Dec. 25, 1928. 1,696,658

M. J. TRUMBLE

PROCESS OF CRACKING HYDROCARBONS

Original Filed Sept. 2, 1924 3 Sheets-Sheet 1

Fig. 1.

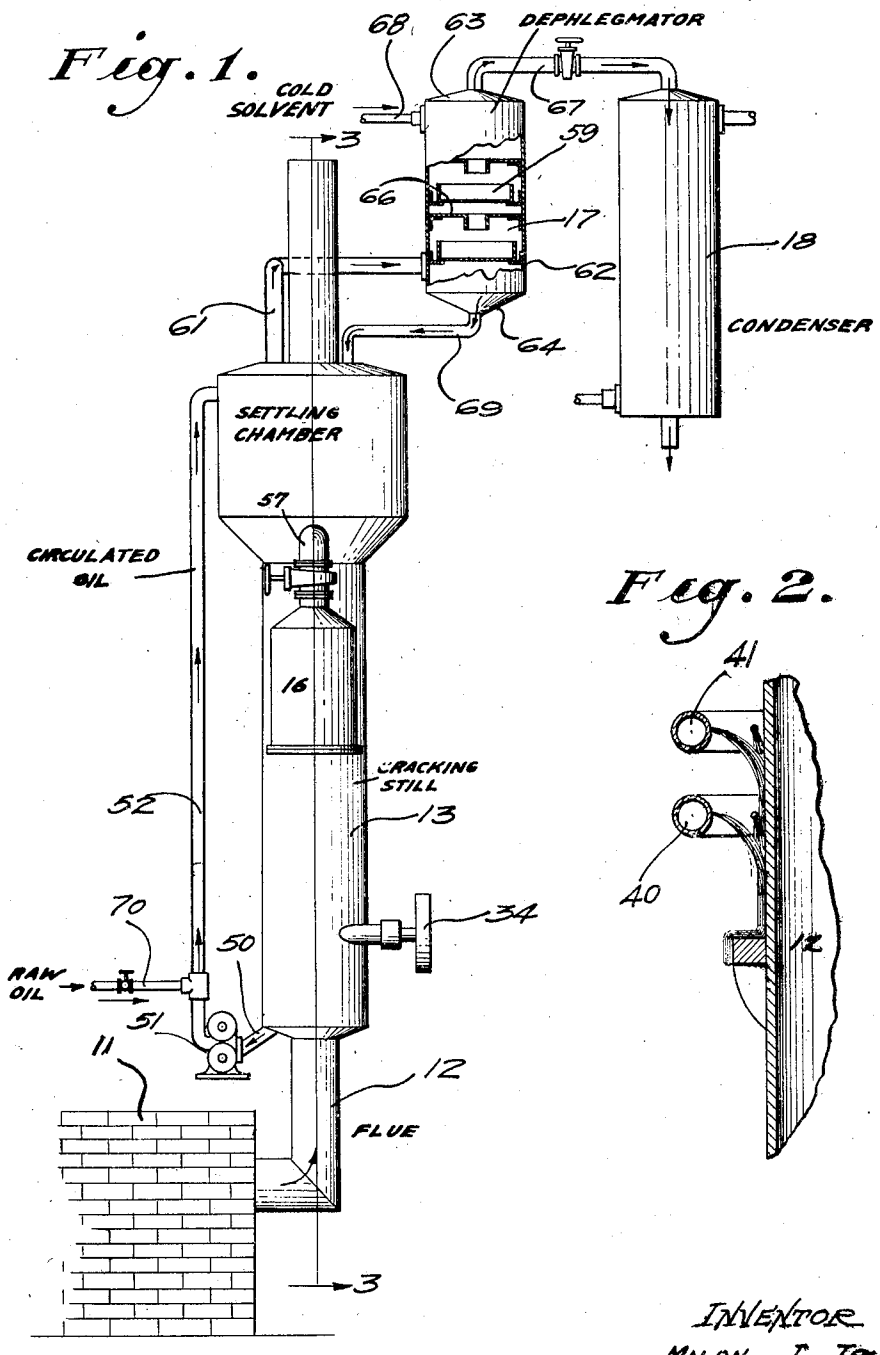


Fig. 2.

