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APPARATUS FOR CONTROLLING TREATMENT OF HYDROCARBON OILS

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FIG.1.

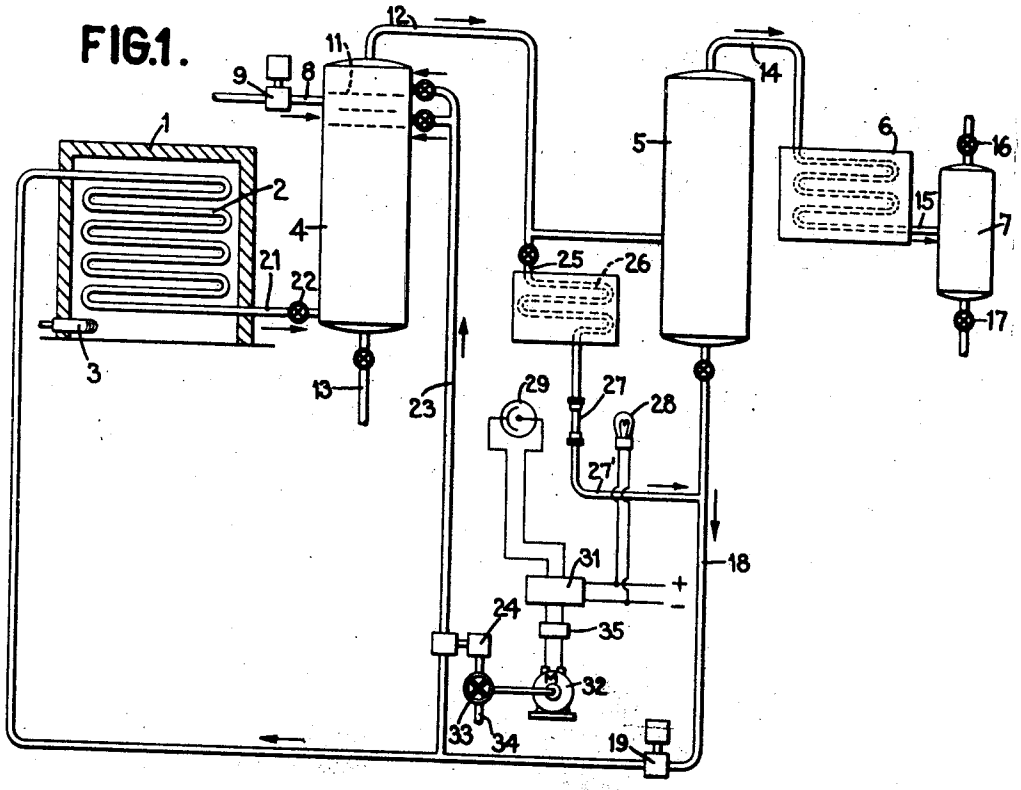
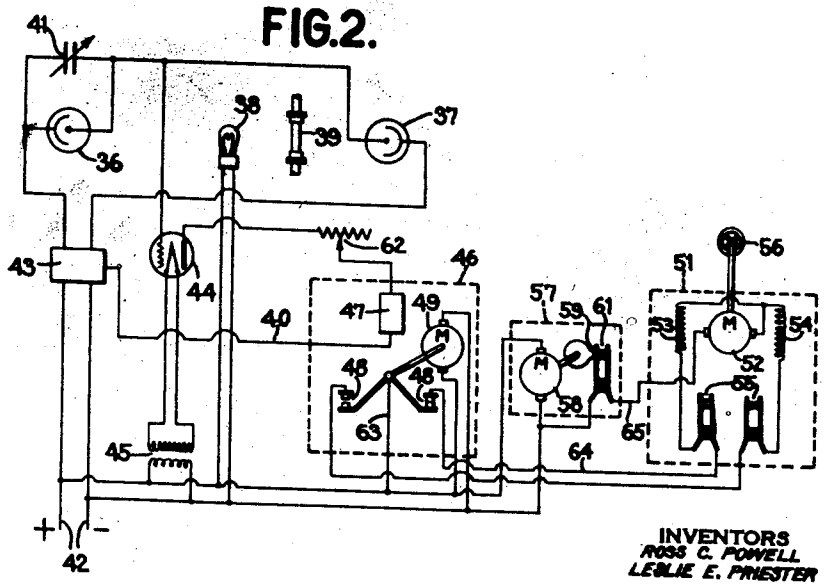


FIG.2.



