May 16, 1950 E. B. MILLER 2,507,538

METHOD AND APPARATUS FOR CATALYTIC TREATMENT OF GASES

Filed Oct. 14, 1947 8 Sheets-Sheet 1

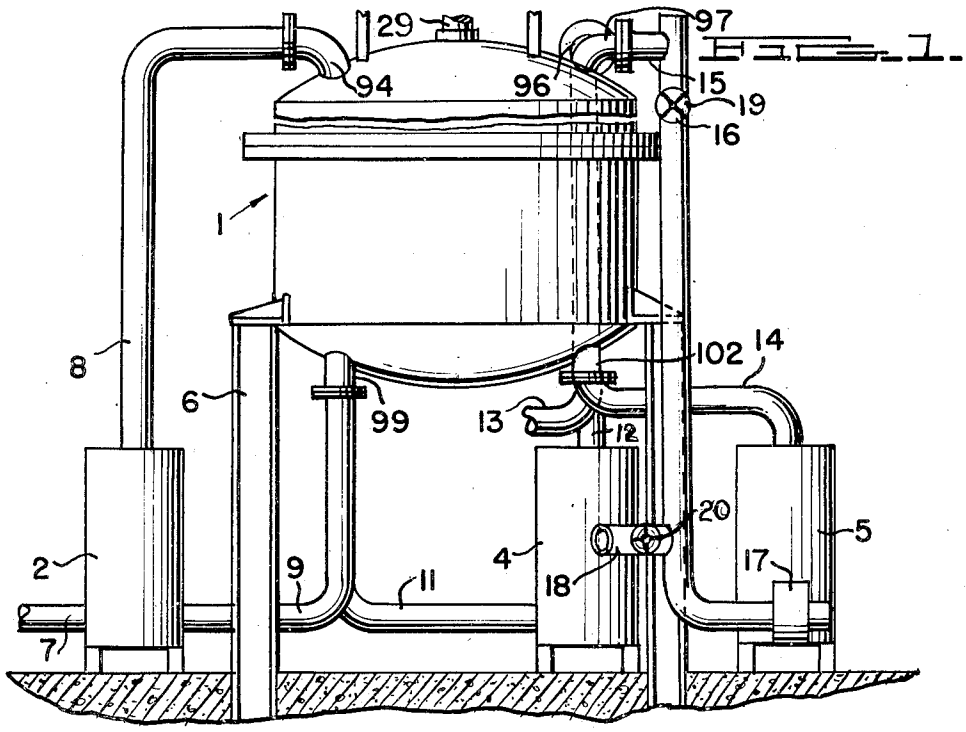


FIG. 1.

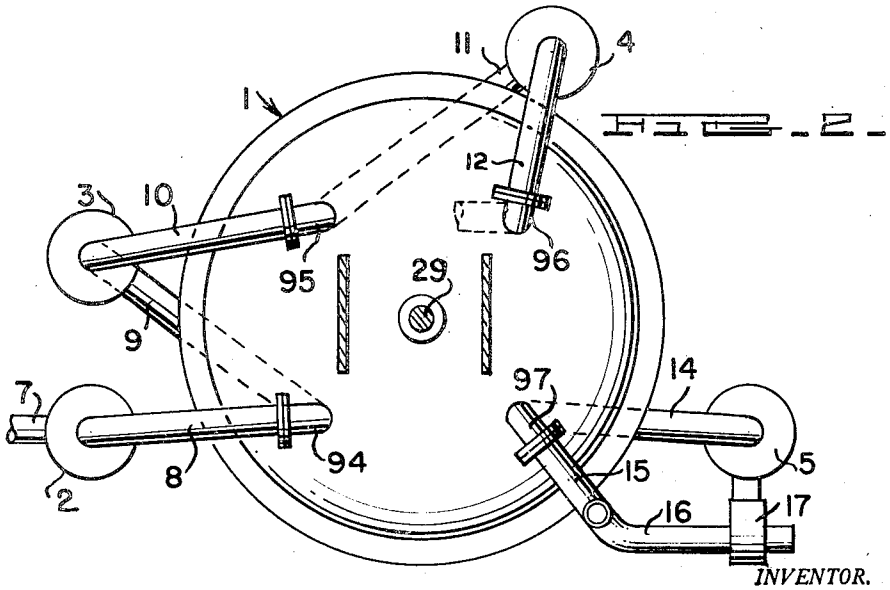


FIG. 2.

INVENTOR.
E. B. Miller
BY Adams & Bush
Attorneys

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METHOD AND APPARATUS FOR CATALYTIC TREATMENT OF GASES

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FIG. 3.

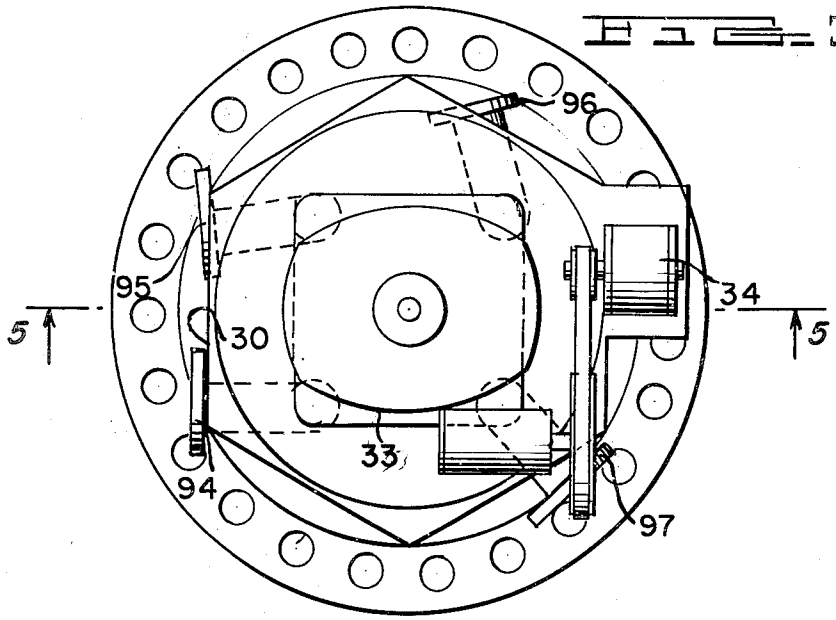
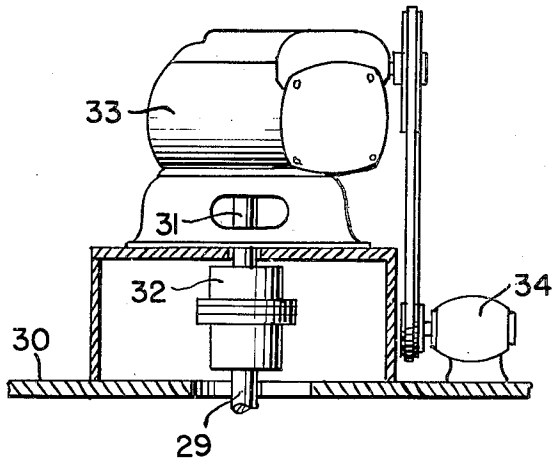


FIG. 4.



