June 9, 1931. L. GILLETT 1,809,114

PROCESS AND APPARATUS FOR CATALYTIC REACTIONS

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Fig. 6.

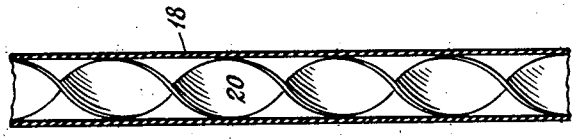
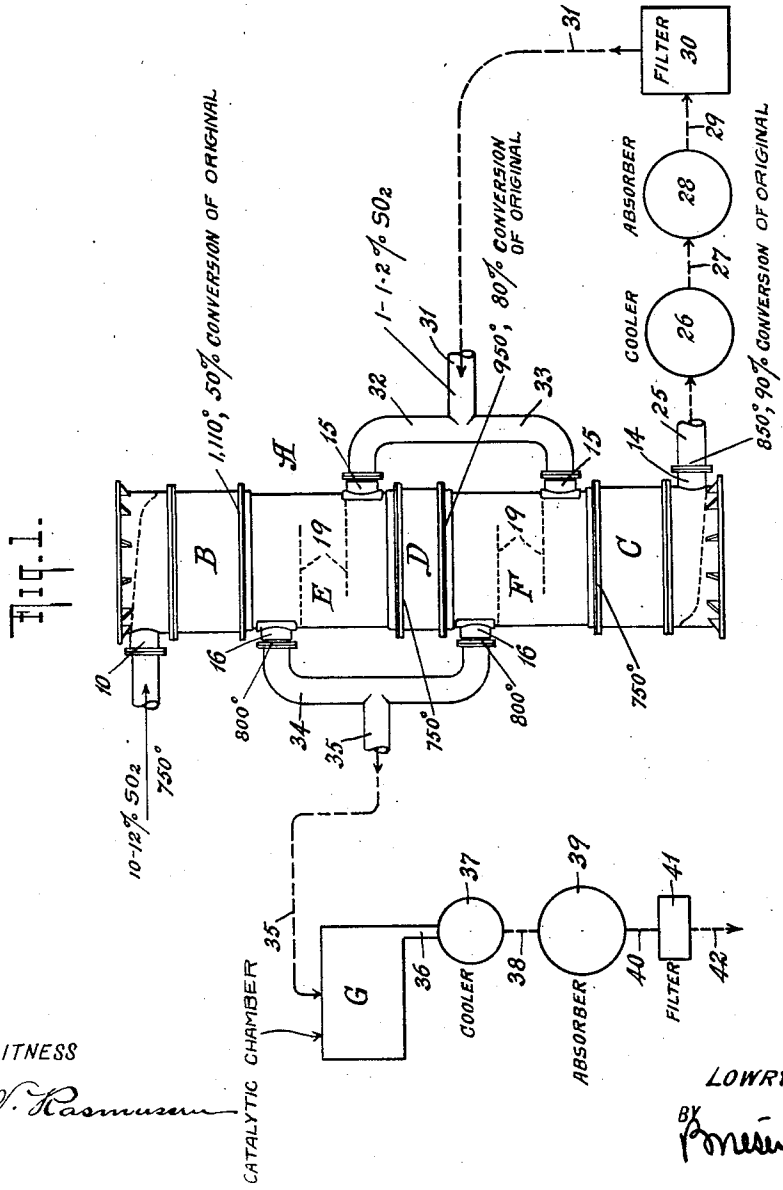


Fig. 1.