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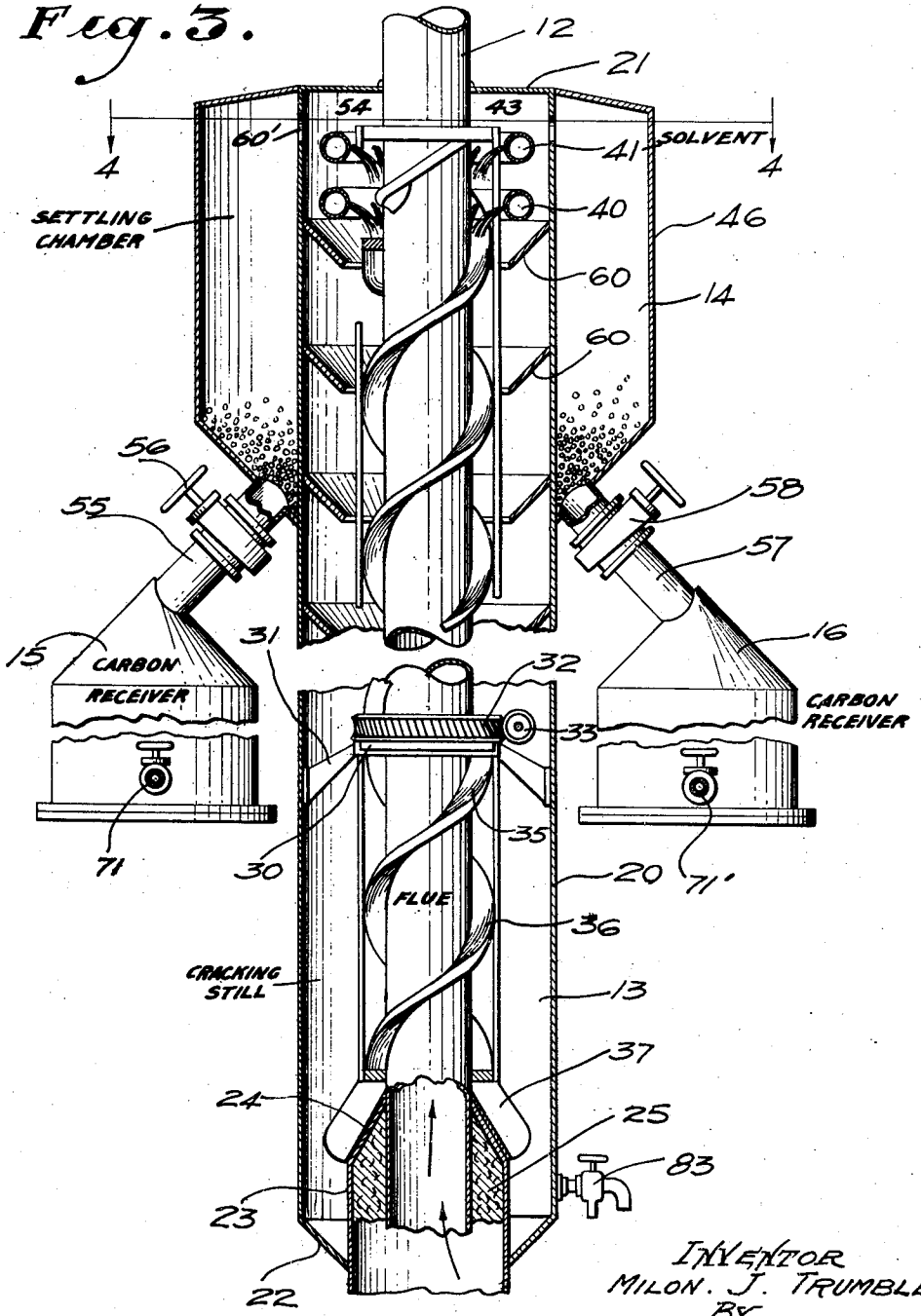
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Fig. 3.



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PROCESS OF CRACKING HYDROCARBONS

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Fig. 6.

