AUTOMATED LUBRICATING OIL REFINING
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This invention relates to the manufacture of lubricating oils and more particularly to an improvement in the solvent extraction unit and process in a refinery.

The present invention provides a system for quickly and automatically determining an important property of lubricating oil hereinafter obtainable only after a long delay. The property automatically and quickly determined is the viscosity index. In the manufacture of lubricating oil, an oil charge stock derived from crude oil is fed to a solvent extraction unit where the valuable fractions of the oil are removed, particularly those compounds which are relatively unstable to oxidation, forming sludge in service and having relatively low viscosity indices. Polycyclic aromatic hydrocarbons contribute substantially to this undesirable portion of the oil. The remaining oil, after the undesirable portions have been removed, is referred to as wax or raffinate, which after dewaxing and, in some cases, finishing by clay treatment or hydrotreating, is the lubricating oil product. The system of the present invention predicts the viscosity index of the lubricating oil being produced before the waxy raffinate is dewaxed.

Prior to the present invention, in order to determine the viscosity index of the lubricating oil being produced, a sample of the waxy raffinate was taken, dewaxed, and then the viscosity index of the dewaxed sample was determined by measuring the viscosity of the oil at two different temperatures, e.g., 100°F and 210°F, then referring to the Dean and Davis relation for viscosity index calculation. This procedure requires hours to conduct, thus making the desired information available only after it is needed, and is not easily carried out automatically. Furthermore, for those oils in a range of relatively low viscosity, e.g., spindle oils and so-called light neutrals, the desirable degree of accuracy is difficult to achieve with a single set of viscosity determinations. Consequently, the resultant viscosity index is apt to be inaccurate and lead to misdirection of the extraction unit.

In accordance with the present invention, the specific gravity of the waxy raffinate is continuously determined. It has been discovered that for a given charge stock there is a good correlation between the specific gravity of the waxy raffinate and the viscosity index of the lubricating oil produced from the waxy raffinate. The correlation for each stock differs one from another depending upon the crude source, the viscosity-distillation characteristics and possibly the dewaxing fractions employed in its preparation. Once the correlation for a charge stock is known, the determination of the specific gravity of the waxy raffinate determines what the viscosity index of the lubricating oil will be after the wax has been removed. Furthermore, in those instances of relatively low viscosity oils as mentioned above, the viscosity index determined in this manner probably can be of greater accuracy than that obtained by means of the direct measurement of a single set of viscosities using the Ostwald or Saybolt viscosimeters as employed commonly in refinery control laboratories. The accuracy of these prior art methods of obtaining the viscosity index can be improved by averaging the results of repeated viscosity determinations. However, this procedure adds more time and manpower to the effort of dewaxing and establishing the viscosity index of waxy raffinate samples from the extraction unit.

The specific gravity information relating to the viscosity index is then fed to the automatic controls of the system, which use this information to control the extraction process.

The present invention can be used in systems which are not automated by manually controlling the operation of the extraction unit in accordance with the specific information. In the system of the present invention the information obtained by measuring the specific gravity of the waxy raffinate is used to reduce the volume of downgraded and slop oil when switching charge stocks and to control the extraction unit to produce the correct viscosity index.

Accordingly, a principal object of the present invention is to provide an improved refinery system and process for producing lubricating oils.

Another object of the present invention is to provide an automated system for producing lubricating oils.

Further objects and advantages of the present invention will become readily apparent as the following description of a specific embodiment of the invention unfolds, and when taken in conjunction with the accompanying drawings, wherein:

Fig. 1 is a schematic diagram of a furfural extraction unit in accordance with the present invention; and

Figs. 2 and 3 illustrate details of automatic controls used in the extraction unit shown in Fig. 1.

The specific example of the present invention illustrated in FIGURE 1 is in a furfural extraction unit. In a furfural extraction unit, the undesirable aromatics and other compounds are extracted from an oil charge stock, using furfural as a solvent, leaving a waxy raffinate, which after being dewaxed and sometimes decolorized is the lubricating oil product.

