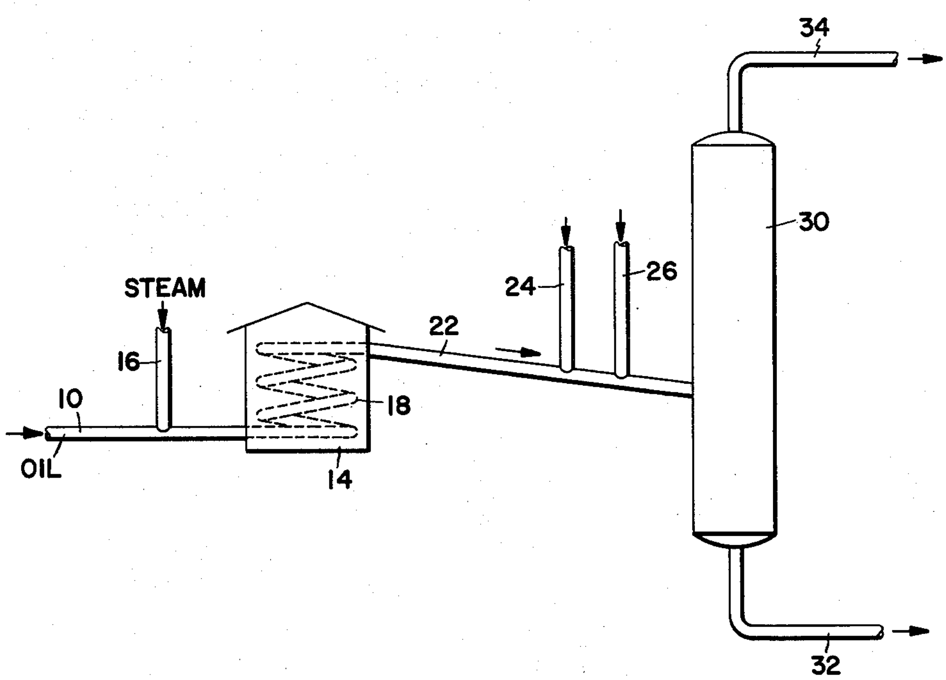

FIG.-1

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HIGH TEMPERATURE THERMAL CRACKING

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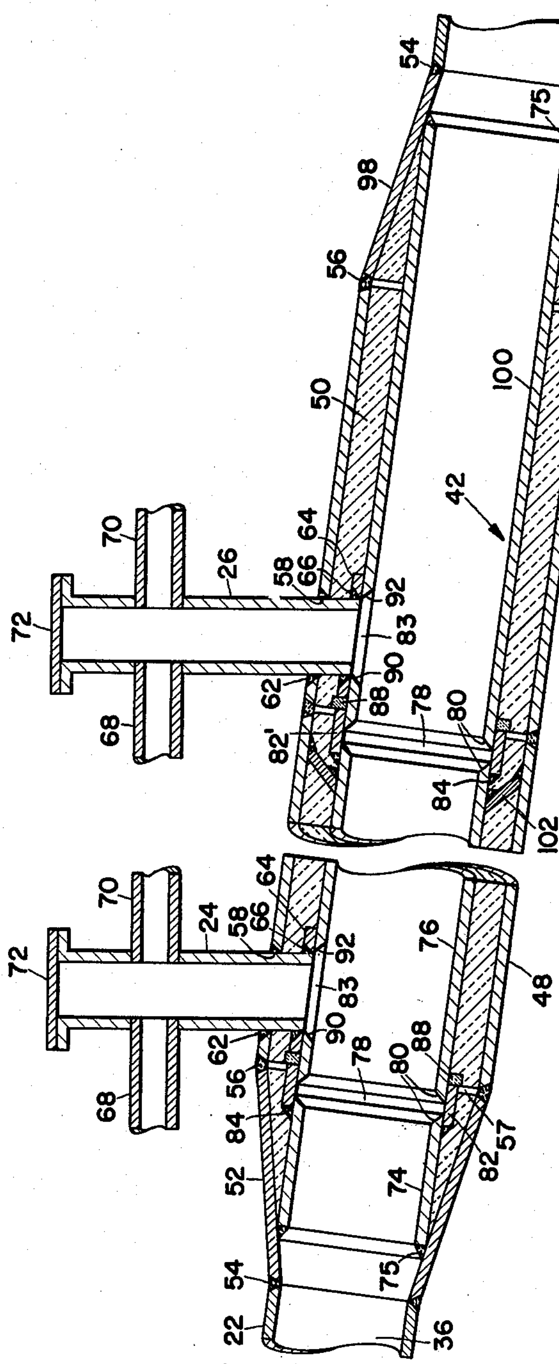
FIG.-2



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HIGH TEMPERATURE THERMAL CRACKING

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This invention relates to the high temperature thermal non-catalytic cracking of hydrocarbons to produce olefins, diolefins, aromatic hydrocarbons, etc., and more particularly relates to thermal cracking in the presence of steam.

