Jan. 3, 1950 R. T. SAVAGE ET AL 2,493,036

METHOD OF AND APPARATUS FOR MINIMIZING DEPOSITION OF CARBONACEOUS MATERIAL

Filed July 1, 1948 2 Sheets-Sheet 1

Fig. 1

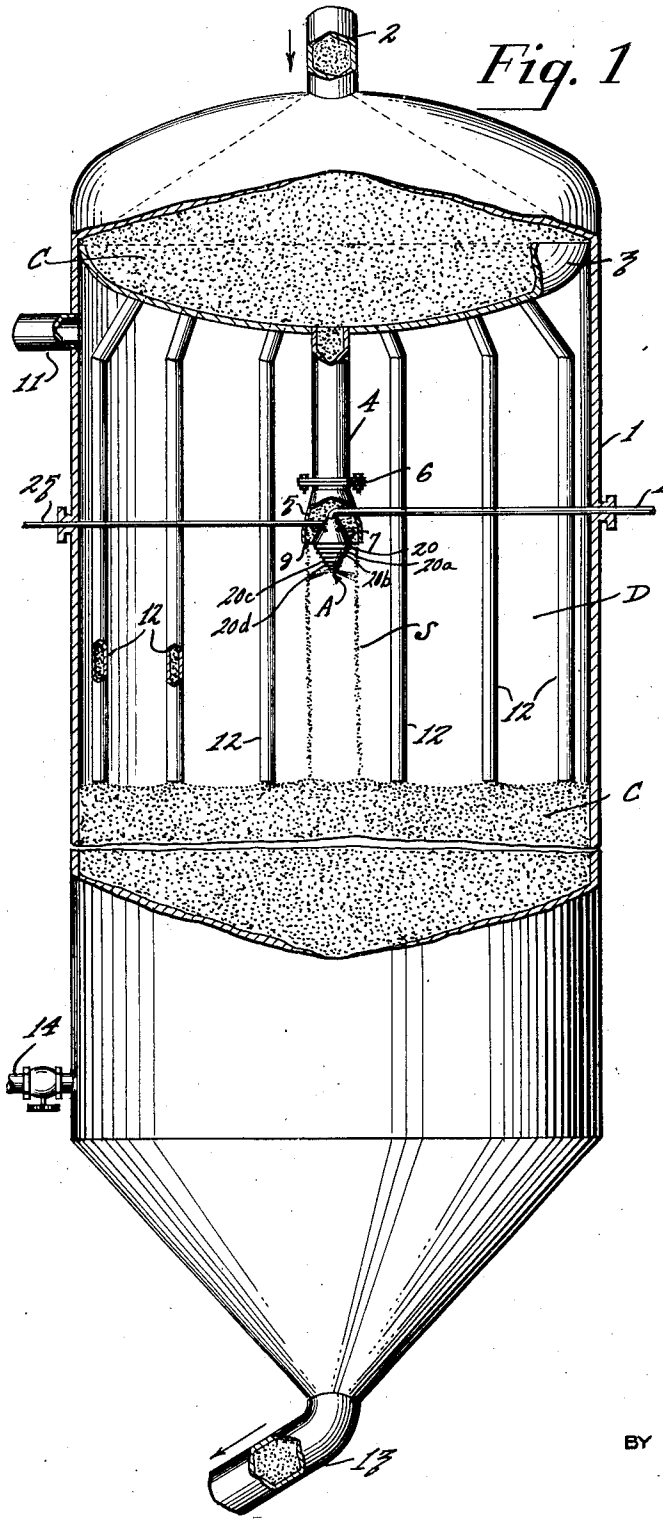


Fig. 2

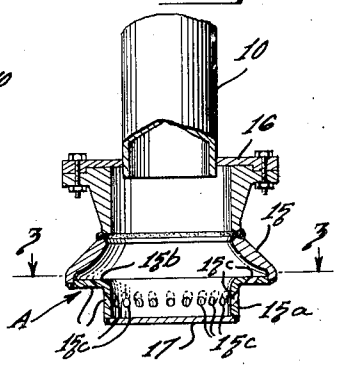
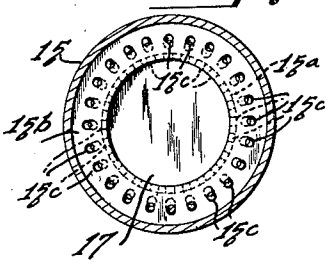


