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A. E. HARNSBERGER ET AL

1,944,318

OIL HEATER

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2 Sheets-Sheet 1

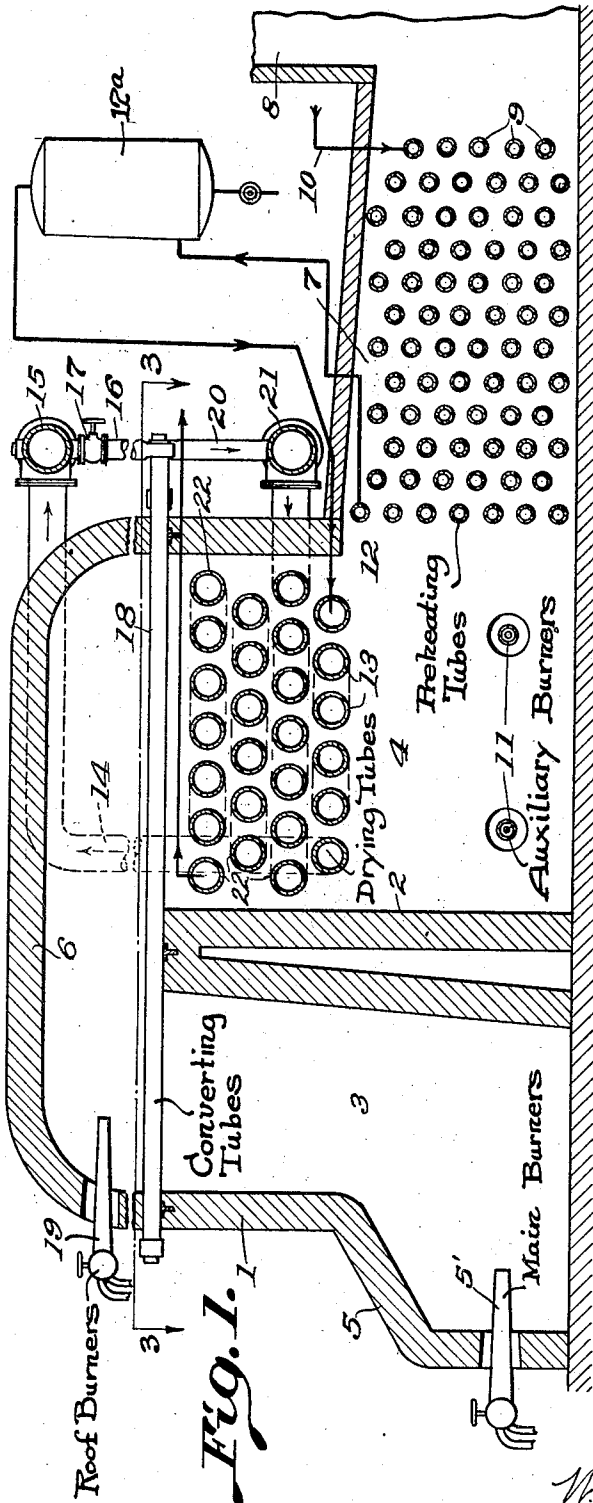
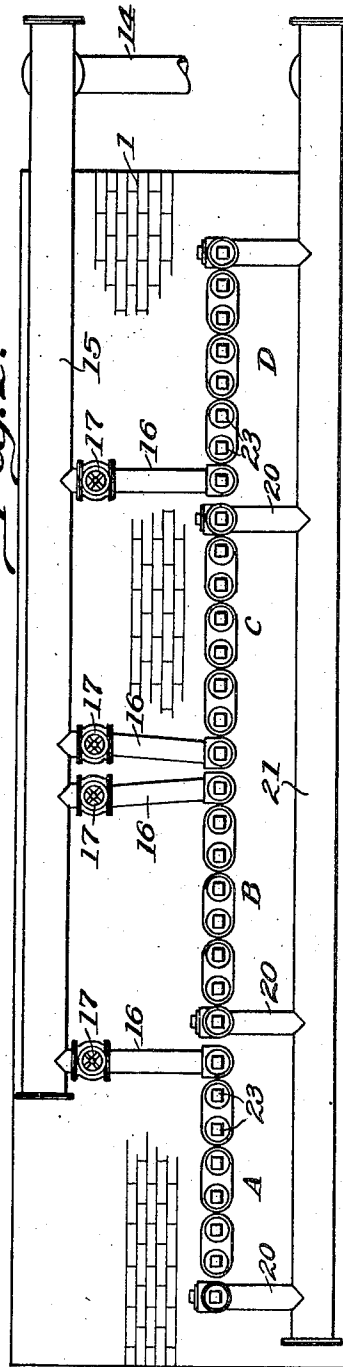


Fig. 2.