Various processes have been described in the prior art on high temperature thermal cracking or steam cracking of hydrocarbons including high boiling liquid hydrocarbons, such as residual oils, gas oils, lower boiling hydrocarbons such as naphtha, and hydrocarbon gases such as ethane, propane, etc. to produce olefins such as ethylene, propylene, diolefins such as butadiene and aromatic hydrocarbons such as benzene, toluene etc. In these high temperature cracking processes it is necessary to quench the products from the cracking zone, that it, chill or cool them suddenly and rapidly to a lower temperature to prevent or minimize side reactions which reduce yields of desired products and increase yields of undesired products.

The high temperature cracking is carried out at a temperature between about 1200° F. and 1600° F. and it is necessary to reduce this temperature abruptly to between about 600° F. and 500° F. by introducing a quench oil or liquid into the cracked products. The quenching step is carried out in the outlet line from the heater or furnace and because of the large temperature differentials and severe operating conditions numerous cracks have appeared in the outlet line carrying the cracked products requiring plant shut downs in some instances. The large differences in temperature resulting from the quenching step cause severe thermal gradients in the outlet line or piping and set up stresses in the outlet line or piping. These gradients cause cracks in the pipe itself and also in the pipe welds.

The shock effect and piping stresses also result from the shifting of the quench points or regions during operation. In the commercial units at least two quench nozzles are installed and alternately used to break off any coke deposits from the outlet line by the difference in temperature occurring in the outlet line when shifting from one quench nozzle to the other. These commercial units have given substantial maintenance problems.

Temperature profiles have been taken at several commercial units which indicate thermal stresses existing in the outlet line or piping and show that substantial temperature differences (both axial and circumferential) exist for as far as four feet downstream of the first quench point or region with the maximum circumferential difference in metal temperature being about 800° F.

According to the present invention an insulated quench injection point design is provided. The design includes an enlarged pipe section insulated with castable material and protected internally by a shroud. The insulation and shroud protect the pressure wall from thermal shocks. The outlet line or pipe is internally insulated and in this way thermal stresses are removed from the outlet pipe and the outlet pipe is then subjected only to piping flexture and pressure stresses. The shroud is provided with slip joints to permit and relieve longitudinal expansion strain. The internal shroud is designed so as to avoid internal obstructions which cause undesirable coke deposits and formations.

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In the drawing:

FIG. 1 represents a diagrammatic showing of a cracking furnace and associated equipment; and

FIG. 2 represents an enlarged vertical cross section of a portion of the outlet line provided with quench points or regions and embodies the invention.

Referring now to the drawing and to FIG. 1 the reference character **10** designates a line through which the hydrocarbon feed, for example, is introduced at a rate of between about 2,000 and 14,000 barrels per day. The hydrocarbon may be a light naphtha fraction or a heavy naphtha fraction or may be a wide cut naphtha fraction. High boiling feeds such as gas oil may be used as a feed oil. The naphtha feed may be a virgin feed and when using a light naphtha fraction the boiling point is between about 60° F. and 220° F. and when using a heavy naphtha fraction the boiling range is between about 290° F. and 440° F. The naphtha or other feed is preferably passed through a heat exchanger (not shown) to preheat the naphtha feed to a temperature between about 275° F. and 305 F. and the preheated hydrocarbon material is then passed on through line **10** into cracking furnace or furnaces **14**. Before being introduced into the cracking furnace the hydrocarbon feed in line **10** is mixed with steam heated to a temperature of about 340° F. and 360° F. and introduced through line **16**. The amount of steam used is between about 70 and 85 mol percent of the oil feed plus steam.