INVENTOR.
E. B. Miller

BY Adams & Bush

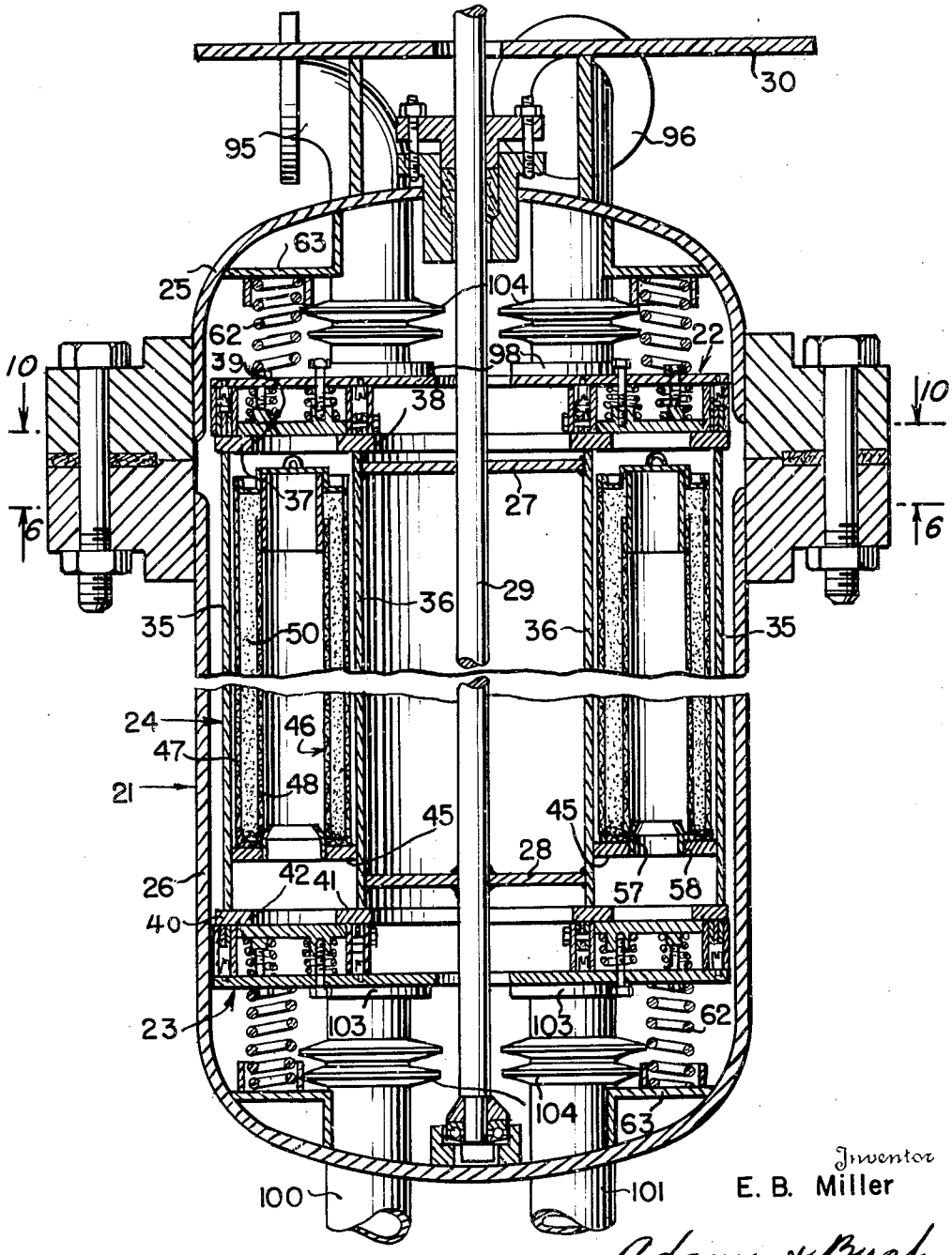
Attorneys

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METHOD AND APPARATUS FOR CATALYTIC TREATMENT OF GASES

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FIG. 5.



Inventor
E. B. Miller

By Adams & Bush

Attorneys

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METHOD AND APPARATUS FOR CATALYTIC TREATMENT OF GASES

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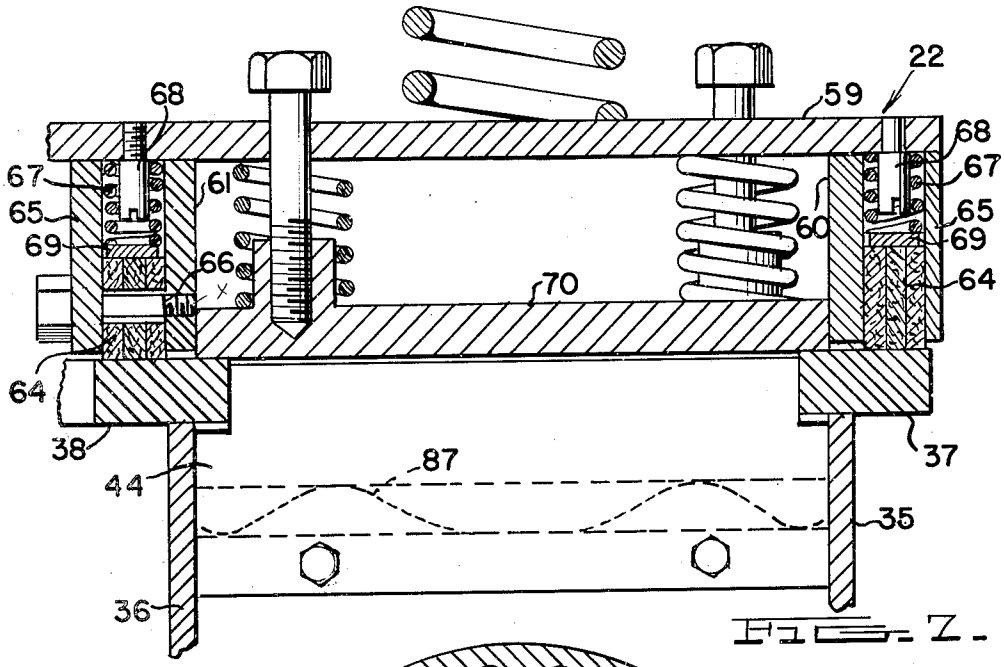


FIG. 7.

