March 25, 1941. F. A. HOWARD 2,236,138

CATALYTIC APPARATUS

Filed Dec. 23, 1938 4 Sheets-Sheet 1

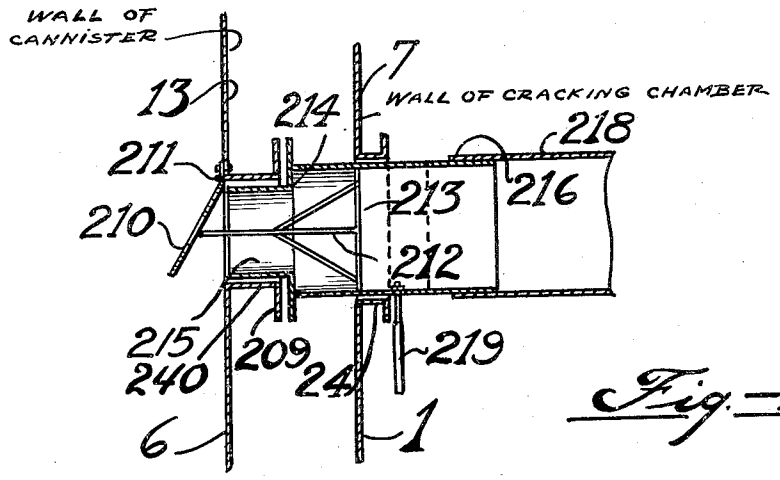
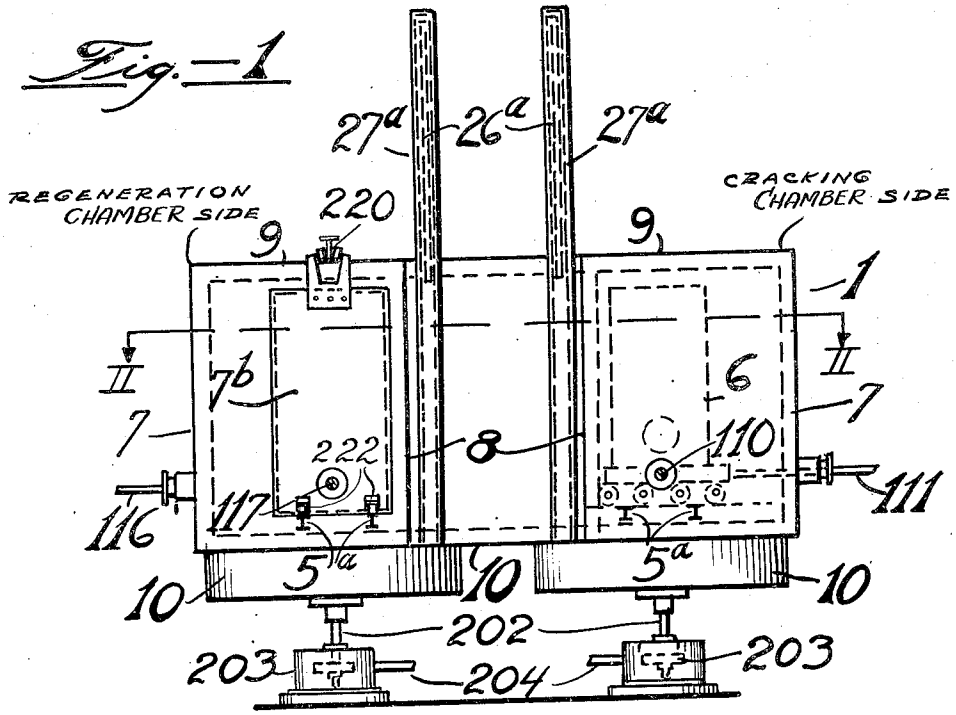