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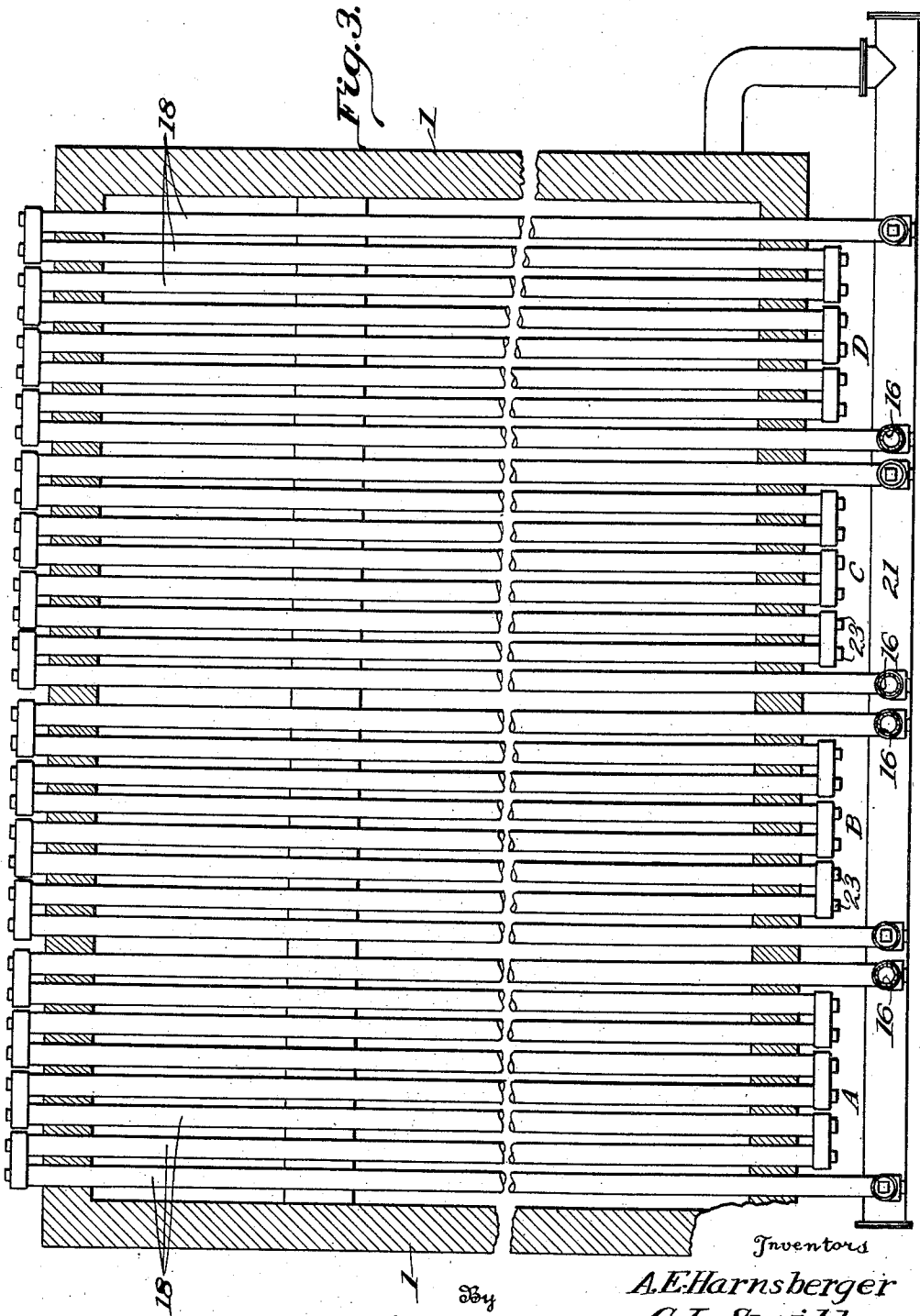
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UNITED STATES PATENT OFFICE

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OIL HEATER

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Serial No. 577,309

7 Claims. (Cl. 196—116)

This invention relates to improvements in tubular heaters of the type employed in the heat treatment of hydrocarbon oils for purposes of effecting distillation, cracking, polymerizing or otherwise treating hydrocarbon oil passed through the heater, whereby to effect changes in the physical or chemical properties of the oil so heated.

