

March 13, 1962

C. H. TERPENNING, JR

3,025,145

RETORT FOR AN AMMONIA DISSOCIATOR AND THE LIKE

Filed July 28, 1958

2 Sheets-Sheet 1

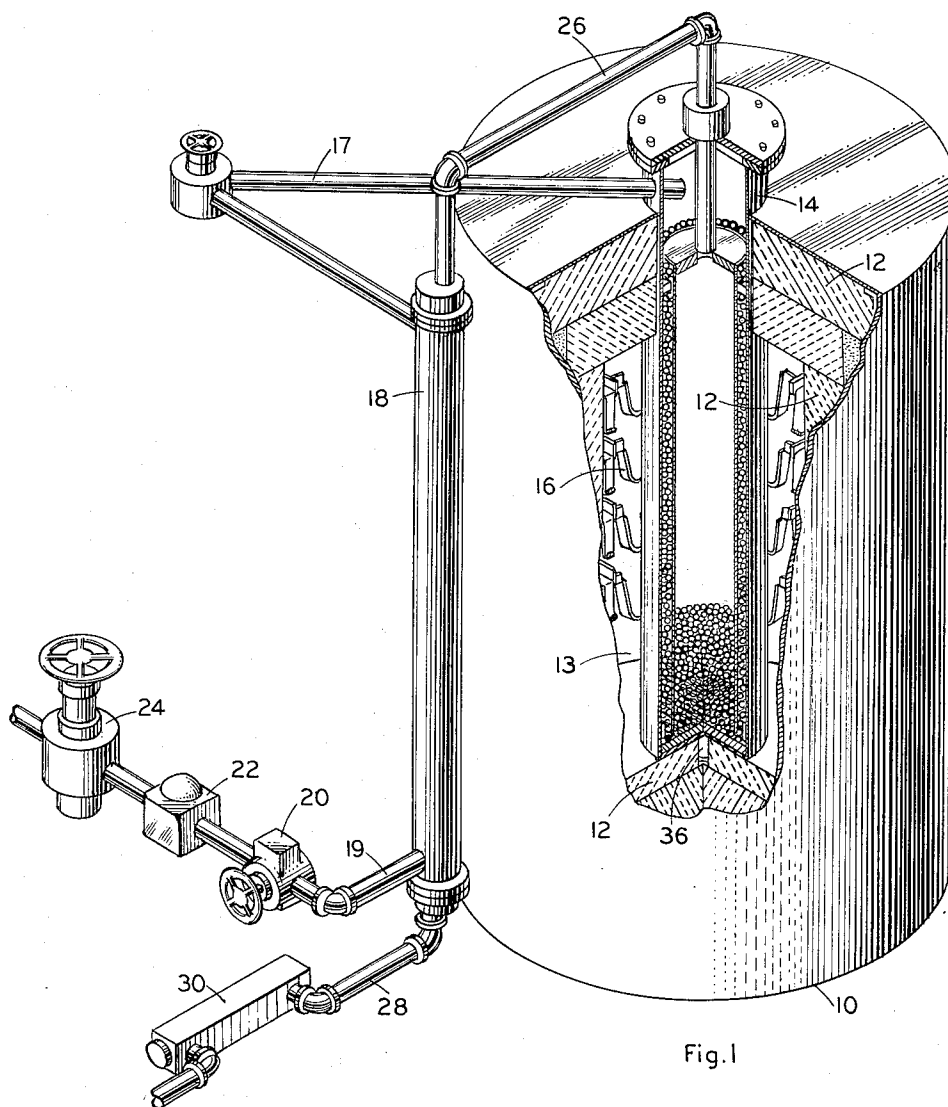


Fig. 1

INVENTOR.

