July 10, 1951 R. C. LASSIAT ET AL 2,559,646

CONVERSION APPARATUS AND ASSOCIATED ARRANGEMENT FOR CONTROLLING DISTRIBUTION OF GASES PASSING THERETHROUGH

Filed May 6, 1947 2 Sheets-Sheet 1

Fig. 1

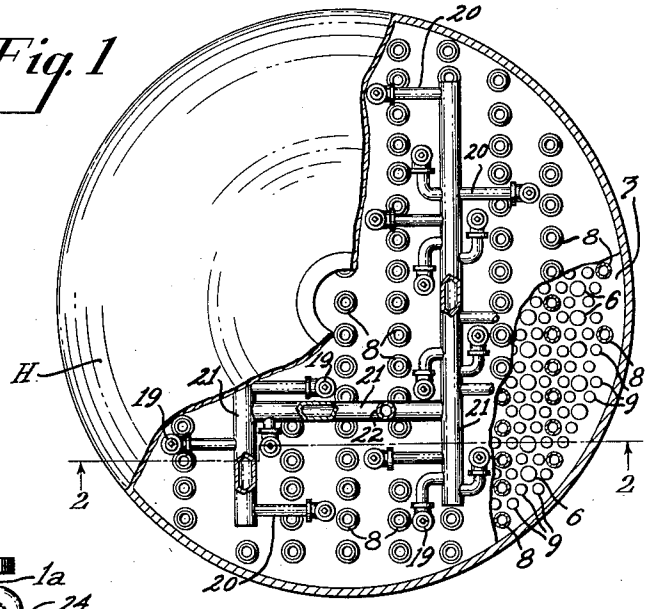


Fig. 2a

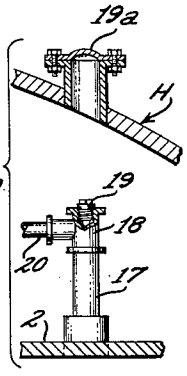


Fig. 2

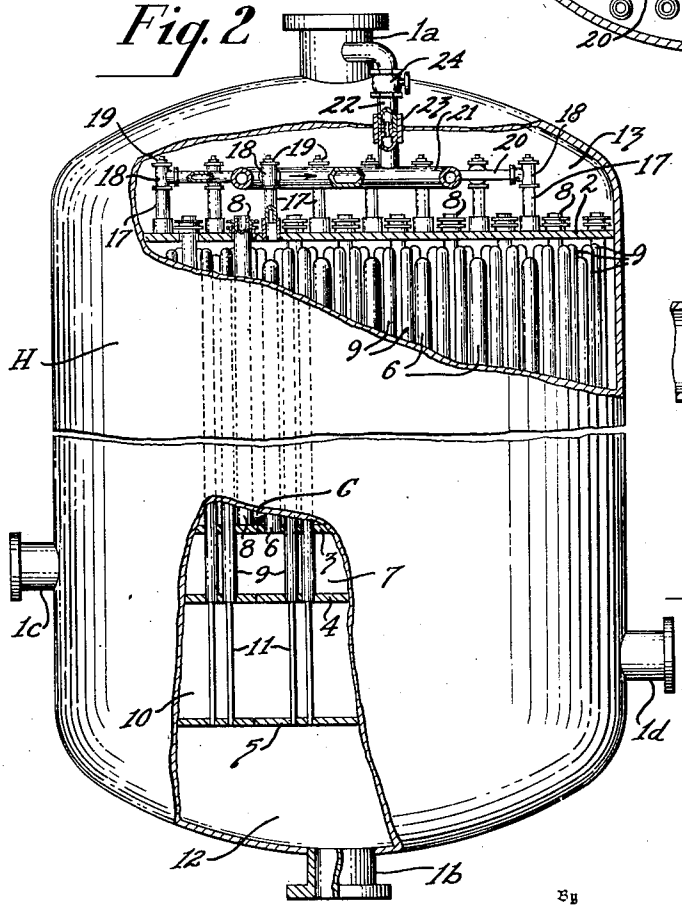
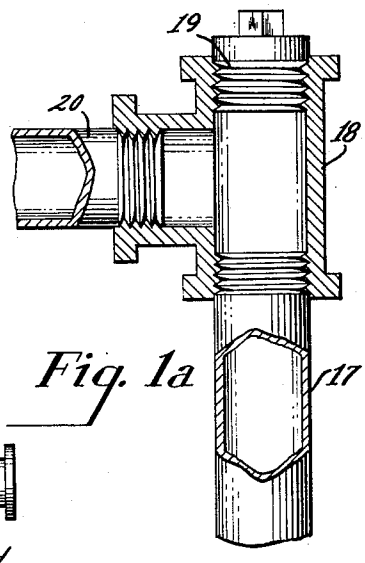


