

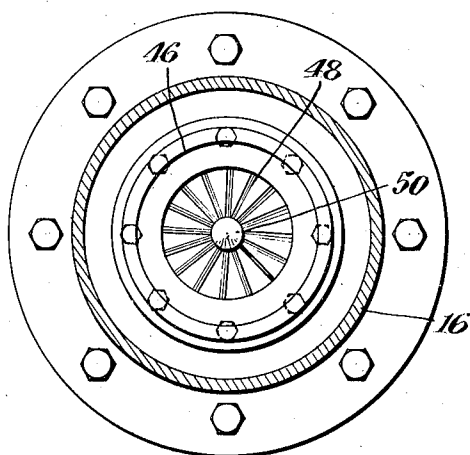
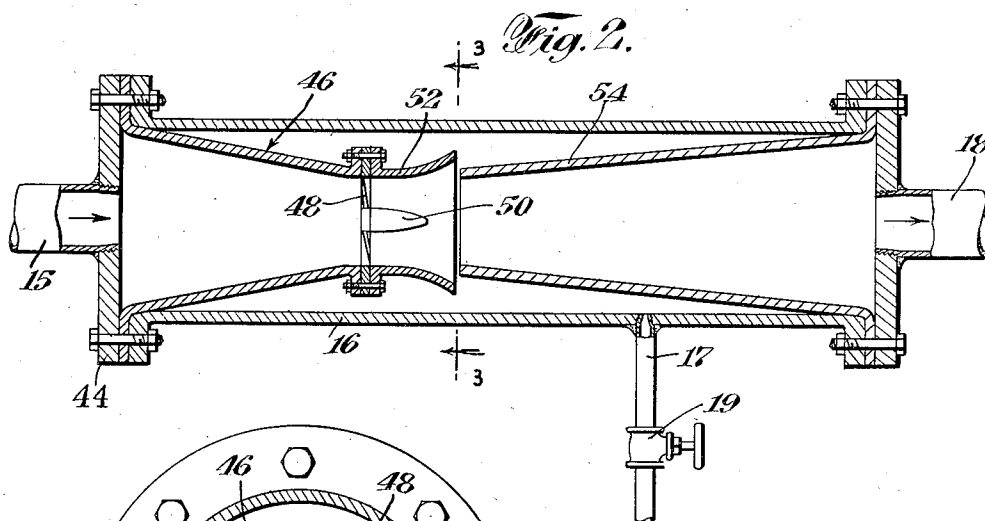
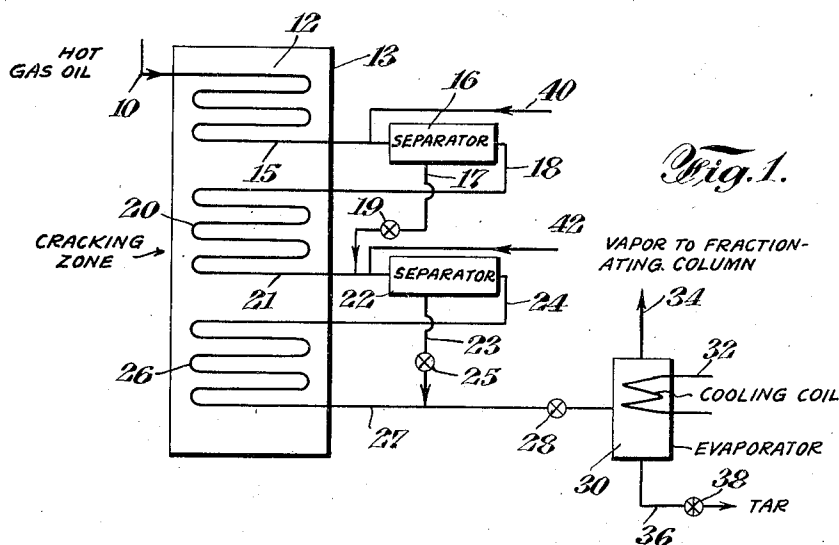
March 5, 1940.

H. M. WEIR

2,192,214

CRACKING PROCESS AND APPARATUS

Filed Aug. 11, 1936



INVENTOR  
HORACE M. WEIR  
BY  
Pindle, Bean & Mann  
ATTORNEYS.

## UNITED STATES PATENT OFFICE

2,192,214

## CRACKING PROCESS AND APPARATUS

Horace M. Weir, Ventnor, N. J.

