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FLUID COKING PROCESS

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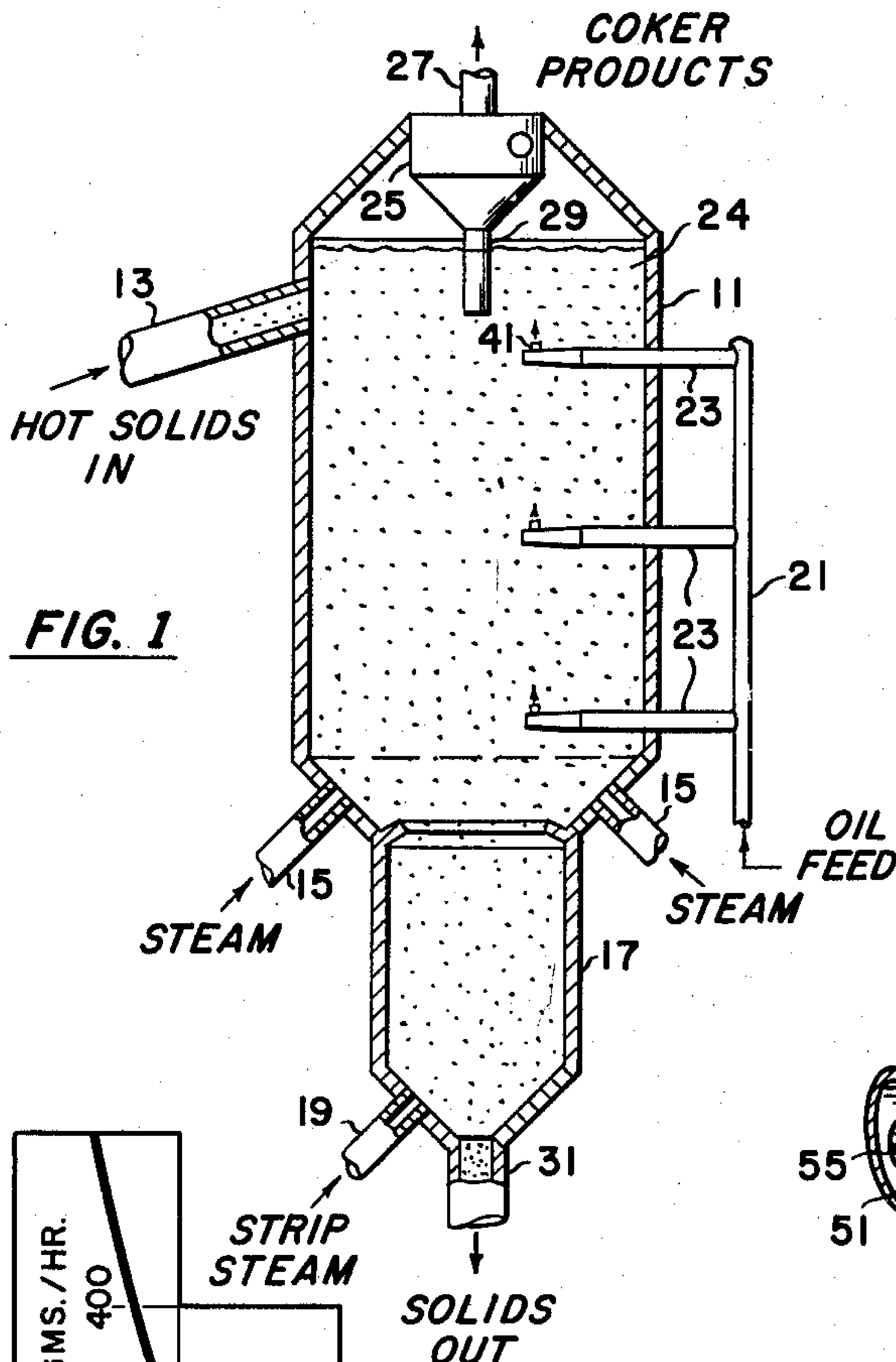