WITNESS

G. V. Rasmussen

INVENTOR

LOWRY GILLETT

BY Brosius & Hellwell

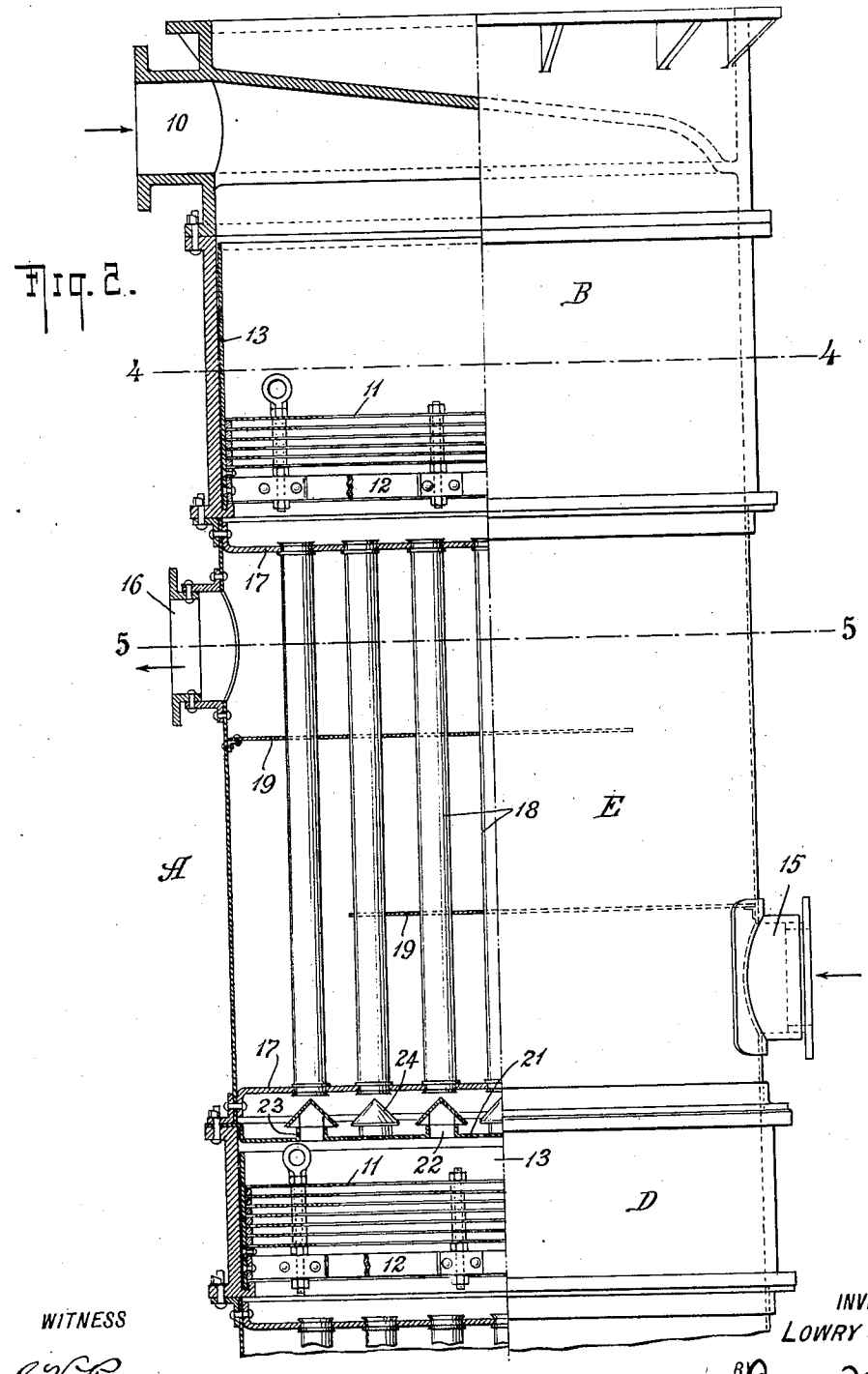
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PROCESS AND APPARATUS FOR CATALYTIC REACTIONS

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Fig. 2.