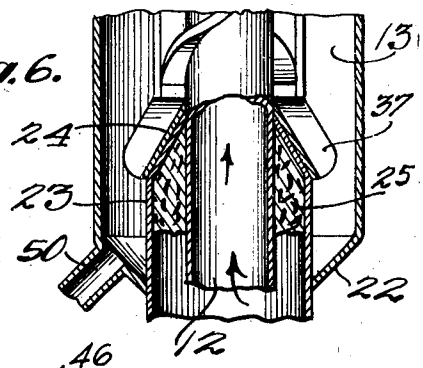
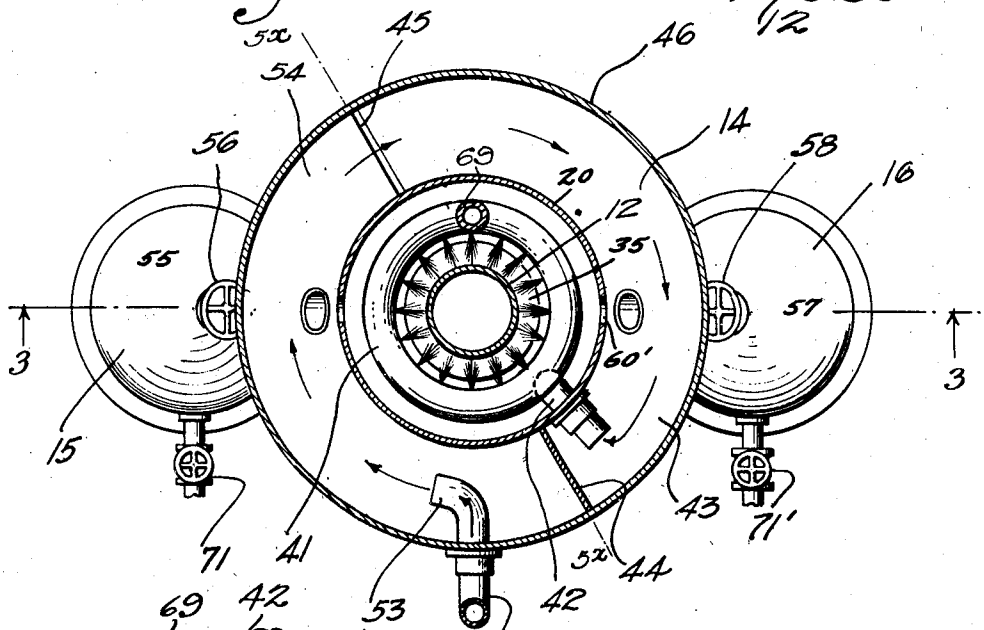


Fig. 4.



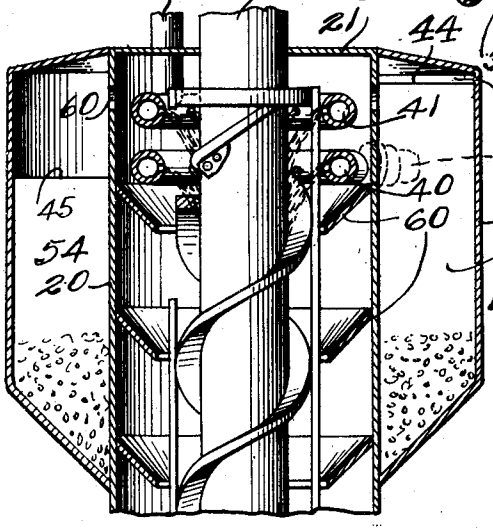


Fig. 5.

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UNITED STATES PATENT OFFICE.

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PROCESS OF CRACKING HYDROCARBONS.

Application filed September 2, 1924, Serial No. 735,357. Renewed October 24, 1928.

My invention relates to the art of cracking hydrocarbons. It is well known, if hydrocarbons, and particularly petroleum oils, are subjected to proper temperature and maintained under sufficient pressure, that a partial breaking up of the oils occurs and low boiling point oils are produced, a considerable proportion of the gasoline now in use in the United States being produced by such cracking processes.

In the operation of these cracking processes, in addition to the gasoline, there is usually produced a residuum containing considerable quantities of free carbon or tarry hydrocarbons, and the principal problem met with in the design and operation of cracking processes is to provide means for disposing of this solid or semi-solid residue and to prevent its interference with the normal operation of the apparatus. I have found, however, that a certain amount of free carbon is very beneficial in the cracking of oil, and I believe that the free carbon may act as a catalyzer in the promotion of the cracking reaction. It is, therefore, an object of my invention to provide a cracking process in which large amounts of free carbon are maintained in intimate association with the oil to be cracked for the purpose of increasing the yield of low boiling point hydrocarbons therefrom.

It is a further object of my invention to provide means by which the solid and semi-solid portions of the residue may be mechanically broken up and mixed with the oil for the purpose of promoting the cracking reaction.