Fig. 1a



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Filed May 6, 1947 2 Sheets-Sheet 2

Fig. 3

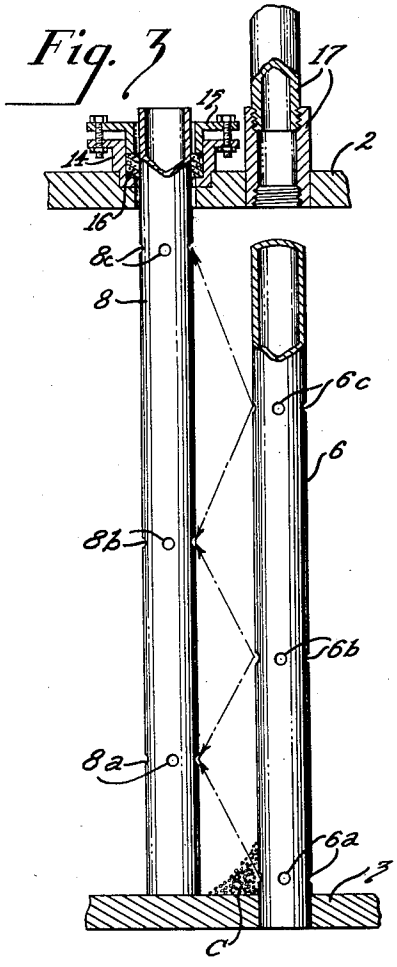


Fig. 5

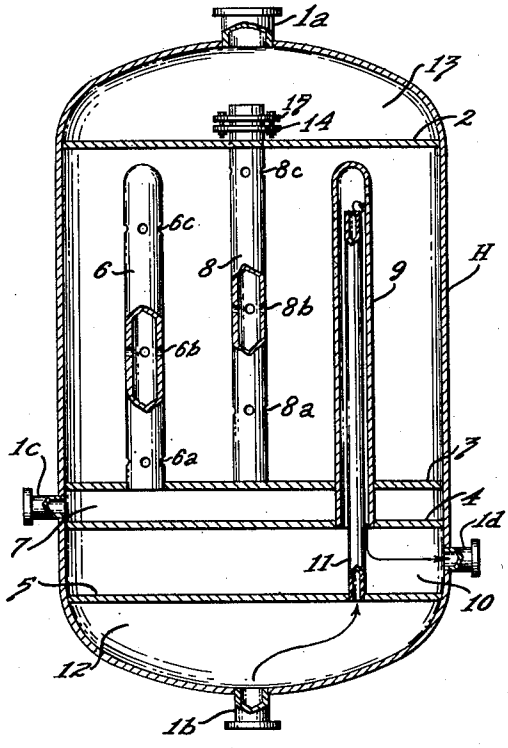
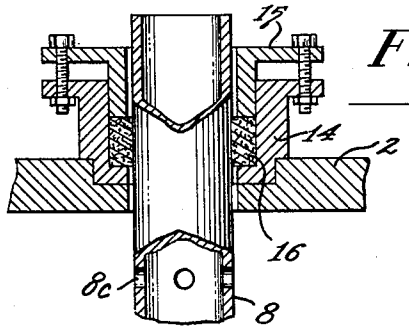


Fig. 4



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UNITED STATES PATENT OFFICE

2,559,646

CONVERSION APPARATUS AND ASSOCIATED ARRANGEMENT FOR CONTROLLING DISTRIBUTION OF GASES PASSING THERETHROUGH

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Application May 6, 1947, Serial No. 746,400

5 Claims. (Cl. 23—288)

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Our invention relates to a converter comprising a reaction chamber containing a fixed bed of catalytic or other contact material.