As shown in FIG. 1, the oil charge stock is fed to the extraction unit through a conduit 17 and pumped into an extraction tower 21 by a pump 23 through a valve 75. Furfural is fed to the extraction unit through a conduit 27 and pumped into the extraction tower 21 by a pump 29 through a valve 76. In the extraction tower 21 the furfural and the oil charge stock mix and the mixture separates into two layers, the lower layer in the tower being rich in furfural and undesirable components and the upper layer in the tower containing most of the desirable oil and minor amounts of furfural. The liquid in the lower layer of the tower 21 is referred to as the extract phase and the liquid in the upper layer of the tower 21 is referred to as the raffinate phase. The undesirable components in the extract phase are referred to as the extract and the desirable oil in the raffinate phase is referred to as waxy raffinate. The extract phase is removed from the extraction tower 21 in a conduit 33 and fed to an extract stripper 43 where the furfural is stripped from the extract. The furfural is removed from the extract stripper in a conduit 45 and the extract is removed from the extract stripper in a conduit 47.

The raffinate phase is removed from the extraction tower 21 through a conduit 35 and fed to a raffinate stripper 37, where the furfural is stripped from the waxy raffinate. The furfural is removed from the raffinate stripper 37 through a conduit 39 and the waxy raffinate is removed from the raffinate stripper 37 through a conduit 41. The waxy raffinate in the conduit 41, after being dewaxed, and decolorized if necessary, will be the lubricating oil product. The furfural recovered in conduits 39 and 45 is reused in the system.

A slip stream of the waxy raffinate in the conduit 41 is fed to a liquid gravimeter 49, which produces an electrical signal representing the specific gravity of the waxy raffinate in the conduit 41. This signal is fed to
The specific gravity of the waxy raffinate in the conduit 41 correlates with the viscosity index of the raffinate after it has been dewaxed for the particular charge stock being supplied through the conduit 17. The parameter controls 51 determine whether the signal applied from the gravimeter 49 is within preset limits. If the signal is between these preset limits it means that the viscosity index of the lubricating oil obtained from the waxy raffinate in conduit 41 is at or close to the desired target value. If, however, the output signal of the gravimeter 49 rises above the upper preset limit set in the comparator 55 or falls below the lower preset limit, the parameter controls 51 will adjust at least one parameter of the extraction process in a direction to restore the specific gravity of the waxy raffinate, and hence the viscosity index of the dewaxed raffinate, to the target value.

FIG. 2 illustrates details of the parameter controls 51 and how they operate to control either the temperature in the extraction tower or the ratio of solvent to charge stock to maintain the specific gravity of the waxy raffinate within predetermined limits. The output signal from the gravimeter 49 is fed to a comparator 55 and to a comparator 56. The comparator 55 determines whether or not the signal applied from the gravimeter 49 is above the lower limit which is set into the comparator 55. If the output signal of the gravimeter 49 drops below this lower limit the comparator 55 applies an enabling signal to a pulser 58. The comparator 56 compares the signal applied from the gravimeter 49 with the upper limit which is set into the comparator 56 and will apply an enabling signal to a pulser 58 if the output signal of the gravimeter 49 rises above this upper limit. The target value for the specific gravity of the waxy raffinate is between the lower limit set into the comparator 55 and the upper limit set into the comparator 56. These upper and lower limits are limits between which the system maintains the specific gravity of the waxy raffinate. The pulser 58 produces an output pulse in response to receiving an enabling signal from the comparator 55. The output pulses from the pulser 57 will change a parameter in the extraction tower 21 in one direction and the output pulses from the pulser 58 will change the parameter in the extraction tower 21 in the opposite direction. Each of the pulser 57 and 58 will not produce a succeeding output pulse after producing an output pulse until after a time delay sufficiently long for the effect of the parameter change caused by the preceding output pulse to reach equilibrium in the conduit 41.