It has been found, however, where considerable amounts of solid or semi-solid carbonaceous material are so produced or present in the usual form of cracking still that there is a marked tendency for these solid or semi-solid residues to adhere to and build up upon the heating surfaces of the still, forming layers of solid carbon which cover these heating surfaces, and not only prevent a proper transfer of the heat to the oil to be treated, but which also tend to cause local overheating at these surfaces, with a consequent damage to the stills.

It is a further object of my invention to provide means for mechanically preventing the adhesion of the carbonaceous material to the heating surfaces, a thin layer of carbonaceous material being maintained to promote the cracking reaction, but the thickness of this layer being so limited as not to impair the heating value of the surfaces.

I have further found that it is desirable that the material which is mechanically removed from the heating surfaces be dissolved and carried in suspension in a carrier or solvent oil. This oil is preferably of such a nature that it will not readily vaporize at the temperatures within the apparatus, and, while not readily affected by the cracking reaction, still has the property of dissolving many products thereof. It is accordingly hereinafter referred to either as a solvent oil or as a carrier oil.

It is a further object of my invention to so circulate this solvent oil that the active heating surfaces of the apparatus are constantly washed thereby, thus carrying away the solid and semi-solid residues, in a thin film descending under the action of gravity, as fast as they are formed.

It is a further object of the invention to provide means for settling from the solvent oil the heavier portions of the suspended material.

Further objects and advantages will be made evident hereinafter.

Referring to the drawing which is for illustrative purposes only,

Fig. 1 is an elevation of an apparatus suited to carry on my process.

Fig. 2 is a diagram showing the method of operation of the heating surfaces.

Fig. 3 is a sectional elevation on the line 3—3 of Fig. 1 on a somewhat larger scale.

Fig. 4 is a section on a plane represented by the line 4—4 of Fig. 3.

Fig. 5 is a section on a plane represented by the line 5—5 of Fig. 3.

Fig. 6 is an enlarged view of the bottom of the cracking chamber in Fig. 1, showing parts broken away.

In the practical operation of my invention I employ a furnace 11 having a flue 12 which projects through a cracking still 13. Surrounding the upper portion of the cracking still 13 is a settling and separating chamber 14, which communicates with carbon chambers 15 and 16. Vapor from the top of the still 13 is delivered to a dephlegmator 17, light vapors being taken from the top thereof to a condenser 18.

The cracking still 13 consists of a tight shell 20 joined by means of a bottom 22 with a heat insulated inner wall 23, which extends up and joins the flue 12 at 24. A heat insula-

tion 25 is provided for the purpose of keeping the wall 23 cool. Supported on an annular ring 30 carried on brackets 31 from the inner wall of the shell 20 is a worm gear 32 driven by a worm 33, which in turn is driven by a suitable pulley 34 outside the still 13. Attached to the worm gear 32 are two helical scrapers 35 and 36, these scrapers fitting tightly about the flue 12 and serving to scrape the solid material from the outer surface thereof. Secured on the lower end of the members 35 and 36 are a series of scrapers 37, which tend to prevent material from adhering to the wall 23. Surrounding the upper end of the flue 12, outside the scrapers 35 and 36, are a main oil distributor 40 and a solvent distributor 41. The distributor 40 is connected, as shown in Fig. 4, by means of a short pipe 42 with one portion 43 of the settling chamber 14, this portion being formed by a high partition 44 and a low partition 45 inside a shell 46, the partitions 44 and 45 extending from the shell 46 to the shell 20 of the cracking still. Material settling in the bottom of the still 13 is delivered by a pipe 50 to a pump 51 which forces this material through a pipe 52 and a nozzle 53 into one end of a portion 54 of the settling chamber 14. The portion 54 is in communication with the portion 43 over the top of the partition 45. The lower end of the portions 43 and 54 are in communication with the carbon chambers 15 and 16, respectively, through a pipe 55 having a valve 56, and through a pipe 57 having a valve 58. Situated inside the shell 20 and projecting inwardly close to the members 35 and 36 are a plurality of cones 60; and the shell 20 is shown as provided with apertures 60′ permitting an equalization of pressure by a movement of gases.

