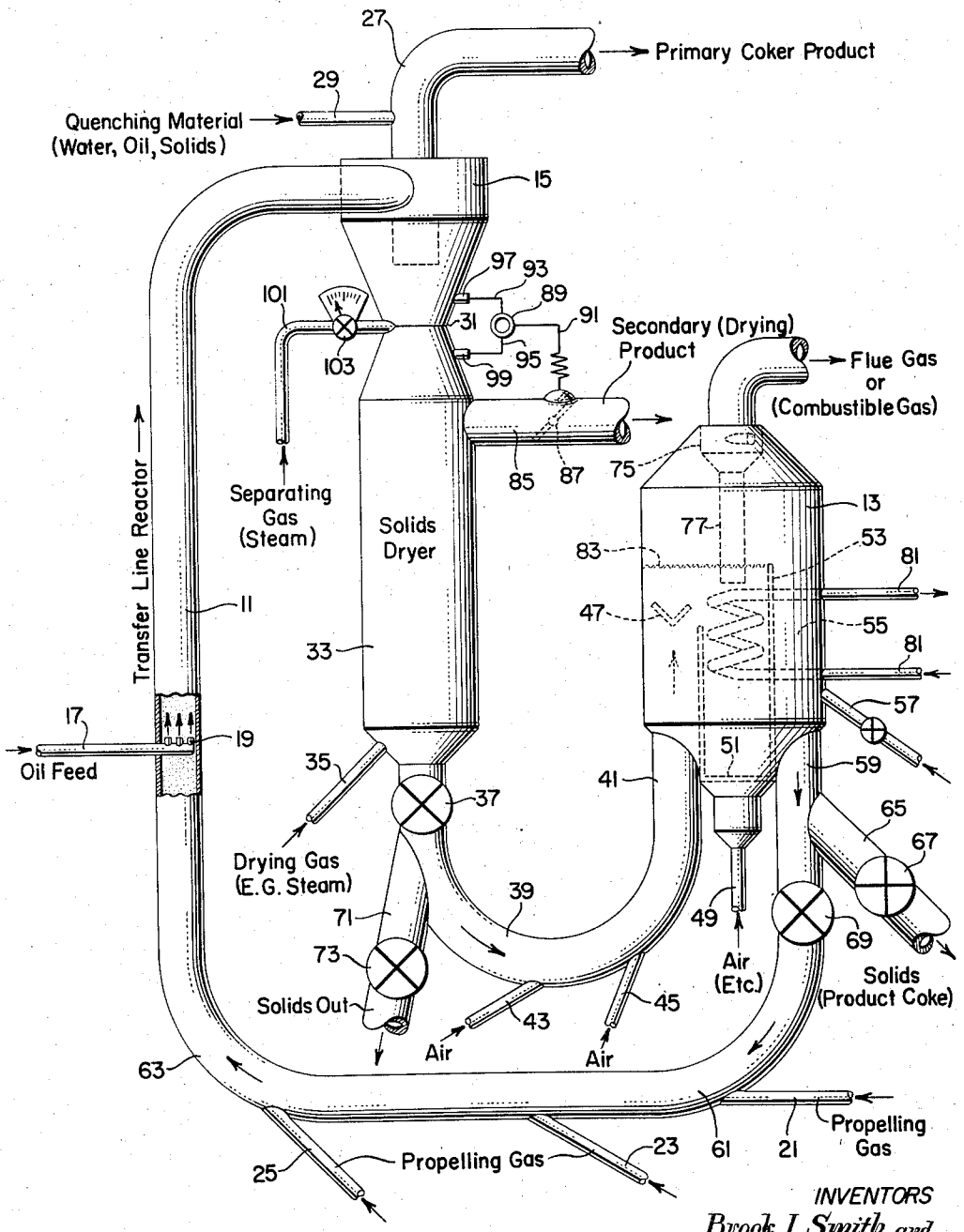
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PRODUCTS SEPARATING SYSTEM

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PRODUCTS SEPARATING SYSTEM

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The present invention relates to an improved vapor products separating system and particularly to an improved system for separating hydrocarbon and similar vapors or gases from other products of thermal reaction processes. The invention has particular application to the separation of primary, or superior, products from secondary, or inferior, products resulting from thermal cracking of heavy hydrocarbon oils. The invention is especially applicable to the separation of primary vapors and gases from a high temperature oil coking operation from secondary products of lower quality, although it is not expressly limited thereto.