The output of the pulser 57 is connected to the pole of a switch 60. The output of the pulser 58 is connected to the pole of a switch 61. The switches 60 and 61 are changed together and with two other switches 62 and 63. When the switch 60 is in its upper position, the output of the pulser 57 will be connected to an input 64 of the parameter stepper 65. The parameter stepper 65 applies a signal representing a temperature to a temperature controller 66. The temperature controller 66 compares the signal applied from the parameter stepper 65 with a signal representing the temperature of the extract flowing out of the bottom of the extraction tower 21. The temperature of the extract is a close approximation of the temperature of the effluent extract phase, which is the most critical operating temperature for controlling the viscosity index. The temperature controller 66 controls the water rate and temperature in the lower cooling coil of the tower 21 and thus controls the temperature of the effluent extract phase. The temperature controller 66 adjusts the water rate and temperature in the lower cooling coil until the temperature of the extract phase flowing out of the bottom of the tower 21 is at the temperature of the signal applied from the parameter stepper 65. When the switch 60 is in its upper position, the switch 61 will also be in its upper position and the output of the pulser 58 will be connected to an input 67 of the parameter stepper 65. The output signal applied to the input 64 of the parameter stepper 65 will cause the parameter stepper 65 to increase the signal and the temperature represented thereby applied to the temperature controller 66 by one increment. Thus, when the specific gravity of the waxy raffinate in the conduit 41 falls below the preset limit set in the comparator 55 the pulser 57 will apply a pulse to the input 64 of the parameter stepper 65 and the temperature of the effluent extract phase in the bottom of the tower 21 will be increased by one increment. A pulse applied to the input 67 of the parameter stepper 65 from the pulser 58 will cause the output signal of the parameter stepper 65 and the temperature represented thereby to decrease by one increment. Thus, when the specific gravity of the waxy raffinate of the conduit 41 rises above the limit set into the comparator 56, the pulser 58 will apply a pulse to the input 67 of the parameter stepper 65 and the temperature of the effluent extract phase will be decreased by one increment.

The temperature of the effluent extract phase is increased, the viscosity index of the lubricating oil produced by the process will be increased and when the temperature of the effluent extract phase is decreased the viscosity index of the lubricating oil produced will be decreased. Thus, when the specific gravity of the waxy raffinate indicates that the viscosity index has fallen below the preset limit as determined by the limit set into the comparator 55, the pulser 59 will produce an output pulse and the temperature of the effluent extract phase will be increased by one increment. As a result the viscosity index of the lubricating oil produced will be increased tending to bring it within the prescribed limits. The pulser 57 will then not produce another output pulse for a predetermined time interval. At the end of this predetermined time interval the waxy raffinate flowing in the conduit 41 will have a specific gravity and the lubricating oil product will have a viscosity index determined by the new temperature of the effluent extract phase in the tower 21. If the specific gravity is still not above the limit set in the comparator 55, the pulser 57 will produce another output pulse causing the parameter stepper 65 to increase its output signal and the temperature represented thereby by another increment.

This process will continue until the specific gravity of the waxy raffinate is raised above the limit set into the comparator 55. In a similar manner the parameter stepper 65 operates in response to the output pulses of the pulser 58 to maintain the specific gravity of the waxy raffinate below the limit set into the comparator 56. If continued incremental changes of the temperature do not bring the viscosity index back within limits and the parameter stepper 65 produces an output signal reaching an upper limiting value or a lower limiting value, as would happen in the case of a unit upset, then the parameter stepper 65 will send a signal to an alarm 68, which will be energized to indicate a unit upset. The stepper 65 conveniently may be an ordinary stepping switch with the different incremental signals representing different temperature levels connected to the contacts of the different positions of the stepping switch. The stepper 65 also generates signals to control the temperatures of the solvent flowing into the tower 21 through the conduit 27 and the charge stock flowing into the tower 21 through the conduit 17. These signals are applied to temperature controllers 71 and 72 over the switches 62 and 63, which will be in the upper positions when the switches 60 and 61 are in their upper positions. The temperature controller 71 controls the temperature of the solvent flowing into the tower 21 through the conduit 27 in accordance with the output signal of the stepper 65 applied over switch 63 and the temperature controller 72 controls the temperature of the charge stock flowing into the tower 21 through the conduit 17 in accordance with the output signal of
the stepper 65 applied over switch 62. These signals from the parameter stepper 65, to which the temperature controllers 71 and 72 are responsive, change with changes in the signal applied to the temperature controllers 71 and 72 and the temperature of the solvent and charge stock so that the temperature gradient in the extraction tower 21 remains constant. These signals are generated by means of additional arms engaging additional contacts on the stepping switch which comprises the parameter stepper 65.