Fig.—7

Fig.—1



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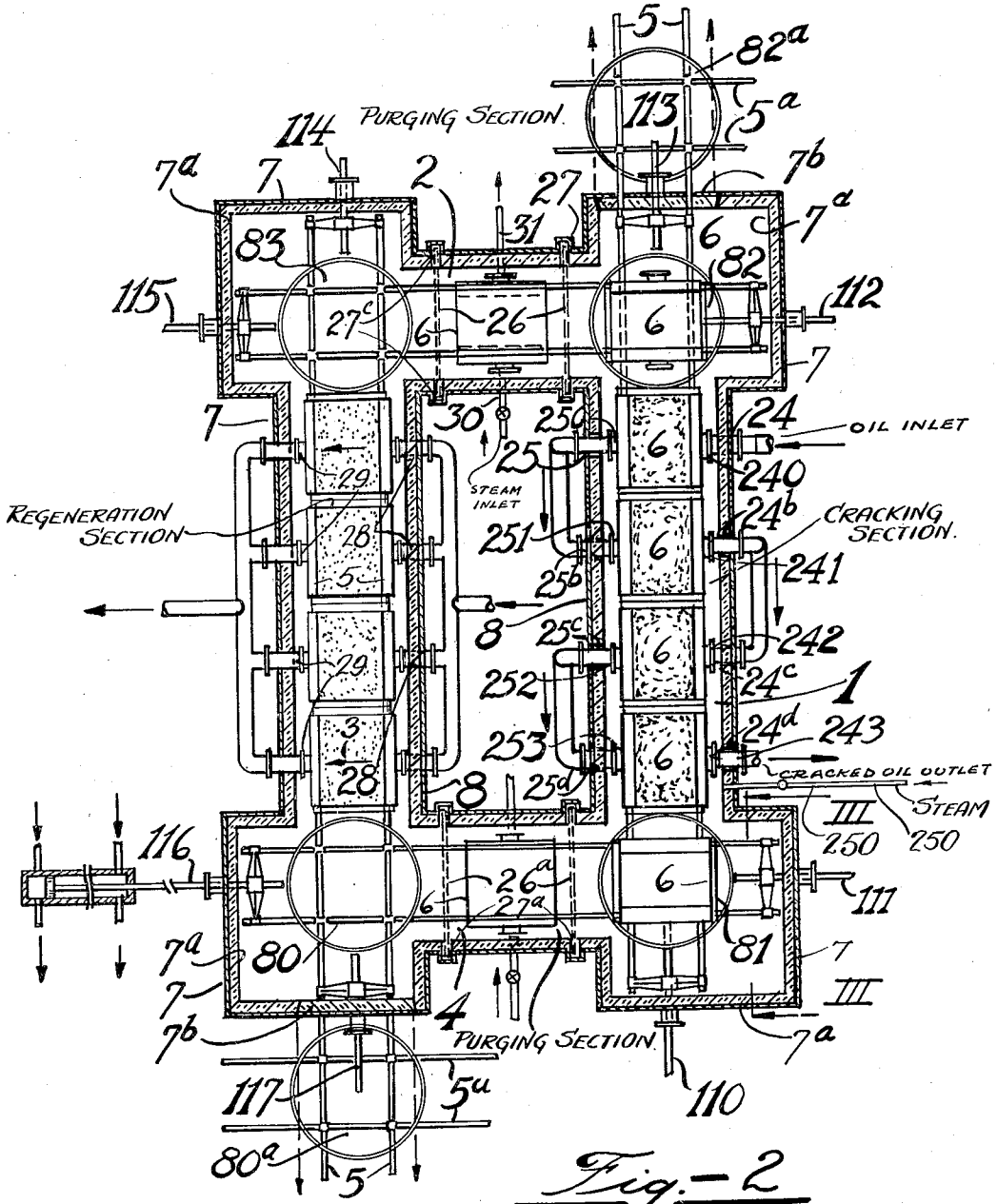