In the prior art, it has been known for some time that certain materials such as medium or heavy hydrocarbon oils and related organic feed stocks can be converted by thermal cracking to low molecular weight materials of considerably greater value than the feed. For example, a heavy residual petroleum oil, of relatively low economic value, may be converted by cracking at moderately high temperatures, e. g. 900° to 1100° F. or so, into motor fuel and gas oil. At higher temperatures (and shorter contact times) the same feed may be converted into starting materials for many useful chemicals. Thus at temperatures of 1200° to 1500° F. or so, heavy residual petroleum oils may be converted to ethylene, acetylene, propylene, butylenes, butadiene, isoprene and benzene, along with other products. These low molecular weight unsaturates and related materials are of considerable value as starting materials in the manufacture of synthetic fibers, plastics, alcohols, ketones, aldehydes, and many other useful products of modern chemistry. Hence this general type of conversion of heavy petroleum hydrocarbon oils is commonly referred to as high temperature cracking or coking for chemicals. The process obviously is applicable to coal tars, pitches, resins, shale oils and other organic residues, in some degree.

In high temperature cracking or coking, or in destructive distillations of organic materials, it is frequently of considerable importance to carry out the thermal reaction to an optimum point and terminate the reaction abruptly when that point is reached. This is particularly true of high temperature coking of heavy oils and pitches to produce low molecular weight olefins and related products. At the temperatures necessary to produce these products in good yields, they are extremely reactive. They tend rapidly to polymerize, alkylate, or otherwise react with each other and with some other materials with which they may come in contact. An object of the present invention is to facilitate the abrupt termination or quenching of reaction when optimum products have been produced.

A preferred method of effecting thermal conversion of heavy oils, pitches, tars, etc., involves contact thereof with preheated solid particles. A mass of preheated solid particles of a size which can be fluidized, carried, and lifted by a gasiform stream is a particularly satisfactory thermal contacting medium, as is well known in the art. For coking heavy oils and pitches at moderately high

temperatures, a fluidized bed of solids with which the feed is contacted in finely divided from is very satisfactory. For higher temperatures, for production of substantial proportions of olefins (e. g. acetylene, ethylene, etc.) and in other cases where contact times must be very short, the use of a transfer line or mobile disperse phase solids reactor is highly advantageous. In such a system, the products to be converted are brought into contact momentarily with a rapidly moving stream of hot solids propelled by and usually suspended in a propellant gas stream. At the end of the contact period, the solids must be separated quickly from the products to terminate the thermal conversion. It is usually desirable to quench the products immediately after separation, i. e. to cool them to a temperature where they cease to react and form degradation products. An object of the present invention is to facilitate such quick separation and quenching.

The most common and frequently the most efficient and satisfactory manner of separating heat carrying particulate solids from gases and vapors is to pass them through a centrifugal separator such as a cyclone. The cyclone may be of the conventional commercial type or it may be of a special quick separation type such as shown, for example, in an application of Matheson, Serial No. 323,972, filed December 4, 1952, now abandoned. While a substantial part of the vaporous or gaseous conversion products may be separated very quickly in a centrifugal separator, there is always some occlusion and entrapment in the solids. Also, the reaction of feed that is only partially converted continues through the separator and into the solids line leading out of the separator. The secondary products thus occluded, trapped, and converted are usually degraded to a substantial extent by reason of their relatively prolonged heating time. A further and particular object of the present inention is to facilitate the separation of primary products of better quality from these secondary products of relatively inferior quality.

Although every effort may be made, and usually is, to disperse the feed evenly onto or among the heat carrying solid particles, some particles always pick up more feed, e. g. a heavier coating of oil, than others. As a result, some solid particles are still relatively moist or bear a tacky or plastic coating of partially coked oil, when other particles are relatively dry and have completed the conversion of the feed which they have contacted. Hence, though primary products should be drawn off after an optimum contact time, some of the solids must go on giving off heat and converting the partially coked feed to some sort of product after the primary products have been withdrawn. It is desirable to prevent substantial admixture of these secondary and inferior products with the primary products which ordinarily are of higher quality. Such is another object of the invention. In the preferred embodiment, this is accomplished by establishing a gas or vapor seal or barrier between the primary and secondary products. The solids continue to dry and to vaporize or crack the adherent oil, but the long contact time products, though often useful for other purposes, are desirably separated from the primary products. Therefore, they are sealed against reverse flow through the separator and are separately withdrawn.