When the switches 60, 61, 62 and 63 are in their lower positions, the parameter controls 51 then control the ratio of solvent to charge stock to control the specific gravity of the waxy raffinate and thereby the viscosity index of the lubricating oil product. In this position the pulses from the pulser 57 and 58 are applied to a parameter stepper 73, which incrementally changes the valve positions of valves 75 and 76 to change the ratio of solvent to charge stock. In this manner the ratio of solvent to charge stock is changed incrementally in response to the specific gravity of the waxy raffinate rising above or falling below the limits set into the comparators 55 and 56 to bring this specific gravity back within the limits. The switches 62 and 63 in their lower positions apply temperature controlling signals from the parameter stepper 73 to the temperature controllers 71 and 72 and the temperature of the solvent and charge stock is controlled in accordance with these signals. These temperature controlling signals are thus in accordance with changes in the ratio of solvent to charge stock so that the temperature in the extraction tower 21 remains substantially constant. The signals are generated by additional arms on the stepping switch comprising the parameter stepper 73. In this manner the system automatically maintains the viscosity index of the lubricating oils being produced at the correct value. The parameter stepper 73, like the parameter stepper 65, will send a signal to actuate the alarm 68 if it steps to a predetermined point in either direction.

The waxy raffinate in the conduit 41 is fed to a plurality of valves 82 through 86, which control the flow of oil from the conduit 41 to conduits 92 through 96, respectively. At any given time only one of the valves 82 through 86 will be open. The selection of the particular valve to be open is controlled by the valve controller 66 in response to the signal from the gravimeter 49. When the charge stock is a paraffinic oil, one of the valves 82 or 83 will be open. When the charge stock is naphthenic oil, the valve 84 will be open. When there is a switch in charge stocks being fed to the extraction unit from one type of paraffinic oil to another type of paraffinic oil, or from a naphthenic oil to a paraffinic oil, or vice versa, there will be a period when the oil being produced in line 41 will not be produced purely from one charge stock but will be a mixture obtained from the two different charge stocks. The oil produced from one type of paraffinic charge stock will usually be of a different grade than the oil produced from a different type of paraffinic charge stock. When there is a switch between two such paraffinic charge stocks, the resulting mixture produced in the conduit 41 will be of lower grade than the higher grade oil produced purely from one of the charge stocks. Accordingly, the mixture should be caused to flow into the same conduit as the lower grade oil produced purely from one of the two charge stocks. That is if the oil produced from the preceding charge stock is of lower grade than the oil produced from the succeeding charge stock, the mixture is caused to flow into the same conduit as the oil produced purely from the preceding charge stock and if the oil produced from the preceding charge stock is of higher grade than that produced from the succeeding charge stock the mixture is caused to flow into the same conduit into which the oil produced purely from the succeeding charge stock will flow. This operation of combining the oil produced from a mixture of charge stocks with the lower grade oil produced purely from one of the charge stocks is accomplished by having the valve 85 open when the oil from the mixture is being produced so that this oil flows into the conduit 95. The operator by means of valves 98 and 100 can cause the oil flowing into conduit 95 to flow into either the conduit 92 or the conduit 93 and accordingly the proper selection of one of the valves 98 or 100 is available for the proper passage of the oil produced from a mixture of charge stocks to be combined with the lower grade oil produced purely from one charge stock.