Carl H. Terpenning, Jr.
BY *M W Goodwin*

His Attorney

March 13, 1962

C. H. TERPENNING, JR

3,025,145

RETORT FOR AN AMMONIA DISSOCIATOR AND THE LIKE

Filed July 28, 1958

2 Sheets-Sheet 2

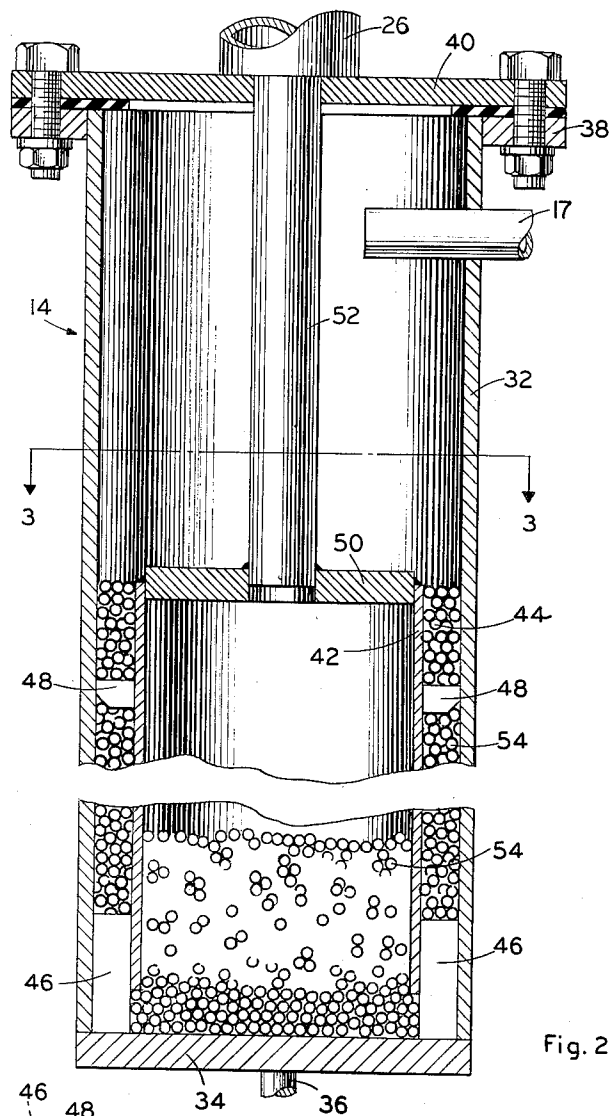


Fig. 2

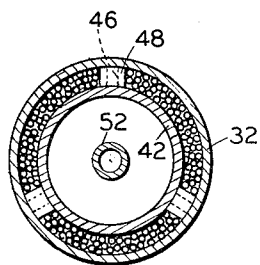


Fig. 3

INVENTOR.

Carl H. Terpenning, Jr.

BY

M. W. Goodwin

His Attorney

1

3,025,145

RETORT FOR AN AMMONIA DISSOCIATOR AND THE LIKE

Carl H. Terpenning, Jr., Shelbyville, Ind., assignor to General Electric Company, a corporation of New York
Filed July 28, 1958, Ser. No. 751,361
8 Claims. (Cl. 23—238)

This invention relates to gas producing equipment and more particularly to an ammonia dissociator having a retort of novel and improved construction.

Ammonia dissociating equipment is utilized to crack or dissociate ammonia into its constituents of hydrogen and nitrogen for use as a protective atmosphere for bright annealing of carbon and stainless steels, furnace brazing of tungsten, silver alloys, etc., reduction of metallic oxides, etc. Such equipment commonly comprises a retort at least partially filled with a catalyst with means being provided for externally heating the retort. Vaporous ammonia is introduced into the retort and is passed through the catalyst whereupon, in the presence of heat, the ammonia will break down into a mixture of hydrogen and nitrogen with a minor percentage of dissociated ammonia. It is of course desirable to maintain the percentage of dissociated ammonia at the minimum level possible.

One known construction of such a retort comprises a cylinder filled with a catalyst and having an ammonia inlet at one end and a nitrogen-hydrogen outlet at its other end. The cylinder is externally heated, and as will be apparent, with such a retort construction and method of heating, there is an appreciable variation in internal temperature between the portion of the cylinder adjacent its periphery and the portion thereof adjacent its longitudinal axis or center. The lower temperature of the center section of the retort reduces the optimum efficiency of the retort with a resulting increase in undissociated ammonia. Another known construction of a retort for ammonia dissociator comprises a tubular coil at least partially filled with a catalyst. The coil is adapted to be externally heated and, inasmuch as the diameter of the tube forming the coil will normally be substantially less than the diameter of the cylindrical retort of the same capacity, it will be appreciated that the heat distribution diametrically across the tube is improved over that obtained with a cylindrical retort resulting in an improvement in efficiency of operation or in other words a lesser percentage of undissociated ammonia. This latter construction, however, is somewhat more costly and complicated to manufacture than the former construction.

It is accordingly the object of this invention to provide a retort of novel and improved construction for use with an ammonia dissociator which will provide an efficiency of operation at least equal to the tubular coil type retort while having a simplicity and economy of construction comparable to the cylindrical type retort.

Other objects and advantages will be obvious and in part pointed out in more detail in the following description.