Converters of the character referred to above, as known in the art, may comprise sets of vertical port-defining tubes which extend through the reaction chamber. During an on-stream period, hydrocarbon vapors or other gases to be converted are passed in either direction from the ports of one set of said tubes to the ports of the other set thereof and, during a subsequent regenerating period, a suitable regenerating medium is passed in similar fashion between said sets of tubes. For the reasons hereinafter stated, the leakage effect of certain slip joints necessarily included in the converter apparatus may change to cause an unbalanced or non-uniform distribution of the vapors or gases as they pass, in the manner described above, along their intended paths from one set of tubes to the other set thereof. In accordance with the invention, a control may be effected on a by-pass system disposed in parallel relation with the aforesaid slip joints and traversed by some of the gases entering or leaving the converter to vary the volume of these gases and compensate for change in such leakage effect to thereby restore normal operating conditions.

More particularly, the aforesaid by-pass system comprises a plurality of manifolded pipes which rise from and open through a tube sheet horizontally disposed near the top of the converter housing and forming the top wall of the reaction chamber. One set of the described tubes extend freely in slip-joint fashion through passages provided, respectively, therefor in this tube sheet and, by adjustment of a valve associated with the manifolded pipes, the volume of gases traversing the aforesaid slip joints may be varied at will for the useful purpose described in this specification.

Various other objects and features of our invention will become apparent from the following detailed description.

Our invention resides in the conversion apparatus, the arrangement for controlling distribution of gases during passage thereof through a reaction chamber, combinations and features of the character hereinafter described and claimed.

For an understanding of our invention and for an illustration of one of the forms thereof, reference is to be had to the accompanying drawings, in which:

Fig. 1 is a plan view, partly broken away, showing the converter housing of Fig. 2;

Fig. 1*a* is an enlarged, vertical sectional view, partly in elevation, showing a detailed feature of the disclosed apparatus;

Fig. 2 is a vertical sectional view, partly in elevation and partly broken away, taken on the

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line 2—2 of Fig. 1 looking in the direction of the arrows;

Fig. 2*a* is a fragmentary sectional view, partly in elevation, showing a detailed feature of the disclosed apparatus;

Fig. 3 is a schematic sectional view, partly in elevation, illustrating the passage of gases between vertical tubes disposed in a reaction chamber;

Fig. 4 is an enlarged, vertical sectional view, partly in elevation, illustrating a detailed feature of the invention; and

Fig. 5 is a vertical sectional view, partly in elevation, schematically illustrating the conversion housing of our invention.

In Figs. 2 and 5, we have shown a vertical housing or shell H which comprises an upper passage 1*a*, a lower passage 1*b*, and side passages 1*c* and 1*d*, all of these passages opening from the interior of said housing to the exterior thereof and being utilizable as hereinafter described. Secured in suitable manner interiorly of the housing H are a plurality of suitably spaced tube sheets 2, 3, 4 and 5 which should be positioned horizontally as shown. A plurality of spaced vertical tubes are supported by the tube sheet 3. As illustrated, there are a group of these tubes, as indicated at 6, which open through said tube sheet 3 and, hence, communicate with a chamber 7 between the tube sheets 3 and 4. Further, as indicated at 8, there are another group of said tubes which terminate at the upper surface of the tube sheet 3 and, hence, are not in communicating relation with the aforesaid chamber 7.

A plurality of spaced vertical tubes 9 are supported by and open through the tube sheet 4, these tubes extending through passages provided respectively therefor in the tube sheet 3. It will be apparent, therefore, that all of the tubes 9 communicate with a chamber 10 between the tube sheets 4 and 5. The upper end of each of the tubes 9 is closed and all of them extend to a horizontal plane closely adjacent the plane of the upper tube sheet 2. A plurality of spaced vertical tubes 11 are supported by and open through the tube sheet 5 so as to communicate with a chamber 12 beneath said tube sheet 5. The tubes 11 are so positioned that each of them extends axially into one of the aforesaid tubes 9. Each tube 11 is open at its upper end which terminates closely adjacent the upper surface of the associated tube 9.

In accordance with known practice, the tubes 6, 8 and 9 may be disposed with respect to each other in spaced relation as illustrated in Fig. 1 and, as will be noted, a plurality of the tubes 9 are disposed in circular row fashion around each of the tubes 6 and 8.