When there is a switch between a naphthenic charge stock and a paraffinic charge stock, the resulting mixture that is produced in conduit 41 is slop oil. When this mixture is being produced in the conduit 41, the valve 86 will be open so that the mixture flows into conduit 96. Any raffinate produced purely from the naphthenic charge stock or the paraffinic charge stock which is allowed to flow into the conduit 96 and mix with the slop oil therein also becomes slop oil.

Prior to the present invention a substantial amount of oil produced purely from one charge stock became slop oil or was downgraded when charge stocks were switched because it was not known precisely when the mixtures produced from two charge stocks started and stopped flowing in the output conduit from the extraction unit. The valve controls 66 in the system of the present invention automatically open and close the proper valves after a mixture produced from two charge stocks starts flowing in conduit 41 and before the mixture stops flowing in the conduit 41. In this manner the amount of slop oil or downgraded oil produced upon switching charge stocks is greatly reduced.

The specific gravities of the waxy raffinates produced from different types of paraffinic charge stocks and naphthenic charge stocks are different. Thus the mixture that results in conduit 41 from switching charge stocks will have a specific gravity different from that of each of the waxy raffinates produced purely from one of the charge stocks. When the mixture first starts flowing in the conduit 41, the specific gravity sensed by the gravimeter 49 will start to change in a direction toward the specific gravity of the waxy raffinate which will be produced from the new charge stock. The specific gravity will continue to change until it reaches the specific gravity of the waxy raffinate produced purely from the new charge stock, at which time the waxy raffinate in the conduit 41 will be produced purely from the new charge stock. When there is a switch in charge stocks, the operator will condition the temperature controllers 66, 71 and 72 to maintain constant fixed flow rates and the valves 75 and 76 to remain at fixed positions so that the automatic parameter controls 51 will not cause parameter changes in the extraction tower 21 in response to the change in specific gravity that occurs while the mixture is flowing in the conduit 41. Some of the oil produced from a mixture at the beginning or end of the time that it is being produced is pure enough that it doesn't have to be downgraded. Accordingly the valve control 53 open and close the proper valves when the specific gravity has changed a predetermined amount after a switch in charge stocks to direct the downgraded oil or slop oil into the proper conduit and again opens and closes the proper valves when the specific gravity comes within a predetermined amount of the specific gravity of the oil produced purely from the succeeding charge stock.

The valve controls 53, in response to the output signal from the gravimeter 49 changing a predetermined amount, cause a signal to be transmitted from a control panel 101 indicating that there has been a switch from one paraffinic charge stock to another, will open the valve 85 and close whichever one of the valves 82 and 83 was open. As a result, the oil mixture flowing in the conduit 41 will flow through the valve 85 into the conduit 95. Thereafter when the output signal from the
gravitometer 49 reaches a second value a predetermined amount from its new value, the valve controls 53 in response thereto will close the valve 85 and open one of the valves 82 or 83. In this manner, the system automatically sends into the conduit 95 only that oil which is a mixture produced from the two paraffinic charge stocks, and the amount of the downgraded oil produced is thus reduced to a minimum.

The valve controls 53, in response to a signal from the control panel 101 indicating that there has been a switch from a paraffinic charge stock to a naphthenic charge stock, and in response to the signal from the gravitometer 49 indicating that the specific gravity has changed a predetermined amount toward its new value, automatically opens the valve 86 and closes the one of the valves 82 or 83 that is open. Thereafter, in response to the output signal from the gravitometer 49 reaching a value a predetermined amount from its new value, the valve controls 53 will close the valve 86 and open one of the valves 82 or 83. When there is a switch from a naphthenic charge stock to a paraffinic charge stock, the control panel 101 will send a signal indicating this switch to the valve controls 53. The valve controls 53, after receiving this signal from the control panel 101 and in response to the output signal of the gravitometer 49 changing a predetermined amount toward its new value, will close the valve 86 and open one of the valves 82 or 83. Then when the output signal of the gravitometer 49 reaches a value of predetermined amount from its new value, the valve controls 53 will close the valve 86 and open one of the valves 82 or 83. Thus whenever there is a switch in charge stocks between naphthenic oil and paraffinic oil, the valve controls 53 send into the conduit 96 only that oil which is a mixture produced partly from naphthenic charge stock and partly from a paraffinic charge stock, and the amount of the slop oil produced is reduced to a minimum. Thus the valve controls 53 automatically prevent waxy raffinate produced purely from one charge stock from becoming part of the downgraded oil flowing into the conduit 95 or part of the slop oil flowing into the conduit 96.