Vapor is taken off from the top of the cracking still 13 through a pipe 61 and delivered to the dephlegmator 17. This dephlegmator consists of a shell 62 having a tight top 63 and a tight bottom 64. Situated inside the shell 62 are a plurality of oppositely concaved pans 65 and 66. Vapor is taken off from the top of the dephlegmator 17 through a pipe 67 and delivered to the condenser 18, which is of any conventional form. Cold solvent or carrier oil may be delivered through a pipe 68 into the top of the dephlegmator 17, this solvent being carried downwardly over the pans 65 and 66 and delivered through a pipe 69 into the distributor 41. The distributors 40 and 41 are perforated so that they tend to spray material on the flue 12. The oil to be treated is delivered through a pipe 70 into the pipe 52. The operation of the apparatus is continuous.

The apparatus may be started in the following manner:

The solvent or carrier oil, which is preferably a distillate having a boiling point somewhat higher than the cracking temperature which it is desired to maintain inside the still at the pressure maintained in the still is delivered through the pipe 68 to the dephlegmator, flowing downwardly therethrough and through the pipe 69 to the distributor 41, being sprayed from the distributor 41 on the outer surface of the flue 12. This solvent oil flows downwardly over the flue 12 and is finally delivered through the pipe 50 to the pump 51. This pump preferably consists of two gears running in mesh and is of well known form now used for circulating hot liquid. The solvent oil is then pumped upwardly through the pipe 52 into the chamber 54, flowing over the partition 45 into the chamber 43 and through the pipe 42 into the distributor 40, being again sprayed upon the hot flue 12 and flowing downwardly thereon. As soon as the solvent oil which is thus circulated over the surface of the flue reaches a temperature slightly above that necessary to crack the raw oil, the valve in the pipe 70 is opened and raw oil is delivered to the pipe 52, flowing upwardly therein and being mixed therein with the solvent oil. This raw oil is then delivered with the solvent oil through the distributor 40 to the outer surface of the flue, flowing downwardly thereover in a thin film. The raw oil is probably partially cracked in the pipe 52 but the greater portion of the cracking takes place during the passage of the oil downwardly in the film of solvent oil on the outer surface of the flue 12. Due to the cracking of the raw oil, hot hydrocarbons and tarry material are formed, which, however, tend to go into solution or suspension in the solvent oil. The flue 12 being at a higher temperature than the solvent oil, there is a tendency for these solid or tarry residues to adhere to the flue 12 and build up a layer of coke thereon. The members 35 and 36, being continuously rotated, tend to scrape off any solid or semi-solid material deposited on the flue and to keep the outer surface of the flue 12 substantially free from any considerable accumulation of carbon. There is, however, a tendency for this carbon to build up and there is always a thin film of carbon on this surface. This thin film of carbon probably acts as a catalyzer, tending to promote the cracking of the oil carried by the solvent. The solvent also serves to dissolve or remove from the surface of the flue 12 the tarry or solid residues formed by the cracking, all of this material passing downward to the pump 51.

The pump 51 breaks up the solid and semi-solid materials, which are then delivered through the pipe 52 and the nozzle 53 into the chamber 14. In the portions 43 and 54 of this chamber the solid residues settle out from the solvent, and the valves 56 and 58 being open, this material gradually settles in the carbon chambers 15 and 16. From time to

time it is necessary to close the valves 56 and 58 and to remove the heavy residue from the chambers 15 and 16, which can be conveniently done through suitable pipes 71 and 71'.

The conical members 60 serve a double purpose. They tend to return to the heating surface 12 any liquid which may splash therefrom and they also serve, with the inner wall of the shell 20, to form pockets in which light vapors collect.

The vapors produced in the still 13 tend to rise and are carried over by the pipe 61 into the dephlegmator, passing upwardly therethrough outside the pans 65 and through central openings in the pans 66. These pans may be kept wet with cold solvent delivered through the pipe 68. After the plant has once been brought into successful operation, however, the supply of oil to either the pipe 68 or the pipe 70 may be cut off to any extent compatible with the desired thermal control.

In the ordinary operation of the plant, heavy distillates are caught by the dephlegmator and returned by the pipe 69 to the distributor 41, the lighter products passing over through the pipe 67 and condensed in the condenser 18, forming the principal commercial product of the plant.

In practice solvent oil is produced as an intermediate product but it gradually breaks up to form low boiling point hydrocarbons and a heavy residue. As a result there is a constant production of such solvent oil and an equally constant breaking up of such solvent. Should the rate of cracking fall so that such solvent is produced faster than it is cracked, the solvent will start to accumulate in the bottom of the cracking still 13, which will become evident to the operator who opens a petcock 83 from time to time. Should he find an accumulation of solvent, he reduces the flow of raw oil through the main intake pipe 70, thus reducing the amount of cold oil fed into the apparatus and increasing the temperature in the still.