WITNESS

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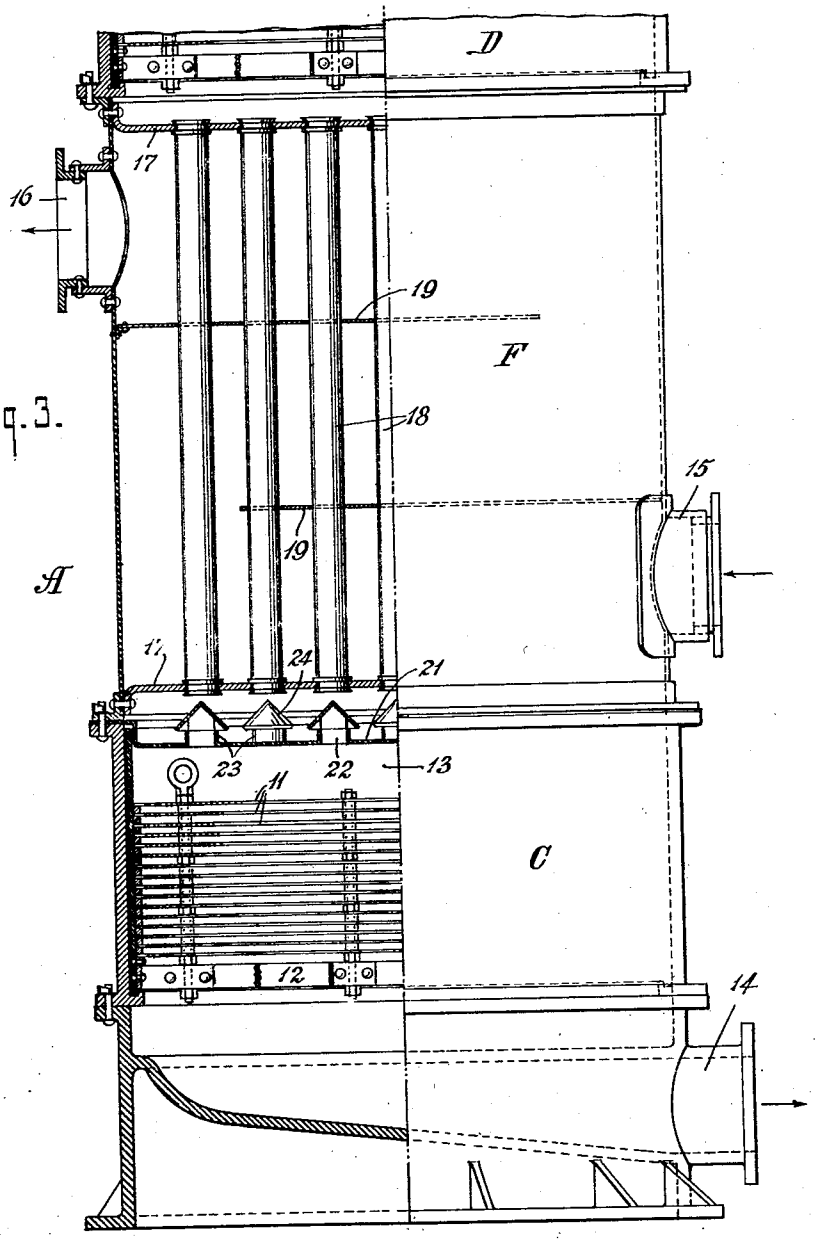
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June 9, 1931. L. GILLETT 1,809,114

PROCESS AND APPARATUS FOR CATALYTIC REACTIONS

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Fig. 3.



WITNESS

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PROCESS AND APPARATUS FOR CATALYTIC REACTIONS

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Fig. 4.

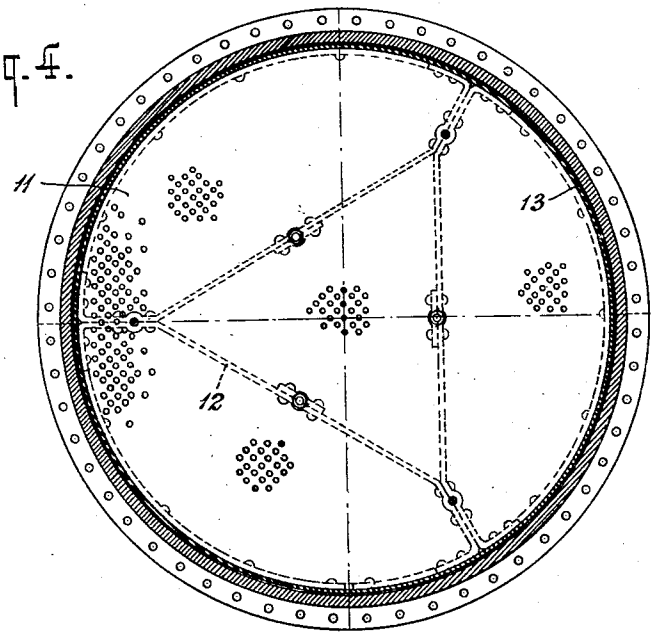
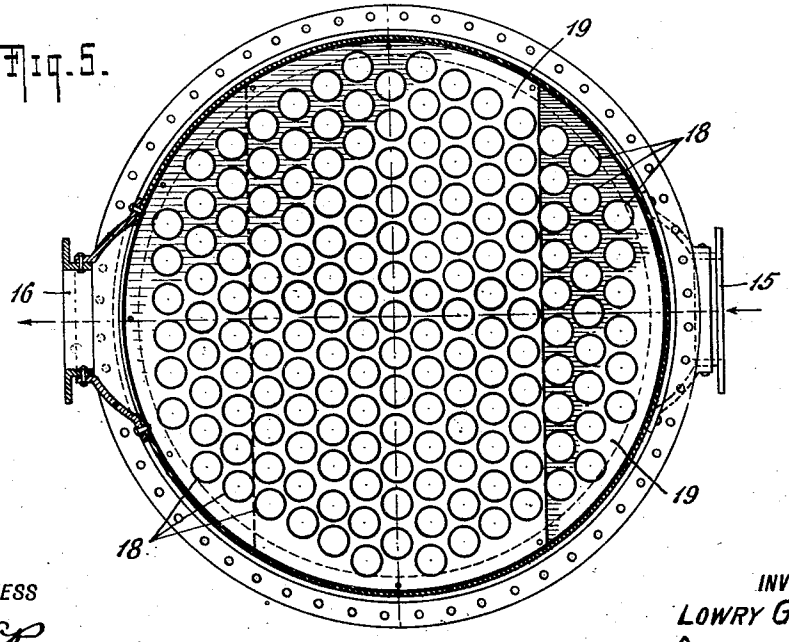