FIG. 3 illustrates the details of the valve controls 53 and how they perform in response to the signal voltage from the gravitometer 49 and to the signals from the control panel 101. As shown in FIG. 3, the control panel 101 comprises four buttons, 105 through 109, respectively, with the legends PARAFFINIC A to B; PARAFFINIC to PARAFFINIC B to A; NAPHTHENIC TO PARAFFINIC; and PARAFFINIC TO NAPHTHENIC. Under the button 107 with the legend NAPHTHENIC TO PARAFFINIC is a switch 107a having two positions marked A and B. The operator of the unit actuates the appropriate button when a switch in charge stocks is being made. If the switch is between two paraffinic charge stocks and the raffinate is presently flowing into the conduit 92, the operator actuates the button 105 having the legend PARAFFINIC to PARAFFINIC A to B. If the switch is between two paraffinic charge stocks and the raffinate is presently flowing into the conduit 93, the operator actuates the button 106 having with the legend PARAFFINIC to PARAFFINIC B to A. The legend A is thus used to designate the conduit 92 and the legend B is used to designate the conduit 93. The remaining two buttons 107 and 108 are actuated by the operator when the switch is between paraffinic and naphthenic charge stocks. If the switch is form naphthenic to paraffinic, the operator actuates the button 107, and thereby actuating the button 107 also positions the switch in position A or B depending upon whether, the raffinate produced from the paraffinic charge stock is to go to the conduit 92 or 93.

When a switch in charge stocks is made, the operator, in addition to actuating the appropriate button on the selector 101, also sets into comparators 103 and 104 values which represent specific gravities between the specific gravity of the raffinate produced purely from the preceding charge stock and the specific gravity of the raffinate produced purely from the succeeding charge stock. The value set in the comparator 103 will represent a specific gravity nearer that of raffinate produced purely from the preceding charge stock and the value set in the comparator 104 will be nearer that produced purely from that of succeeding charge stock. The value set into the comparator 103 will be sufficiently near the specific gravity of the raffinate produced purely from the preceding charge stock that it can be mixed therewith without deleteriously affecting the lubricating oil product made from the raffinate. Similarly the value set into the comparator 104 is selected to be sufficiently near the specific gravity of the waxy raffinate produced purely from the succeeding charge stock that it can be mixed therewith without deleteriously affecting the properties of the lubricating oil product made from the raffinate. As the specific gravity of the waxy raffinate changes from that of the raffinate produced purely from the preceding charge stock, the output signal of the gravitometer 49 will first pass through the value set in the comparator 103 and then through the value set in the comparator 104. The comparator 103 will produce an output signal when the output signal of the gravitometer passes through the value set therein and the comparator 104 will produce an output signal when the output signal of the gravitometer passes through the value set therein. When there has been a switch from one paraffinic charge stock to another, and the valve 82 is open when the switch is made so that the raffinate from the former charge stock is flowing into the conduit 92, the operator will actuate the button 105 which will apply a signal to the valve controls 53. This signal will enable a selector circuit 109, which also receives the output signals of the comparators 103 and 104. The selector enabling the selector circuit 109 from the button 105 sets a flip-flop 110 in the selector circuit 109. When the flip-flop 110 has been set, it applies an enabling signal to a gate 111 in the selector circuit 109. The gate 111, upon being enabled, will pass any output signal produced by the comparator 103. An output signal from the comparator 103, after passing through the gate 111 is applied to an output line 112 of the selector circuit 109. The signal on line 112 is applied through an OR gate 113 to the O input of a valve operator 114, and through an OR gate 115 to the C input of a valve operator 116. The valve operator 114, in response to receiving a signal at its O input, will open the valve 82. The valve operator 116, in response to receiving a signal applied to its C input, will close the valve 82. Thus the valve controls 53 will automatically open the valve 85 and close the valve 82 when the specific gravity of the oil flowing in conduit 41 passes through the value set in comparator 103. The output signal from the gate 111 also sets a flip-flop 117 in the selector circuit 109. The flip-flop 117 upon being set enables a gate 118 in the selector circuit 109. The gate 118, upon being enabled, will pass to an output line 119 of the selector circuit 109 any output signal from the comparator 104. Such a signal on line 119 will pass through an OR gate 120 to the C input of the valve operator 114, which, in response to this signal, will close the valve 85. The signal on line 119 will also pass through an OR gate 121 to the O input of a valve operator 122 which, in response to receiving a signal at its O input, will open the valve 83. Thus the valve 85 will automatically be switched to flow into the conduit 41 when the specific gravity of the oil flowing in the conduit 41 passes through the value set in comparator 104. Thus when there is a switch from one paraffinic charge stock to another and the waxy raffinate produced from the former paraffinic charge stock is flowing through the valve 82 into the conduit 92, the oil produced in the conduit 41 will automatically be switched to flow into the conduit 95 when the specific gravity of the oil in the conduit 41 passes through the value set in the comparator 105 and...
then will automatically be switched to flow into the conduit 93 when the specific gravity of the oil in the conduit 41 passes through the value set in the comparator 104. The output signal of the comparator 104 passing through gate 118 also resets the flipflops 110 and 117, conditioning the selector circuit 109 to respond to the next signal applied thereto from the control panel 101.