The invention has specific reference to a tubular heater which has been particularly adapted for use in connection with high temperature oil cracking systems and embodies the provision of means for continuously passing vaporized streams of oil through a plurality of substantially horizontally arranged tube banks provided in the heating section of the still, and wherein provision is made for securing efficient heat transfer between the oils passing through the tubes of the still and the furnace gases to the end of providing an oil heater economical and efficient in its construction and operation, one wherein repairs and adjustments can be made with facility and one wherein provision is made in the arrangement and form of the tubes of the heater and the flow of oil through said tubes to secure sustained operation without permitting of undue coke or carbon accumulations in the oil passages of the tubes.

In vapor phase oil cracking stills of the tubular type, considerable difficulty has been encountered in securing efficient and economical designs by which carbon accumulation in the tubes can be reduced to a minimum degree to avoid interference with the continued operation of the still for extended runs or periods of operation and to reduce repair and maintenance costs. A vapor phase converter is required to operate at high temperatures since to effect the desired cracking reactions, it is necessary that the oil passed through the heater be heated to a temperature varying between 1000° F. and 1150° F. This means high furnace gas temperatures which latter temperatures are sufficiently high so that if there is any interference in the matter of heat transfer between the furnace gases and the oils undergoing heating in the tubes, such as by obstructing carbon deposit in the tubes, the metal of the obstructed tubes is rapidly deteriorated by the lack of heat transfer and the excessive heating of the metal to temperatures where the tube or tubes so affected breaks down or ruptures.

In accordance with the present invention, we have provided an oil heater of the character specified wherein the oil undergoing heating is

positively advanced in serial flow through a plurality of connected tubes arranged in the heating section of the still and wherein an equalized flow of oil vapor passes through each of said tubes so that proper heat exchange exists between all portions of the still tubes and the furnace gases developed in the still.

With these and other objects in view, which will appear as the description proceeds, the invention consists in the novel features of construction, combination of elements and arrangements of parts hereinafter fully described and pointed out in the appended claims.

In the accompanying drawings:

Fig. 1 is a vertical longitudinal sectional view taken through an oil heater constructed in accordance with the features of the present invention;

Fig. 2 is a view in rear elevation of the heater and disclosing the distributing pipes for delivering oil to the converting tubes of the heater;

Fig. 3 is a horizontal sectional view taken through the upper portion of the heater on line 3—3 of Fig. 1 and disclosing in plan the arrangement of the first pass of converting tubes provided in the heater.

Referring more particularly to the drawings, the numeral 1 designates the wall structure of my improved oil heater or converter. The wall structure may be formed from the usual refractory materials to provide a heat retaining enclosure. The converter is provided with a transversely arranged bridge wall 2, disposed to divide the interior thereof into combustion and tube chambers 3 and 4 respectively. The combustion chamber is provided with a Dutch oven formation in which is arranged one or more main burners 5' by which the internal temperatures of the converter are obtained through the development of combustion gases. The compartments 3 and 4 communicate with each other over the top of the bridge wall 2 and the top of the bridge wall is spaced and disposed below the roof 6 of the converter. By this arrangement, the furnace gases developed by the combustion of fuels discharged from the burners 5' pass generally upwardly through the chamber 3, thence horizontally over the top of the bridge wall and generally downwardly through the tube chamber 4. These furnace gases are then passed through the horizontal outlet duct 7 and escape to the atmosphere by way of a vertical stack 8 of suitable height.

Arranged in the duct 7 is a bank of serially connected tubes 9 and the oil to be heated enters this bank of tubes by way of a pipe line 10 under

suitable pressure. During the serial flow of the oil through the tubes 9, the temperature of the oil is raised sufficiently to vaporize its lower boiling compounds but usually insufficiently to effect any material cracking of the oil passing through this bank of tubes. Ordinarily, the tubes 9 are referred to as "economizer" tubes since said tubes are largely heated by the waste furnace gases issuing from the principal heating sections of the converter, although, if desired, additional burners 11 may be provided to supplement the heat of the furnace gases generated by the operation of the burners 5' so that such waste furnace gases will possess a sufficient high temperature to secure the desired vaporization of the oils in the tubes 9. After the passage of the furnace gases over the tubes 9, said gases are led to the atmosphere through the stack 8.