As shown particularly in Fig. 3, the upper end of each tube 6 is closed and all of these tubes

extend to a horizontal plane closely adjacent the plane of the upper tube sheet 2. Each tube 8 extends freely through a passage provided therefor in said tube sheet 2, all of said tubes 8 being open at their respective upper ends so as to communicate with a chamber 13 above the tube sheet last named.

Referring to Figs. 3 and 4, the tube sheet passage through which each tube 8 extends has sufficient diameter to accommodate the lower portion of a stuffing box 14 which may be welded to the adjacent tube sheet surface. A gland 15 bolted to each stuffing box 14 cooperates with the latter to hold a packing ring 16 in association with the adjacent surface of that tube 8 which extends through the associated stuffing box assembly, the packing ring 16 being formed of suitable wear-resisting and heat-resisting material such as asbestos.

In known manner, each tube 6 comprises three or any other suitable number of spaced circular rows of passages or ports 6a, 6b, 6c whereas each tube 8 comprises three or any other suitable number of similar rows of spaced passages or ports 8a, 8b and 8c, each row of these passages or ports opening from the interior of the associated tube to the exterior thereof. As clearly appears, the aforesaid rows of passages on the respective tubes 6 as horizontally alined and the same holds true as regards the rows of passages on the respective tubes 8. However, on the respective tubes 6 and 8, the rows of passages are arranged in offset or staggered relation, thus in effect dividing the bed of catalytic material hereinafter described equally into a plurality of zones.

Referring particularly to Figs. 1 and 2, the upper tube sheet 2 is shown as having a plurality of spaced pipes 17 opening therethrough and extending vertically therefrom, the upper end of each of these pipes carrying a T-fitting 18 having its longitudinal axis extending in a vertical direction. As illustrated particularly in Fig. 1a, a readily detachable closure plug 19 is threaded into the upper portion of each fitting 18. In known manner, the upper sloping wall portion of the housing H may have associated therewith detachable plates 19a, Fig. 2a, which are alined vertically with the respective pipes 17. After removal of these plates, suitable mechanism may be utilized to detach each plug 19 from its fitting 18 whereupon, as known in the art, suitable pieces, pellets or fragments of catalytic or other contact material C may be passed downwardly through each pipe 17 so as to fill the space around the tubes 6, 8 and 9 between the tube sheets 2 and 3. After completion of this operation, the plugs 19 are threaded to the respective fittings 18 and the aforesaid plates 19a are secured, in sealed relation, to said upper sloping wall portion of the housing H.

Arrangements of the character described above have been used extensively for cracking or otherwise converting hydrocarbon vapors. Thus, in practice, the converter is alternately on-stream and in regeneration, the hydrocarbon vapors traversing the catalyst C during the on-stream period and a regenerating medium such as air being utilized to burn carbonaceous material from the catalyst during the regenerating period. As these operations proceed, a suitable cooling medium such as a molten salt solution is admitted to the housing chamber 12 by way of the passage 1b, the cooling medium passing upwardly through the tubes 11, then downwardly through the tubes 9 and then into the housing chamber 10 from which it passes by way of the passage 1d. This cooling medium, in the chamber between the tube sheets 2 and 3, controls the temperature of the catalyst during the regenerating and on-stream periods.

During the on-stream period, hydrocarbon vapors to be converted may be admitted to the housing chamber 7 by way of the passage 1c. If so, these vapors pass upwardly through the tubes 6 and are engaged with the catalyst C at the ports 6a, 6b, and 6c of each tube 6. Thereupon, the conversion operation is effected while the vapors are engaged with the catalyst and while moving along paths as indicated by the arrows in Fig. 3. Thereafter, the converted products are disengaged from the catalyst at the ports 8a, 8b and 8c of the respective tubes 8, enter the housing chamber 13 and pass to any suitable destination by way of the housing passage 1a.

With an arrangement of the character described, it is desirable for the number of the ports 6a, 6b, 6c, 8a, 8b, 8c and the dimensions thereof to be such that there is substantially uniform distribution of the hydrocarbon vapors as they move within the reaction chamber between the aforesaid ports in the manner described above. This condition obtains as indicated in the diagrammatic representation of Fig. 3 provided, first, that the total volume of hydrocarbon vapors passing through the tube 6 leaves the respective ports 6a, 6b and 6c thereof in the approximate ratio 0.2:0.4:0.4 and, second, that the total volume of hydrocarbon vapors passing through the tube 8 enters the respective ports 8a, 8b and 8c thereof in the approximate ratio 0.4:0.4:02. The described uniform distribution of the hydrocarbon vapors during the on-stream period is highly advantageous because insuring utilization of all of the contact material for its intended purpose and thereby avoiding establishment in the reaction zone of spaces or areas which are more or less "dead."