If there is a switch in paraffinic charge stocks and the valve 85 is open so that the waxy raffinate produced from charge stock is flowing into the conduit 93, then the operator will actuate the button 106, which will apply a signal to the selector circuit 123, which in turn will apply a signal to the next circuit as the selector circuit 109. The selector circuit 123, after being enabled by a signal from the button 106, will apply a signal through the OR gate 113 to the O input of the valve operator 114 and through an OR gate 124 to the C input of the valve operator 122 in response to receiving a signal from the comparator 103. The valve operator 114 will accordingly at this time open the valve 85 and the valve operator 122 will close the valve 83. The oil in the conduit 41 will thus be switched from flowing into the conduit 93 to flow into the conduit 95. The selector circuit 123, after these operations have been performed by the valve operators 114 and 122, and in response to receiving a signal from the comparator 104, will then apply a signal through an OR gate 125 to the O input of the valve operator 116 and will apply a signal through the OR gate 120 to the C input of the valve operator 114. Accordingly, the valve operator 114 will close the valve 85 and the valve operator 116 will open the valve 82. Thus the oil in the conduit 41 will be switched from flowing into the conduit 95 to flow into the conduit 92 when the specific gravity thereof passes through the value set in the comparator 104. In this manner, when the charge stock is switched from one paraffinic oil to another, the valve operators are automatically operated so that all of the oil produced purely from one of the paraffinic charge stocks flows into the conduits 72 and 73 and that part of the oil mixture which is to be combined with the lower grade oil produced purely from just one of the charge stocks flows into the conduit 96. In this manner, the amount of downgraded oil when switching from one paraffinic charge stock to another is reduced to a minimum.