Application August 11, 1936, Serial No. 95,331

5 Claims. (Cl. 196—61)

It is generally recognized in the oil cracking art that the formation of coke is one of the principal difficulties that must be guarded against. It is well known that if the proportion of tarry materials rises above certain determinable values during the progress of a stream of hydrocarbons through a highly heated cracking zone, precipitation of these tars on the walls of the apparatus will occur and that an important, even though small, percentage of the tar will be transformed into adhering solid coke. Fouling of the surfaces with solid material necessitates interruption of the cracking operation to clean the apparatus. Because of this situation, it is common practice to give the hydrocarbon stream only a limited treatment and then withdraw it from the cracking zone, when it is cooled and separated into its resultant components of tar, gas-oil, naphtha and gas. The residual gas-oil is usually recycled.

This practice has two definite disadvantages. There is an appreciable operating loss resulting from the fact that on each cycle the oil must be cooled and re-heated, and the withdrawal of the gas is a disadvantage. The gas produced in the cracking process tends to approach an approximate equilibrium and the presence of a large amount of such gas (particularly the unsaturated constituents) tends greatly to inhibit the formation of large additional quantities of gas. It is also known that a portion of the unsaturated constituents of the gas will be polymerized to form compounds which are liquids within the boiling range of the desired motor fuels.

I have discovered that coke is formed only if liquid tar is present in the hydrocarbon stream and I have further found that this tar forms as a fog in the stream even though temperature and pressure conditions are such that the original charging stock should be completely vaporized. Molecular changes which take place during cracking produce this fog and the fog must form before sufficient liquid will collect on the tube walls to cause coke formation.

Based on this discovery, I have found that the problem can be solved by the removal of this fog at various stages during the cracking operation. As a result, the difficulties above pointed out are avoided and definitely improved results are obtained by intensifying the cracking factors of time and temperature very materially. The invention is applicable both to high pressure cracking, such as the operations carried on at 1000 pounds per square inch, as well as to low pressure cracking. The temperature and time factors which have heretofore been employed in these two

different types of processes are quite different one from the other. In like manner the intensified conditions permitted by my process will differ. As a matter of fact, the degree of intensification which I can employ depends almost entirely on the economics, of the operations. Factors such as the desired or necessary octane number of the gasoline, the balance between the value of gas and fuel oil, and other similar factors all will enter into the calculation. By removing the incipient coke-forming material, I eliminate a physical limitation which has heretofore existed to prevent ideal performance, but in view of the many variable factors it is impossible to give any precise and accurate definition of the benefits which flow from my invention.

In carrying out my invention, I take advantage of the fact that the liquid droplets of the fog are always of a greater density than the gas or vapor present even at the highest operating pressures. This permits me to accomplish the separation by centrifugal force. In the preferred embodiment of the invention the cracking zone is divided into a plurality of sections and the separating equipment is interposed between them. These separators must be quite efficient and the ordinary tangential drum type separator such as frequently used at the discharge end of a cracking equipment ordinarily is substantially useless for this purpose. Later I describe one form of separator excellently suited to the purpose but it is probable that other types may also be employed. However, one feature of design that must be taken care of in any separator useful for this process, is that means must be provided for quickly removing the tarry liquid from the action of the hot gases. If this is not done, the liquid will tend to coke in the separators and destroy their efficiency. This criticism would apply to the use of most types of steam condensate separating apparatus now on the market which rely upon impingement against vertical baffles along which the liquid trickles, whereas, I prefer to cause the heated hydrocarbons to impinge on stationary baffles to deflect the stream to give it a rotary motion and thereby I can cause the material in the gaseous phase to traverse a path different from the liquid droplets in a denser phase in such a way as to cause the desired separation.

Preferably the cracking zone is divided into more than two sections and accordingly two or more separators will be required. In such case the tar discharge from all the separators may be brought to a common point. However, I have found that this ordinarily will not be de-

sirable, particularly with high pressure systems. Obviously it is essential that the pressure in the tar discharge line be maintained only slightly below the pressure in the separator. In high pressure systems, if the tar is discharged direct to the atmosphere, a valve must be provided which at all times must maintain just the right pressure. This is difficult to arrange with a high pressure drop, and I have found that it is better to discharge the tar from one separator back into the main line just in advance of the next separator, with the last separator discharging into the line just in advance of the main pressure-control valve which regulates the pressure of the system. Thus each tar discharge pipe will by-pass a section of the cracking zone. This means that there will be some pressure drop but it will be so slight that it can readily be adjusted. Preferably the pressure is so controlled that only enough gas will flow through the tar discharge pipes to insure that they will be kept properly swept out.