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APPARATUS FOR CONTROLLING TREATMENT OF HYDROCARBON OILS

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3 Claims. (Cl. 196—132)

This invention relates in general to the art of producing lower boiling hydrocarbons from higher boiling ones and more especially to an oil conversion cyclic process in which variations of the cleanliness of the cycle condensate from the desired range are automatically adjusted by the effect produced by variations in the color thereof.

In processes involving the heat treatment of hydrocarbon oils and particularly the cracking thereof, it is essential that the type of stock used should be carefully selected. In the cracking of hydrocarbon oils, for instance, it is desirable to subject oil to high temperatures which may result in detrimental coke if care is not exercised in selecting or producing in the process an exceptionally clean stock to be subjected to said high temperatures.

In the so-called vapor phase cracking processes, the oil being introduced into the heating zone is subjected to relatively high temperatures, while optionally being maintained under superatmospheric pressure, in order to produce gasoline of high anti-knock quality. If a clean oil is not used in such a treatment objectionable coke is deposited in the heating zone which obviously shortens the length of any one operation and furthermore decreases, due to the insulating effect of the deposited coke, the maximum heat that may be imparted to the oil.

This invention is particularly adapted to automatically controlling the cleanliness of the oil being passed through the heating zone.

An object of the invention is to provide a process of automatically controlling the cleanliness of the oil being introduced into the system.

Another object of the invention is to provide a process in which the cleanliness of the cycle condensate produced in a cracking operation is automatically controlled by variations in the color thereof.

A further object of the invention is to provide a process in which variations in the color of the cycle condensate produced in a cracking operation automatically actuates adjusting mechanism for correcting said change in color to thereby control the cleanliness of the cycle condensate by restoring the oil to its desired color.

Still another object of the invention is to provide an apparatus suitable for carrying out the process.

With these and other objects in view, which may be incident to the improvements, the invention consists in the several method steps and the parts and combinations to be hereinafter set forth and claimed, with the understanding that the manner of carrying out the invention may be varied without departing from the spirit and scope of the appended claims.

In accordance with the invention the color of the oil being treated is used as a criterion of the cleanliness thereof. It has been found that variations in the color of the oil correspondingly indicate variations of its cleanliness. In practicing my invention the color variations may be detected prior to any substantial change in color of the large body of oil being used and the necessary changes in operation automatically effected to prevent any substantial variations in the cleanliness of the oil from that desired.

In carrying out the invention when applied to a cracking operation, a sample of the vapors passing to the fractionating zone may be withdrawn, condensed and passed through a suitable sight glass. The oil passing through the sight glass is generally light in color and permits the passage of light rays therethrough. A suitable apparatus, which has been calibrated with respect to a standard color, may be associated with the sight glass in such a manner that any variations in the color of the condensed sample will automatically actuate suitable control mechanism for accomplishing the necessary changes in operating conditions to thereby correct against any changes in the cleanliness of the cycle condensate. It has been found that variations in the color of the cycle condensate may be readily detected and corrected by employing a photoelectric cell arrangement which, due to its sensitiveness, readily effects the necessary changes in operating conditions to maintain the cycle condensate of the desired cleanliness.

In order to make the invention more clearly understood, there is shown in the accompanying drawing, means for carrying the same into practical effect without limiting the improvements in their useful applications to the particular constructions which, for the purpose of explanation, have been made the subject of illustration.

Figure 1 is a diagrammatic elevational view of an apparatus suitable for carrying out my invention.

Figure 2 is a view of an electrical wiring diagram associated with the sight glass for carrying out the invention.

The invention is to be illustrated as applied to the cracking of hydrocarbon oils, but it will be readily understood from the detailed description thereof that it is not limited to the cracking of oils but has other applications in the petroleum art.