Fig. 5.



WITNESS

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Patented June 9, 1931 1,809,114

UNITED STATES PATENT OFFICE

LOWRY GILLETT, OF SYOSSET, NEW YORK, ASSIGNOR TO GENERAL CHEMICAL COMPANY, OF NEW YORK, N. Y., A CORPORATION OF NEW YORK

PROCESS AND APPARATUS FOR CATALYTIC REACTIONS

Application filed November 24, 1924. Serial No. 751,802.

My invention relates to catalytic processes and apparatus, and particularly to such as are suitable for the conversion of sulfurous anhydride (SO_2) into sulfuric anhydride (SO_3). The object of my invention is to conduct such catalytic reactions under conditions of great economy and uniformity of results, and to reduce the size of the apparatus required, thereby saving in factory space and in the cost of the plant. A further object of my invention is to preserve the apparatus in a working condition without cleaning for a long time, by making special provision for the trapping of solid impurities, and particularly dust and scale carried by the gases under treatment.

A typical and satisfactory apparatus embodying my present invention and suitable for carrying out my improved process, is illustrated by the accompanying drawings, in which Fig. 1 is a diagrammatic elevation of the entire plant adapted for the conversion of sulfurous acid (SO_2) into sulfuric acid; Figs. 2 and 3 are vertical sections, on an enlarged scale, showing the upper and the lower portions respectively of a column forming part of the apparatus; Figs. 4 and 5 are horizontal sections on lines 4—4 and 5—5 respectively of Fig. 2; and Fig. 6 is a detail vertical section of a portion of the heat-transferrer.

At 10, I have indicated the inlet through which the gases to be treated (for instance a mixture containing from 10 to 12% of SO_2) are admitted to the upper portion of a column-like structure A which, in the particular embodiment shown, comprises five superposed sections or compartments, of which the upper-most and lowermost, B and C, as well as the middle compartment, D, constitute catalytic converters connected in series, while the two intermediate compartments, E and F (immediately above and below the middle compartment D), are heat-exchangers or transferrers. The two transferrers are constructed alike, and the three converters are of the same general construction, but differ somewhat in power, as will be explained below. This construction provides a plurality of separate converter stages connected in series and having heat exchangers intermediate the successive converter stages.

Each of the converters contains the catalytic material (such as platinized asbestos) supported in any suitable manner. For instance, I have invented for this purpose a special novel construction in which the catalytic material rests on superposed spaced perforated plates 11 mounted in a carrier or basket composed of an open-work bottom or spider 12 and a shell 13, with accessories to properly space and secure the plates. The entire carrier or basket may be removed, together with the plates 11 and the catalytic material, as soon as the top of the converter section is opened. As shown in Figs. 2 and 3, the sections of column A are connected in such a way as to allow them to be taken apart readily. The converters B, C, D, differ as to the number of layers of catalytic material (between the perforated plates 11), the upper converter having the smallest number of such layers (for instance, five), the middle converter D a larger number (for instance six) and the lower converter C a still larger number (for instance, fifteen). The purpose of this difference will be explained below. The lower converter C is provided, at the bottom, with an outlet 14.