As hereinbefore described, the lower ends of the respective tubes 8 are anchored to the tube sheet 3 whereas the upper ends thereof pass through the tube sheet 2, the respective stuffing box assemblies being provided to permit free relative movement between the tubes 8 and the tube sheet 2 during expansion and contraction of the apparatus resulting from change in temperature of parts thereof. Each stuffing box assembly, then, defines a slip joint and, through these slip joints, vapors flow due to the fact that they are not leak-proof and that a pressure differential exists across the tube sheet 2.

In order to maintain the desired uniform distribution of the hydrocarbon vapors substantially as referred to above, it is necessary that the leakage effect through the slip joints bear a definite relation to the uppermost vapor inlet ports 8c. Theoretically, these stuffing box assemblies may be fabricated so that each of them has a definite leakage characteristic when first constructed. However, normal wear and mechanical imperfections alters these leakage characteristics and, in the absence of the control arrangement hereinafter described, there is undesired unbalancing of distribution of the hydrocarbon vapors while passing along the described paths from the tubes 6 to the tubes 8.

In accordance with the invention, each of the fittings 18 hereinbefore described has a pipe 20 connected thereto, all of the pipes 20 being connected to communicating conduits 21. The

manifolding system thus formed is connected to a vertical conduit 22 which extends through the upper wall portion of the housing H where it includes a suitable slip joint arrangement as indicated at 23. Above the aforesaid housing wall portion, the conduit 22 has a valve 24 included therein and, beyond this valve, the discharge end of said conduit is connected to the upper housing passage 1a. As hereinbefore stated, each of the fittings 18 is carried by a pipe 17 and all of the pipes 17 communicate with the catalyst-containing chamber between the tube sheets 2 and 3. Therefore, with the arrangement described above, the manifolding system formed from the pipes 17, fittings 18, pipes 20, conduits 21 and 22 forms a vapor by-pass disposed in parallel relation with respect to the slip joints formed by the respective stuffing box assemblies. Thus, vapors passing from the upper ports 6c to the tubes 6 may pass into the housing chamber above the tube sheet 2 by any one of three separate paths as follows: First, through the ports 8c and then through the tubes 8; second, between the packing rings 16 and the adjacent surfaces of the respective tubes 8; and, third, through the above described manifolding arrangement.

By adjustment of the valve 24, the rate of flow of vapors through this by-pass may be adjusted at will to compensate either for increased vapor flow through the stuffing box slip joints as caused, for example, by wear of the packing rings 16 or for decreased vapor flow through said slip joints as caused, for example, by deposition of foreign material between the packing rings 16 and the associated tubes 8. In accordance with the invention, the dimensions of the ports in the tubes 8 are so selected that, for an intermediate setting of the valve 24 and for average leakage at the slip joints defined by the respective packing rings 16, satisfactory distribution of the hydrocarbon vapors, as hereinbefore described, is obtained between the ports 6a, 6b, 6c on the one hand and the ports 8a, 8b, 8c on the other hand.

If, during continued operation of the apparatus, the packing rings 16 become worn to thereby decrease the resistance to passage of vapors through the stuffing box assemblies, there is resultant unbalancing of the desired distribution of vapors between the ports of the tubes 6 and 8 particularly at the upper ends thereof, resulting in non-uniform conditions within the contact mass. This occurs by reason of the fact that an increased volume of vapors leaves the upper ports 6c of the respective tubes 6, this being measured by the aforesaid decrease in resistance to vapor flow at the packing rings 16. When this happens, the valve 24 may be closed to suitable extent to thereby decrease the volume of vapors traversing the aforesaid manifolding system. By so doing, the volume of vapors leaving the upper ports 6c of the respective tubes 6 is restored to normal value and, as a result, the unbalanced condition of vapor distribution within the reaction chamber is eliminated. Alternatively, should a condition develop which decreases vapor flow through the stuffing box slip joints, the valve 24 may be opened to suitable extent so as to compensate for the development of this condition and maintain the desired uniformity of vapor distribution within the reaction chamber.