FIG. 1

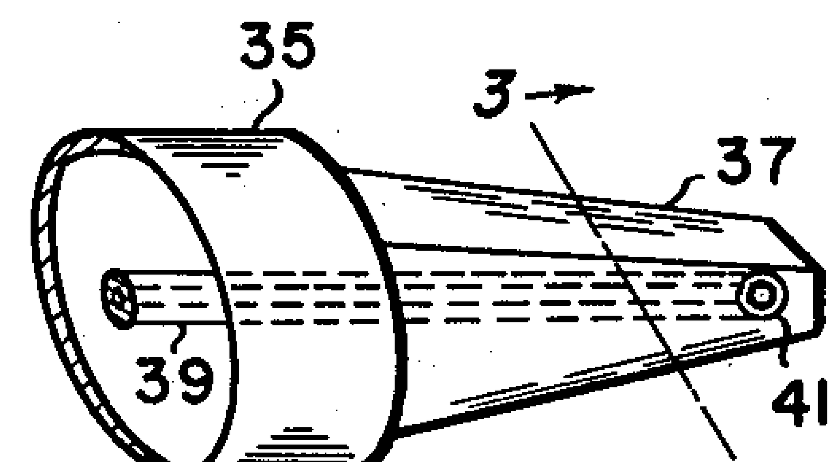

FIG. 2

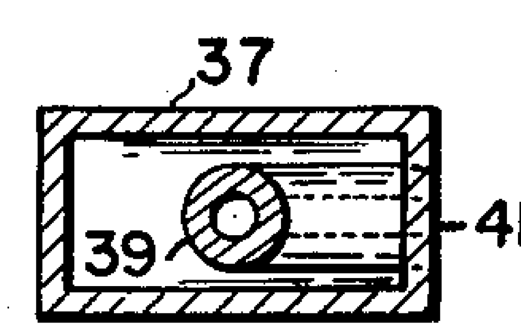

FIG. 3

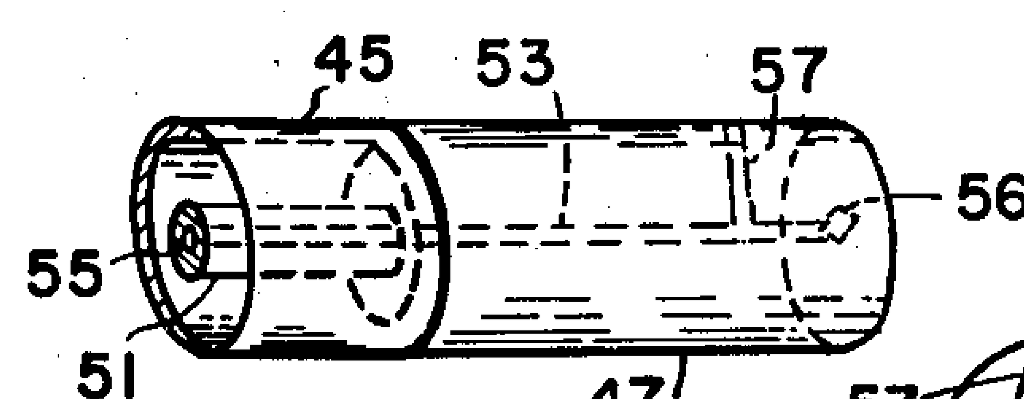

FIG. 4

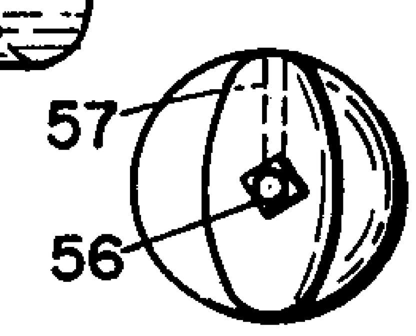

FIG.-4A

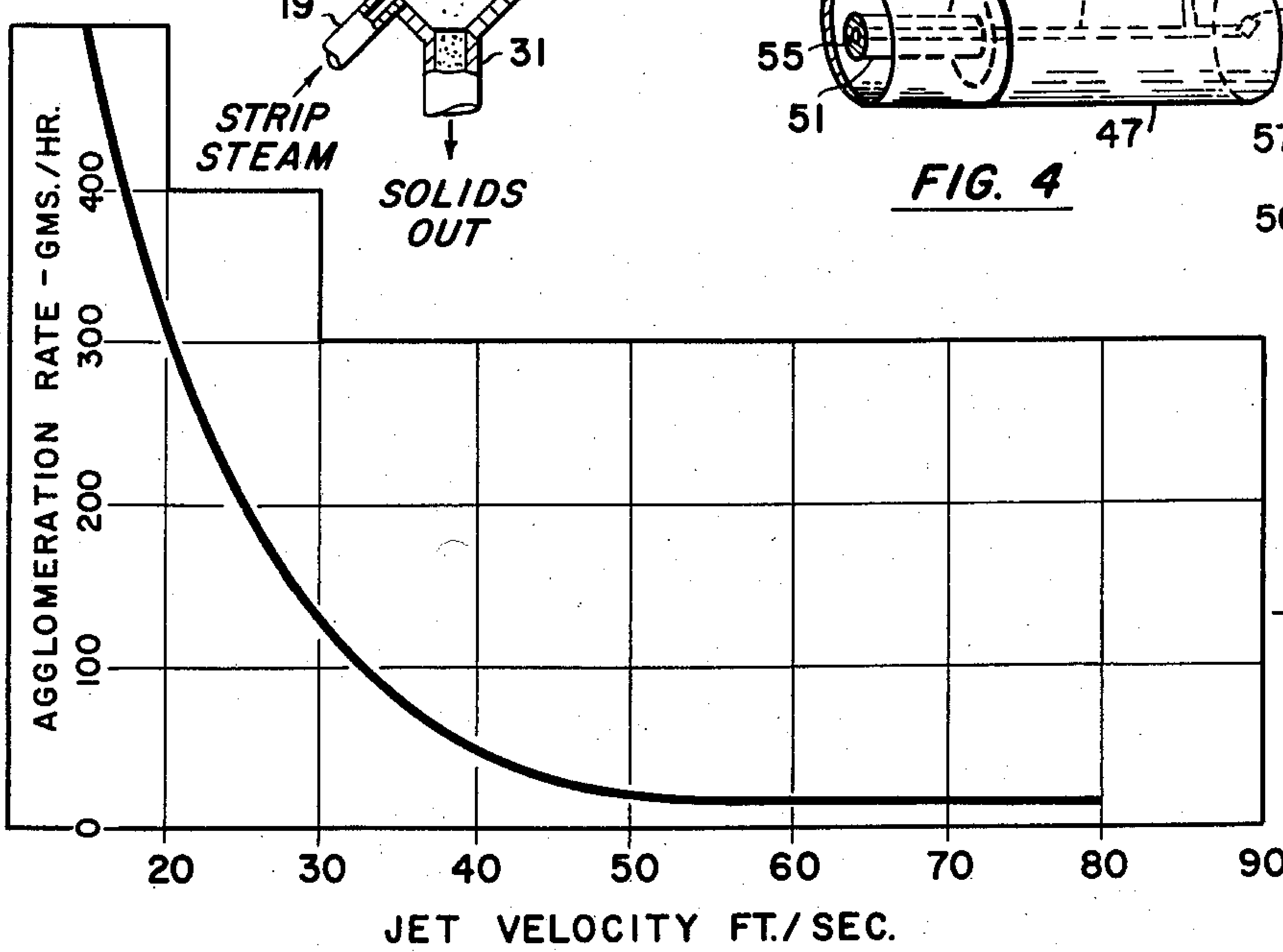

FIG. 5

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FLUID COKING PROCESS

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The present invention relates to a fluid coking process and a feed apparatus therefore. More particularly the invention relates to a process and apparatus for handling highly viscous residual oils with a minimum of agglomeration and bogging of the fluidized bed which is utilized to supply heat for the coking reaction.