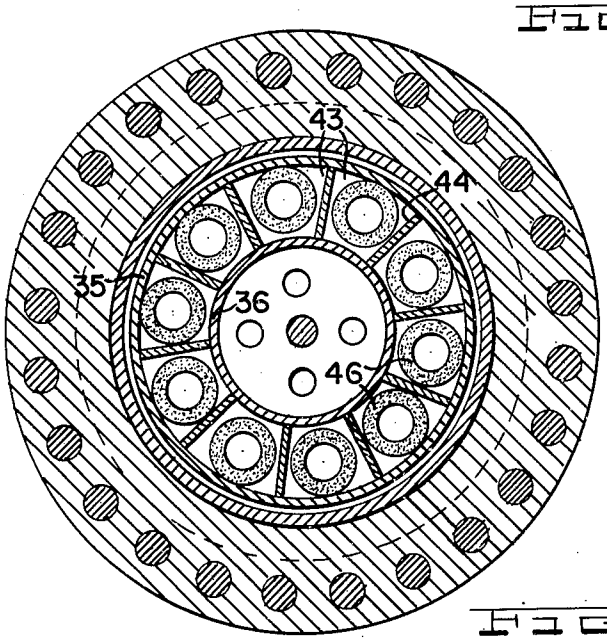


FIG. 8.

Inventor
E.B. Miller

By Adams & Bush

Attorneys

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METHOD AND APPARATUS FOR CATALYTIC TREATMENT OF GASES

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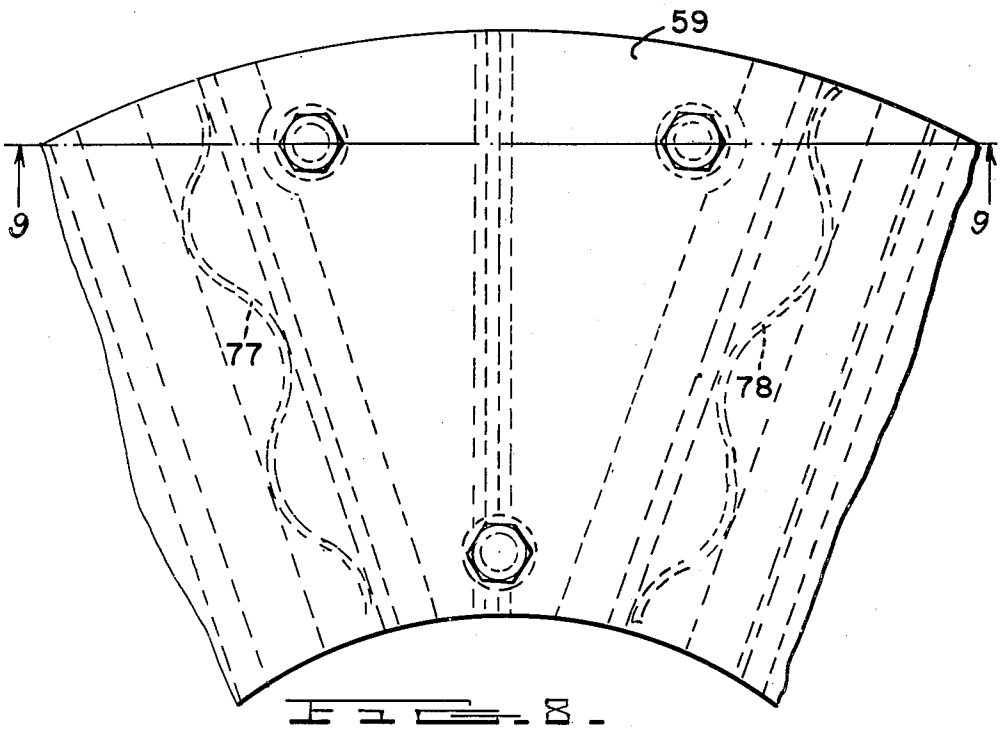
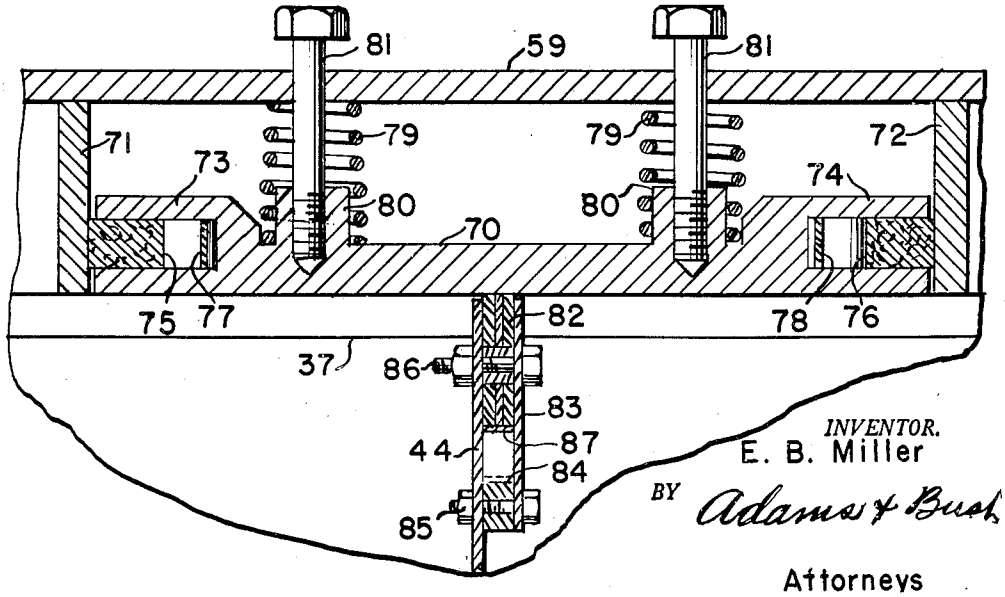


FIG. 8.

FIG. 9.



