has been found useful under certain conditions is that shown in Fig. 3, in which a tight joint is maintained by means of a packing ring 12. In this construction the upper edge of the converter shell 1 is turned inwardy to form a horizontal flange 13, the inner edge of which fits loosely around the circular flange 9 and supports the packing 12. The packing is retained in position by a vertical ring 14 that is welded to the upper surface of the horizontal flange 13, while the packing is maintained under suitable pressure by the floating ring 15 of angle iron construction that is retained above it by means of suitable bolts 16. In this manner a gas-tight construction is obtained which has at the same time the advantage of being easily dismounted for purposes of cleaning or repair.

The modification of Fig. 4 shows the application of the invention to converters of the boiling bath type in which pressure may be applied to the boiling liquid in order to vary its boiling point. In this type of converter it is necessary to provide a flexible coupling which will be more or less balanced against the increased pressure used on the surface of the liquid, and consequently the flexible flanges are placed within the vapor space above the boiling bath. The bath chamber is made up of the lower tube sheet 25, which is of the usual construction, and the converter shell 21, the upper portion of which is turned inwardly as at 30 and extends downwardy for a short distance parallel to the outer part of the shell. The upper tubesheet 24 supports the circular flange 29, which in turn supports the top piece 22, as in Fig. 1 and the catalyst tubes 26 are fastened into the upper and lower tube sheets in the usual manner. The bath liquid, which may be mercury, mercury alloys, or any similar liquid having a suitable boiling point, surrounds the catayst tubes and during operation its vapors are condensed in the reflux condensers 31 and returned to the bath, suitable pressure being applied to the refluxes at 32 in any suitable manner. The flexible connection between floating superstructure and the converter shell 21 is effected by means of the flexible flanges 33, which flex outwardly into the vapor space of the converter in response to any relative movement between the converter shell 21 and the upper tube sheet 24. It will be noted that the pressure on the upper and lower portions of the pleated flange 33 is the same, so that the metal of the flange is under compression while the converter is in operation rather than under tension as in Fig. 1. For this reason the flange is able to stand much higher pressures than is the case with the

reverse construction, and as the relative movement between the two parts in question is very slight, no difficulty is experienced in retaining a tight connection.

As a result of the flexible connection between the upper and lower portions of the converter it is possible to use metal baths, either boiling or non-boiling, as temperature regulating media, which is not so easily done when there is danger of leakage of poisonous vapors or exposure of the bath material to the air. The high heat conductivity and heat capacity of metallic baths make them much more desirable than non-metalic substances and therefore produce great improvements in the operation of catalytic converters.

The operation of converters constructed according to the present invention is no different from those of the ordinary tube sheet construction once they are running, but the flexibility is of great assistance in starting and stopping the operation. Formerly it was necessary to use great care in heating up and cooling down these converters, for sudden changes would result in great internal stresses and warping both of the tubesheets and of the tubes. By the use of a floating tubesheet construction such as has been described the converters can now be heated to operating temperatures in far less time and can be cooled down as rapidly as desired without danger of leakage, and the flexible closure member permits the use of almost any desired bath material.

What is claimed as new is:

1. A catalytic rigid converter comprising a converter shell, a lower tubesheet set welding into said converter shell, catalyst tubes supporting an upper tubesheet, a superstructure above said upper tube sheet and provided with a gas inlet, and flexible means enclosing the space between said superstructure and said converter shell.

2. A catalytic rigid converted comprising a converter shell, a lower tubesheet set into said converter shell and forming therewith a bath chamber, catalyst tubes set into said lower tube sheet and supporting an upper tube sheet, a bath liquid in said chamber, which during operation of the converter must be completely shut off from the outside air and flexible means enclosing the space between said upper tube sheet and said converter shell.

3. Apparatus according to claim 2, in which at least one component of the bath liquid is mercury.

4. A catalytic rigid converter comprising a converter shell, a lower tube sheet set into said converter shell and forming therewith a bath chamber, catalyst tubes set into said lower tube sheet and supporting an upper tube sheet, reflux condensers in communication with the upper portion of said converter shell, a bath liquid in said bath chamber at least one of the components of which is mercury, means for applying pressure to the space above said bath liquid, and a flexible connection between said upper tubesheet and said converter shell.

5. Apparatus according to claim 4, in which the closure includes a thin pleated flange of a flexible metal which is so disposed that pressure within the bath chamber is exerted on the outer portions of the pleats.

6. A catalytic rigid converter comprising a converter shell, a lower tubesheet set into said converter shell to form therewith a bath chamber, catalyst tubes set into the central portion of said lower tube sheet and supporting an upper tube sheet, a superstructure above said upper tubesheet and provided with a gas inlet, at least one vertical baffle in said bath chamber between the converter shell and said catalyst tubes, and flexible means inclosing the space between said superstructure and said converter shell.

Signed at Pittsburgh, Pennsylvania, this 26th day of May 1930.

ALPHONS O. JAEGER.