It has previously been proposed to coke heavy residual oils by spraying them or otherwise introducing them into a fluidized bed of finely divided solid particles which are substantially inert catalytically. The process operates quite satisfactorily in general, but difficulties are frequently encountered with agglomeration of the solid particles into relatively large masses which interfere with fluidity or mobility of the bed and finally tend to cause bogging of the bed and interruption of the coking operation.

It has been recognized that it is highly desirable to obtain as uniform a dispersion of the feed in the fluidized solids bed as is possible. The finely divided solid particles used are commonly of a size range from about 20 to 400 microns average diameter. Such particles tend readily to adhere to each other when coated with the relatively viscous residual oils which are typical of coking feed stocks. If the ratio of oil to a given mass of solids near a point in the coking bed where the feed is introduced is too great, a number of particles adhere together because they do not have sufficient heat content to fully evaporate and crack the residuum feed and reduce the residue to dry coke.

It has also been recognized in the art that it is desirable to introduce the feed at a relatively large number of separate points in the fluidized bed to improve distribution. Even this is not completely satisfactory because in the relatively dense fluid beds employed, ranging usually between 30 to 60 pounds per cubic foot apparent density, the usual atomized feed jets cannot penetrate very far. Particles of solid materials, such as coke granules near the feed nozzles receive more than their share of oil even when the oil is finely atomized and dispersed.

According to the present invention improved dispersion is obtained by injecting the oil not as an atomized spray but as a small continuous and relatively streamlined jet which projects at an optimum velocity above about 35 and up to about 75 feet or so per second into the fluidized mass. It has been found, quite unexpectedly, that the projection of a solid stream within this optimum velocity range markedly reduced agglomeration of the bed particles as compared with higher or lower jet velocities. Above about 75 feet per second, power requirements begin to become excessive. Moreover this system has the important advantage of avoiding the introduction of an atomizing fluid such as steam, which is necessary with conventional atomizing jets.

When injecting oil as a solid stream the critical jet velocity is much more important than is the case with an atomized spray nozzle. It is therefore highly important to prevent restriction of the flow from the nozzle

with consequent impairment of the optimum jet velocity. Hence, one feature of the present invention involves the design of the nozzle such that a continuous or non-atomized stream of oil may be projected at a definite velocity without plugging. This is accomplished by the use of a hot fluid jacket around the feed line substantially to the point where it emerges from the nozzle.

Thus the present invention relates to a method of coking with emphasis particularly upon the manner of introduction of feed when it relates to the particular design and arrangement of feed nozzles needed to accomplished such a feed method. The invention will be more clearly understood by referring to the attached drawing wherein

Fig. 1 is a vertical sectional view of a coking system including a plurality of feed nozzles according to the invention,

Fig. 2 is an enlarged detailed perspective view of a suitable nozzle tip for use in the process,

Fig. 3 is a transverse sectional view taken substantially on the line 3—3 of Fig. 2, looking in the direction of the arrows,

Fig. 4 is a perspective view of a somewhat modified nozzle tip,

Fig. *4a* is an end view of the nozzle of Fig. 4,

Fig. 5 is a graph showing the relation between jet velocity in a smooth solid stream and the agglomeration rate in a typical fluidized solids coking system employing coked particles as the heat carrying solids.

Referring first to Fig. 1, the coking vessel **11** is of conventional design with provision such as an inlet line **13** for introducing preheated solid particles, preferably coke particles, of a size ranging somewhere between 20 and about 400 microns average diameter. A fluidizing gas such as steam is introduced through one or more inlets **15**, and the bottom of the vessel is constructed to provide a stripping zone **17** into which a stripping gas such as steam may be introduced at **19**.