By this simple arrangement the pressures are practically self-adjusting even though there be substantial variations in the over-all pressure of the system. I have also found that the injection of a liquid in advance of a separator is helpful in mechanically clearing the fog. The tar from the previous separator may thus have a beneficial function, and this action may be supplemented by a further injection at this point of a liquid such as gas-oil or heavier hydrocarbon material such as a refractory high-boiling distillate. However, it is to be borne in mind that temperature equilibrium will not be established immediately after injection, and hence I may use a lighter cut and still obtain the desired liquid phase scrubbing effect on the hydrocarbons being processed. If desired, the liquids discharged from the separator may be promptly cooled somewhat, before being returned to the line.

This invention can readily be understood from the accompanying drawing which illustrates an example of the same in conjunction with a type of apparatus which has been found particularly suited to the purpose. In the drawing, Fig. 1 is a diagrammatic flow sheet showing the passage of the hydrocarbon liquid through a cracking zone prepared for the operation of my process; Fig. 2 is an enlarged longitudinal section through a separator useful for this process, and Fig. 3 is a section (again slightly enlarged) on line 3—3 of Fig. 2.

Referring to Fig. 1, the hydrocarbon to be treated, such as a gas-oil, is introduced through pipe 10 into section 12 of the cracking zone. As is well understood, the fluid will ordinarily have been brought (in a preheater not shown) almost to cracking temperature, and may, therefore, be partly or wholly in the gaseous phase. The original liquid is introduced under pressure by a pump not shown into the preheater and thence into the cracking zone. In the drawing, the cracking zone sections are indicated as coils, but it is to be understood that this is only a conventionalized showing and any usual form of cracking apparatus may be employed, such as a series of parallel pipes connected to a pair of headers. It is also to be understood that the cracking zone indicated by the numeral 13 is heated by an appropriate furnace, not shown, to the desired cracking temperature.

The hydrocarbon stream, substantially in vaporized condition, enters section 12 of the

cracking apparatus, where it is brought up to and maintained at cracking temperature. As a result, a portion of the oil is converted to gas, naphtha and tar. The stream, now carrying some or all of the tar as a fog of fine droplets, passes by pipe 15 to separator 16 where the bulk of this fog is separated preferably through centrifugal action as will later be described. The hydrocarbon stream consisting essentially of gas, naphtha and gas oil which has not been substantially cooled, passes through section 20 of the cracking apparatus where it is subjected to further cracking treatment, after which it passes by pipe 21 into separator 22. The tarry material separated by separator 16 is conducted by pipe 17 to pipe 21 just before the latter enters separator 22. Pipe 17 is provided with a valve 19 set to compensate for the pressure drop in section 20, and allow the tar and a small amount of gas and vapor to pass.

In like manner, the hydrocarbon stream leaving separator 22 passes by pipe 24 to section 26 where it is given its final cracking treatment and it is to be understood that the aggregate cracking in sections 12, 20 and 26 may be considerably more intense than that usually practised in a single cycle, so that very little, if any, unconverted gas-oil will remain, and so-called "reforming" treatments ordinarily will be unnecessary. The discharge from section 26 passes through pipe 27 to valve 28 which maintains the desired pressure in the system, and thence at a lower or atmospheric pressure to an evaporator 30 which may be provided with a cooling coil 32. This evaporator is intended for separation of the tar which is discharged by pipe 36 controlled by valve 38. The gas and vapors of naphtha and any residual oil are taken to a fractionating column as is well understood in the art.

The tarry liquid from separator 22 is conducted by pipe 23 to pipe 27 just in advance of valve 28. Pipe 23 is provided with a valve 25 for controlling the pressure drop. Pipes 40 and 42 are provided so that additional liquid may, if desired, be introduced into the hydrocarbon stream as it enters separators 16 and 22.