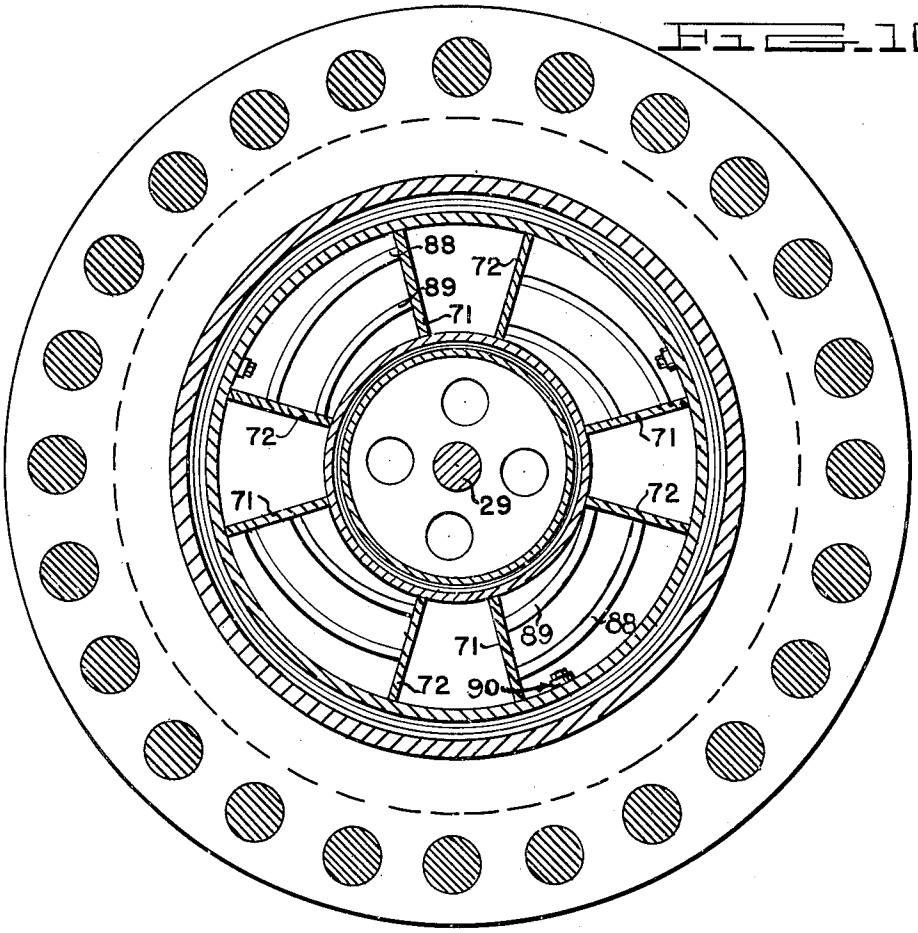
INVENTOR.
E. B. Miller
BY Adams & Bush
Attorneys

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METHOD AND APPARATUS FOR CATALYTIC TREATMENT OF GASES

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FIG. 10.



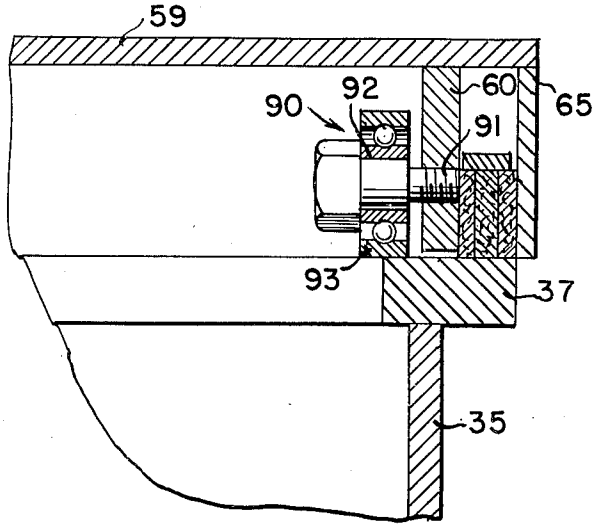


FIG. 11.

INVENTOR.
E. B. Miller
BY Adams & Bush
Attorneys

May 16, 1950 E. B. MILLER 2,507,538

METHOD AND APPARATUS FOR CATALYTIC TREATMENT OF GASES

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FIG. 12

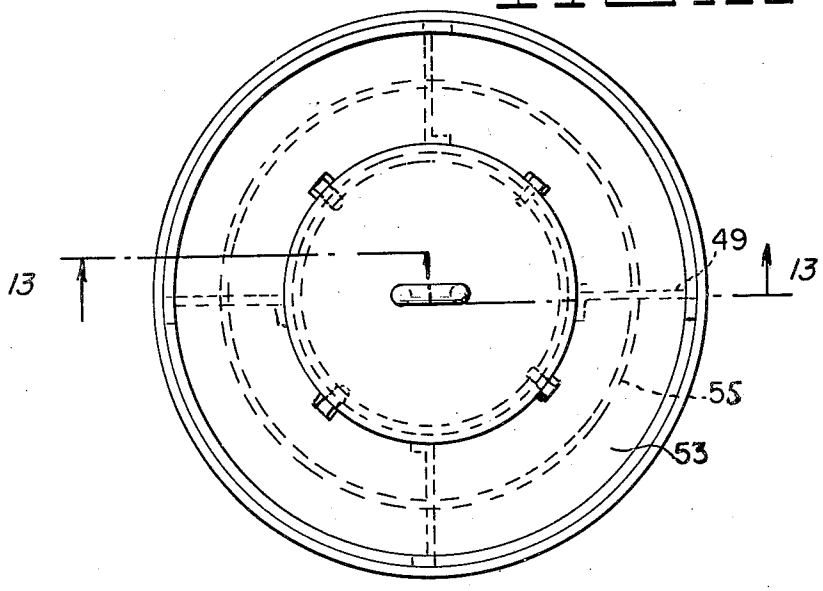
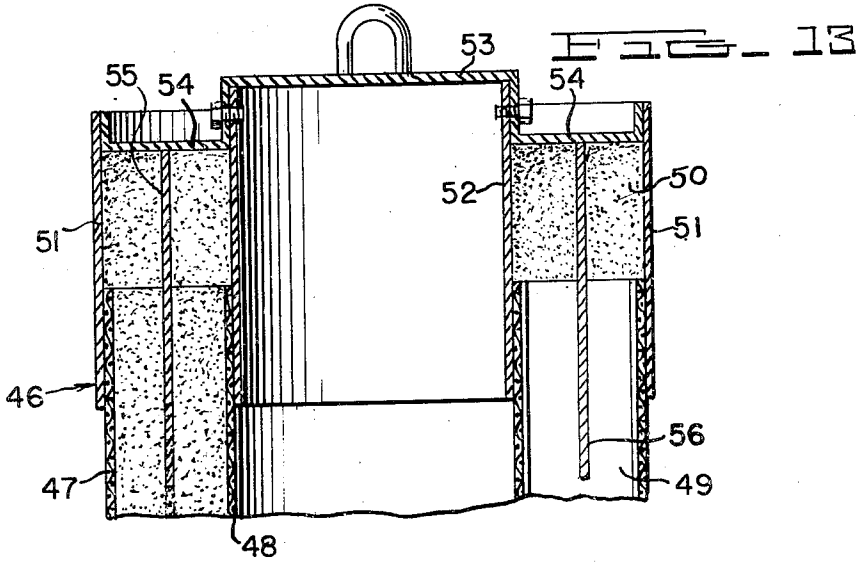