In treating California oils, I have operated with excellent results with oil temperatures, at the inlet 50 of the pump 51, of from 750 degrees Fahrenheit to 850 degrees Fahrenheit, and with pressures up to 180 pounds per square inch. I believe this temperature must be in excess of 700 degrees Fahrenheit to produce good commercial results and that pressures in excess of 20 pounds gauge are also necessary to the best results.

I have found that it is advisable to maintain a large volume of circulating solvent as compared with the raw oil. For example, the quantity of raw oil introduced in a given time through the pipe 70 may be less than 2 per cent of the total fluid circulated in the same time through the pipe 52. This gives a large volume of solvent on the heating surfaces, which are thoroughly washed thereby.

I also provide means such as the scrapers 35 and 36 for mechanically removing adherent matter from the heating surfaces. This adherent matter is initially a tarry hydrocarbon, but if allowed to remain on the heating surface it rapidly cokes, producing a hard mass of low heat conductivity which prevents the oil from taking heat from the heating surface and causes a local overheating at that surface. By rapidly circulating a solvent oil over the heating surface, I am able to dissolve the greater portion of said tar before it cokes, and by the use of the scrapers I am able to mechanically remove the coke.

I also provide means such as the gear pump 51 for breaking up the carbon into fine particles, and I provide means such as the chamber 14 in which the heavy matter, carried in suspension in the oil, is allowed to settle. This heavy matter, consisting largely of free carbon, then settles in the carbon chambers 14 and 15 and is periodically removed therefrom.

My invention comprises several novel conceptions. I provide means for covering a heating surface, such as the outside of the flue 12, with a rapidly flowing film of oil. This film of oil may be largely solvent oil, that is, oil which does not readily crack at the still temperatures, but which acts as a solvent or carrier for the heavy hydrocarbons produced by the cracking. The rapid circulation of this oil over the heating surface keeps this surface washed so that the heavy cracked products are carried away as fast as they are formed. This rapid circulation of the film also increases the efficiency of heat transfer from the heating surface, not only by keeping the heating surfaces free from adherent solids, but also by washing off gas bubbles as fast as they form.

By flowing the oil in a film, the escape of vapors is also facilitated, the vapors readily escaping to cooler portions of the still, where they cannot interfere with the ready transfer of heat through the body of the oil. The rapid circulation also mixes the oil and prevents local overheating.

While I have described a definite apparatus and certain more or less definite steps of a process, I do not wish my invention to be limited to the particular embodiment shown or described, but wish the scope of my invention to be defined wholly by the annexed claims.

I claim as my invention:

1. A process for cracking liquid hydrocarbons under pressure which comprises: flowing said hydrocarbon downwardly in a film over an external vertical surface contained within a pressure chamber; heating said surface internally to a temperature sufficient to cause the cracking of said hydrocarbons; removing the residual carbonaceous products of said cracking action from said surface by a combined mechanical and wash-

ing process; removing the vapor products of said cracking action from said pressure chamber, and condensing said vapors.

2. A process for cracking liquid hydrocarbons under pressure which comprises: flowing said hydrocarbons downwardly in a film over an external vertical surface contained within a pressure chamber; heating said surface internally, by means of flue gases, to a temperature sufficient to cause the cracking of said hydrocarbons; mechanically preventing the deposition of the residual carbonaceous products of said cracking action upon said heated surface; removing said residual products from said surface by suspension in such liquid hydrocarbons flowing over said surface as are physically stable under the conditions of the pressure chamber; removing the vapor products of said cracking action from said pressure chamber, and dephlegmating and condensing said vapors.

3. A process for cracking liquid hydrocarbons under pressure which comprises: flowing said hydrocarbons downwardly in a film over an external vertical surface contained within a pressure chamber; heating said surface internally by means of flue gases to a temperature sufficient to cause the cracking of said hydrocarbons; flowing a carrier oil which is substantially stable under the conditions in the pressure chamber over said surface to remove, by carrying in suspension and solution, the residual carbonaceous products of said cracking action; mechanically preventing the deposition of said residual products upon said surface, and maintaining an intimate contact between said products and said carrier oil; removing the resulting vapor products of said cracking action from said pressure chamber, and dephlegmating and condensing said vapors.