Fig. 3



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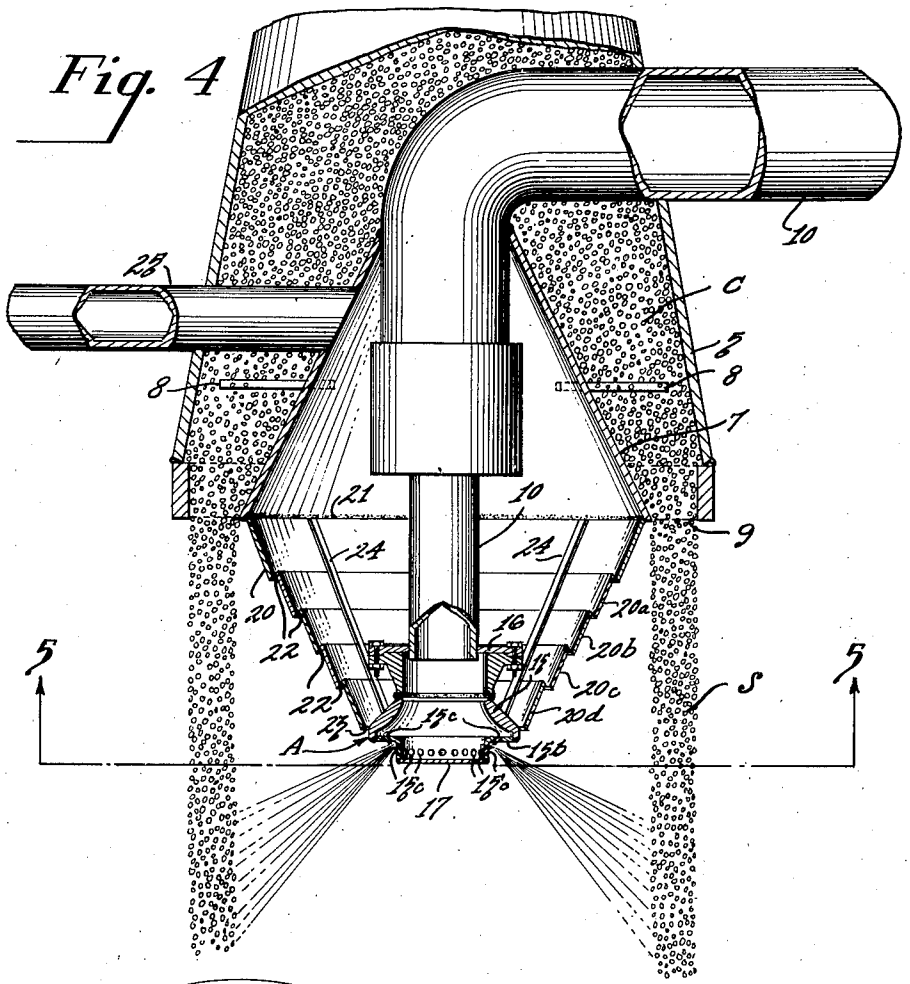
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Jan. 3, 1950 R. T. SAVAGE ET AL 2,493,036