FIG. 13



INVENTOR.
E.B. Miller

BY Adams & Bush

Attorneys

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METHOD AND APPARATUS FOR CATALYTIC TREATMENT OF GASES

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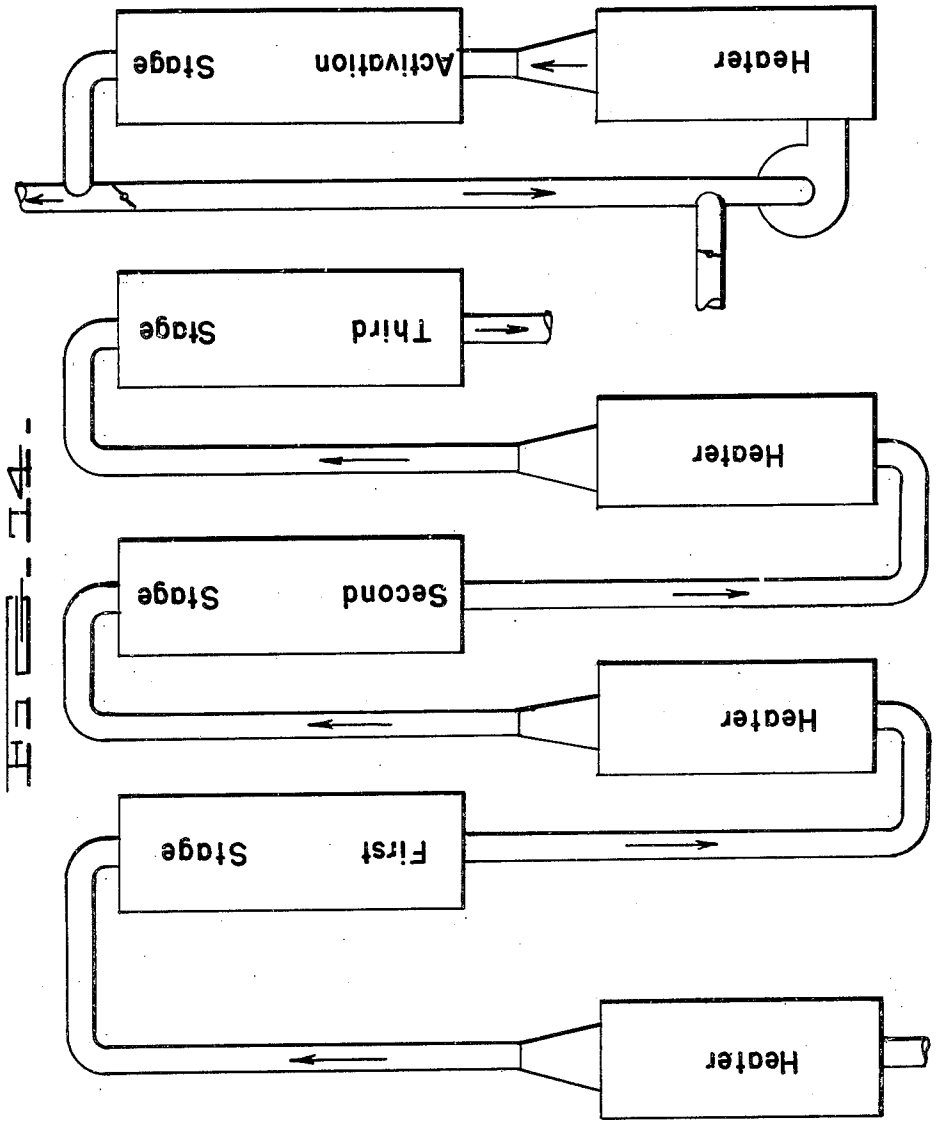


FIG. 34.

INVENTOR.
E. B. Miller

BY Adams & Bush

Attorneys

Patented May 16, 1950 2,507,538

UNITED STATES PATENT OFFICE

2,507,538

METHOD OF AND APPARATUS FOR CATALYTIC TREATMENT OF GASES

Ernest B. Miller, Houston, Tex.

Application October 14, 1947, Serial No. 779,325

3 Claims. (Cl. 196—52)

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This invention relates to catalyzing gaseous reactions and has more particular reference to a method of and apparatus for catalytic cracking of hydrocarbon vapors and the like.

One object of the present invention is to provide a novel method of and apparatus for catalytic cracking of hydrocarbon vapors and the like to produce lighter hydrocarbons.

Another object of the invention is to provide a converter in which a plurality of catalyzing units are successively moved into and through one or more reaction chambers and then into and through an activation chamber in which they are prepared for a repetition of the cycle.

Another object of the invention is to provide a converter as characterized above wherein the reaction and activation chambers are mounted within a pressure vessel to permit equalization of pressures within and without the chambers.

Another object of the invention is to provide a converter in which a large surface area of relatively thin layers of granular catalytic material, offering a minimum of resistance to the flow of gases, is condensed into a small cubic space.

Another object of the invention is to provide a system for catalytic cracking of vapors including a converter as characterized above, wherein means are provided for controlling the temperature of the vapors to be cracked during their passage through the converter.

Another object of the invention is to provide a system for catalytic cracking of vapors as characterized above, wherein means are provided for continuously heating and re-circulating a regenerating medium through the activation chamber of the converter.

Other objects and advantages of the invention will appear in the specification, when considered in connection with the accompanying drawings, in which:

Fig. 1 is a side elevation showing the mounting and arrangement of the apparatus of the invention, but omitting the converter driving mechanism;

Fig. 2 is a plan view of the apparatus shown in Fig. 1;

Fig. 3 is a plan view of the converter;

Fig. 4 is a side elevation, partly in section, of the converter driving mechanism;

Fig. 5 is a vertical sectional view of the converter, taken on line 5—5 of Fig. 3, but omitting the driving mechanism;

Fig. 6 is a horizontal sectional view of the converter, taken on line 6—6 of Fig. 5, but drawn to a smaller scale;

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Fig. 7 is an enlarged vertical sectional view of the seal shown in the right hand side of the upper manifold of Fig. 5;

Fig. 8 is a plan view of the seal shown in Fig. 7;

Fig. 9 is a vertical sectional view taken on line 9—9 of Fig. 8;

Fig. 10 is a horizontal sectional view, taken on line 10—10 of Fig. 5;

Fig. 11 is a partial vertical sectional view of a manifold, showing the details of a roller;

Fig. 12 is a plan view of a tubular catalyst containing unit;

Fig. 13 is a vertical sectional view, with part broken away, taken on line 13—13 of Fig. 12; and

Fig. 14 is a diagrammatic view showing the flow of vapor to be cracked and the flow of the regenerating medium through the system.

In general, the invention comprises a method of and apparatus for continuously directing the flow of the vapor to be treated into and through one or more reaction chambers, heating the vapor to a predetermined temperature prior to its passage into each reaction chamber; continuously heating and directing the flow of a regenerating medium into and through an activation chamber; and continuously and successively moving a plurality of catalyzing units into and through the chambers.

For purposes of illustration, the invention will be described in connection with the catalytic treatment of hydrocarbon vapors to produce lighter hydrocarbons, for example, a vaporized gas oil. Gas oil is one of the fractions derived from topping crude oil, and, prior to being treated, is vaporized at about 15 lbs. pressure in the usual manner, which forms no part of this invention.