4. A process for cracking liquid hydrocarbons under pressure which comprises: flowing said hydrocarbons downwardly in a film over an external vertical surface contained within a pressure chamber; heating said surface internally by means of flue gases to a temperature sufficient to cause the cracking of said hydrocarbons; flowing a carrier oil which is substantially stable under the conditions of the pressure chamber over said surface to remove, by carrying in suspension and solution, the residual carbonaceous products of said cracking action; subsequently removing said suspended residual products from said carrier oil, and recycling said carrier oil through said pressure chamber; mechanically preventing the deposition of said residual products upon said heated surface, and maintaining an intimate contact between said products and said carrier oil; removing the resulting vapor products of said cracking action from said pressure chamber, and dephlegmating and condensing said vapors.

5. A process for cracking liquid hydrocarbons under pressure which comprises: flowing said hydrocarbons downwardly in a film over an external vertical surface contained within a pressure chamber; heating said surface internally by means of flue gases to a temperature sufficient to cause the cracking of said hydrocarbons; flowing a carrier oil which is substantially stable under the conditions of the pressure chamber, over said surface to remove by carrying in suspension and solution the residual carbonaceous products of said cracking action; mixing said carrier oil containing said residual products with raw uncracked hydrocarbons; subsequently partially settling said suspended residual products from said mixture, and subjecting said partially clarified mixture to said heating process; mechanically preventing the deposition of said residual products upon said heated surface, and maintaining an intimate contact between said products and said carrier oil; removing the resulting vapor products of said cracking action from said pressure chamber, dephlegmating and condensing said vapors.

6. A process for cracking liquid hydrocarbons under pressure which comprises: flowing said hydrocarbons downwardly in a film over an external vertical surface contained within a pressure chamber; heating said surface internally by means of flue gases to a temperature sufficient to cause the cracking of said hydrocarbons; flowing a carrier oil which is substantially stable under the conditions in the pressure chamber, over said surface to remove, by carrying in suspension and solution, the residual carbonaceous products of said cracking action; mechanically preventing the deposition of said residual products upon said surface, and maintaining an intimate contact between said residual products and said carrier oil; removing the resulting vapor products of said cracking action from said pressure chamber, by passage through a dephlegmator in which said vapors are brought into intimate contact with cold carrier oil flowing through said dephlegmator in a direction opposed to the flow of said vapors; said carrier oil flowing from said dephlegmator to said heating surface; said vapors passing from said dephlegmator to a condenser.

7. A process for cracking liquid hydrocarbons under pressure which comprises: flowing said hydrocarbons downwardly in a film over an external vertical surface contained within a pressure chamber; heating said surface internally by means of flue gases to a temperature sufficient to cause the cracking of said hydrocarbons; flowing a carrier oil which is substantially stable under the conditions of the pressure chamber, over said surface to remove, by carrying in suspension and solution, the residual carbonaceous prod-

ucts of said cracking action; mixing said carrier oil containing said residual products with raw uncracked hydrocarbons; subsequently partially settling said suspended residual products from said mixture, and subjecting said partially clarified mixture to said heating process; removing the resulting vapor products of said cracking action from said pressure chamber, by passage through a dephlegmator in which said vapors are brought into intimate contact with cold carrier oil flowing through said dephlegmator in a direction opposed to the flow of said vapors; said carrier oil flowing from said dephlegmator to said heating surface; said vapors passing from said dephlegmator to a condenser.

8. A process of cracking a hydrocarbon under pressure which comprises: flowing said hydrocarbon downwardly in a film over an external vertical heated surface; heating said surface internally to a cracking temperature by upwardly moving flue gases; uniting with said solvent raw oil and flowing the resulting mixture similarly in a film repeatedly downwardly and in contact wtih said heated surface while maintaining the surface at an oil cracking temperature by means of the flue gases, and carrying in suspension in said mixture the unvaporized products of said cracking, and dephlegmating and condensing the resulting vapors.

9. A cracking apparatus comprising: a vertical chamber; an upwardly extending flue passing through said chamber; mechanical scraping means rotatable about said flue; means for supplying a thin film of oil descending under the action of gravity in contact with said flue; means for withdrawing vapors and gases from said chamber; means for removing liquid and solid residual mixture from said chamber; means for separating said solid and liquid residual substances; separate means for withdrawing said solid residue, and means for returning residual oil for treatment.

In testimony whereof, I have hereunto set my hand at Los Angeles, California, this 26th day of August, 1924.

MILON J. TRUMBLE.