METHOD OF AND APPARATUS FOR MINIMIZING DEPOSITION OF CARBONACEOUS MATERIAL

Filed July 1, 1948 2 Sheets-Sheet 2

Fig. 4



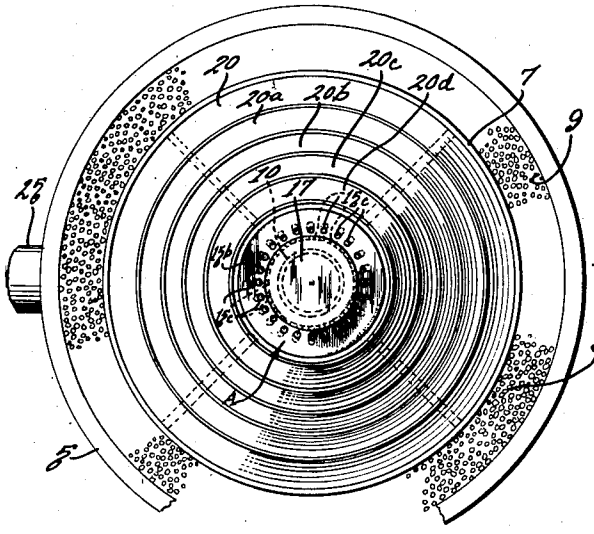


Fig. 5

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UNITED STATES PATENT OFFICE

2,493,036

METHOD OF AND APPARATUS FOR MINIMIZING DEPOSITION OF CARBONACEOUS MATERIAL

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Application July 1, 1948, Serial No. 36,304

3 Claims. (Cl. 196—52)

1

Our invention relates to a hydrocarbon conversion system and has particular reference to a method of and apparatus for at least substantially preventing deposition of carbonaceous material on one or more mechanical parts extending into an atomizing zone forming a part of said system.

More particularly, our invention relates to a hydrocarbon conversion system wherein at least a substantial portion of the gravitating contact material is controlled for movement as a freely falling curtain or stream of contact material having tubular configuration. The atomizer is disposed in the lower area of a zone located within said tubular curtain and this zone is defined by a housing adapted to exclude atomized material therefrom. In accordance with the invention, one or more annular streams of vapors is or are passed through said housing and directed downwardly in sweeping relation with respect thereto so as to substantially prevent deposition of migrating atomized material thereon.

Various other objects and advantages of our invention will become apparent from the following detailed description.

Our invention resides in the method of and apparatus for minimizing deposition of carbonaceous material in an atomizing zone, features and arrangements of the character hereinafter described and claimed.

For an understanding of our invention and for an illustration of one form of apparatus with which the invention may be practiced, reference is to be had to the accompanying drawings, in which:

Fig. 1 is a vertical sectional view, partly in elevation, showing a conversion housing and associated apparatus as constructed in accordance with one form of the invention;

Fig. 2 is a vertical sectional view, partly in elevation, showing an atomizer;

Fig. 3 is a horizontal sectional view, partly in plan, taken on the line 3—3 of Fig. 2;

Fig. 4 is an enlarged vertical sectional view, partly in elevation, showing the apparatus of the invention; and

Fig. 5 is an inverted plan view looking from the line 5—5 of Fig. 4.

In an application of Reuben T. Savage, Serial No. 766,714, filed August 6, 1947, there is disclosed a hydrocarbon conversion process involving utilization of an arrangement for engaging atomized liquid hydrocarbon material with a freely falling stream or curtain of contact material. For purposes of explanation as regards our

2

invention, we have included in this application a general disclosure of the subject matter illustrated and described in the aforesaid Savage application.

Thus, referring particularly to Fig. 1, we have shown a vertical housing 1 which, in horizontal cross section, may be circular or of any other suitable configuration. The housing 1 defines a reaction zone wherein hydrocarbon material is cracked or otherwise converted in the presence of contact material C which moves downwardly therethrough under the influence of gravity, the contact material C being introduced into said housing 1 in suitable manner, as by an inlet pipe 2 extending through the top housing wall at the center thereof.