Referring now to the drawings, there is shown, in Figs. 1 and 2, one embodiment of apparatus and the arrangement thereof for carrying out the method of this invention. The apparatus shown includes a four-stage converter 1, three stages of which are used as reaction chambers in which the vapor is brought into intimate contact with the catalyst, the fourth stage is used as an activation chamber in which the catalyst is regenerated; a heater 2 for heating the vapor prior to its passage through the first reaction stage; a second heater 3 for heating the vapor between the first and second reaction stages; a third heater 4 for heating the vapor between the second and third reaction stages; and a fourth heater 5 for heating the regenerating medium prior to its passage through the regeneration stage. The converter is preferably supported in

a raised position by a suitable framework, indicated at 6.

The vapor to be treated is delivered from a source of supply (not shown) to the first reaction stage heater 2 by means of a pipe line 7. The vapor is heated in the heater to from 850° F. to 900° F., and then passes through pipe line 8 to the first reaction stage of the converter. During its passage through the first stage of the converter the hot vapor is brought into intimate contact with the catalyst and partially cracked. After passing through the first stage of the converter, the partially cracked vapor passes through pipe line 9 to the second reaction stage heater 3, where it is heated to from 900° F. to 950° F. From the second stage heater 3, the heated, partially cracked vapor passes through pipe line 10 to the second reaction stage of the converter. During its passage through the second stage, the hot partially cracked vapor is brought into intimate contact with the catalyst and further cracking takes place. After passing through the second stage of the converter, the vapor passes through pipe line 11 to the third reaction stage heater 4, where it is heated to from 950° F. to 1000° F. From the third stage heater 4, the heated vapor passes through pipe line 12 to the third reaction stage of the converter. During its passage through the third stage the hot partially cracked vapor is brought into intimate contact with the catalyst and the final cracking takes place. After passing through the third stage, the completely cracked vapor is delivered through pipe line 13 to the usual condensing and fractionating equipment (not shown).

The regenerating medium, preferably air, is supplied to the regenerating medium heater 5, where it is heated to from 1000° F. to 1200° F., and from the heater passes to the activation stage of the converter through pipe line 14. During its passage through the activation stage the heated air is brought into intimate contact with the catalyst and burns off the carbon from the catalyst and restores or regenerates it for reuse. From the activation stage, the hot air passes through pipe line 15 to a conduit 16, from which it is either discharged to the atmosphere or is recirculated through the heater 5. One end of the conduit 16 is connected to the inlet of a fan or blower 17 and the other end opens to the atmosphere. The conduit 16 also has connected thereto a second conduit 18, which is open to the atmosphere. Valves 19 and 20, located in the conduits 16 and 18, respectively, permit partial recirculation of the heated air through the heater and activation stage of the converter as a means of economizing heat. The converter is similar in construction to the dehydrator shown in my co-pending application Ser. No. 706,108, filed October 28, 1946, for Method of and apparatus for dehydrating gas and recovering condensable hydrocarbons therefrom, and comprises a pressure vessel 21; upper and lower annular manifolds 22, 23, fixedly mounted within the vessel; a compartmentized annular drum 24 rotatably mounted within the pressure vessel between and in communication with the manifolds; and suitable driving mechanism for rotating the annular drum.

The pressure vessel 21 is preferably formed in two parts, an upper flanged shell or cap 25 and a lower flanged shell 26 suitably secured together, as by bolting, to form a gas-tight joint.

The annular drum 24 is fixedly attached, as by means of plates 27, 28, to a central vertical shaft 29 suitably journalled in bearings carried by the upper and lower shell members 25, 26. The mechanism for rotating the annular drum is supported on a platform 30 mounted on the upper shell 25 and includes a shaft 31 connected to the upper end of the shaft 29 by a coupling 32. The shaft 31 is driven by suitable reduction gearing mounted in a housing 33, the reduction gearing being belt-driven by a motor 34.

The rotatable annular drum 24 comprises two spaced concentric cylinders 35, 36 which form the side walls; two spaced annular plates 37, 38, each secured to the top of the cylinders 35, 36, respectively form the top of the drum, the space between the annular plates 37, 38 forming an annular opening 39 in the top of the drum; two spaced concentric annular plates 40, 41, each secured to the bottom of the cylinder 35, 36, respectively form the bottom of the drum, the space between the annular plates 40, 41, forming an annular opening 42 in the bottom of the drum.

The rotatable annular drum is divided into a plurality of compartments 43 by radial partitions or diaphragms 44. In each of the radial compartments 43, near the bottom thereof, there is provided a plate 45 attached to the walls of the compartment, as by welding, to form a gas-tight joint. Each plate 45 forms a support for one or more tubular catalyst containers 46. In the particular embodiment shown, only one such container is shown mounted in each compartment.

The catalyst containers 46 are identical in construction and, as best shown in Figs. 12 and 13, each comprises two concentric tubular wire screens 47, 48 held in spaced relation by a plurality of longitudinal radial fins 49, with the annular space between the screens closed at the bottom. The mesh of the screens is such as to retain a granular catalyst material 50 in the annular space between the screens. Although the invention is not limited thereto, it is preferred to employ a catalyst wherein granular silica gel or a substance having substantially the same structure is the carrier for the active material, preferably aluminum oxide.

Each of the containers 46 is closed at its top by means of concentric hoops 51, 52 mounted on the concentric screens 47, 48, and a cover plate 53 detachably connected to the inner hoop 52, as by screw bolts, and having a depending annular flange 54 fitting between the hoops 51, 52. A depending annular fin 55 is secured to the flange 54 and projects downwardly between and below the hoops 51, 52, and fits in slots 56 formed in the upper ends of the radial fins 49, all as shown in Fig. 13. The construction being such that, as the catalyst settles down, leaving a space between the top portion of the wire screens devoid of catalyst, the fin 55 will prevent gas or vapor from passing through the space devoid of catalyst. Each container is detachably mounted on a nozzle 57 projecting upwardly from an opening 58 formed in the plate 45, as clearly shown in Fig. 5. The nozzle 57 is secured in the opening 58, as by welding, to form a gas-tight joint.

The top and bottom manifolds 22, 23 are mounted on the top and bottom of the annular drum 24, in communication with the annular openings 39, 42 formed in the top and bottom of the drum. The manifolds are identical in construction and each is formed in the shape of an annular through having an annular top

(or bottom) 59 and annular side walls 60, 61 (see Fig. 7).