Fig. - 2

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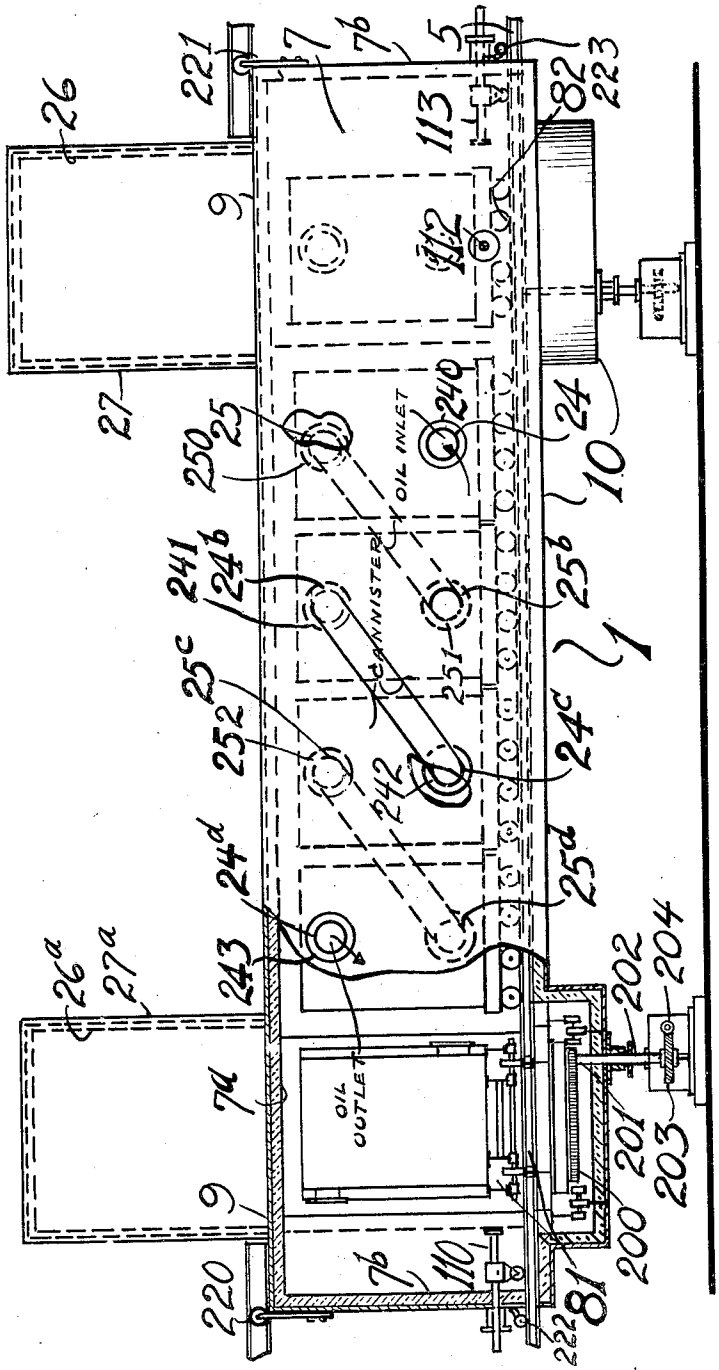


Fig. —3

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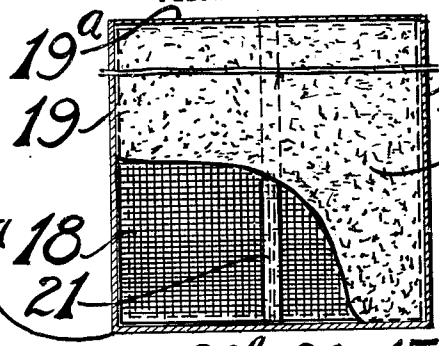