The cracking furnace (or furnaces) is one which contains a heating coil **18** and the naphtha is heated to a high temperature in the furnace between about 1200° F. and 1500° F. and the time of reaction or time of residence of the naphtha at the high temperature is maintained from a few seconds such as two seconds to a fraction of a second as, for example, 0.5 second depending on the temperature used, the longer times being used with the lower temperatures. The pressure during cracking is between about 17 p.s.i.g. and 20 p.s.i.g.

The cracked products at the high temperature leave the cracking furnace through transfer or outlet line **22** and are immediately quenched to a temperature of between about 500° F. and 600° F. by the introduction into line **22** of a quenching medium through spaced lines or nozzles **24** or **26**, but first preferably through line **24**. The quenched mixture is introduced into the bottom portion of separator tower **30**. The quench lines **24** or **26** may be fed from a manifold (not shown).

A plurality of quench points or nozzles is shown in the drawing. The vertically extending quench nozzles **24** and **26** are horizontally spaced along the outlet transfer line **22** leading from the cracking furnace **14** to the tower **30**. The quench nozzles **24** and **26** are cylindrical and circular in horizontal cross section. The quench nozzles **24** and **26** are used alternately during the operation of the unit.

The cracked products from line **22** are passed into the lower portion of tower **30** and separated into a bottoms fraction which is withdrawn through line **32**. The tower **30** is under pressure between about 0.5 and 3 p.s.i.g. The vaporous and gaseous reaction products pass overhead through line **34** and are further treated to recover desired olefins, diolefins, benzene and toluene in any conventional manner.

Referring now to FIG. 2 a portion of the outlet transfer line **22** is shown enlarged and includes the quench nozzles **24** and **26** shown in greater detail. The transfer line **22** slopes down at an angle at about 7° from the horizontal from the inlet end **36** of the transfer line to the outlet end **38** of the transfer line. The inlet end **36** and outlet end **38** of the transfer line **22** are of substantially the same diameter.

A metal shroud or sleeve generally indicated at 42 is of substantially the same diameter as the inlet end 36 and outlet end 38 of the transfer line 22. Transfer line 22 is cylindrical and circular in vertical cross section.

As pointed out above the reaction products leaving the cracking furnace 14 are at a temperature between about 1200° F. and 1600° F. and when these reaction products have been quenched down to a temperature between about 500° F. and 600° F., thermal stresses and strains are set up in the transfer outlet line 22 and cracks have occurred in the uninsulated outlet line corresponding to line 22. The present invention overcomes these defects and deficiencies by providing an insulation in the quenching region of the transfer line 22. Surrounding the inner metal shroud or sleeve 42 and spaced therefrom is a pipe or tubular member 48 which is circular in vertical cross section. The shroud or sleeve 42 is tubular or a pipe formed of a plurality of annular sections as will be presently described. Pipe 48 is of a larger diameter than the transfer line 22. The space between pipe 48 and sleeve 42 is filled with insulation material 50.

The end of enlarged pipe 48 adjacent nozzle 24 is spaced from the end 36 of transfer line 22 and connecting the adjacent ends of sleeve 42 and transfer line 22 is a reducer or tapered section or pipe 52 which at its end adjacent pipe end 36 of transfer line 22 is of substantially the same size as transfer line 22 and at its other end or enlarged end is substantially the same diameter as the outer surrounding pipe 48. The reducer section 52 is welded to transfer line 22 and pipe 48 as indicated at 54 and 56.

A construction joint 57 comprising a weld joint is provided in the space between the outer pipe 48 and inner sleeve 42 adjacent weld 56. Construction joint 57 is provided to permit assembly of this invention.

The quench nozzles 24 and 26 are spaced along the transfer line 22. Each quench nozzle 24, 26 extends down through an opening 58 in the outer surrounding pipe 48 and is welded thereto as at 62. The lower end of each quench nozzle 24, 26 has an annular flange 64 or washer welded to its exterior wall as at 66. The flange or washer is concentric with the axis of nozzle 24 and extends outwardly from the quench nozzle 24, 26 which cooperates with the inner sleeve or shroud 42 presently to be described. The flange or washer 64 is not secured to the exterior wall of sleeve or shroud 42 but is slidably mounted on middle section 76 of sleeve 42 to permit relative movement of washer 64 to section 76 of sleeve 42.

Each quench nozzle 24, 26 has quench oil inlet lines 68 and 70 which extend at right angles to the vertically arranged nozzles. The quench oil enters the quench nozzles 24, 26 through oil inlet lines 68, 70. Each nozzle has a removable closed upper end 72 to permit rodding out of any coke which may be formed during operation in quench nozzles 24, 26.