Referring to Figure 1, there is shown a furnace 1 having a heating coil 2 positioned therein. The furnace 1 may be heated by suitable burners 3. An enlarged reaction chamber is designated by the numeral 4, a suitable dephlegmating zone, such as a fractionating tower, is designated by the numeral 5 and the numerals 6 and 7 designate a suitable condenser and a gasoline distillate receiver, respectively.

While a particular type of cracking apparatus has been shown, it is to be clearly understood that this is merely for illustrative purposes and any type may be employed.

The fresh charge, which may be in the nature of a reduced crude or a heavy gas oil, may be forced through a suitable inlet line 8 by means of a pump 9 into the upper portion of the reaction chamber 4. The reaction chamber 4 may be provided with suitable baffle plates or bubble trays 11 for the purpose of assisting in a preliminary fractionation of the vapors resulting in the enlarged chamber 4 as will be hereinafter explained. The fresh charge, which may be preheated, if desired, introduced into the reaction chamber 4, is contacted with highly heated upwardly rising vapors, the formation of which will be later explained, thereby imparting heat to the fresh charge to accomplish distillation thereof. The vapors resulting from the fresh charge together with the highly cracked vapors resulting from the heat treatment of oil passing through the coil 2 are conducted through a line 12 into the lower portion of the bubble tower 5. Unvaporized constituents of the oil collected in the bottom of the reaction chamber 4, which may be in the nature of a fuel oil, may be withdrawn through a valved line 13 and conducted to storage or, if desired, passed to a suitable flashing operation.

The vaporous constituents introduced into the bubble tower 5 are therein fractionated to remove the heavier fractions therefrom. In order to facilitate fractionation of the vapors in the bubble tower 5 thereby producing the desired reflux condensate therein, any suitable refluxing medium may be employed. The resulting vaporous constituents which may be of the desired end point may then be passed through a line 14 into the condenser 6 wherein they are condensed. The liquid resulting from the condenser 6 may be passed through a line 15 to the gasoline distillate receiver 17 which may be provided with a valved gas outlet 16 and a valved liquid drawoff 17.

The reflux condensate formed in the lower portion of the bubble tower 5 as the result of fractionation therein, in accordance with my invention, is a condensate of any desired color suitable to be recycled to the heating coil 2 wherein it may be raised to a high cracking temperature. The reflux condensate may be withdrawn from the bubble tower 5 through a valved line 18 and forced by means of a pump 19 through the heating coil 2. The condensate being forced through the heating coil 2 may be subjected to cracking conditions at a high crack per pass and as a result of the cleanliness of the oil, detrimental coke deposition is prevented. The highly heated oil from the heating coil 2 may be passed through a line 21 into the reaction chamber 4 wherein it is digested in the vapor phase. If desired, a preliminary digestion or soaking of the oil may be accomplished by providing an additional coil suitably positioned within the furnace 1. By means of a pressure reduction valve 22 positioned in the line 21, a differential pressure may, if desired, be maintained between the heating coil 2 and the reaction chamber 4.

The upwardly rising cracked vapors in the reaction chamber 4 contact the downwardly flowing fresh charge thereby imparting heat thereto to strip lighter constituents therefrom. The vapors in the reaction chamber 4 may be suitably refluxed by introducing a portion of the reflux condensate formed in the bubble tower 5 into the reaction chamber 4. As shown, a portion of the reflux condensate may be forced through the line 23 by means of a pump 24 into the upper portion of the reaction chamber 4. If desired, the reflux may be cooled before entering the chamber 4. It will be readily understood that by passing the upwardly rising vapors in the reaction chamber 4 through the baffles or bubble trays 11 and in addition introducing a refluxing medium into them, objectionable heavier ends of the vapors are removed.

My invention is particularly adapted to the control of the color of the cycle condensate collected in the lower portion of the bubble tower 5. The cycle condensate collected in the lower portion of the bubble tower 5 forms in a relatively large body and any change in color, which is used as a criterion of the cleanliness of the stock, is very gradual and may become objectionable. In accordance with my invention, the color of the reflux to be formed is determined prior to its actual formation. One advantageous manner of controlling the color before formation to thereby collect an exceptionally clean cycle condensate is illustrated. The portion of the reflux condensate introduced into the upper portion of the reaction chamber 4 removes or knocks back heavy undesirable constituents from the vapors. By regulating the quantity of the refluxing medium being introduced through the line 23, excellent control of the cleanliness of the cycle condensate may be obtained. It is to be understood that my invention is not limited to refluxing a part of the condensate as illustrated in the drawing, as other refluxing mediums extraneous to those produced in the system may be satisfactorily employed.