From the outlet side of the bank of tubes 9, a pipe 12 leads to an evaporator (not shown) where high boiling liquid oils, unvaporized in the tubes 9, are removed and the desired vaporized oils are then transmitted to a bank of serially connected drying tubes indicated at 13 in the chamber 4 of the converter. It has been found in the operation of vapor phase converters that the vaporized oil should be in a substantially dry state and free from small liquid particles or mist before such vaporized oils enter the high temperature cracking sections of the converter tubes. The presence of liquid in the vapors results in carbon formation on the inner walls of the tubes. Apparently due to the high temperatures, this mist is rapidly evaporated to a point of dryness, leaving an objectionable carbon deposit which, if permitted to accumulate, obstructs or blocks proper vapor flow through the tubes. We therefore pass the vaporized oil, prior to its delivery to the high temperature cracking tubes, through what we term the "drying" tubes, which have been indicated at 13. The temperature of the furnace gases around the tubes 13 is such that it does not effect any appreciable cracking of the oil vapor flowing through said tubes, although the temperature is sufficiently high to vaporize any liquid or mist of high boiling hydrocarbons present in the vapor. The tubes 13 are of such diameter that if there is any carbon accumulation, vapor flow through the tubes is not seriously obstructed. For instance, these tubes may possess an internal diameter of approximately 12 inches and, moreover, are capable of being readily cleaned from positions exterior of the side walls of the converter in connection with which the tubes are supported.

From the tubes 13 the heated oil, now in a gaseous or vaporous condition and free from fine liquid particles, is transferred by way of a pipe line 14 to a manifold 15 extending horizontally with respect to the converter and disposed contiguous to the top or roof of the converter adjacent to its rear wall. It will be understood that the pipe 14 and the manifold 15 are suitably covered with a heat insulating material to minimize loss in temperature of the heated oil vapors passed therethrough. The manifold 15 is provided with spaced depending pipe members 16, each of which is provided with a control valve 17 which may be adjusted, in accordance with the indications of heat measuring instruments (not shown) to obtain equalized delivery of oil vapors to each of the pipe members. These pipe members extend vertically downwardly from the manifold 15, are lagged with heat insulating coverings and have their lower ends connected with a plurality of horizontally disposed tubes 18 which,

collectively, constitute what may be termed the first pass of converter tubes. The tubes 18 are connected with corresponding tubes comprising a plurality of groups as indicated at A, B, C and D, the tubes 18 of each group being united for the serial flow of oil vapor therethrough. The pressure on the oil vapor passing through the tubes 18 and related pipe members is preferably sufficiently high to overcome pipe friction and provide for the necessary vapor velocities and in this connection use may be made of pressures of the order of 50 pounds per square inch, although it will be understood that this pressure is subject to considerable variation depending on the character of the cracking reactions desired.

Heretofore in converters of this character, the tubes 18 have had their inlet and outlet ends connected with adjoining inlet and outlet manifolds so that vapor flow through said tubes was effected in parallel or multiple streams with the vapor flowing in but a single direction. We have observed however that when said tubes are arranged in multiple to provide the independently flowing parallel vapor streams, it is practically impossible to secure uniform distribution of the oil vapor to each of such tubes. Certain tubes invariably receive more oil vapor than the remaining tubes, with the result that the tubes through which an insufficient amount of oil vapor travels overheats, since there is not sufficient oil vapor present in those tubes to conduct away from the walls of the tubes the heat imparted to the latter by the furnace gases. Again, obstructing deposits might accumulate in such tubes which is also the cause of or contributes to the overheating of tubes. In such high temperature furnaces, it is imperative that the proper rate of heat exchange take place between the furnace gases and the oils or oil vapors passing through the tubes. If this rate or balance of heat exchange is impaired, overheating of the tubes as a direct consequence takes place, causing the tubes so affected to break down structurally under the high temperatures of the furnace gases, and causing their short life. Tube failure results in necessitating the immediate discontinuance of the converting operations until repairs can be made, so, therefore, it is not only the cost of the defective tube or tubes but the loss of the entire operation of the converter while the repairs are being made that makes such shut-downs so highly expensive and undesired. By providing for the serial flow of oil vapor through the various tubes of each of the groups A, B, C and D, we have provided a construction which insures a proper delivery of oil vapor and passage thereof through each of the tubes and in this way overcome one of the major objections to the parallel type of heater. The tubes 18 are located in the high temperature region of the converter and are therefore subject to the greatest influences of destruction set up by the furnace gases. It is therefore of very considerable importance that these tubes should be protected as far as possible against destruction by the defective heat exchange. In certain instances, we have found it advisable to supplement the burners 5' by the use of roof burners 19 which we have found to be highly effective in quickly raising the temperature of the oil vapors entering the tubes 18 from a non-cracking temperature to a cracking temperature in excess of 1000° F. The tubes 18 are approximately 6 inches in outside diameter to increase somewhat the velocity of the vapor travel therethrough in order that the oil vapor will rapidly attain a cracking