Fig.—6

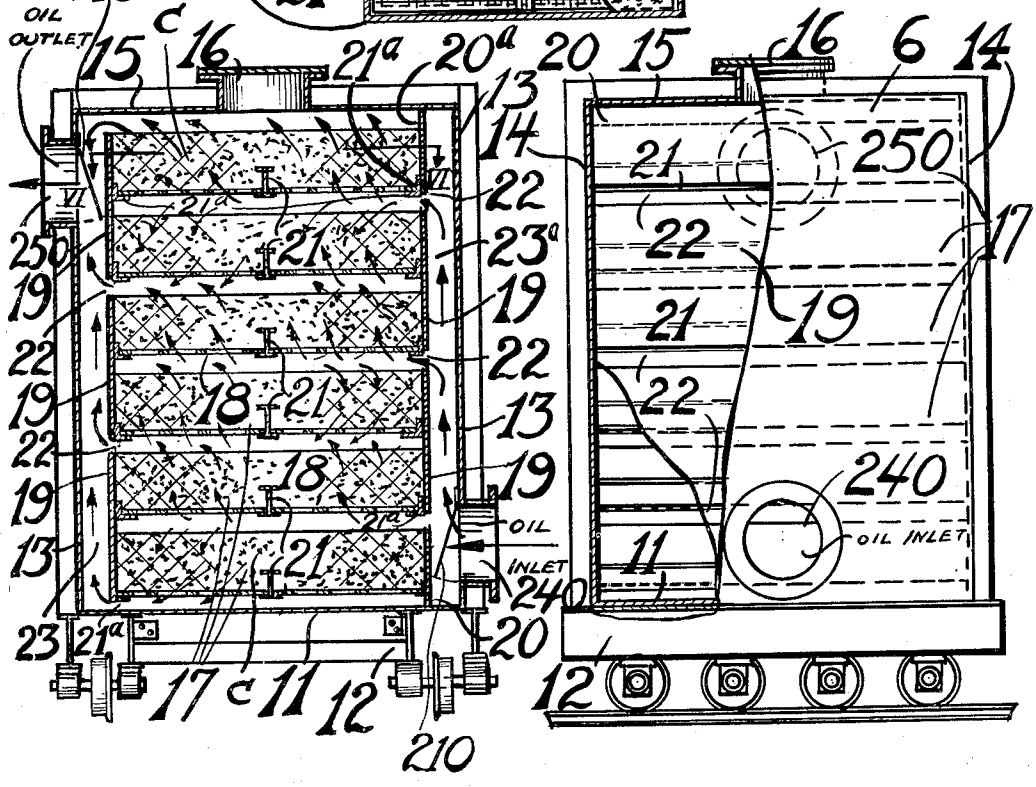


Fig.—4 Fig.—5

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2,236,138

CATALYTIC APPARATUS

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3 Claims. (Cl. 196—52)

This invention consists in the novel features hereinafter described, reference being had to the accompanying drawings, which show a form of catalytic apparatus selected to illustrate this invention and the said invention is fully disclosed in the following description and claims.

This invention relates more particularly to apparatus for catalytic cracking of relatively heavy hydrocarbons to form motor fuel, in a cycle of operations including the cracking operation proper, the purging and the regeneration and conditioning of the catalyst.

In the catalytic cracking of relatively heavy hydrocarbons to form hydrocarbon fractions boiling within the gasoline range, it is necessary periodically to discontinue the cracking operation to remove carbonaceous deposits formed on the catalyst as a result of the cracking operation and thus regenerate the catalyst. Usually the regeneration step, properly so-called, involves an oxidation or burning of the carbonaceous material in the presence of an oxygen-containing gas such as air or air diluted with an inert gas such as nitrogen, carbon dioxide, steam, or the like. Furthermore, the regeneration step is usually preceded and followed by a purging of the catalyst, i. e. a treatment with superheated steam or the like to remove gaseous and volatile matter. Just prior to reuse in the reaction chambers or zone, the catalyst must be brought up to or cooled down to proper temperature for cracking purposes.

It has been previously proposed to operate a catalytic cracking process in a contiuuous manner by passing a stream of catalyst through the cracking zone in a direction either countercurrent or concurrent with respect to the flow of vapors undergoing cracking, through the cracking zone. The difficulties that have been encountered in such a process are ineffective sealing of vapors against escape, attrition of catalyst, and the fact that it is difficult to maintain intimate contact between moving catalyst and vapors in the reaction chamber.

An object of this invention is to provide an apparatus for carrying out catalytic reactions such as catalytic cracking of relatively heavy hydrocarbons by moving a canister or canisters containing the catalyst into a reaction zone, permitting fluids to be reacted upon to flow through the catalyst contained in the canister until the catalyst has become spent, whereupon the canisters containing the spent catalyst are moved out of the reaction zone and another or other canisters containing fresh or regenerated catalyst are moved into said reaction zone, all carried out in a cycle of operations, wherein an effective seal against the escape of fluid is maintained, avoidance of attrition or disintegration or other physical injury to the catalyst is prevented and intimate contact between catalyst and vapors is achieved.