In one form, the novel and improved retort of this invention comprises a pair of vertically arranged elongated cylinders disposed concentrically one within the other with the outer cylinder being closed at both ends and with the inner cylinder being closed at one end and spaced radially inwardly of the outer cylinder to provide an annular gas passage between the cylinders which is adapted to contain a catalyst. The other open end of the cylinder is in gas flow communication with the annular passage between the cylinders, and a pair of gas conduits are adapted to be connected, respectively, to the annular passage adjacent the closed end of the inner cylinder and to the interior of the inner cylinder adjacent its closed end. The retort is adapted to be heated externally so that, as vaporous

2

ammonia is introduced into the conduit connected to the annular passage for flow therealong through the catalyst, the ammonia will be heated and dissociated into nitrogen and hydrogen. The dissociated ammonia will then flow in a reverse direction through the inner cylinder and, inasmuch as the dissociated ammonia will be at an elevated temperature, it will transfer additional heat to the annular passage from inside the retort so as to maintain a substantially constant temperature across the annular passage and thus materially improve the operating efficiency of the retort.

A more detailed understanding of the invention may be had from the following description taken in connection with the appended drawings in which:

FIG. 1 is a simplified perspective view, partly in section, of an ammonia dissociator incorporating a retort constructed in accordance with the present invention;

FIG. 2 is an enlarged fragmentary longitudinal cross sectional view of the retort of FIG. 1; and

FIG. 3 is a reduced cross sectional view substantially along the line 3—3 of FIG. 2.

With reference to the drawings and particularly FIG. 1, an ammonia dissociator of a type of which this invention is concerned comprises a combustion chamber 10 having side, top and bottom walls lined with refractory material 12 and forming an internal heating space 13 into which extends a vertically arranged retort 14. A ribbon resistance heating element 16 is mounted about the walls of the heating space 13 providing means for externally heating the portion of the retort disposed within the heating space 13. Suitable external electrical connections, not shown, are provided for connecting the heating element to a source of power. A vaporous ammonia inlet conduit 17 is connected to the retort 14 and to an end of a heat exchanger 18 with the portion of the heat exchanger to which the inlet conduit 17 is connected being connected at its opposite end to a conduit 19 leading through serially connected reducing valve 20, solenoid control valve 22 and manual control valve 24 to a source of liquid ammonia. A nitrogen-hydrogen outlet conduit 26 is connected at one end to the retort 14 and at its other end to the heat exchanger 18 with the portion of the heat exchanger to which the conduit 26 is connected, being further connected at its outlet end to a conduit 28 connected through a flowmeter 30 and adapted to terminate in a furnace or storage tank.

The retort 14 constructed in accordance with this invention comprises an outer cylinder or housing 32 closed at its bottom end by a plate 34 having a centering member 36 which as is shown in FIG. 1 is engageable in a recess in the bottom refractory lining of the combustion chamber to center the bottom end of the retort in the combustion chamber. The top of the outer cylinder 32 is provided with an external annular flange 38 to which is bolted a top cover plate 40 with a seal between the plate and flange. Disposed concentrically within the outer cylinder 32 is an inner cylinder 42 having an outer diameter less than the inner diameter of the outer cylinder to provide an annular passage 44 between the cylinders. The bottom end of the inner cylinder is spaced from the bottom plate 34 of the outer cylinder and is centered in the outer cylinder by a plurality of spacers 46 suitably fixed to the inner cylinder and engaging the bottom wall 34 and the inner wall of the outer cylinder adjacent the lower end thereof. A plurality of additional spacers 48 are fixed to the outer wall of the inner cylinder adjacent the upper end thereof and are engageable with the inner wall of the outer cylinder to center the top portion of the inner cylinder within the outer cylinder. A cover plate 50 is welded to the top of the inner cylinder to close the same and a pipe 52 extends into a central aperture in the top plate 50 and connects the interior of the inner cylinder

with the outlet conduit 26. The top of the inner cylinder is preferably spaced at a substantial distance from the top of the outer cylinder, and the inlet conduit is preferably connected to the space between the tops of the cylinders so that vaporous ammonia introduced through the conduit 17 will be distributed evenly around the annular passage 44. The annular passage 44 is substantially filled with a catalyst 54 as is also the bottom portion of the inner cylinder.