The above features and objects of the invention and others not expressly mentioned will be more fully and clearly understood by reference to a specific embodiment of the invention. For this purpose, reference will next be made to the attached drawing showing, somewhat diagrammatically, an apparatus for carrying out the process of the invention.

A transfer line reactor 11 leads from a burner or heater 13 to a gas-solids separator 15. Hot particulate solids, which are of suitable particle size for suspension in a gas stream, such as sand, metal shot or other metal

particles, Carborundum, alumina, silica, glass beads, ceramics, etc., or coke particles derived from coal or petroleum, or even spent catalyst particles may be used. These serve as the heat carrying media. The particles most suitable for entrainment in a gasiform stream through the reactor **11**, are usually between about 40 and 500 microns average particle diameter but may be as small as 20 or as large as about 2000 microns. Coke particles produced in the process are commonly preferred, although the invention is not limited thereto. The particles preferably are substantially non-catalytic for high temperature coking for chemicals.

The oil or like feed to be converted is fed into the reactor through a line **17**, preferably being atomized by introduction through a plurality of nozzles **19** or by introduction at the throat of a venturi in the stream of suspended solids to achieve good distribution. Steam may be introduced with the feed if desired. The upflowing hot solid particles, preferably preheated to a temperature of 1250° to 1600° F. or more, are propelled by steam, hydrocarbon gas or other inert gas, introduced through lines **21, 23, 25** in such volume as to carry the solids in the desired degree of dispersion, e. g. at a density of 0.1 to 20 pounds per cubic foot. Steam is preferably used. The reactor temperature may be 1200–1600° F., preferably 1300–1400° F. The reactor pressure may vary from atmospheric to 50 p. s. i. g. or so, but is preferably 5 to 15 p. s. i. g. The steam used may vary from 5 to 100% by weight of feed, preferably 20 to 30%.

The velocity of the solids-laden gasiform fluid stream through reactor **11** is preferably at least 8 feet per second and may be as much as 100 feet per second or more. The oil spray is vaporized and rapidly cracked to the desired low molecular weight unsaturates. The vapors so produced are quickly separated from the solids in separator **15**. The total contact time in reactor **11** and separator **15** is 0.001 to about 1 second, preferably 0.05 to about 0.5 second.

The primary vapor products separated in centrifugal separator or cyclone **15** are taken upwardly through an outlet line **27** and are immediately quenched by injecting into line **27** a stream of relatively cooler liquid such as water or oil through a line **29**. The oil feed itself may be used as quenching medium, if desired, being recycled to the coking line later. Cool solids, such as coke particles, may be used in lieu of or with the liquid coolant. In this case, the quenching material may be entrained in the product and separated therefrom in a later separation stage, not shown. Some of the quenching material may flow down line **27**, if desired, to join the downflowing separated solids.

The separated solids pass downwardly from the separator through a constricted passageway **31** of the vena contracta or venturi type into a drying zone **33** of larger cross-section. Here the occluded gases and vapors and the later cracked products, not separated in the primary stage, are stripped by an upflowing stream of stripping fluid such as steam or other inert gas introduced through a line **35**. The stripped and spent solids, under control of a valve **37**, are returned through a reverse bend **39** to the burner or reheater **13**, previously mentioned.

The burner or reheater **13** is shown to be of the fluid bed type for purposes of illustration. The solids, e. g. coke particles, which have grown by accretion of coke in the coking operation, flow upwardly through inlet line **41**, under the propelling and/or buoyant effect of a lifting gas such as air, introduced through one or more lines **43, 45**. A baffle member **47** spreads out and distributes the solids entering the burner bed. A fluidizing and/or burning gas, such as air or air plus a fuel, is introduced through inlet **49** and grid **51** at the bottom of the burner or reheater to fluidize and burn or reheat the solids. When their temperature has been raised sufficiently, the solids overflow a partition member **53** defining a separating zone **55**, from which flue gases separate and pass upwardly. The downflowing solids may be stripped of occluded combustion gases, if desired, by a suitable stripping fluid introduced through a line **57**. The reheated solids return to the transfer line reactor through a standpipe **59** and reverse bends **61, 63**, under the propelling effect of gas introduced through lines **21, 23, 25**, as previously mentioned.