A shallow receptacle-like member 3 may be suitably supported in the upper portion of the housing 1, said member 3 having a central discharge pipe 4 opening therethrough and extending downwardly therefrom. If desired, the lower end of the pipe 4 may have a frusto-conical pipe 5 suitably secured thereto, as by a flange-and-bolt connection 6. With an arrangement of this character, the lower end of the pipe 5 has diameter somewhat greater than that of the lower end of the pipe 4. Obviously, the pipes 4 and 5 may be replaced by a single pipe having desired uniform diameter throughout the length thereof.

Disposed interiorly of said discharge pipe 5, immediately adjacent the lower end thereof, is a frusto-conical member 7, the lower surface of which, preferably but not necessarily, is positioned in the same horizontal plane as the lower surface of the pipe 5, said conical member 7 being suitably supported in the position shown, as by a plurality of bars 8 secured thereto and to said pipe 5. The external diameter of the lower surface of the conical member 7 is suitably less than the internal diameter of the lower surface of the pipe 5 and, accordingly, these two surfaces define an annular passage 9 utilizable as hereinafter described. The pipe 5 and the conical member 7 should be symmetrically related to each other and, if so, the width of the annular passage 9 is uniform throughout the circular length thereof. Preferably, the arrangement is such that the exterior sloping surface of the conical member 7 forms with the interior sloping surface of the pipe 5 a path which diverges in a direction leading upwardly from the aforesaid annular passage 9.

A pipe 10, adapted to be traversed by hydrocarbon material, which is either partially or entirely in the liquid phase, extends from the ex-

terior of the housing 1 to the interior thereof and, if desired, this pipe 10 may enter the aforesaid pipe 5 at any suitable level and pass downwardly therethrough in coincidence with the longitudinal axis thereof. If so, the pipe 10 passes through the aforesaid conical member 7 to which it is welded or otherwise suitably secured in sealed relation and terminates a suitable distance below said conical member 7 where it communicates with and supports an atomizer A of any suitable type which, as herein illustrated, is of the general character disclosed in the pending application of James E. Evans, Serial No. 756,032, filed June 20, 1947, although, if desired, the atomizer A may be of the character disclosed in the pending application of Reuben T. Savage, Serial No. 792,810, filed December 19, 1947. A pipe 11 adapted to be traversed by hydrocarbon vapors extends from the exterior of the housing 1 to the interior thereof and, preferably, this pipe 11 is positioned at a higher level than the aforesaid pipe 10.

As shown, the pipe 4, the pipe 5, the conical member 7 and the atomizer A should be so related to each other that their respective longitudinal axes are in coincidence with each other and also with the longitudinal axis of the housing 1.

In operation, regenerated or other heated contact material C having suitable reaction temperature passes continuously from the pipe 2 and, to suitable extent, fills the receptacle 3 which defines an upper zone of the housing 1. From the receptacle 3, the contact material gravitates downwardly through the pipe 4, the pipe 5 and then through the annular passage 9 which, as hereinafter more fully described, has width such that it restricts or controls the downward flow of contact material under the influence of gravity while moving along the described path above the plane of the annular passage 9. Below the plane of said annular passage 9, the contact material falls freely under the influence of gravity as a tubular curtain or stream S, which is not necessarily circular in horizontal section, until it comes to rest upon and at least partly defines the upper surface of the bed B of gravitating contact material which defines the reaction zone proper, the bottom surface of the bed of contact material engaging a tube sheet, not shown, which is horizontally disposed in the housing 1 and suitably secured to the interior surface thereof. As the contact material falls freely below the plane of the annular passage 9, it is engaged by liquid hydrocarbon material after atomization thereof by the aforesaid atomizer A which, as shown in Fig. 4, is supported interiorly of the tubular curtain S by the aforesaid pipe 10.

In view of the foregoing, it clearly appears that the atomizer A is disposed in a chamber D of the housing 1, said chamber D being bounded, at its lower end, by the zone defined by the upper surface of the bed B and, at its upper end, by the aforesaid zone defined by the receptacle 3.