In the operation of the ammonia dissociator of FIG. 1, liquid ammonia is introduced through the valves 24 and 22 and is expanded in the expansion valve 20 to partially vaporize the ammonia and substantially reduce the pressure thereof. The low pressure partially vaporized ammonia is then passed through the heat exchanger 18 where it is vaporized and the vaporous ammonia is then passed through the inlet conduit 17 into the retort 14 and through the annular passage 44 and catalyst therein. The heat provided by the heating element 16 together with the catalyst results in the breaking down of the ammonia into nitrogen and hydrogen which is passed into the bottom of the inner cylinder and returned through the inner cylinder to the outlet conduit 26 and thence through the heat exchanger 18 to a furnace or storage tank. The partially vaporized ammonia passing through the heat exchanger 18 provides cooling for the outgoing hot nitrogen and hydrogen mixture, and correspondingly the outgoing hot gases provide heat to vaporize the incoming partially vaporized low pressure ammonia. The return flow of the heated nitrogen and hydrogen through the inner cylinder provides additional heating of the annular passage 44 from the inside diameter thereof so as to substantially reduce any temperature differential across the annular passage with a resulting material increase in efficiency of operation of the retort.

For example, with the retort constructed as described utilizing an outer cylinder having a four-inch inner diameter and an inner cylinder having a two-inch outer diameter so as to provide a one-inch wide annular space therebetween and with twenty-two inches of the outer cylinder being exposed to heat, 99.95 per cent ammonia dissociation has been obtained at a retort flow of 250 cubic feet per hour. The particular catalyst utilized was ¼ inch balls of porous refractory material which had been dipped in an iron base solution and then baked. The relatively small size of the catalyst balls permits a relatively high velocity gas flow through the annular passage 44 and provides a high degree of turbulence for good surface contact of the gases with the catalyst. The porosity of the balls provides additional surface area for the same size balls thus providing an increase in the efficiency of the catalyst.

For the particular retort and catalyst described, a space velocity of 2200 cubic feet of gas per hour per cubic feet of catalyst was utilized with an operating temperature externally of the retort of 1650° F., which is substantially lower than operating temperatures previously being deemed necessary. The improved heat distribution provided by the retort of this invention permits the use of a higher rate of gas flow through the retort for the same efficiency of operation thus increasing the output of the equipment. In this connection it has been determined that a one-inch wide annular passage in a retort constructed in accordance with this invention will provide optimum heat distribution consistent with desirably high rates of gas flow. Additionally the improved heat distribution characteristic of the retort, contributes to the use of a lower external temperature which materially increases the service life of the equipment.

It should also be noted that the decrease in operating temperature of the equipment results in a decrease in temperature of the outgoing nitrogen-hydrogen mixture thus reducing the amount of cooling required for the outgoing gases. It should also be noted that the heat exchanger 18,

as shown in FIG. 1, is located in downstream relation to the expansion valve 20 rather than in an upstream relation thereto as has been previously practiced. The relative location of the heat exchanger and expansion valve, shown in FIG. 1, results in the vaporizing of the ammonia in the heat exchanger being accomplished at a substantially lower pressure than if the location of these units were reversed. For example, in a specific embodiment of the invention, the pressure of the incoming ammonia was reduced from 300 p.s.i.g. to 10 p.s.i.g. by the expansion valve and prior to passage of the ammonia into the heat exchanger. Accordingly, the internal stresses on the heat exchanger are correspondingly reduced resulting in a simpler, more economical construction for the heat exchanger. The vaporizing of the ammonia at a lower pressure of course requires less heat thus enabling the vaporizing to be accomplished by the outgoing nitrogen-hydrogen mixture without requiring additional heating means as heretofore was necessary. Thus, with the lower operating temperatures obtainable with the use of the retort of this invention and the relative location of the heat exchanger and expansion valve, additional heating of the incoming ammonia as well as additional cooling of the nitrogen-hydrogen mixture is eliminated, thus reducing the overall cost and installation requirements of the equipment.

While the retort of the present invention has been described in terms of an ammonia dissociator, it will be understood and apparent that its use is not necessarily limited to this specific application but may be useful in other gas producing equipment utilizing a catalytic process requiring external heat. It will be understood, as will be apparent to those skilled in the art, that many changes could be made in the construction heretofore shown and described and that different embodiments of the invention could be made without departing from the scope thereof. Accordingly, the foregoing description and drawings should be taken only in an illustrative sense and not as limiting the invention, it being intended that the invention herein described shall be limited only by the terms of the appended claims which shall include within their scope and meaning all structure which logically falls within the language of the claims.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. In an apparatus for conducting a gaseous endothermic reaction, the combination of a pair of elongated concentric cylindrical members defining a narrow annular chamber therebetween, a catalyst for promoting the reaction positioned in said annular chamber, heaters surrounding the outer of said pair of cylindrical members for heating the catalyst, an inlet conduit communicating with said annular chamber for delivering gas to one end of said annular chamber, means providing communication between the opposite end of said annular chamber and the interior of the inner cylindrical member, and an outlet conduit communicating with the interior of said inner cylindrical member at the other end thereof to pass the reacted gas through the interior of the inner cylindrical member in heat exchange relation with the catalyst to minimize the temperature gradient across the catalyst bed.