Each of the transferrers E, F, is provided with an inlet 15 at the bottom, for the admission of the cooling medium, and with an outlet 16 at the top. The horizontal walls or partitions 17 located above such outlets and below said inlets receive tubes 18 through which the gases undergoing conversion pass downwardly from one converter to the next, while the cooling medium flows in contact with the outer surfaces of the tubes 18, being preferably compelled, as by baffles 19, to follow a sinuous path. In order to prevent the gas streams in the tubes 18 from flowing chiefly along the inner surfaces of said tubes and leaving a relatively stagnant core, it is advisable to locate a helical wall 20 within each of these tubes, so that the stream will be whirled and all of its particles brought in contact with the metallic cooling surfaces.

Between the lower end of each of the transferrers and the upper end of the converter

located immediately below, I prefer to arrange a purifier or dust collector for arresting dust and other solid matter suspended in the gases under treatment, and preventing such matter from reaching the converters C and D and impairing their efficiency. Such collector may consist of a pan-like body 21 having apertures 22 (generally less in number than the tubes 18) with tubular projections 23 extending upwardly and covered by caps or cowls 24 which act as deflectors to throw any dust or other foreign matter laterally away from the apertures 22 and into the pan-like body 21, whence the matter thus collected may be removed from time to time.

The outlet 14 is connected by a pipe 25 to the inlet of a cooler 26 (of any suitable construction) the outlet of which is connected by a pipe 27 with the inlet of an absorber 28 which may be of any approved construction suitable for the absorption of the converted gas (that is to say, in the present case, SO_3). From the absorber, the remaining gas passes through a pipe 29 to a filter 30 (for instance a coke filter) and then through a pipe 31 and branches 32, 33 to the inlets 15 of the transferrers E, F.

From the outlets 16 of the transferrers the gases pass to a final converter G. This may be of the same character as the converters B, C, D, but is more powerful, having a greater number of layers of catalytic material, preferably about as many as the three converters B, D, C, have together. The outlets 16 are connected to the inlet of the final converter G by pipes 34, 35. From the outlet of the converter G the gases pass through a pipe 36 to a cooler 37, and then through a pipe 38 to an absorber 39, to pass subsequently through a pipe 40 to a filter 41 and thence to the stack through a pipe 42.

The operation, in the case of gases containing, say from 10 to 12% of SO_2, is as follows:

These gases, having a temperature of about 750° F., enter at 10 and pass through the upper converter B, where about 50% of the SO_2 present is converted into SO_3 by the well-known catalytic reaction, the temperature of the gases being thereby raised to about 1100° F. The hot gases then pass downwardly through the helical paths within the tubes 18 of the upper transferrer E, and are there cooled to the original admission temperature (750° F.). As the gases issue from the lower ends of the tubes 18, they are not allowed to pass directly to the second converter D, but are deflected by the cowls 24 so that dust and other solid matter will be deflected into the pan-like collector 21, while the gases thus freed of solid matter will pass through the apertures 22 to the second converter D. In view of the fact that the gases admitted to the second converter contain a considerably smaller proportion of SO_2 than the gases originally admitted at 10 (the gases entering the second converter may contain, for instance, from 5 to 6% of SO_2), the second converter has been made more powerful than the first, by increasing the number of layers of catalytic material. In this second converter, the conversion is carried to the point where about 80% of the original SO_2 content has been converted into SO_3, the temperature rising to about 950° F. At this temperature, the gases pass into the lower transferrer F, where their temperature is again reduced to the original admission temperature (750° F.). The cooled gases are then led through the dust-separator interposed between the second transferrer F and the third converter C, and being thus further freed of any solid matter, are brought, at this temperature of about 750° F., into contact with the catalytic material in the converter C. The fact that at this point the gases are comparatively rich in SO_3 and poor in SO_2 (containing, for instance, from 2 to 2.5% of SO_2), is taken care of by again increasing the number of layers of catalytic material, and thus, when leaving the converter C through the outlet 14, the gases will have about 90% of the original SO_2 content converted into SO_3, and their temperature may be, for instance, about 850° F. It will be seen that the gases are thus subjected to catalytic action in a plurality of separate converter stages, each containing a successively increasing amount of platinum catalytic material, and are cooled intermediate the several conversion stages to the temperature desired for the following conversion.