If desired, a plurality of pipes 12 may be spaced uniformly around the interior surface of the housing 1. The upper ends of these pipes 12 communicate with the chamber defined by the member 3, which may support said pipes, and the lower ends thereof terminate at the upper surface of the aforesaid bed of contact material, said pipes 12 being adapted to be traversed by a portion, preferably a minor portion, as 20% more or less of the total amount of contact material gravitating through the housing 1. The pipes 12, when utilized, contributes as regards maintenance of

the surface of the bed B at a level approximately that of the lower ends of said pipes.

As stated, the bed B of contact material gravitates through the housing 1 and any suitable known or other arrangement, not shown, may be utilized for discharging the spent contact material from the housing 1 for passage through a discharge pipe 13. Likewise, any suitable known or other arrangement, not shown, may be provided for disengaging cracked or converted vapors from the contact material C so that they may pass through an outlet pipe 14.

Referring particularly to Figs. 2, 3 and 4, the atomizer A hereinbefore referred to should be one which produces fog, mist, spray or other liquid particles having suitable dimensions from the liquid hydrocarbon material admitted thereto. As shown, the atomizer A comprises a casing 15 having a top wall 16 through which the lower end of the aforesaid pipe 10 opens and to which said pipe is secured. The casing 15 has a lower wall 17 above which said casing 15 comprises vertical and horizontal circular plate portions 15*a* and 15*b* related to each other in right-angle relation. In the form of atomizer herein shown, although not necessarily, a row of ports or passages 15*c* open through the respective casing portions 15*a* and 15*b*, these ports 15*c* being alined in sets. Hydrocarbon material admitted by the pipe 10 to the casing 15 passes to and through each of said ports 15*c*. The atomizer A is disposed interiorly of the tubular curtain S a suitable distance below the annular passage 9 and, preferably, said atomizer A is so positioned that its rows of ports 15*c*, or equivalent are concentrically related to the curtain S.

When hydrocarbon material is to be cracked in the housing 1, the contact material C hereinbefore referred to should be catalytic in character and the temperature thereof, upon admission to the housing 1, should range betwen 800° F. and 1000° F. or higher for example, about 900° F. Any suitable kind of catalytic contact material may thus be utilized such, for example, as activated clay pellets, or synthetic silica-alumina pellets or beads, etc. having suitable major dimensions such as between $\frac{1}{8}$ and $\frac{3}{4}$ of an inch. Other suitable catalysts for cracking include synthetic plural oxide composites, silicious or non-silicious in character and containing, for example, zirconia, alumina or beryllia. In lieu of a cracking operation, other types of conversion operations such, for example, as one wherein hydrocarbon material of the character referred to below is desulphurized under known conditions with catalytic contact material of the general character referred to above, or equivalent. Or, reforming or dehydrogenation of naphthas or other normal liquid hydrocarbons may be effected in the presence of the above or other desired types of catalyst, certain of which are well known in the art. In lieu of the conversion operations described above, heavy hydrocarbon material may be vaporized and viscosity-broken in the presence of inert contact material of suitable character such, for example, as fused silica and alumina.

During operation with suitable cracking contact material, vapors such, for example, as vaporized gas oil, naphtha or lighter hydrocarbons having suitable elevated temperature, as in a range from 850° F. to 950° F. are admitted continuously to the housing 1 by way of the conduit 11. Simultaneously, liquid hydrocarbon material such, for example, as a suitable residual stock, topped or reduced crude having temperature elevated into

a suitable range as, for example, from 400° F. to 800° F. is charged continuously through the pipe 10 under superatmospheric pressure ranging, for example, from 10 lbs. to 200 lbs. per square inch gauge or as otherwise may be required for causing the atomized liquid material from the atomizer A to engage and properly penetrate the contact material forming the hereinbefore described falling curtain S of contact material. The liquid hydrocarbon material thus traversing the pipe 10 passes through the atomizer casing 15 and the alined atomizer ports 15c of the respective sets thereof are traversed, respectively, by streams of hydrocarbon material which pass toward and engage each other to produce resultant streams of atomized material which, as a mist or fog, pass downwardly in inclined relation and penetrate the curtain S throughout a circumferentially complete inner area thereof, Fig. 4.