In a modification of the use of the present apparatus, following the cracking, the canister containing the spent catalyst is moved out of the reaction zone and into a purging zone where it is subjected to a steaming operation or otherwise treated with some hot inert gas to remove gaseous and volatile matter. Thereafter, the canister is moved into the regenerating zone where the purged catalyst is purified or regenerated by burning off the contaminating material. After completion of the regeneration step, the canisters containing the regenerated catalyst are moved into a tempering and purging zone where gases, which may contain oxygen, are removed from the catalyst to prevent overheating or explosions during the subsequent cracking. In this latter steaming or purging operation, the catalyst is at the same time heated uniformly to cracking temperatures, e. g. by using a tempering and purging gas whose temperature is about 820° F.

In the accompanying drawings,

Fig. 1 is a front elevation of the apparatus.

Fig. 2 is a horizontal section taken along the line II—II of Fig. 1.

Fig. 3 is a side elevation, partly in section, of the cracking zone side of the apparatus shown in Fig. 2, the section referred to being taken along line III—III of Fig. 2.

Fig. 4 is an enlarged sectional view of one of the canisters shown in Fig. 2.

Fig. 5 is a side elevation partly in section of the view shown in Fig. 4.

Fig. 6 is a cross section on the line VI—VI of Fig. 4 showing a top and bottom view of a tray.

Fig. 7 is a detail drawing of the exterior and interior pipe connection in the wall to the canister.

Referring to Figs. 1 and 7, the cracking apparatus shown includes an endless tunnel having four chambers hereinafter more fully identified and described. The usual preheating and fractionating apparatus is not shown in the drawings since this accessory apparatus is well known to those skilled in the oil cracking art. It will be understood, therefore, in the ensuing description that oil to be cracked and led into the reaction chamber has been brought up to cracking tem-

peratures by any suitable system of preheaters and also that the cracked vapors leaving the cracking apparatus are fractionated in known manner to obtain the desired cuts. Similarly, waste heat boilers for supplying steam for purging, tempering and other purposes are not included in the drawings.

As shown, the apparatus comprises a continuous tunnel-like structure having a cracking zone 1, a purging zone 2, a regeneration zone 3, and a tempering and purging zone 4. The apparatus is provided with tracks 5 extending throughout the entire system upon which runs a line of canisters 6, and between the several zones there are turntables 80 81, 82 and 83, adapted to rotate the canisters so that they may be moved, after turning in the new direction, into the adjacent chamber, the mover means being hydraulic rams 110, 111, 112, 113, 114, 115, 116, and 117, or some such suitable device. In the illustration shown, fourteen canisters (six shown) may be employed.

The tunnel shown is formed by enclosing vertical walls 7 and 8, roofing portion 9 and lower portion 10, each wall or portion carrying heat insulation material 7a (see Fig. 2 and Fig. 3).

In order to permit the withdrawal from or entry of a canister 6 to the chamber, wall 7 has a removable section 7b which may be moved horizontally. A convenient means of accomplishing this removal is to support the said wall sections 7b on wheeled truck 223 adapted to run on tracks 5 extended outside the tunnel and by overhead trolley 221. When the wall section has been moved outwardly beyond branch or spur line 5a, a canister 6 may be drawn from turntable 82 by ram 113 or 117. In moving wall section 7b outwardly, ram 113 also, of course, moves outwardly (see Figs. 2 and 3). Another canister on tracks 5a may now be moved onto turntable 82a, rotated and moved on tracks 5 onto turntable 82. Removable section 7b is then returned to the position shown in Fig. 2. By a similar procedure, a car may be moved out of or into chamber 4 by temporarily removing wall sections 7b and operating ram 117 and turntable 80a. Removable wall sections 7b may have bevelled edges and in closed position, may seat on corresponding bevelled surfaces of the stationary walls 7, 8 and 10. Obviously, other means could be provided for providing a removable wall section similar to 7b.

A mechanism adapted to operate turntable 81 (see Fig. 3) comprises gear 200, engaging pinion 201 securely mounted on shaft 202 and gears 203 and 204, the former being securely mounted on shaft 202 so that by rotating member 204 preferably by a motor, turntable 81 is rotated. The other turntables may be rotated by similar mechanism.