temperature. These tubes may or may not contain catalysts or cores but in the preferred embodiment of our invention, these tubes are plain and are not provided with internal cores or other obstructions.

After the oil vapors attain the desired temperatures, which are usually in excess of 1000° F., the cracked vapors leave the discharge tubes of the groups A, B, C and D and pass through heat insulated downwardly extending branches 20 to a correspondingly protected header or manifold 21 arranged below and extending parallel with a header or manifold 15, in which the oil vapors discharged from the groups of tubes 18 are mingled and attain an equalized temperature. Since cracking is a function of time and temperature and since comparatively high velocities obtain in the tubes 18, it is desirable to continue the conversion reactions in order to secure a desired yield of low boiling oils. This is obtained by passing the oil vapors from the header 21 into the lower pass of a bank of serially connected "time" tubes 22 which are arranged in the chamber 4 of the converter between the drying and conversion tubes 13 and 18. The tubes 22 may possess an outside diameter of 12¼ inches to effect a somewhat retarded rate of flow of the vapors as compared with their rate of flow in the smaller tubes 18. In travelling through the tubes 22, the vapors flow generally in counter-current relationship to the descending furnace gases passing through the chamber 4 so that when the cracked vapors are discharged from the outlet tube 22, they will possess a desired cracking temperature, which offsets loss of heat due to the endothermic character of an oil cracking reaction and also to compensate for the drop in temperature of the furnace gases following contact with heat absorbing surfaces. The cracked vapors discharged from the tubes 22 may then be shock chilled to arrest conversion reactions and subjected to the usual fractionation operations common in cracking of oils.

The various tubes employed in our converter are supported in conjunction with the walls of the converter setting and since adjacent tubes are connected for serial oil flow, the return bends used in uniting adjacent tubes are located exteriorly of the converter walls. These return bends are provided with the usual threaded plugs 23 which may be removed to provide for the cleaning of any tube or its independent removal from the converter and substitutions therefor. The tubes 18 extend longitudinally of the converter and are located over the chambers 3 and 4 to receive the benefit of the furnace heat through radiation and convection, whereas the tubes 13 and 22 extend transversely of the converter at right angles to the tubes 18 and are located solely in the tube chamber 4.

In view of the foregoing, it will be seen that the present invention provides a converter peculiarly suitable for the vapor phase cracking of hydrocarbon oils and one wherein a novel arrangement of tubes is provided to insure sustained operation of the converter for prolonged periods under high furnace temperatures, to minimize premature destruction of the tubes through overheating and contributory causes, to minimize the deposition of carbon in the tubes and obstruction of vapor flow therethrough and the disadvantages of improper heat transfer and provides generally a converter in which repairs and adjustments can be made quickly and with facility.