As stated, hydrocarbon vapors, which in connection with a cracking operation preferably have temperature substantially higher than that of the liquid hydrocarbon material admitted to the atomizer A, are admitted to the housing 1 by way of the pipe 11. These vapors pass through the housing 1, concurrently as regards the contact material C and in the presence thereof, are converted to cracked products. In so doing, the heat content of these vapors assists as regards vaporization of the liquid hydrocarbon material entering said housing 1 through the atomizer A and provides a desired control on the space velocity of the entire charge traversing the housing 1. Simultaneously, in the manner described above, atomized liquid hydrocarbon material is engaged with the falling curtain S of contact material with resultant vaporization of such atomized liquid material and formation of cracked products while passing through the housing 1 concurrently as regards the contact material C. As regards the total charge entering the housing 1, the ratio of vapors to liquid material may be such as is suitable and desirable. Thus, for example, between 10% and 30% of the charge may be in the liquid phase for passage to the atomizer A and the remainder in the vapor phase for passage through the pipe 11.

As particularly described in the aforesaid Savage application, Serial No. 766,714, the thickness of the curtain S and the density of the pieces of contact material forming said curtain are sufficient to entirely or at least substantially prevent passage therethrough of any of the atomized liquid material which is produced and directed into engagement therewith by the atomizer A. This curtain, then, positively prevents or almost entirely minimizes migration of atomized liquid material to interior surfaces of the housing 1 and the pipes 12 in the event that the latter are utilized. Consequently, formation of carbonaceous material on the metallic housing and pipe surfaces is entirely or substantially prevented. This is highly desirable by reason of the fact that, if there is any substantial formation of carbonaceous material in the locations stated, chunks thereof separate from the main mass and move into and through the bed B of contact material with resultant partial or complete plugging of the outlets, not shown, at the bottom of the housing. Should this happen to any substantial extent, it is necessary for operation of the system to be discontinued for cleaning purposes and this, of course, is undesirable.

In view of the foregoing, it will be understood that hydrocarbon material admitted to the housing 1 by way of the pipes 10 and 11 is converted in the presence of the contact material C and, as described in the aforesaid Savage application, Serial No. 766,714, this hydrocarbon material passes through the housing 1 in concurrent relation as regards the gravitating contact material from which the cracked products are disengaged and passed to any suitable destination by way of the pipe 14. In known manner and by suitable means, not shown, a suitable gaseous medium such as steam is admitted to the lower portion of the housing 1, below the pipe 14 and under pressure above that existing at the level thereof, to prevent passage of hydrocarbon vapors through the pipe 13. Simultaneously, spent contact material leaves the housing 1 by way of the pipe 13 and, after regeneration, is returned to the inlet pipe 2 for readmission to said housing 1.

As stated above, it is a feature of the disclosed process that the curtain S, at least to substantial extent, prevents migration of atomized liquid material into engagement with the interior surface of the housing 1. However, interiorly of said curtain S and as stated in the pending application of Raymond C. Lassiat, Serial No. 776,202, filed Setpember 26, 1947, there may be migration of atomized liquid material as caused principally by the splashing effect which occurs when the atomized liquid material engages the interior curtain surface, such migration being undesired for the reasons hereinafter stated. In accordance with the present invention, such undesired migration of atomized liquid material is effectively controlled, the desired result being obtained in an improved manner compared with the procedure described in the aforesaid Lassiat application.

Thus, as shown particularly in Fig. 4, a frusto-conical member 20 has its larger, upper end welded or otherwise suitably secured, as at 21, in sealed relation to the lower interior surface of the conical member 7. Associated with the frusto-conical member 20 is a lower frusto-conical member 20*a*, the external diameter of the lower member 20*a* being slightly less than the internal diameter of the upper member 20 with resultant formation of an annular passage 22. As shown, the extreme lower portion of the upper member 20 overlaps the extreme upper portion of the lower member 20*a* and, accordingly, the annular passage 22 faces downwardly more or less in a vertical direction.