Referring particularly at this point to Figs. 4, 5 and 6, each canister 6 consists of a wheeled truck supporting structure 12 and a box-like superstructure formed by base 11, crown-plate 15, sidewalls 13 and end walls 14. Each canister has six trays 17, containing catalyst C, which trays are open at the top, having perforate base portion 18 and imperforate side and end walls 19 and 19a, respectively, the trays being superposed one above the other and also spaced apart in the manner shown. Each tray is supported by center beam 21 welded to walls 14 and by angle irons 21a also welded to walls 14. The spaces between the trays are baffled on both sides of the stack of superposed trays by providing three pairs of adjacent trays with common imperforate sidewalls 19 on one side of the stack and two pairs of trays on the other side having similar sidewalls 19, the oppositely disposed common sidewalls being in staggered relation with respect to each other. Furthermore, the wall 19 of uppermost tray 17 is extended to the inner surface of crown-plate 15 where it is welded at 20a. Similarly the wall 19 of the lowermost tray 17 is extended to base 11 and welded thereto at 20. The combined effect of the arrangement of trays and baffles described provided an internal manifold which causes a fluid led into the canister to flow therethrough in parallel along the paths indicated by the arrows in Fig. 4.

Manholes 16 permit access to the interior of the canister, and the spaces 22 between the trays are of sufficient depth to permit a workman to make temporary repairs or for some other purpose. Preheated oil from furnaces and the like, is led into the canister through inlet port 240 and any known suitable detachable pipe coupling means may be used for making the connection between the oil supply line or conduits and the oil inlets and similarly, detachable pipe couplings are provided for connecting regeneration gas lines with the interior of the canisters in regeneration chamber 3. Similar pipe connections may be employed to conduct vapors or gases exiting through outlet port 250 to conduits directed to desired points. In the same manner, steam or other purging gas lines conveying gas into the canisters located in purging zones 2 and 4, must likewise be provided with detachable connections. A convenient pipe coupling for the foregoing purposes is the swinging damper and telescoping pipes arrangement shown in Fig. 7. The buggy or canister 6 has, as explained, a side-wall 13, which wall carries a flanged opening 240. This opening is disposed in operative position on the cracking side, in registry with an opening 24, 24b, etc. in wall 7 of the tunnel. Pipe line 218 conducting hydrocarbon oil from the preheaters (or the next canister in line) has pipe line 216 telescoped within it, as shown. Pipe 216 has an end section of more restricted cross-sectional area 215, which section is adapted to project into canister flanged inlet 240. In order to operate swinging damper 210 which swings about pivot 211, a vertical rod 213 disposed within pipe 216 carries tightly mounted thereon a horizontal rod 212 braced by a spider and adapted to engage at its inner end damper 210. Operating connection 219 is manually adapted to move pipe 216 and with it damper 210 inwardly or outwardly as desired. In operation, i. e. when the hydrocarbon oil, steam or regeneration gas is flowing into the canisters 6, rod 212 maintains a damper 210 open and a pressure contact between flange 214 of pipe 216 and the flange 209 of inlet 204 substantially prevents fluid escape.

Similar connections are provided at 250, 251, 241, 242, 252, 253 and 243. In each instance the detachable connection is disposed in tunnel wall openings 25, 24b, 25b, 24c, 25c, 25d and 24d, respectively. In the regeneration chamber 3, regeneration gas is fed through a manifold whose branch pipes are disposed in wall openings 28 and the exit gases are conducted out through a similar manifold whose branch pipes likewise are disposed in wall openings 29, and both manifolds are provided with detachable pipe connections shown in Fig. 7.

It has been noted that the fluid enters the canister at the bottom and is withdrawn at the

top (see Fig. 4). In order to accomplish this result and also series flow through the several canisters as in the cracking side of the apparatus, the pipes connecting canister to canister must be disposed as indicated in Fig. 3. On the other hand, in the regeneration side, by means of turntable 83, four canisters may be arranged so as to accommodate the manifold at openings 28, i. e. the canisters are preferably arranged so that all four gas intakes are at the lower level i. e. at 240 in Fig. 4, while the exhaust is at the level of 250 and this is possible since the flow of regeneration gas is in parallel, with respect to the several canisters. It is obvious, of course, that other means are possible for making suitable connections between the canisters and either other canisters or an outside source other than those described above. As a further safety precaution to avoid accidents, such as flashing, it is preferable to maintain an atmosphere of steam within the tunnel to prevent flashing when disconnecting canisters containing hot catalyst and heated hydrocarbons and consequently, it is preferred to employ both the above described swinging damper and also fill the tunnel with steam, preferably under a gauge pressure of say 5 lbs. per square inch.