A plurality of compression springs 62, mounted on brackets 63 suitably secured to the inner walls of the vessel 21, yieldably press the top and bottom manifolds against the top and bottom, respectively, of the annular drum, as shown in Fig. 5. The top and bottom manifolds are held stationary relative to the rotation of the annular drum by means hereinafter to be described and, to prevent the escape of gas between the rotating drum and the manifolds, sealing ring gaskets 64 are placed at the junction of the side walls of the manifold and the drum. The sealing ring gaskets 64 are held in tight sealing engagement with the top and bottom of the drum by means of annular hoops 65 which encircle the baskets and hold them against the side walls of the manifold, as shown in Fig. 7. The upper (or lower) ends of the hoops 65 are secured to the top (or bottom) plate of the manifold, as by welding. The ring gaskets are retained between the hoops 65 and the side walls 60, 61 of the manifolds by means of a plurality of circumferentially spaced threaded bolts 66, which engage the ring gaskets and the lower portions of the hoops and side walls. The ring gaskets 64 are yieldably held in engagement with the top and bottom of the drum 24 by means of a plurality of compressed springs 67 mounted on stud bolts 68 secured to the top (or bottom) of the manifolds and engaging annular plates or members 69 mounted on the top (or bottom) of the ring gaskets, all as clearly shown in Fig. 7.

At four circumferentially spaced points in the top and bottom manifolds, there are located seals which, by reason of the sliding contact of the radial partitions 44 against the under surface of the bottoms of the seals, divide the manifolds and drum into four sectors, each sector gas-tight with respect to the adjacent sectors. The seals are identical in construction and the details thereof are best shown in Figs. 7, 8 and 9. Each seal includes a bottom or sealing plate 70 mounted within the manifold between spaced radial partition walls 71, 72. The bottom plate 70 is yieldably urged against the top (or bottom) of the drum and rests on the concentric annular plates 37, 38 which form the top of the drum (or plates 40, 41 which form the bottom of the drum), as shown in Fig. 7. The side edges of the plate are bifurcated, as shown at 73, 74, for the reception of gasket strips 75, 76, which are yieldably pressed outwardly against the partition walls 71, 72 of the seal by leaf springs 77, 78, as shown in Figs. 8 and 9.

The means for yieldingly pressing the bottom plate 70 of the seal against the top (or bottom) of the drum comprise a plurality of compression springs 79 mounted on projections 80, formed on the upper surface of the plate 70. The springs 79 engage the top (or bottom) of the seal and are held in position by bolts 81 projecting through the top (or bottom) of the seal and the coiled springs and threaded into the projections 80 formed on the plate 70.

Each radial partition or diaphragm 44 has a portion of its top and bottom edges extending upwardly (or downwardly) between the edges of the openings in the top and bottom of the drum. A gasket 82 is secured on these portions and extends above (or below) their top (or bottom) edges and engages the under face of the bottom plate 70 of the seal.

Plates 83 are secured to the tops and bottoms

of the partitions and are held spaced therefrom by a spacer strip 84, the plates and spacer strip being secured to the partitions by bolts 85. The gaskets 82 are confined between the partitions and the plates 83, as by means of bolts 86, and are pressed upwardly (or downwardly) against the under surface of the bottom plates 70 of the seals by means of leaf springs 87, all as shown in Fig. 9.

In order to prevent the gaskets 82 from being unduly pressed upwardly (or downwardly) when the gaskets are not engaging the bottoms of the seals, means are provided for spanning the reaches of the manifolds between the seals. These means comprise spaced pairs of curved plates 88, 89 which extend between and are secured to the partition walls of the seal, as shown in Fig. 10. The bottom surfaces of the plates 88, 89 are in the same horizontal plane as the bottom surfaces of the bottom plates 70 of the seals, so that, as the gaskets 82 move out of engagement with the bottom plate of the seal, they immediately engage the plates 88, 89.

A plurality of rollers 90 are mounted within the top and bottom manifolds. These rollers are circumferentially spaced within the manifolds and are adapted to engage the annular plates 37, 40 which form parts of the top and bottom, respectively, of the rotatable drum. These rollers are adapted to prevent frictional surface engagement between the side walls of the manifolds and the top and bottom of the drum. These rollers are identical in construction and mounting and each comprises a threaded stud bolt 91 screwed into the outer side wall 60 of the manifold; a ball race 92 fixedly mounted on the bolt, and a wheel 93 mounted on the ball race, all as shown in Fig. 11.

Four pipes or conduits 94, 95, 96 and 97 having threaded ends project through the cap of the vessel 21 and have their threaded ends secured to the top plate of the top manifold by means of lock-nuts 98, which form gas-tight joints. The pipes are welded to the cap and hold the top manifold stationary relative to the rotation of the drum. The four pipes are circumferentially spaced with respect to the top manifold and each is secured to and communicates with the manifold at a point located between the seals.

Four additional pipes 99, 100, 101 and 102, having threaded ends, project through the bottom of the vessel 21 and have their threaded ends secured to the bottom plate of the bottom manifold by means of lock nuts 103 which form gas-tight joints. These pipes are welded to the bottom of the vessel 21 and hold the bottom manifold stationary relative to the rotation of the drum. These pipes are circumferentially spaced with respect to the bottom manifold and each is secured to and communicates with the manifold at a point located between the seals. The width of the seals with respect to the radial compartments 43 containing the catalyzing units is such that at all times at least one of the partitions or diaphragms 44 is engaging the bottom plate 70 of the seal in gas-tight engagement. From the foregoing, it will readily be seen that by the engagement of the radial partitions with the seals, the manifold and drum are divided into four gas-tight chambers or sectors, which form the first, second and third reaction stages and the activation stages. The drum 24 carrying the tubular catalyst containers is rotated counter-clockwise as viewed in Fig. 2, and, as it rotates, the tu-

bular catalyst containers are successively moved through the four sectors or stages in the following order: the activation stage, the third reaction stage, the second reaction stage and the first reaction stage. The four pipes 94, 95, 96 and 97 are connected to pipe lines 8, 10, 12 and 15, respectively; and the four pipes 99, 100, 101 and 102 are connected to pipe lines 9, 11, 13 and 14, respectively, by means of which the vapor and hot air flow into and through the converter.

The flow of the vapor through the reaction stages and the flow of the hot air through the activation stage are shown schematically in Fig. 14.

The vapor to be cracked, after being heated to the optimum cracking temperature in the first reaction stage heater, passes through pipe line 8 to the converter and enters the top manifold of the first stage through pipe 94. Then it moves downwardly from the manifold and through the opening in the top of the drum into the various compartments of the drum containing the catalyst containers, as are at that time contained within the sector forming the first reaction stage. The vapor passes through the pervious layer of catalytic material into the interior of the tubular containers, thence downwardly through the openings in the plates 45 into the bottom of the drum and through the opening therein into the bottom manifold. From the bottom manifold the now partially cracked vapor passes through pipes 99 and 9 to the second reaction stage heater where the temperature of the vapor is again raised to the optimum cracking temperature. From the second reaction stage heater, the vapor passes through pipes 10 and 95 into the top manifold of the second reaction stage. The vapor moves downward through the second reaction stage, in a manner similar to its downward movement through the first reaction stage and during its passage further cracking takes place. After passing through the second reaction stage, the vapor passes through pipes 100 and 11 to the third reaction stage heater 4 where the temperature of the vapor is again raised to optimum cracking temperature. From the third reaction stage heater the vapor passes through pipes 12 and 96 into the top manifold of the third reaction stage. The vapor moves downwardly through the third reaction stage in a similar manner to its downward movement through the other reaction stages and, during its passage, the final cracking takes place. After passing through the third reaction stage, the vapor passes through pipes 101 and 13 to the condensing and fractionating apparatus (not shown).