In accordance with known practice, the conversion operation may be effected by causing the hydrocarbon vapors to pass through the reaction chamber in a direction the reverse of that hereinbefore described. Thus, these vapors may be admitted to the housing chamber 13 by way of the housing passage 1a whereupon they enter the upper ends of the tubes 8 and are engaged with the catalytic material C at the ports 8c, 8b and 8a. Thereafter, the conversion operation is effected while the vapors are engaged with the catalyst and during movement thereof along paths the reverse of those indicated by the arrows in Fig. 3. Finally, the converted products are disengaged from the catalyst at the ports 6c, 6b and 6a of the respective tubes 6 and, at the lower ends of said tubes 6, enter the housing chamber 7 from which they pass to any suitable destination by way of the housing passage 1c.

After termination of an on-stream period, which may be effected by passing the hydrocarbon vapors through the reaction chamber in either direction as described above, the catalytic material C should be regenerated to burn deposited carbonaceous material therefrom by passing a regenerating medium such as air therethrough. As known in the art, this regenerating medium, the same as described above with respect to the hydrocarbon gases, may be passed in either direction through the reaction chamber, this depending on the particular housing chamber, whether the chamber 7 or the chamber 13, to which this regenerating medium is initially admitted.

Thus, as regards the apparatus of this invention, hydrocarbon vapors, during the on-stream period, may be passed in either direction through the reaction chamber and, during the regenerating period, the regenerating medium, likewise, may be passed in either direction through said reaction chamber. For either type of operation and for either of the aforesaid streams of gases, the valve 24 of the manifolded by-pass system may be adjusted, when required, to insure substantially uniform distribution of gases as they pass from one set of tubes (the tubes 6 or 8) to the other set of tubes (the tubes 8 or 6). Accordingly, during the on-stream period, all or substantially all of the contact material functions in the desired manner and uniformly for conversion purposes and, during the regenerating period, the deposited carbonaceous material is burned uniformly from the contact material throughout substantially the entire area thereof.

In the preceding part of this specification, we have described a particular type of stuffing box assembly for association with each of the tubes 8. It shall be understood, however, that the invention is not to be limited to the disclosed arrangement. Thus, for example, stuffing box assemblies of different character may be utilized and, in lieu of such assemblies, a simple sealing ring or the like may be associated with each tube 8 in the area thereof which extends through the tube sheet 2. Provided that these sealing rings have variable leakage characteristics, the volume of gases passing therethrough may be controlled or varied as and for the purpose hereinbefore described.

The invention is also applicable to metered flow arrangements between a distributor or equivalent and a tube sheet as disclosed in the pending Lassiat et al. application Ser. No. 651,662, filed March 2, 1946, now Patent No. 2,547,021, as illustrated particularly in Fig. 3 thereof.

It shall be understood that the invention is not to be limited to the particular manifolding system as disclosed which froms a by-pass disposed in parallel relation with respect to the passages formed in the tube sheet 2 for the upper ends of the respective tubes 8. Obviously, as will

be understood by those skilled in the art, various other equivalent arrangements may be utilized as desired for controlling the volume of gases passing through the tube sheet passages in order to insure substantially uniform distribution of all of the gases as they pass in either direction through the reaction chamber for the purposes hereinbefore referred to.

Obviously many modifications and variations of the invention as hereinbefore set forth may be made without departing from the spirit and scope thereof and therefore only such limitations should be imposed as are indicated in the appended claims.

We claim:

1. In apparatus of the character described, a housing, spaced upper and lower tube sheets horizontally supported in said housing and defining therebetween a reaction chamber adapted to contain contact material, an upper and a lower chamber respectively above and below said reaction chamber, cooperating sets of vertical tubes arranged in parallel relation in said reaction chamber, the tubes of one set thereof being anchored in said lower tube sheet and opening therebelow into said lower chamber, the tubes of a second set extending freely through passages provided therefor in the upper tube sheet and opening into the upper chamber, each of the tubes of both of said cooperating sets of tubes comprising ports adapted to be traversed by gases passed between said upper and lower chambers and intermediately through the contact mass in said reaction chamber, a stuffing box assembly associated with a portion of each tube of said second set which extends through the passage provided therefor in said upper tube sheet, each stuffing box assembly comprising a packing ring encircling the associated tube and forming a slip joint at said passage having a variable leakage characteristic, a plurality of spaced pipes extending above and having lower terminal ends opening through the upper tube sheet, said pipes collectively defining a multi-branch path extending from the reaction chamber, which path is disposed in parallel relation with respect to said slip joints, and an externally accessible valve for varying the gas-passing capacity of said path.