What is claimed is:

1. In a converter for cracking oil in the vapor phase, a heat-confining wall structure arranged to provide burner and tube chambers spaced by an intervening bridge wall over the top of which said chambers communicate, combustion developing means arranged adjacent to the lower part of the burner chamber, an outlet duct for furnace gases communicating with the lower part of the tube chamber, a plurality of independently regulable horizontally disposed tube coils supported at their ends by said wall structure and intermediately of their lengths by the bridge wall, said coils being arranged openly in said converter above the burner and tube chambers and below the roof of the converter, each of said coils being composed of a plurality of spaced parallel tubes through which oil vapor to be heated flows serially, a vapor manifold located exteriorly of said wall structure and operable to supply each of the independent tube coils with oil vapor whereby to cause the vapor to travel in serial flow through each of the tube coils and with multiple delivery of vapor simultaneously to each of the coils from said manifold, a second manifold disposed exteriorly of the wall structure of the converter into which oil streams heated in said tube coils and discharged therefrom are merged in a single stream, and a bank of serially united parallel tubes arranged openly in said tube chamber below the first-named tube coils and extending at right angles thereto and through which oil vapor heated in the multiple tube coils is passed following discharge in a merged stream from said second manifold.

2. In a converter for cracking oil in the vapor phase, a heat-confining wall structure arranged to provide burner and tube chambers spaced by an intervening bridge wall over the top of which said chambers communicate, combustion developing means arranged adjacent to the lower part of the burner chamber, an outlet duct for furnace gases communicating with the lower part of the tube chamber, a plurality of independently regulable horizontally disposed tube coils supported at their ends by said wall structure and intermediately of their lengths by the bridge wall, said coils being arranged openly in said converter above the burner and tube chambers and below the roof of the converter, each of said coils being composed of a plurality of spaced parallel tubes through which oil vapor to be heated flows serially, a vapor manifold located exteriorly of said wall structure and operable to supply each of the independent tube coils with oil vapor whereby to cause the vapor to travel in serial flow through each of the tube coils and with multiple delivery of vapor simultaneously to each of the coils from said manifold, a second manifold disposed exteriorly of the wall structure of the converter into which oil streams heated in said tube coils and discharged therefrom are merged in a single stream, and a bank of serially united parallel tubes arranged openly in said tube chamber below the first-named tube coils and extending at right angles thereto and through which oil vapor heated in the multiple tube coils is passed following discharge in a merged stream from said second manifold, said last-named tubes being each of greater cross sectional area than the corresponding area of each of the individual tubes found in the tube coils.

3. In a converter for cracking oil in the vapor phase, a heat-confining wall structure arranged to provide burner and tube chambers spaced by

an intervening bridge wall over the top of which said chambers communicate, combustion developing means arranged adjacent to the lower part of the burner chamber, an outlet duct for furnace gases communicating with the lower part of the tube chamber, a plurality of independently regulable horizontally disposed tube coils supported at their ends by said wall structure and intermediately of their lengths by the bridge wall, said coils being arranged openly in said converter above the burner and tube chambers and below the roof of the converter, each of said coils being composed of a plurality of spaced parallel tubes through which oil vapor to be heated flows serially, a vapor manifold located exteriorly of said wall structure and operable to supply each of the independent tube coils with oil vapor whereby to cause the vapor to travel in serial flow through each of the tube coils and with multiple delivery of vapor simultaneously to each of the coils from said manifold, a second manifold disposed exteriorly of the wall structure of the converter into which oil streams heated in said tube coils and discharged therefrom are merged in a single stream, a bank of serially united parallel tubes arranged openly in said tube chamber below the first-named tube coils and extending at right angles thereto and through which oil vapor heated in the multiple tube coils is passed following discharge in a merged stream from said second manifold, and a third bank of tubes arranged in the lower part of the tube chamber for preheating oil vapor prior to its delivery to said first-named manifold.

4. In a converter for cracking oil in the vapor phase, a heat-confining wall structure arranged to provide burner and tube chambers spaced by an intervening bridge wall over the top of which said chambers communicate, combustion developing means arranged adjacent to the lower part of the burner chamber, an outlet duct for furnace gases communicating with the lower part of the tube chamber, a plurality of independently regulable horizontally disposed tube coils supported at their ends by said wall structure and intermediately of their lengths by the bridge wall, said coils being arranged openly in said converter above the burner and tube chambers and below the roof of the converter, each of said coils being composed of a plurality of spaced parallel tubes through which oil vapor to be heated flows serially, a vapor manifold located exteriorly of said wall structure and operable to supply each of the independent tube coils with oil vapor whereby to cause the vapor to travel in serial flow through each of the tube coils and with multiple delivery of vapor simultaneously to each of the coils from said manifold, a second manifold disposed exteriorly of the wall structure of the converter into which oil streams heated in said tube coils and discharged therefrom are merged in a single stream, a bank of serially united parallel tubes arranged openly in said tube chamber below the first-named tube coils and extending at right angles thereto and through which oil vapor heated in the multiple tube coils is passed following discharge in a merged stream from said second manifold, and valve means arranged between said first-named manifold and each of said tube coils to vary the rate of delivery of oil vapor to each of said tube coils.