2. In an apparatus for conducting a gaseous endothermic reaction, the combination of a pair of elongated vertically arranged concentric cylindrical members defining a narrow annular passage for containing a reaction promoting catalyst, heaters surrounding the outer of said pair of cylindrical members for heating the catalyst, an inlet passage communicating with the upper end of said annular passage for delivering gas thereto, means providing communication between the lower end of said annular chamber and the interior of the inner cylindrical member, and an outlet conduit communicating with the interior of said inner cylindrical member at the upper end thereof to pass the reacted gas through the interior of the inner cylindrical member in heat exchange relation with

5

the inner wall of the annular passage to minimize the temperature gradient across the catalyst bed.

3. A device as defined in claim 2 wherein a plurality of centering members concentrically position and support the inner cylindrical member within the outer cylindrical member.

4. In an apparatus for conducting a gaseous endothermic reaction, the combination of a pair of elongated vertically arranged concentric cylindrical members defining a narrow annular passage for containing a reaction promoting catalyst, heaters surrounding the outer of said cylindrical members for heating the catalyst, an inlet passage communicating with the upper end of said annular passage for delivering gas thereto, the lower end of the inner of the cylindrical members being open and spaced above the lower end of the outer cylindrical member to provide communication between the annular passage and the interior of the inner cylindrical member, and an outlet conduit communicating with the interior of the inner cylindrical member at the upper end thereof to pass the reacted gas through the inner cylindrical member in heat exchange relation with the inner wall of the annular passage to minimize the temperature gradient across the catalyst bed.

5. The device described in claim 4 wherein the upper end of said inner cylindrical member is spaced below the upper end of the outer cylindrical member to provide a plenum chamber to distribute the incoming gas uniformly in the annular passage.

6. An ammonia dissociator comprising a retort including a first vertically arranged elongated housing having a peripheral wall, a second housing having a peripheral wall defining a central passage and positioned within the peripheral wall of the first housing to define an outer passage of uniform thickness therewith, a catalyst at least partially filling the outer passage, means surrounding the peripheral wall of the first housing for heating the catalyst in the outer passage, an inlet gas conduit connected in fluid flow communication with the outer passage adjacent its upper end, an outlet gas conduit in fluid flow communication with the upper end of the central passage, the inlet and outlet conduits being in heat exchange relationship externally of the retort to heat the incoming gas, and an expansion valve positioned on the upstream side of the heat exchanger in the inlet gas conduit to substantially reduce the pressure of, and at least partial-

6

ly vaporize, the ammonia before it passes into said heat exchanger.

7. In the process for dissociating liquid ammonia in an endothermic reaction to obtain gaseous products therefrom, the improvement which comprises the step of passing the ammonia through an expansion valve to vaporize the same, at least in part, prior to passing it into heat exchange relationship with the output gaseous products of the process to complete the vaporization of the ammonia prior to subjecting it to the endothermic reaction.

8. In an apparatus for conducting a gaseous endothermic reaction, the combination of a pair of elongated members positioned one within the other and respectively providing walls spaced apart a uniform thickness to define a catalyst chamber, a catalyst bed for promoting the reaction positioned in said chamber, means for heating the catalyst through the wall of one of said members, an inlet conduit communicating with said catalyst chamber for delivering incoming gas thereto, means providing an outlet from the opposite end of said catalyst chamber and means communicating with said outlet, means for passing the reacted gas in heat exchange relation with the wall of the other of said members to heat the catalyst bed thereby to minimize the temperature gradient across the catalyst bed.

References Cited in the file of this patent

UNITED STATES PATENTS

1,286,135	Somermeier	Nov. 26, 1918
1,450,569	Williams et al.	Apr. 3, 1923
1,689,684	Reed	Oct. 30, 1928
1,855,134	L'Heure	Apr. 19, 1932
1,893,492	Brill	Jan. 10, 1933
1,959,219	Reed	May 15, 1934
2,032,652	Chaffaut	Mar. 3, 1936
2,034,693	Datin	Mar. 24, 1936
2,190,548	Pleydell	Feb. 13, 1940
2,615,795	Peck et al.	Oct. 28, 1952
2,898,183	Fausser	Aug. 4, 1959

FOREIGN PATENTS

37,369	Norway	July 16, 1923
--------	--------	---------------

OTHER REFERENCES

45	Babor et al.: General College Chemistry, 1940, published by Thomas Y. Crowell Co., N.Y., pp. 382-383.
----	---