A feed manifold **21** brings preheated oil to a plurality of feed nozzles **23** which are preferably spaced more or less equally in a vertical and lateral or arcuate arrangement around the periphery of the vessel **11**. These nozzles preferably project for some distance into the vessel so as to avoid having the feed contact the vessel walls directly.

The hot solid particles which form a fluidized solids bed **24** are preferably preheated to a temperature sufficient to establish a fluid bed temperature of at least 900° F. and not more than about 1200° F. for coking to produce motor fuels and gas oil from petroleum residua. Where it is desired to produce chemical raw materials such as olefins and aromatics the bed temperature should be substantially higher and contact time is much shorter. The feed is vaporized and cracked by contact with the hot particles and the vaporous or gaseous products pass upwardly through a solids separator such as a cyclone **25** and to a suitable recovery system not shown through outlet **27**. The separated solids are returned to the bed through solids return line or dipleg **29**.

Since the coking process is endothermic, the coke particles gradually are cooled and are withdraw from the bottom of the vessel, for example, through stripper **17** into an outlet line **31**. From here, at least a part of the solids are taken to a heater and reheated for return through line **13**. Inasmuch as coke is produced in the process, part of it may be withdrawn as a product.

The tips of the nozzle members **23** are shown considerably enlarged in Figures 2, 3 and 4. The form shown in Fig. 2, generally designated **35**, consists primarily of a cylindrical body with a tapered or wedge shaped end portion **37** which is hollow substantially throughout its length to provide for steam jacketing. An inner tubular feed line **39** extends through the tip and is preferably turned at right angles near its outlet end so as to project substantially vertically within the coking vessel as indicated at **41**. It is found that in order to prevent excessive atomization of the jet the terminal portion of the bore should be straight and its length should a least 5 times its diameter. The nozzle structure of Fig. 2 is shown in cross-section in Fig. 3 where it will be noted that the feed line **39** and the perpendicular extension **41** are sourrounded by the hollow jacket space so that a jacketing medium may be kept flowing through the tip to keep its temperature at an optimum level at all times and prevent clogging or coking within the nozzle tip. Otherwise plugging of the nozzle might occur on fluctuations of temperature or while starting up or shutting down the system.

The nozzle tip structure shown in Fig. 4 is somewhat similar to that of Fig. 2 but is not jacketed completely out to its outlet. It comprises a cylindrical body **45** having an extended end portion **47**. The feed line indicated at **51** is essentially the same as feed line **39** of Fig. 2 but the end portion of the nozzle **45** is not hollow, being bored only to provide a smooth flow line **53** of the same diameter as the flow line **55** in feed line **51**. It may be formed conveniently by drilling longitudinally and transversely, plugging the end of the longitudinal bore **53** with a plug **56**. This simplifies construction and facilitates cleaning if line **53** should become clogged. A vertical bore **57** at least 5 times as long as its diameter joins the bore **53** so that a continuous or "solid" stream of oil may be fed therethrough. In cross-section, the nozzle tip may be generally elliptical with the major axis of the ellipse arranged vertically as shown in Fig. *4a*. Alternatively, it may be merely flattened so as to be narrow in the vertical plane. The diameter of the bore is relatively small and the velocity should be maintained between the general limits of 35 and 75 feet per second. The unjacked portion of this nozzle is relatively short. The steam jacket, when used, is primarily for cooling, not for heating, under usual coking conditions, to avoid coking of the feed within the nozzle.

The temperature of preheating of the oil feed is of some importance. It is desirable to reduce the viscosity of the feed as far as is reasonably possible without approaching the point where thermal cracking would take place within the nozzle by reason of the feed temperature. It has been found that the optimum preheat temperature for the feed is about 500° to 600° F.