5. In a converter for cracking oil in the vapor phase, a heat-confining wall structure arranged to provide burner and tube chambers spaced by an intervening bridge wall over the top of which

said chambers communicate, combustion developing means arranged adjacent to the lower part of the burner chamber, an outlet duct for furnace gases communicating with the lower part of the tube chamber, a plurality of independently regulable disposed tube coils supported at their ends by said wall structure and intermediately of their lengths by the bridge wall, said coils being arranged openly in said converter above the burner and tube chambers and below the roof of the converter, each of said coils being composed of a plurality of spaced parallel tubes through which oil vapor to be heated flows serially, a vapor manifold located exteriorly of said wall structure and operable to supply each of the independent tube coils with oil vapor whereby to cause the vapor to travel in serial flow through each of the tube coils and with multiple delivery of vapor simultaneously to each of the coils from said manifold, a second manifold disposed exteriorly of the wall structure of the converter into which oil streams heated in said tube coils and discharged therefrom are merged in a single stream, a bank of serially united parallel tubes arranged openly in said tube chamber below the first-named tube coils and extending at right angles thereto and through which oil vapor heated in the multiple tube coils is passed following discharge in a merged stream from said second manifold, and auxiliary combustion developing means arranged between the roof of said converter and the tube coils.

6. In a converter for cracking oil in the vapor phase, a heat-confining wall structure arranged to provide burner and tube chambers spaced by an intervening bridge wall over the top of which said chambers communicate, combustion developing means arranged adjacent to the lower part of the burner chamber, an outlet duct for furnace gases communicating with the lower part of the tube chamber, a plurality of independently regulable horizontally disposed tube coils supported at their ends by said wall structure and intermediately of their lengths by the bridge wall, said coils being arranged openly in said converter above the burner and tube chambers and below the roof of the converter, each of said coils being composed of a plurality of spaced parallel tubes through which oil vapor to be heated flows serially, a vapor manifold located exteriorly of said wall structure and operable to supply each of the independent tube coils with oil vapor whereby to cause the vapor to travel in serial flow through each of the tube coils and with multiple delivery of vapor simultaneously to each of the coils from said manifold, a second manifold disposed exteriorly of the wall structure of the converter into which oil streams heated in said tube coils and discharged therefrom are merged in a single stream, a bank of serially united parallel tubes arranged openly in said tube chamber below the first-named tube coils and extending at right angles thereto and through which oil vapor heated in the multiple tube coils is passed following discharge in a merged stream from said second manifold, and a bank of vaporizing tubes disposed in the outlet duct leading from the tube chamber for preheating oil prior to the delivery of at least a fraction thereof to said first-named manifold.

7. In a converter for cracking oil in the vapor phase, a heat-confining wall structure arranged to provide burner and tube chambers spaced by an intervening bridge wall over the top of which said chambers communicate, combustion develop-

ing means arranged adjacent to the lower part of the burner chamber, an outlet duct for furnace gases communicating with the lower part of the tube chamber, a plurality of independently regulable horizontally disposed tube coils supported at their ends by said wall structure and immediately of their lengths by the bridge wall, said coils being arranged openly in said converter above the burner and tube chambers and below the roof of the converter, each of said coils being composed of a plurality of spaced parallel tubes through which oil vapor to be heated flows serially, a vapor manifold located exteriorly of said wall structure and operable to supply each of the independent tube coils with oil vapor whereby to cause the vapor to travel in serial flow through each of the tube coils and with multiple delivery of vapor simultaneously to each of the coils from said manifold, a second manifold disposed exteriorly of the wall structure of the converter into which oil streams heated in said tube coils and discharged therefrom are merged in a single stream, and a bank of serially united parallel tubes arranged openly in said tube chamber below the first-named tube coils and extending at right angles thereto and through which oil vapor heated in the multiple tube coils is passed following discharge in a merged stream from said second manifold, the flow of the merged stream of oil vapor serially through said last-named tubes being substantially counter-current to the passage of furnace gases through the tube chamber.

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