In carrying out my invention as exemplified by the drawing, a sample of the vapors and any liquid that may be present passing through the vapor line 12 may be withdrawn through a small branch line 25 preferably branched from a lower portion of the vapor line 12. The sample withdrawn may be passed to a suitable condenser 26 wherein it is condensed. The liquid oil resulting from the condenser 26 may then be passed through a sight glass 27 and, if desired, returned to the system through the line 27' as illustrated.

In Figure 1 we have shown diagrammatically an electrical arrangement associated with the cracking system whereby any variations in the color of the condensed sample will be detected and the necessary change in the quantity of refluxing medium being introduced into the reaction chamber 4 automatically controlled. The electrical arrangement may comprise a source of light 28, a photo-electric cell 29, a suitable control mechanism 31, a motor 32 and a motor operated valve 33. The source of light 28 may be energized from any suitable source of power such, for instance, as a commercial lighting circuit or, if desired, from a storage battery. The photo-electric cell 29 is so adjusted that when the oil passing through the sight glass 27 is of the desired color and characteristics, which have been previously determined, no electric current will

flow from the photo-electric cell to actuate the control mechanism 31. When there are any variations in the color of the oil or other characteristics, to effect the transmitted light, the current produced by the cell 29 will vary proportionately to the variations of the characteristics of the oil which effects the light beams passing from the source of light 28 through the sample of oil to the photo-electric cell 29. The current thus produced is conducted to the controller 31 which may be of any suitable type, such for example, as suitable relays for opening and closing the circuit. The controller 31 may likewise be connected to a suitable power supply, not shown, for supplying the necessary electrical energy thereto. Depending on the change in the oil passing through the sight glass 27, the controller 31 will close a circuit therein for starting the motor 32 in one direction or the other. The motor 32 may be connected to a suitable power operated valve 33 which may be positioned in a steam line 34 connected to the pump 24 for introducing steam thereinto to actuate it.

The motor will thus open or close the valve 33 thereby forcing more or less steam into the pump 24 which in turn forces more or less refluxing medium into the chamber 4 as the case may be. It will be appreciated from the above that any variations in the color or other characteristics of the sample passing through the sight glass 27 will automatically be compensated and controlled by varying the amount of reflux through the operation of the pump 24.

It may be desirable to maintain the latest valve setting on the pump 24 after actuation of the control arrangement for a period long enough for any change produced in the color of the cycle condensate to become evident in the sight glass 27. The sample being passed through the sight glass 27 may be of varying color which may result in too many changes of the valve setting. This will result in varying amounts of reflux being introduced into the reaction chamber 4 before the effect produced by the original change of refluxing becomes evident. In order to avoid this possible hunting of the motor for the correct valve setting to control the amount of reflux, a suitable interrupter switch 35 may be interposed in the circuit between the controller 31 and the motor 32. The interrupter may be set to interrupt the current passing through the motor for a period sufficiently long for the effect produced by the original change in the reflux rate to become evident in the sight glass 27. If the correct amount of reflux is not being forced into the reaction chamber 4 after the first adjustment, the motor 32 will be again actuated when the interrupter closes the circuit thereby forcing more or less reflux, as the case may be, into the reaction chamber in order to obtain the desired clean vapor fraction therefrom.

The operation of the invention from the foregoing will be apparent to those skilled in the art. It has been found that the photo-electric cell arrangement is very sensitive and a close control of the color may be obtained. The color of the cycle condensate satisfactory to be returned to the cracking coil 2 and subjected to a high crack per pass while passing therethrough, will vary depending on the oil being treated. The color may for instance be between 5 and 30 on a ½" Lovibond scale. In accordance with the invention the color may be controlled between any ranges and it has been found that excellent control may for instance be had between say, 14 and 16.