Mode of operation

Hydrocarbon oil heated by any suitable furnace or the like, to a temperature of about say 820–900° F. is introduced into the first canister in reaction zone 1 through 240 (Fig. 2). The heated oil passes through the catalyst contained in trays 17 in the manner indicated by the arrows in Fig. 4, that is to say, the oil enters into main passage 23*a*, escapes into spaces 22 and then passes up through the perforate bases 18 of trays 17 and down through the open top of said trays, then passing to passageway 23 and exiting at outlet 250 (Fig. 4).

Referring again to Fig. 2, as indicated by the arrows, in on-stream operation, the oil enters into the first canister at 240 and exits at 250, as stated, thence enters the next canister through 251, exits at 241, then enters the next canister at 242, exits at 252 and finally enters the last canister in line at 253, the cracked oil leaving the system at 243 to be led to the fractionating apparatus. The temperature of both the catalyst and the oil is maintained at about 820° F. to 900° F. and a gauge pressure of about 5 to 45 lbs./sq. in. is maintained on the vapors during the cracking operation. Since the reaction is endothermic it may be desirable to add heat to the oil undergoing cracking, and this may be accomplished by steam-jacketing the oil conduits outside the cracking chamber, as between points 25 and 25*b*, 24*b* and 24*c*, etc., and injecting superheated steam into the jackets. Other suitable heating means may be employed.

From the foregoing description it can be seen that the oil flows through the trays in each canister in parallel and in series through the line of canisters.

After the cracking operation which continues for about say 7 to 8 minutes, the oil feed line to 240 is disconnected for the purpose of shifting canisters to regenerate the catalyst. From the previous description of the device illustrated in Fig. 7, it will be obvious that the canisters may be disconnected by moving handle 219 outwardly. In the like manner, the feed and exhaust lines of the other canisters are disconnected and moved away from the canisters so that the line of canisters may be moved. In order to obtain constant oil flow, two units of the moving canister apparatus described herein are employed and full feed of hydrocarbon vapors is carried through one unit while the other is shifting canisters.

In shifting canisters the below procedure is followed:

It will be noted from Fig. 2 that, there is there shown a canister on turntable 82. After lifting gate 26 to the position shown in Fig. 3, this canister is moved into zone 2 and thereafter gate 26 is lowered. Into runway 27*c* a similar gate 26 is lowered, thus forming a substantially closed chamber or zone 2. Next, the canister in zone 1 nearest zone 2, is moved toward turntable 82 by hydraulic ram 110, which urges the four canisters in zone 1, now disconnected from feed and exit lines, toward turntable 82. It is more convenient to push the line of canisters by means of hydraulic ram 110 part way toward turntable 82, i. e. until the second car in line occupies the position of the first car in zone 1 in Fig. 3, and after detaching the second in line from the first, pulling the latter onto turntable 82 by means of hydraulic ram 113.

The canister in zone 2 is then purged in the closed zone 2 by treatment with an inert gas such as superheated steam, combustion gas, CO_2, or the like, which gas may be at a temperature of about 820° F. During the purging operation, the temperature of the catalyst which originally is about 820° F. should therefore change very little. Steam or the like for purging the catalyst is introduced through conduit 30 and the waste gases are withdrawn at 31. The flow of steam through the canister is exactly the same as that already described in connection with the flow of vapors through a canister during cracking except that the flow of steam may be in the direction opposite that of the previous flow of hydrocarbon oil. This operation is completed in about say a minute more or less, and the gate 26 in runway or housing 27*c* is raised and the canister is drawn onto turntable 83 by means of ram 115, rotated and then moved into regeneration chamber 3 by means of hydraulic ram 114. Meanwhile gate 26 is lowered into housing 27*c*.