In accordance with our invention, frusto-conical members 20*b*, 20*c* and 20*d* are disposed, in the order named, below the frusto-conical member 20*a*. The relation between each pair of members 20*a* and 20*b*, 20*b* and 20*c*, 20*c* and 20*d* is the same as described above with respect to the members 20, 20*a*. Hence, in addition to the described annular passage 22, the aforesaid pairs of frusto-conical members define successively lower annular passages 22 having progressively decreasing diameter.

Referring particularly to Fig. 4, the lowermost frusto-conical member 20*d* forms with the exterior surface of the atomizer casing 15 a lower annular passage 23 which, the same as the other annular passages 22, faces downwardly generally in a vertical direction.

In any suitable manner, the frusto-conical members 20*a*, 20*b*, 20*c* and 20*d* may be secured in the relation described above and as shown in Fig. 4. To this end, a plurality of spaced bars

or rods 24 may be welded, bolted or otherwise suitably secured to interior surfaces of the respective frusto-conical members to thereby form a unitary assembly.

As shown in Figs. 1 and 4, a pipe 25 extends from the exterior of the housing 1 to the interior thereof where the inner end of said pipe 25 opens through the upper conical member 7. In view of the previous description, it will be understood that the assembly comprising the members 7, 20, 20*a*, 20*b*, 20*c* and 20*d* constitute a housing which defines the boundary of a zone having the atomizer A disposed in the lower area thereof, this zone being sealed except for the passages 22, 23.

While hydrocarbon material is undergoing conversion in the housing 1 as hereinbefore described, suitable vapors are passed continuously by way of the pipe 25 into the aforesaid zone under pressure exceeding that existing in the chamber D of the housing 1. These vapors may be of any suitable character such, for example, as steam which may be superheated to approximately 600° F. or higher, or hydrocarbon vapors such as those which are admitted to the housing 1 by way of the conduit 11.

Resulting from the operation described immediately above, circumferentially complete streams of vapors traverse the passages 22 and the passage 23 respectively, these passages being formed at different respective levels in the lower boundary of the aforesaid zone. These vapor streams are directed downwardly in generally a vertical direction so that they sweep along the portion of the zone boundary below the member 7 to thereby shield the latter from migrating atomized material as hereinafter more particularly described.

As hereinbefore described, during a hydrocarbon conversion operation, streams of atomized liquid material pass downwardly in inclined relation and at high velocity from the respective sets of alined atomizer ports 15*c*, substantially all of this atomized liquid material engaging the tubular curtain S through out a circumferentially complete inner area thereof. Particularly by reason of this high velocity condition, some of this atomized liquid material, either alone or having fines of the contact material entrained therein, migrates or tends to migrate upwardly within the area enclosed by the upper portion of the tubular curtain S. However, due to the presence of the housing or boundary defined by the members 20, 20*a*, 20*b*, 20*c* and 20*d*, the atomized liquid material last named is prevented from migrating into the zone defined by said members. In this manner, migrating atomized material is prevented from reaching the atomizer casing and the vertical portion of the pipe 10 to thereby prevent formation thereon of a carbonaceous deposit which would adversely affect operation of the system.

It will be understood, then, that in the absence of the aforesaid housing or boundary arrangement comprising the members 20, 20*a*, 20*b*, 20*c*, and 20*d*, a part at least of any upwardly migrating atomized liquid material would be deposited on the upper portion of the atomizer casing 15 and on the adjacent vertical portion of the pipe 10 with resultant production of carbonaceous material which, in the course of time, would form hanging or other adherent deposits of such carbonaceous material having sufficient length either to interfere with proper operation of the atomizer or to break into chunks which would move into and through the bed B of contact material with resultant development of a plugged condition at the bottom of the housing 1. An operation of this character, of course, is undesired and is at least substantially prevented, in accordance with the invention, by utilization of the described housing or boundary arrangement formed from the members 20, 20*a*, 20*b*, 20*c* and 20*d* which function in the manner described to prevent formation of carbonaceous material on the metallic parts disposed within the zone defined thereby.