In Figure 2 we have shown more in detail an electrical arrangement that may be used for automatically controlling the color of the cycle condensate. Referring to this figure, there is shown a pair of photo-electric cells 36 and 37, a source of light 38 and a sight glass 39 for passing the sample of condensed vapors therethrough.

The photo-electric cells are connected in opposition, that is, the anode of one is connected to the cathode of the other. The photo-electric cell 36 is shunted by a condenser 41 and this cell and condenser are used to take care of the major portion of the out of balance current due to absorption of the light by the oil in the sight glass 39. The electrical energy for the arrangement shown is conducted from a suitable source such as a commercial lighting circuit or batteries by conductors 42 to a suitable transformer 43. The transformer may be of any desired type suitable for producing the desired voltage.

Suitably connected to the circuit of the photo-electric cells is an amplifying tube 44. The necessary voltage for the source of light 38 and the amplifying tube 44 may be supplied through branch leads from the conductors 42, as illustrated, the voltage to the filament of the amplifying tube 44 being stepped down to that desired by means of the transformer 45.

The plate circuit of the amplifying tube 44 is connected to a suitable controller indicated generally by the numeral 46. The controller 46 may comprise a deflection galvanometer 47, such as a milliammeter, suitably connected to the grid circuit of the amplifying tube 44 and to the transformer 43 by means of a conductor 40, thereby completing the circuit through the photo-electric cells, a plurality of contact points 48 of a relay and a motor operated contactor 49. The motor operated contactor 49 may be suitably connected to the galvanometer 47 in order that it will close one set of the contact points 48 depending on the deflection of the needle of the galvanometer 47. The motor operated contactor 49 may be of the type adapted to close either pair of the contact points 48 at desired intervals.

The controller 46 may be connected to a motor operated valve indicated generally by the numeral 51. The motor operated valve may comprise a reversible motor 52, having fields 53 and 54 wound in the opposite direction to provide a split field type of motor, and a plurality of contact points 55. The motor 52 may be suitably connected to a valve indicated by the numeral 56.

An interrupter 57 may be suitably connected to the motor operated valve 51. The interrupter 57 is adapted to complete the electric circuit at specified intervals, that is, it is generally adjusted so that the circuit is completed after sufficient time has elapsed for any change in color produced by the change in the refluxing rate to become evident in the sight glass. The interrupter 57 may comprise a motor 58, having a suitable means associated therewith, such as a cam 59, for closing a pair of contacts 61 to complete the circuit therethrough at specified intervals of time.

The motor 49 of the controller 46 and the motor 58 of the interrupter 57 may be synchronized in order that closing of either of contacts 48, effected by operation of the motor 49, will simultaneously occur when the contacts 61 are closed by operation of the motor 58. In this manner the electrical circuit is completed when any changes

set up by the change of color of the reflux condensate, actuate the galvanometer 47.

The equipment described will be balanced so that when oil of the desired color is passing through the sight glass 39 no variations or pulsations in the current will occur. By adjusting a resistance 62 connected in the plate circuit of the amplifying tube 44 a zero setting may be obtained for the galvanometer 47. This zero setting will be maintained as long as the color of the oil passing through the sight glass 39 does not vary beyond predetermined limits.

Explaining now the operation of the arrangement shown in Figure 2, we will assume that the color of the oil passing through the sight glass 39 has become too dark, which would indicate that an insufficient quantity of reflux was being introduced into the chamber 4 thereby permitting the return of reflux condensate to the heating coil 2 of not the desired cleanliness. This change in color would affect the light being transmitted to the oil passing through the sight glass 39 from the source of light 38 thereby setting up pulsations or currents in the cell 37 proportional to the color change. These pulsations or currents passing through the amplifying tube 44 are amplified and are then conducted to the galvanometer 47 through the grid circuit including the resistance 62. The amplified pulsations or currents will cause the deflection of the galvanometer needle thereby, through cooperation with the motor 49, establishing contact between the pair of contacts 48 which are closed when more reflux is to be pumped into the chamber 4. The contacts 48 are supplied with electrical energy from one of the conductors 42 through a conductor 63 to the closed contacts 48, thence to contacts 55 which are closed by the current passing through a conductor 64. The current will then pass through the closed contacts 55 to the field 53 thereby causing the motor 52 to rotate in the desired direction for opening the valve 56 suitably connected thereto. By opening the valve 56 more steam is admitted to the pump 24 thereby increasing its speed for forcing additional reflux into the chamber 4. The electrical circuit is completed through a conductor 65 connected to the contact 61 of the interrupter 57. As before described, the contacts 61 are closed by the cam 59, associated with the motor 58, simultaneously with the closing of one pair of the contacts 48. The current passing through the contact 61 is then conducted to one of the branch leads from the conductors 42 as shown.