In Fig. 5 there is shown graphically the relation between jet velocity and agglomeration rate in grams. The data were obtained mainly in a small scale apparatus. The agglomerates were measured as material retained on a 12-mesh screen. It was found that in a small apparatus a velocity below 35 feet per second resulted in substantial agglomeration of the solids. Thus when coke was used as the heat carrying solid material it was found that as much as 0.44 to 2.75% by weight of the coke was agglomerated to a size that would not pass the 12-mesh screen. At the other end of the scale it was found that increasing the velocity above 70 feet per second was satisfactory as regards operation but consumed excessive power. It appears that jets of optimum velocity have sufficient energy to penetrate the fluid coke bed and are dispersed by the shearing action of the coke particles in the path of the jet. Too low a velocity does not result in sufficient shearing or sufficient penetration in distance.

The data of Fig. 5 have been substantially confirmed by subsequent operation in a larger coking unit so that the data appear to be sound and well substantiated. It will be obvious that various modifications may be made in the process and in the design of jet nozzles as well as in the arrangement and number of jets. The number of feed points will be as many as is required; for example, the number will vary considerably with the size and shape of the coking vessel as will also the arrangement of the nozzles. Ordinarily it is preferred to project the feed vertically or substantially toward the vertical. However, as long as the feed does not impinge on the vessel walls, so as to cause formation of coke deposits, it may be projected slant-wise or even horizontally.

The nozzle may be and preferably is longitudinally adjustable, in many cases, so that it can be projected into the vessel to a variable extent as may be desirable. It is also desirable to arrange each nozzle so that it can readily be withdrawn for inspection and/or replacement.

What is claimed is:

1. A process of coking heavy residual hydrocarbon oils in a dense turbulent fluidized bed of hot finely divided solid particles which comprises preheating the oil feed to a temperature approaching but below incipient thermal cracking to reduce its viscosity substantially to a minimum, then injecting the non-viscous liquid oil feed vertically in a plurality of substantially continuous solid stream oil jets without substantial atomization directly into said fluidized bed at vertically spaced points therein at a jet velocity above about 35 feet per second to minimize agglomeration of the finely divided solid particles, each solid stream oil jet passing through a terminal confined passageway having its length at least five times that of the diameter thereof.

2. A process according to claim 1 wherein finely divided solids comprise coke particles in the size range between about 20 and 400 microns average diameter.

3. A process according to claim 1 wherein said finely divided solids in said fluidized bed are at a temperature above 900° F.

4. A process according to claim 1 wherein the jet velocity of said continuous solid stream oil jets is between about 35 and 75 feet per second.

5. A process for coking heavy residual oils in the presence of finely divided solids which comprises forming a dense turbulent fluidized bed of hot solid particles in a coking zone, then injecting residual oil preheated to a temperature of at least about 500° F. and approaching but below incipient thermal cracking temperature to reduce the oil viscosity directly into said dense fluidized turbulent bed at a plurality of regions spaced one above the other within said dense turbulent fluidized bed as a plurality of vertically spaced substantially continuous solid stream oil jets without substantial atomization at a jet velocity between about 35 and 75 feet per second to supply sufficient energy to said solid oil streams to penetrate said dense fluidized bed of solid particles and to be dispersed by the shearing action of said solid particles of said fluidized bed in the path of said solid oil streams to distribute the oil feed on said finely divided solids and to minimize agglomeration of said finely divided solids, each solid stream oil jet passing through a terminal confined passageway having its length at least 5 times that of the diameter thereof.

References Cited in the file of this patent

UNITED STATES PATENTS

2,433,726	Angell	Dec. 30, 1947
2,436,160	Blanding	Feb. 17, 1948
2,453,592	Putney	Nov. 9, 1948
2,485,315	Rex et al.	Oct. 18, 1949
2,490,798	Gohr et al.	Dec. 13, 1949
2,606,144	Leffer	Aug. 5, 1952
2,635,010	Sanders et al.	Apr. 14, 1953
2,636,780	Barnes	Apr. 28, 1953
2,701,788	Schutte	Feb. 8, 1955
2,702,267	Keith	Feb. 15, 1955
2,709,675	Phinney	May 31, 1955
2,731,400	Jahnig et al.	Jan. 17, 1956