A branch line **65** is provided for withdrawing hot product coke from standpipe **59**, under control of valves **67, 69**. Heat may be recovered from the withdrawn product by passing it through a suitable heat exchanger, not shown. If desired, product coke also may be withdrawn at a lower temperature from the outlet line **39** of the solids dryer through a branch line **71**, under control of a valve **73**.

Combustion gas may be withdrawn from burner vessel **13** through a gas-solids separator **75** which may be of the conventional cyclone type. Separated solids are returned to the bed through solids return line **77**. The flue gases pass overhead through outlet line **79**.

The quantity of coke produced in most coking processes is much greater than is needed to supply the process heat requirements. If desired, a heat exchange coil **81** may be placed in the fluid bed **83** in the burner vessel to generate steam or to provide heat for other uses, in which case a larger portion or all of the coke product may be burned. Where coke values are low, this may be very desirable.

The secondary products accompanying the solids from separator **15** and those produced in drying the solids in the solids drying zone **33** are withdrawn through a secondary product line **85**. The respective pressures in separator **15** and dryer **33** are kept fairly well in balance by a control valve **87** operated by a differential pressure controller **89** connected thereto by a control line **91**. The controller **89** is also connected respectively to the separator and the upper part of the solids drying zone by leads **93, 95** which terminate in pressure sensing devices **97, 99**.

In order to maintain a clean separation of primary and secondary products, a separating gas that is inert and is easily separated, when condensed, from the products, is injected at the vena contracta or the venturi constriction, through a line **101**. The preferred separating gas usually is steam, although light hydrocarbon gases such as ethane or propane may be used if desired. The quantity is regulated by a variable valve **103** and is preferably just enough to maintain a seal between vapors in the separator **15** and vapors in the dryer **33**. Furthermore the velocity of the upflowing separating gas through the constricted passageway **31** is held at a value which will allow the separated solids to pass downwardly through the constricted passageway **31**, e. g. a velocity about 0.5 feet per second or less, preferably about 0.1 feet per second. The differential vapor or gas pressure between separator and drying zone is kept between about −5 and +5 inches of water, a differential not greater than ±1 inch being preferred.

It will be understood that the fluid bed burner may be replaced by a fluidized transfer line type burner, if desired. For instance, at temperatures above about 1400° F., a transfer line burner could be used to hold residence time and carbon monoxide formation to a minimum. The reactor may, in some cases, be replaced by a fluid bed reactor, although for very short contact times this is not very satisfactory, a transfer line system being preferable. Various other arrangements and modifications may be made by those skilled in the art without departing from the spirit and purpose of the invention. It will be understood that the terms "vapor" and "gas" or "gasiform" material, as used in the claims, are synonymous, since the primary and secondary products, and the sealing gas or vapor, may be either gas or vapor.

What is claimed is:

1. The process of converting a heavy hydrocarbon oil to low molecular weight products including unsaturates and aromatics, having a tendency to degenerate at high

temperatures, and coke, which comprises contacting said oil momentarily with hot particulate solids in the disperse phase at a temperature of about 1200° to 1600° F. for a period of time in the range of 0.001 to 1 second to form primary products in vapor form and coke, quickly separating in a primary separation stage the primary vapors from said solids and coke while some further conversion of oil is still taking place on said solids to form secondary products, quenching and separately recovering the primary products immediately to prevent degeneration, quickly passing the separated solids downwardly from said primary separation stage through a passage having a sharply constricted section therein into a solids drying zone where said further conversion is completed to form said secondary products, establishing a vapor seal in said sharply constricted section of said passage between said primary and said secondary products by introducing a sealing gas into said constricted section by injection of an inert gas which has a maximum upflow velocity of about 0.5 ft./sec. so as to permit the separated solids to flow downwardly and to prevent substantial mixture of the secondary products with the primary vapor products while keeping the pressure in the primary separating stage and the drying zone substantially in balance and separately recovering secondary products.

2. Process according to claim 1 wherein the pressure differential is between −1 and +1 inch of water.

3. Process according to claim 1 wherein the particulate solids are coke particles.

4. Process according to claim 1 wherein the vapor seal is a steam seal.

5. Process according to claim 1 wherein the vapor seal is a low molecular weight hydrocarbon seal.

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