The burning off of carbon and the removal of other impurities from the catalytic material is effected in the activation stage. The regenerating medium, preferably air, is pumped, by means of a fan or blower, through the regenerative medium heater 5 and from the heater through pipes 14 and 102 into the bottom manifold of the activation stage. From the bottom manifold, the hot air passes through the opening in the bottom of the drum into the bottom of the various compartments of the drum as are at that time contained within the sector forming the reactivation stage. Thence, upwardly through the openings in the plates 45 and up into the interior of the tubular catalyst container, through the pervious layer of catalyst material in the compartments of the drum. As the hot air passes through the catalyst material, the carbon formed thereon is burned off and other impurities are removed. The hot air then passes through the opening in the top of the drum into the top manifold. From the top manifold, the hot air passes through pipes 97 and 15 into the conduit 16 from which it is exhausted to the atmosphere. If desired, in order to conserve heat, a portion of the hot air discharged into conduit 16 may be recirculated through the regenerating medium heater and the activation stage. By mounting the annular drum and the manifolds within a pressure vessel, the method may be carried out with high pressure gases and, too, the equalization of pressure within the drum, manifolds and vessel permit the drum and manifolds to be made of lighter weight material, which adds considerably to the efficient and economical operation of the converter. This equalization of pressure is accomplished by means of a small opening formed in that portion of the pipe line 94 within the vessel 21. And too, due to the unequal temperature of the gas as it passes through the various sectors, thereby resulting in unequal expansion of the parts of the drum and manifolds, it is considered desirable to provide each of the eight pipes 94, 95, 96, 97, 99, 100, 101 and 102 with expansion joints 104 located a short distance from their points of connection to the manifolds.

From the foregoing, it will be seen that there has been provided a novel method of and improved apparatus for catalytic cracking of petroleum vapors. The method comprises, broadly, the steps of continuously circulating a catalytic material in a closed path; continuously heating and directing the flow of the vapor to be cracked through the catalytic material at one or more points in its closed path; and continuously heating and directing the flow of a regenerating medium through the catalytic material at another point in its closed path to regenerate the catalyst.

At this point, it may be well to point out that the vapor to be cracked flows through the catalyst in the same direction in all the reaction stages, viz., from the outside to the inside of the tubular containers, while the regenerating medium flows through the catalyst in the opposite direction in the activation stage, viz., from the inside to the outside of the tubular containers. This reversal of flow, as it were, has an important bearing in the practice of the method of the invention. In the reaction stages, due to the flow from "outside to inside" of the tubular containers, the reaction progressively decreases from the outside to the inside, which results in a heavier deposit of carbon, and other impurities, on the catalytic material adjacent to the outer circumference of the tubular containers. Accordingly, by reversing the flow of the regenerating medium, in the instant case, hot air, the deposited carbon and other impurities are more quickly and efficiently removed.

While the invention has been described in connection with the cracking of vapors obtained from gas oils, obviously, it is also applicable to other catalytic reactions in which vapors are subjected to the action of a suitable solid catalyst, such as hydro-forming, reforming, and the like. For example, it may be employed in hydro-forming ordinary gasoline to produce gasoline of a higher octane value for use as motor fuel. In that case, the range of temperatures and pressures will be changed to suit the particular conditions under which the system is operated. For hydro-forming, the temperature ranges will be around from 900° F. to 1000° F., while the pressure will be from 10 to 50 pounds per square inch. An ordinary

molybdenum catalyst(MoO$_3$ about 10%) may be effectively employed in this process. It will be activated with air or any suitable source of oxygen. The time required for the completion of the cycle will be about the same (ten minutes or more).

Obviously, the invention is not restricted to the particular embodiments thereof herein shown and described. Moreover, it is not indispensable that all of the features of the invention be used conjointly, since they may be employed advantageously in various combinations and subcombinations.

What is claimed is:

1. In the catalytic cracking of hydrocarbons involving the contact of a catalyst with vaporized hydrocarbons with resultant deposition of carbon on the catalyst and the subsequent treatment of the catalyst in an oxidizing atmosphere to burn the carbon and regenerate the catalyst for further contact with the hydrocarbons, the improvement which comprises rotating a series of separated thin beds of catalyst directly in succession and substantially continuously relative to and through a reaction zone and a regenerative zone; continuously directing the flow of the vaporized hydrocarbons through said reaction zone; heating the vaporized hydrocarbons to an optimum reaction temperature prior to their passage through the reaction zone; continuously withdrawing the cracked hydrocarbons from the reaction zone; and continuously directing the flow of a hot oxidizing medium through the regenerating zone to burn the residual gas in the beds therein and also to oxidize the carbon on the catalyst; and continuously withdrawing the resulting carbonaceous gases from said regenerating zone.

2. In the catalytic cracking of hydrocarbons involving the contact of a catalyst with vaporized hydrocarbons with resultant deposition of carbon on the catalyst and the subsequent treatment of the catalyst in an oxidizing atmosphere to burn the carbon and regenerate the catalyst for further contact with the hydrocarbons, the improvement which comprises rotating a series of separated thin beds of catalyst directly in succession and substantially continuously relative to and through a succession of reaction zones and a regenerating zone; continuously directing the flow of the vaporized hydrocarbons in succession and in series through said reaction zones; heating the vaporized hydrocarbons to an optimum reaction temperature prior to their passage through each of the reaction zones; continuously withdrawing the cracked vaporized hydrocarbons from the last one of the reaction zones; continuously directing the flow of a hot oxidizing medium through the regenerating zone to burn the residual gas in the beds therein and also to oxidize the carbon on the catalyst; and continuously withdrawing the resulting carbonaceous gases from said regenerating zone.

3. The method, as set forth in claim 2, wherein the direction of the series flow of the vaporized hydrocarbons is opposite to the direction of rotation of the catalyst beds, whereby the vaporized hydrocarbons will always make their last passage through freshly generated catalyst beds.

ERNEST B. MILLER.

REFERENCES CITED

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

UNITED STATES PATENTS

Number	Name	Date
2,236,138	Howard	Mar. 25, 1941
2,246,654	Arveson	June 24, 1941
2,304,398	Campbell	Dec. 8, 1942
2,310,244	Lassiat	Feb. 9, 1943
2,317,379	Hemminger	Apr. 27, 1943
2,347,829	Karlsson et al.	May 2, 1944