Near its inlet end, the shroud or sleeve 42 is made up of a small annular or tubular section 74 which is about the same diameter as the transfer line 22. At its end near the inlet 36 of the transfer line, the annular section 74 is welded as at 75 to the inner wall of reducer section 52 a short distance downstream from weld 54 connecting the inlet end 36 of transfer line 22 and the smaller diameter end of reducer section 52. As pointed out above, the inner sleeve or shroud is formed of a plurality of sections and these sections are arranged and installed to have a smooth inner surface with no obstructions which would encourage the formation of coke deposits. In the specific form of the present invention the shroud includes three sections.

Annular section 74 is spaced from the next adjacent annular middle section 76 as shown at 78. The adjacent ends of sections 74 and 76 are bevelled as at 80 and spaced to permit expansion of the sections 74 and 76 of the sleeve 42 during the operation of the process. The adjacent ends of the sections 74 and 76 are cut away or beveled 45° to form a V-shape. The annular or tubular sections 74 and 76 are of substantially the same diameter.

Surrounding the annular space 78 is a small length of an annular section or ring 82 which is of a slightly larger diameter than the inner sections 74 and 76 to overlap the opening or space 78 and to close it and form a continuous passageway through the inner sleeve or shroud 42. One end only of ring 82 is welded as at 84 to the outer wall of annular section 74 upstream from space 78. The ring 82 is slidably mounted on middle section 76. The spaced sections 74 and 76 form a slip joint with ring 82 so that ring 82 permits relative movement of the adjacent ends of sections 74 and 76 when these sections expand during use. Ring 82 can slide on the exterior of section 76.

Annular section 76 in its upper wall has an enlarged opening 83 to receive the lower end of nozzle 24 in an unobstructed manner. The washer or flange 64 is adjacent to and spaced from ring 82 by an annular section of compressible insulation 88 or a removable form during casting to allow for thermal expansion or growth of section 76 of the sleeve or shroud 42 during operation of the unit.

Opening 83 is formed by cutting away a portion of the top of sleeve or shroud 42. The upstream outwardly beveled edge 90 of the sleeve or shroud 42 cutout is in line with the nozzle 24 outside diameter in cold position to allow for thermal expansion during operation. The other outwardly beveled edge 92 of the section 76 is positioned downstream of nozzle 24 a short distance in the cold position to allow for thermal expansion during operation.

The other quench nozzle 26 is used alternately to the nozzle 24 and has parts which are the same as those associated with quench nozzle 24. The quench nozzle 26 functions in the same manner as quench nozzle 24 and the parts associated therewith are given the same reference characters as have been given the quench nozzle 24.

A second slip joint is provided adjacent nozzle 26 and includes ring or annular section 82' which is substantially the same as ring 82 above described and another slip joint around nozzle 26 including flange or washer 64' which is substantially the same as flange or washer 64. The slip joints function in the same manner in both places.

The outlet end 38 of transfer line 22 has substantially the same diameter as transfer line 22 and a reducer section 98 similar to reducer section 52, above described, is provided to connect the outlet end 38 of transfer line 22 with the outer larger diameter pipe 48 in a manner similar to that above described in connection with the inlet end 36 of the transfer line. The same reference characters are used to designate similar elements.

An outlet annular section 100 similar to inlet annular section 74 is provided adjacent outlet end 38 and the construction and arrangement of adjacent parts is the same as that of inlet end section 74.

Arranged in the entire space between the outer pipe 48 and the inner sleeve or shroud 42 and extending from weld 75 at end 36 to 75 at end 38 is the castable insulation designated 50. This insulation should be of medium weight about 65 to 85 lbs. per cubic foot with a maximum total shrinkage of about 0.3% at 1000° F. and a maximum thermal conductivity of about 3 B.t.u./hr.-square feet-° F./in. at a mean temperature of 500° F. Loose heat insulating material of other types such as asbestos, kaolin, etc. may be used instead of the castable insulation.

The insulation is introduced into the space provided between the inner sleeve 42 and the outer pipe 48 and the insulation material should be vibrated or rodded into place to eliminate all voids.

In a steam cracking unit where about 5000 barrels per day of oil are heated to a cracking temperature of about 1400° F., the cracked products are introduced into the transfer line 22 and quenched by the introduction of about 18,000 barrels per day of a quench liquid which contains aromatic hydrocarbons and has a low Conradson carbon level to reduce the temperature of the cracked products to about 550° F. At the beginning of the operation quench nozzle **24** is used and the other quench nozzle **26** is held in standby position.