If the color of the oil passing through the sight glass 39 becomes too light, pulsations or currents will set up thereby deflecting the needle of the galvanometer in the opposite direction. When this condition exists, the pair of contacts 48 and 55 shown as opened in Figure 2, will be closed, the other contacts 48 and 55 being opened, and the field 54 will become energized through the closed contacts 55 thereby causing the motor 52 to rotate in a direction opposite to that just described. In this manner less steam will be forced into the pump 24 by the closing of the valve 56. The electrical circuit under these conditions from the motor 52 is completed as already described.

It is to be clearly understood that the necessary equipment for carrying out my invention may be varied and any well known equipment employed. While a particular circuit arrangement has been illustrated, it will be appreciated that variations therein may be made by those skilled in the art without departing from the scope of the invention. If desired, the entire electrical arrangement illustrated may be assembled as a compact unit and located at the desired point in the refinery.

It is also within the scope of the invention to have a suitable automatic recorder associated with the electrical arrangement described for the purpose of automatically recording color variations.

While the invention has been described in connection with changing the rate of reflux to the tower 4, it is to be clearly understood that it is also applicable to many other uses. For instance, in any type of cracking operation involving considerable equipment prior to the final fractionation of the cracking vapors, it is possible to vary the reflux rate into the vessel preceding the final fractionator. It will also be apparent that in addition to or together with varying the reflux rate being introduced into the primary fractionator, the rate of firing of the burners 3 and/or the rate of flow through the coil 4 may be varied in accordance with my invention in order to clean up the reflux condensate being returned to the cracking system.

In operating in accordance with our invention oil is forced through the cracking coil 2 while under a superatmospheric pressure of from 250 to 1000 pounds per square inch and therein raised to a cracking temperature of from 800° F. to 1100° F. The cracked products at the elevated temperature may then be introduced into the reaction chamber 4 optionally operated by a reduced pressure, if desired, and the upwardly rising vapors contacted by the downwardly flowing fresh charge. The highly heated vapors impart heat to the fresh charge thereby stripping lighter constituents therefrom. A suitable refluxing medium, such as reflux condensate formed in the system, is introduced through the line 23 by means of the pump 24 to knock back any undesirable heavy constituents of the upwardly rising vapors in the chamber 4. The vapors of the desired cleanliness are conducted through the line 12 and introduced into the lower portion of the bubble tower 5 wherein they are fractionated to produce a reflux condensate and an overhead vapor fraction of the desired end point.

In controlling the color of the reflux condensate being formed in the lower portion of the bubble tower 5, a sample of the vapors and any condensed liquid passing through the line 12 is withdrawn through the line 25, condensed and passed through the sight glass 27. If the color of the condensed sample passing through the sight glass 27 is satisfactory no variations will be set up in the photo-electric cell arrangement. If, however, the color is either too dark or light, as the case may be, pulsations or currents corresponding to the change in color of the sample will be set up in the photo-electric cell arrangement thereby increasing or decreasing the speed of the pump forcing more or less reflux through the line 23. In this manner a quick indication of the reflux condensate going off color is possible and the necessary changes to restore the color of the reflux to that desired are automatically made. It will be apparent that before any appreciable change in color of the reflux takes place within the bubble tower 5, the necessary prior warning with its resultant correction has taken place.

For example, reflux condensate having a color of between 5 and 30 on a ½" Lovibond cell may satisfactorily be returned to the cracking coil and therein subjected to high cracking conditions of

temperature and pressure. The photo-electric cell arrangement disclosed has been found to be satisfactory in detecting slight variations in color and any desired color of the oil may be controlled and maintained in accordance with the invention. If an oil having a color of 15 on a ½" Lovibond cell is desired, the invention is adapted to automatically correct any variations from that color, thereby resulting in excellent control of the cleanliness of the oil being treated.