2. Apparatus according to claim 1 wherein said plurality of spaced pipes extending above said upper tube sheet are connected to form a manifold system within said upper chamber, and said manifold system is connected to a pipe extending outside of the housing to the outlet of said upper chamber, said externally accessible valve being associated with said last named pipe.

3. In apparatus of the character described, an enclosed housing, an upper horizontal tube sheet and a lower horizontal tube sheet spaced therebelow within said housing forming between said tube sheets a reaction chamber adapted to contain contact material, said upper tube sheet being spaced from the top of said housing to provide between said top and said tube sheet an upper chamber, and said lower tube sheet forming the upper boundary of a lower chamber partitioned from said reaction chamber by said tube sheet, a set of laterally spaced hollow vertical tubes anchored in said lower tube sheet and terminating within said reaction chamber, the vertical tubes of said set having bottom ends passing through said lower tube sheet and opening into said lower chamber and said tubes being also

provided with spaced ports opening into said reaction chamber; a second set of laterally spaced hollow vertical tubes extending into said reaction chamber and passing in freely sliding relation through openings provided therefor in said upper tube sheet, the tubes of said second set having open ends terminating within said upper chamber, and the tubes of said second set being also provided with ports opening into said reaction chamber and spaced to cooperate with the defined ports in the tubes of said first set of vertical tubes for passage of gases between the respective ports; a plurality of spaced pipes anchored in and extending upwardly from said upper tube sheet, said pipes extending through said upper tube sheet and opening into said reaction chamber, the last named pipes being connected to a common outlet pipe passing externally through said housing, and a valve in said outlet pipe for varying the gas-passing capacity of said plurality of upwardly extending pipes.

4. Apparatus according to claim 3 wherein the defined openings in said upper tube sheet, through which said second set of vertical tubes pass in freely sliding relation, are provided with stuffing box assemblies surrounding the tubes of that set at said openings, and each of said stuffing box assemblies comprises a packing ring encircling the associated vertical tube and forming a slip joint having a variable leakage characteristic.

5. In apparatus of the class described, an enclosed housing, inlet and outlet openings associated with said housing for the passage of gases into and from said housing, spaced upper and lower tube sheets horizontally supported in said housing and providing therebetween a reaction chamber adapted to contain contact material, a set of perforated vertical tubes anchored in said lower tube sheet and extending upwardly into said reaction chamber, said tubes opening into said lower chamber, a second set of perforated vertical tubes passing freely through passages provided in said upper tube sheet, the tubes of said second set terminating in open ends within said upper chamber, a slip joint assembly encircling the tubes of said second set within said upper chamber at said passages, said slip joint assembly having a variable leakage characteristic permitting passage of gases, a plurality of spaced parallel pipes extending upwardly from the upper tube sheet and opening into said reaction chamber providing an auxiliary path for passage of gases, and valve means associated with said plurality of pipes for varying the gas-passing capacity of said pipes, whereby adjustment can be made to compensate variation in the gas leakage characteristic of said slip joint, thereby controlling the quantity of gas passing transversely through said contact material in said reaction chamber between the uppermost perforations in said several sets of vertical tubes.

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REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
2,108,087	Thayer	Feb. 15, 1938
2,283,208	Houdry	May 19, 1942
2,432,543	Prickett	Dec. 16, 1947

Certificate of Correction

Patent No. 2,559,646 July 10, 1951

RAYMOND C. LASSIAT ET AL.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows:

Column 3, line 29, for the words "as horizontally" read *are horizontally*; column 4, line 37, for "0.4:0.4:02" read *0.4:0.4:0.2*; column 6, line 72, for "froms" read *forms*;

and that the said Letters Patent should be read as corrected above, so that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 28th day of August, A. D. 1951.

[SEAL]

THOMAS F. MURPHY,
Assistant Commissioner of Patents.