The metal used in the construction of the transfer line and quenching apparatus is stainless steel (18–8) and 2¼ chrome steel. The shroud **42** and reducer **52** are made of the stainless steel and the outer shell **48** is made of the chrome steel.

In one specific design the transfer line **22** is 12" in inside diameter, the reducer sections **52** and **98** have a smaller end diameter of about 12 inches and a larger end diameter of 20". The inner sleeve or shroud **42** has an inside diameter of about 12" and the internal diameter of the outer larger pipe **48** is about 20". The length from the inlet end **36** of transfer line **22** at weld **54** to the outlet end **38** of the transfer line **22** at weld **54** is about 19 feet. Each reducer section **52** and **98** is about 2 feet long and the total length of pipe **48** is about 15 feet. The shroud **42** is made of three stainless steel (18–8) sections but may be made of a different number of sections. In this specific design there are three inner sections, **74**, **76** and **100** making up the inner sleeve or shroud **42**. The quench nozzles **24** or **26** are about 10 ft. apart.

The ring or washer **82** which forms a flange on the lower end of the quench nozzle **24** extends outwardly about 4" from the quench nozzle **24**. The sections making up the sleeve or shroud **42** are about ⅜ of an inch thick. The transfer line **22** slopes down at an angle of about 7° from the inlet end **36** at least 13 feet beyond the second quench nozzle **26**.

The element **102** is a conventional conical vapor stop.

What is claimed is:

1. An apparatus including a furnace for heating fluids, a transfer line, a separating tower, said transfer line connecting said furnace and said tower, quench means for introducing a quench medium into a quench section of said transfer line, said quench section of said transfer line including an inner tubular shroud of about the same internal diameter as said transfer line and having a substantially smooth inner surface, a larger diameter tubular member surrounding said shroud and spaced therefrom and having its ends secured to said transfer line to form an enclosed space, heat insulating material filling said enclosed space between said inner shroud and said larger diameter tubular member, said tubular shroud being formed from a plurality of sections spaced from each other and provided with a cylindrical slip joint overlying adjacent ends of said sections to permit relative movement of said sections during use of the apparatus under different temperature conditions.

2. An apparatus according to claim 1 wherein said quench means includes a vertically arranged tube extending through openings in said outer tubular member and said shroud, said shroud at said opening therethrough being cut out as a bevelled opening to permit expansion

of said shroud without interfering with said quench tube opening.

3. An apparatus according to claim 2 wherein the inner end of said quench tube is provided with a slip joint means comprising a concentric ring slidably mounted on the exterior wall of said shroud.

4. An apparatus of the character described which includes a transfer line for receiving high temperature fluids, a tubular member of larger diameter than said transfer line surrounding a quench section of said transfer line and spaced therefrom, means for sealing the ends of said tubular member to said transfer line, said transfer line including a plurality of sections spaced apart and forming a smooth flow path therethrough, slip joint means surrounding said spaces between said sections and being rigidly secured to one section only of each pair of sections and slidably mounted on the adjacent section of each pair.

5. An apparatus according to claim 4 wherein the space between said transfer line and said outer tubular member is filled with heat insulating material.

6. An apparatus according to claim 4 wherein a vertically arranged tube extends through said quench section of said transfer line and said tubular outer member and is provided at its lower end with slip joint means slidably mounted on the exterior wall of said transfer line, said tube being fixedly attached to said outer tubular member.

7. In an apparatus including a furnace, a transfer line leading from said furnace to a separating tower, the improvement which includes a quench section of the transfer line having a tubular member of a diameter larger than that of said transfer line, an inner sleeve member of substantially the same internal diameter as said transfer line spaced inwardly from said tubular member and forming a smooth flow path therethrough, a reducer section at each end connecting the ends of said larger diameter tubular member with the end of said transfer line, said inner sleeve member being made of separate sections spaced apart to permit expansion and contraction of said sleeve sections during operation and a short cylindrical section of a larger diameter than said sleeve member secured at one end only to the one end of one of said sleeve sections and slidably mounted on said adjacent sleeve section to overlap the space between adjacent sleeve sections.

8. The improvement according to claim 7 wherein heat insulation material is in the space between said larger diameter tubular member and said inner sleeve member.

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