It has been found, as before mentioned, that the color of the reflux condensate being introduced into the cracking zone will vary depending on the nature of the charging stock. A straw colored reflux condensate has been found to be generally satisfactory and particularly one having a green cast. Generally when the oil becomes dark, such as having a brown cast, the cleanliness thereof is not satisfactory and the necessary changes are made to produce the desired lighter color. These colors are merely examples and should not be construed as being restrictive of the scope of the invention.

From the foregoing, it will be apparent that the invention is not limited to the control of operating conditions of a cracking operation. It is within the scope of the invention to control the cleanliness of any oil being treated. For instance, in the production of lubricating oils, the stock being treated is introduced into a treating chamber filled with contact material. The quantity of oil being introduced depends on the cleanliness thereof and the invention is readily applicable to automatically control the rate of feed of the oil to the treating chamber when the color thereof varies from predetermined limits.

While there has been shown and described the preferred embodiment of the invention, it is to be understood that the invention is not confined to the precise details of construction herein set forth, by way of illustration, as it is apparent that many changes and variations may be made therein, by those skilled in the art, without departing from the spirit of the invention, or exceeding the scope of the appended claims.

What we claim is:

1. In combination with an oil cracking unit wherein oil is subjected to cracking, the cracked products separated into vapors and residue, the vapors fractionated in primary and secondary fractionating zones and the secondary condensate formed in the secondary fractionating zone returned to the cracking unit for further cracking treatment, an apparatus for regulating the opacity of the secondary condensate which comprises regulatable means for introducing variable amounts of cooling fluid into said primary fractionating zone, means for separately condensing a portion of vapors passing from said primary fractionating zone to said secondary fractionating zone, means responsive to the opacity of the condensate formed by separately condensing said portion of vapors for regulating the amount of cooling fluid introduced into said primary fractionating zone and means interrupting the operation of said last named regulating means for a predetermined time interval to permit the changed condition of the vapors leaving the primary fractionating zone, effected by the changed amount of cooling fluid introduced thereinto, to be determined by said means responsive to the opacity of the condensed portion of the changed vapors prior to further regulation of said regulating means.

2. In combination with an oil cracking unit wherein oil is subjected to cracking, the cracked products separated into vapors and residue, the vapors fractionated in primary and secondary fractionating zones and the secondary condensate formed in the secondary fractionating zone returned to the cracking unit for further cracking treatment, and apparatus for regulating the opacity of the secondary condensate which comprises regulatable means for introducing variable amounts of cooling fluid into said primary fractionating zone, means for separately condensing a portion of vapors passing from said primary fractionating zone to said secondary fractionating zone, means responsive to variations in the opacity of the condensate formed by separately condensing said portion of vapors above and below the desired opacity for regulating the amount of cooling fluid introduced into said primary fractionating zone to obtain a secondary condensate of uniform opacity, and means for interrupting the operation of said last named means for a predetermined time interval to permit the changed condition of the vapors leaving the primary fractionating zone, effected by the changed amount of cooling fluid introduced thereinto, to be determined by said means responsive to the opacity of the condensed portion of the changed vapors prior to further regulation of said regulating means.

3. In combination with an oil cracking unit wherein oil is subjected to cracking, the cracked products separated into vapors and residue and the vapors fractionated in primary and secondary fractionating zones, an apparatus which comprises means for returning a part of the secondary condensate formed in the secondary fractionating zone to the cracking operation for further treatment, regulatable means for introducing another part of said secondary condensate into said primary fractionating zone as refluxing medium, means for separately condensing a portion of vapors passing from said primary fractionating zone to said secondary fractionating zone, means responsive to the opacity of the condensed portion of the vapors for regulating the quantity of said secondary condensate introduced into said primary fractionating zone, and means interrupting the operation of said last named means for a predetermined time interval to permit the changed condition of the vapors leaving the primary fractionating zone, effected by the changed quantity of said secondary condensate introduced thereinto, to be determined by said means responsive to the opacity of the condensed portion of the changed vapors prior to further regulation of said regulating means.

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