In Figs. 2 and 3, I show the detailed construction of the separator 16 and the separator 22 will be the same. The pipe 15 is connected by flange 44 with the cylindrical separator casing 16. Inside the casing 16 is the Venturi throat 46 carrying in its mouth the turbine plate 48. This plate is composed of radially arranged blades positioned with their edges slightly overlapping, somewhat like the blades in a blower, but in this case the plate 48 is stationary and the blades give a rapid swirling or rotary motion to the vapors and fog of tarry droplets that pass through them. Preferably a streamlined member 50, circular in cross section, is provided at the center of the discharge side of the plate 48 in order to act as a guide to eliminate a vortex from the rapidly whirling vapors that emerge from the plate 48. 52 is the discharge mouth of the venturi which is formed with a gradual increase in radius so that the fog droplets will follow along its surface. Cylindrical expansion nozzle 54 has its inlet end inside the mouth of member 52 with a slight clearance between them to provide an annular slot through which the droplets of tar will pass out to the casing 16. Pipe 17 conducts the collected tarry liquid from the casing, and ordinarily valve 19 should be set to permit this liquid and a small amount of vapor to pass through.

The bulk of the gas and vapor substantially

freed from tar will expand in nozzle 54 which converts a portion of the kinetic energy of rotation to pressure head prior to the emergence of the tar-free hydrocarbon stream into pipe 18.

5 While I have principally described the process and equipment as useful for cracking petroleum hydrocarbons, it may also have other uses such as in the polymerization of hydrocarbon gases to liquids. In such case, tar is usually formed and  
10 its removal by the means described above is advantageous. Also it is to be understood that the cracking process here selected for illustration as well as the details of the apparatus may be modified in many particulars without departing from  
15 the spirit of my invention.

What I claim is:

1. In a process of reacting hydrocarbons under conditions of heat and pressure to change their molecular structure, the steps of heating liquid  
20 hydrocarbons to convert them into the vapor phase, passing the vaporized hydrocarbons through a reaction zone at a cracking temperature and under pressure adapted to cause molecular changes to take place including the forma-  
25 tion of a fog of extremely finely divided droplets of tarry material produced in liquid phase without substantial temperature drop; causing substantially immediately the stream of vaporized hydrocarbons and fog of tarry material to flow  
30 forward directly under substantially uniform pressure and without substantial drop in temperature and acquire a rapid whirling motion while moving continuously forward whereby said minute fog droplets are thrown to the periphery  
35 of the advancing stream, substantially immediately withdrawing a portion of the peripheral layer of such stream to effect separation of said fog droplets and avoiding recontact within subsequent portions of the cracking zone between said  
40 withdrawn fog of liquid droplets and the main portion of the stream advancing through the cracking zone.

2. A process as defined in claim 1 and in which there are at least three cracking treatments and  
45 two tar fog separating treatments of the fog laden hydrocarbon stream.

3. An apparatus for reacting hydrocarbons under conditions of heat and pressure to change their molecular structure comprising means for heating liquid hydrocarbons to convert them into the vapor phase, means for cracking the hydrocarbons at a cracking temperature and under pressure adapted to cause molecular changes to

take place including the formation of a fog of extremely finely divided droplets of tarry material produced in liquid phase without substantial temperature drop, means for causing the stream of vaporized hydrocarbons and fog of  
5 tarry material to flow forward substantially immediately under substantially uniform pressure and without drop in temperature and acquire a rapid whirling motion while moving continuously forward so that the minute fog droplets are  
10 thrown to the periphery of the advancing stream, means for withdrawing substantially immediately a portion of the peripheral layer of such stream to effect separation of the fog droplets and for avoiding recontact within subsequent portions  
15 of the cracking zone between said withdrawn portion and the main portion of the stream advancing through the cracking zone.

4. An apparatus as defined in claim 3, in which the means for causing the vaporized hydrocarbons and fog to whirl and effect separation of the fog droplets from the hydrocarbon stream comprises a turbine plate having radially arranged, slightly overlapping blades which are adapted to give a rapid swirling action to the stream of hydrocarbon vapors and fog of tarry droplets that pass through the turbine plate.

5. In a process of reacting hydrocarbons under conditions of heat and pressure to change their molecular structure, the steps of passing vaporous hydrocarbons through a reaction zone at a cracking temperature and under pressure adapted to cause molecular changes to take place including the formation of a fog of extremely finely divided droplets of tarry material produced in liquid phase without substantial temperature drop; causing substantially immediately the stream of vaporous hydrocarbons and fog of tarry material to flow forward directly under substantially uniform pressure and without substantial drop in temperature and acquire a rapid whirling motion while moving continuously forward whereby said minute fog droplets are thrown to the periphery of the advancing stream, substantially immediately withdrawing a portion of the peripheral layer of such stream to effect separation of said fog droplets and avoiding re-contact within subsequent portions of the cracking zone between said withdrawn fog of liquid droplets and the main portion of the stream advancing through the cracking zone.

HORACE M. WEIR.