In the regeneration chamber it will be noted, as indicated by the arrows, that regeneration gas is admitted through branch pipes disposed in tunnel wall openings 28 and withdrawn through corresponding pipes in openings 29 and passes through the catalyst once, i. e. preferably the gas is not recirculated. Also it is preferred to place four canisters in line for this operation. As previously indicated, the flow of regeneration gas through the canisters in chamber 3 is controlled by a manifold so that the gas flows through the canisters in parallel. Since it is preferable to introduce the gas at the bottom of the canister, if the canister has the internal construction shown in Fig. 4, the canister inlets must, of course, be adjacent and at the same level. On the cracking side of the apparatus this is not true since there, as seen, the inlets are alternately disposed on opposite sides of the successive canisters. Hence when the canisters are moved into regeneration chamber 3, they must have been previously rotated on turntable 83 so that the gas inlets are all disposed on the intake manifold side and the outlets disposed on the exhaust manifold side. The regeneration gas, of course, contains free oxygen preferably from 1% to 15%. The temperature of this gas,

if it contains only about 1% oxygen, should be at least about 750° F., but somewhat lower temperatures may be employed where a higher percentage of oxygen is contained in the regeneration gas or where superatmospheric pressure is employed. The gauge pressure of the gas during regeneration may be from 5 lbs./sq. in. to 105 lbs./sq. in. with about 40 lbs./sq. in. preferred. Since a rather large amount of regeneration gas, say 3000 volumes per volume of catalyst per hour is employed, it is preferable to avoid a large pressure drop, to pass the gas through the canisters in parallel, as indicated in the drawing.

After regeneration, the canister nearest zone 4 is shifted into zone 4 by means of hydraulic rams 114, 115 and 116 in a manner analogous to that already explained in the shifting of a canister from the reaction zone to zone 2, explained above. The gates 26a are lowered into gateway 27a and the regenerated catalyst is purged and tempered by steam or other inert gas in the same manner as the catalyst in zone 2. After purging and lifting of the gate 26a in housing 27a, the canister is moved onto turntable 81 and thence into zone 1.

The catalyst employed may be any adsorbent material, natural or synthetic, which, under the conditions employed, catalyzes the reaction involved.

To recapitulate, the present invention provides a catalytic apparatus for carrying out chemical reactions, particularly oil cracking, which apparatus provides means for moving a body of catalyst into a reaction zone and also means for replacing said body of catalyst, when spent, with a body of fresh or revivified catalyst, whereupon the spent catalyst is purged, revivified, again purged and then returned to the reaction phase. In other words, the process carried out in the apparatus embodying the present invention is cyclic with respect to the catalyst which in one complete cycle of any given portion of the catalyst passes through four phases, as indicated.

It is obvious that numerous modifications could be made in various features of the present invention without departing from the spirit thereof, and it is to be distinctly understood that the present invention is not limited to the precise details of construction and arrangement hereinbefore set forth or to the manner of employing the apparatus described.

I claim:

1. A catalytic oil cracking apparatus provided with a plurality of movable enclosed chambers disposed in a tunnel-like circuit forming a cracking section, a purging section, a catalyst regeneration section and a second purging section, means for moving the said chambers through the said sections, detachable conduits for supplying reactable vapors directly to the chambers in the cracking section, separate detachable conduits for withdrawing reaction vapors directly therefrom, detachable conduits for supplying a regeneration gas directly to the chambers in the regeneration section and separate detachable conduit means for withdrawing combustion vapors directly therefrom.

2. The apparatus set forth in claim 1 in which the chambers comprise enclosed box-like canisters containing vertically spaced trays having perforated bottoms each tray being adapted to support a bed of catalyst, each canister having inlet and outlet parts permitting vapor passage into and withdrawal from, respectively, the interior of said canisters.

3. The apparatus set forth in claim 1 in which the several chambers comprise canisters containing a plurality of horizontal trays, vertically spaced and so arranged as to provide spaces between the sides of said trays and the inner side walls of said canisters, adjacent pairs of trays having common sidewalls, oppositely disposed and forming a manifolding means internal of the said canisters.

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