However, the formation of a carbonaceous deposit on the members last named would be disadvantageous for the reasons hereinbefore stated and, therefore, it is necessary to prevent or substantially minimize formation of such a carbonaceous deposit thereon. It is for this reason that the hereinbefore described annular passages 22, 23 are provided. As stated, the respective vapor streams passing therefrom are directed downwardly in generally a vertical direction. They engage the arrangement comprising the members 20, 20*a*, 20*b* etc. at different respective levels where the vapor velocity is sufficient to effect the desired shielding action. Thus, the vapor streams form a barrier around and immediately adjacent the described members which effectively prevents them from being engaged by migrating atomized material. Consequently, little or no carbonaceous material is formed thereon.

Of significance as regards the foregoing is the annular passage 23 which is so positioned that the stream of vapors flowing downwardly therethrough sweep the adjacent vertical surface of the casing 15 to thereby substantially prevent deposition thereon of any atomized liquid material which tends to migrate upwardly.

It shall be understood that the invention is not to be limited to the particular housing or boundary arrangement hereinbefore described. Thus, for example, the desired sweeping action may be effected under some circumstances by the provision of a single annular passage.

Obviously many modifications and variations of the invention as hereinbefore set forth may be made without departing from the spirit and scope thereof and therefore only such limitations should be imposed as are indicated in the appended claims.

We claim as our invention:

1. In the art of converting hydrocarbons in the presence of contact material having conversion temperature and adapted to gravitate through a chamber as a tubular curtain of freely falling contact material, the method which comprises atomizing liquid hydrocarbon material in the lower area of a zone located within said curtain and having a boundary adapted to exclude atomized material therefrom, directing a circumferentially complete stream of the atomized material into engagement with the curtain contact material, passing vapors through an annual passage formed in the boundary of said zone, and directing the annular stream of vapors downwardly in sweeping relation with respect to the boundary of said zone to thereby substantially prevent deposition of migrating atomized material thereon.

2. In the art of converting hydrocarbons in the presence of contact material having conversion temperature and adapted to gravitate through a chamber as a tubular curtain of freely falling contact material, the method which comprises atomizing liquid hydrocarbon material therefrom, directing a circumferentially complete stream of the atomized material into engagement with the

curtain contact material, passing vapors through annular passages formed in the boundary of said zone at different respective levels and having, respectively, progressively decreasing diameter in a downwardly extending direction, and directing the annular streams of vapors downwardly in sweeping relation with respect to the boundary of said zone to thereby substantially prevent deposition of migrating atomized material thereon.

3. In apparatus of the character described, a conversion housing, means disposed interiorly thereof and comprising inner and outer members forming an annular metering passage adapted to cause gravitating contact material to form a tubular curtain of contact material freely falling below said metering passage, an atomizer supported interiorly of said curtain below said metering passage, means enclosing a portion of said atomizer and forming a chamber with said inner member, and means for passing vapors into said

chamber, said second named means comprising a plurality of frusto-conical members secured in assembled relation to define a plurality of downwardly-facing annular passages.

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The following references are of record in the file of this patent:

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Certificate of Correction

Patent No. 2,493,036 **January 3, 1950**

REUBEN T. SAVAGE ET AL.

It is hereby certified that errors appear in the printed specification of the above numbered patent requiring correction as follows:

Column 3, line 75, for the word "contributes" read *contribute*; column 4, line 58, for "normal" read *normally*; column 8, line 61, for "annual" read *annular*;

and that the said Letters Patent should be read with these corrections therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 16th day of May, A. D. 1950.

[SEAL]

THOMAS F. MURPHY,
Assistant Commissioner of Patents.