The cooler 26 brings the temperature of the gases down to one suitable for the efficient absorption of SO_3 to form H_2SO_4 in the absorber 28. The remaining gases, which are relatively cool and still contain from about 1 to 1.5% of SO_2, pass through the filter 30 to the transferrers E, F, where these gases act as a cooling medium for the hot gases passing through the tubes 18. By this cooling action, as they absorb heat from the gases streaming through the tubes 18, the gases leaving the transferrers at 16 are brought to a higher temperature, for instance about 800° F., and at this temperature they pass to the final converter G, where the conversion of SO_2 into SO_3 is completed, or at least carried as far as practical considerations will permit. I have found it desirable to send a larger portion of the gases from pipe 31 through the first transferrer E, and a smaller portion through the second transferrer F; for instance, two-thirds of these gases may pass through the pipe 32, and one-third through the pipe 33. The cooling action will thus be properly proportioned in view of the fact that the gases enter the tubes 18 of the first transferrer at a considerably higher temperature than the tubes of the second transferrer (1100° and 950° F., respec-

tively, in the example given). Suitable cocks or valves would be placed at appropriate points of the pipes, to enable the flow to be controlled or varied as desired, and a blower or like device may be employed to propel or draw the gases through the apparatus. As these elements may be of a well-known type, I have not deemed it necessary to show them in the drawings.

The advantages of my invention reside in a great simplification of the plant, there being but few pipe joints, thereby reducing the changes of leakage. Furthermore, as a minimum number of layers of catalytic material is used, the resistance to the flow of the gases is reduced, as are also pressure losses, and less power is required to cause the gases to pass through the apparatus. A further saving in initial cost and running expenses is effected by the use of a relatively small amount of catalytic material, and by the fact that this material is not allowed to become heated excessively, the heat being removed when the temperature of the gas reaches the point at or above which little or no conversion into SO_3 takes place. The process is also economical for the reason that the heat of the incoming gases which have undergone partial conversion is sufficient to raise the temperature of the gases used for cooling purposes (that is, the gases from which a large proportion of SO_3 has been removed in the absorber 28) to the proper point for the final conversion in converter G.

Various changes may be made in the specific forms shown and described without departing from the spirit of my invention, as set forth in the claims.

I claim as my invention:

1. The process of carrying out catalytic gas reactions, which consists in subjecting the gases under treatment to a catalytic reaction in successive stages with an amount of catalytic material increasing from one stage to the next, absorbing the gaseous product resulting from such reaction, and using the gases remaining after such absorption, as a cooling medium for the gases which have become heated by part of the said catalytic reaction.

2. The process of carrying out catalytic gas reactions, which consists in subjecting the gases under treatment to a partial catalytic reaction in successive stages with an amount of catalytic material increasing from one stage to the next, absorbing the gaseous product resulting from such partial reaction, using the gases remaining after such absorption, as a cooling medium for the gases which have become heated by that part of the catalytic reaction which precedes said absorption and thereby heating such remaining gases, and then subjecting the remaining gases thus heated, to a further catalytic reaction with an amount of catalytic material exceeding that employed in the last preceding catalytic reaction stage.

3. The process of carrying out catalytic gas reactions, which consists in subjecting the gases under treatment to a catalytic reaction in successive stages with an amount of catalytic material increasing from one stage to the next, absorbing the gaseous product resulting from such reaction, cooling the gases on their way from one of said reaction stages to the next, to approximately their original admission temperature, by means of the unconverted residue of the gases which have been partially converted by the catalytic reaction, subsequently cooled, and have had the product of the conversion removed therefrom by absorption, thereby heating such unconverted residue and then subjecting the residue gases thus heated to a further catalytic reaction with an amount of catalytic material exceeding that employed in the last preceding catalytic reaction stage.

4. An apparatus of the character set forth, comprising a plurality of catalytic converters connected in series, a cooler interposed between two successive converters, an absorber having an inlet connected to the outlet of the last of said converters and an outlet connected to the inlet of said cooler, and a final converter connected to the outlet of said cooler, said converters containing catalytic material in an amount increasing from one converter to the next.

5. An apparatus of the character set forth, comprising a plurality of catalytic converters connected in series, a cooler interposed between two successive converters, an absorber having an inlet connected to the outlet of the last of said converters and an outlet connected to the inlet of said cooler, and a final converter connected to the outlet of said cooler, said converters containing catalytic material in an amount increasing from one converter to the next, and the said final converter containing approximately as much catalytic material as the others together.

6. An apparatus of the character set forth, comprising a plurality of catalytic converters connected in series, a plurality of coolers arranged in alternation with said converters, and an absorber having an inlet connected to the outlet of the last of said converters and an outlet connected to the inlets of different coolers.

In testimony whereof I have hereunto set my hand.

LOWRY GILLETT.