When the charge stock is switched from a naphthenic to a paraffinic oil, the operator actuates button 107, which applies a signal to a selector circuit 126, which has the same circuitry as the valve operators 114 and 122 and in response operates in response to the signal applied from the control panel 101 and the output signals of the comparators 103 and 104 in the same manner as the selector circuits 109 and 123. After the selector circuit 126 has been enabled by a signal from the button 107, the selector circuit 126, in response to receiving a signal from the comparator 103, will then apply a signal to the C input of the valve operator 127 and a signal through an OR gate 128 to the O input of a valve operator 129. The valve operator 127, in response to receiving this signal applied to its C input, will close the valve 84 cutting off the flow of oil from the conduit 41 into the conduit 94 and the valve operator 129, in response to receiving this signal applied to its O input, will open the valve 86, thus permitting flow from the conduit 41 into the conduit 96. The selector circuit 126, after performing these actions, is ready to respond to a signal from the comparator 104. When such a signal occurs, the selector circuit 126, in response to such signal, will apply a signal to a pair of gates 130 and 131, and will apply a signal through an OR gate 132 to the C input of the valve operator 129. The valve operator 129, in response to receiving a signal applied to its C input, will close the valve 86, thus cutting off the flow of oil from the conduit 41 into the conduit 96. When there is a change from naphthenic charge stock to paraffinic charge stock, the operator in addition to actuating the button 107, also positions the switch 107a at the position designated A or the position designated B depending upon which of the conduits 92 or 93 is selected for the waxy raffinate to be produced from the paraffinic charge stock. If the conduit 93 is selected, the operator will position the switch 107a at position B, which when applied to the circuit 130, then will apply a signal to the valve operator 129. Then the selector circuit 126 applies a signal to the gate 130 in response to receiving a signal from the comparator 104, it will pass through the gate 130 and through the OR gate 121 to the O input of the valve operator 122, which in response to receiving this signal will open the valve 83, thus permitting oil to flow from the conduit 41 into the conduit 93. If, on the other hand, the conduit 92 is selected for the waxy raffinate to be produced from the paraffinic charge stock, the operator will position the switch 107a, in position A, which will then apply a signal to enable the gate 131. Then when the selector circuit 126 applies a signal to the gate 131 in response to receiving a signal from the comparator 104, it will pass through the enabled gate 131 and through the OR gate 125 to the O input of the valve operator 116, which in response thereto will open the valve 82 permitting oil to flow from the conduit 41 into the conduit 92. Thus, when there is a switch in charge stocks from naphthenic oil to paraffinic oil, the valve 84 and the valve 86 when the specific gravity of the raffinate in the conduit 41 passes through the value set in comparator 103 and then close the valve 86 and open one of the valves 82 or 83 when the specific gravity of the oil in the conduit 41 passes through the value set in comparator 104.

When there is a change in charge stocks from paraffinic to naphthenic oil, the operator will actuate the button 108, which will apply a signal to a selector circuit 133, which also receives the output signals from the comparators 103 and 104 and has the same circuitry as the selector circuits 109, 123, and 126. In response to receiving a signal from the button 108, in response to receiving a signal from the comparator 103 will apply a signal through the OR gates 115 and 124 to the C inputs of the valve operators 116 and 122. Since the switch is from a paraffinic charge stock, one of the valves 82 or 83 will be open so that oil will be flowing from conduit 41 into one of the conduits 92 or 93. If the valve 82 is open, the valve operator 116, in response to receiving a signal applied to its C input, will close the valve 82, and if the valve 83 is open, the valve operator 122, in response to receiving a signal applied to its C input, will close the valve 83. Thus, the flow of oil from the conduits 92 or 93 will be cut off. At the same time the selector circuit 133, in response to receiving the signal from the comparator 103 will apply a signal through the OR gate 128 to the O input of the valve operator 129, which in response thereto will open the valve 86 permitting oil to flow from the conduit 41 into the conduit 96. The selector circuit 133 will then be ready to operate in response to a signal from the comparator 104. In response to receiving such a signal, the selector circuit 133 will apply a signal through the OR gate 132 to the C input of the valve operator 129 and will apply a signal to the O input of the valve operator 131, which is the valve operator 129, in response to receiving a signal applied to its C input, will close the valve 86 thus cutting off the flow of oil from the conduit 41 into the conduit 96, and the valve operator 127, in response to receiving a signal applied to its O input, will open the valve 84, permitting oil to flow from the conduit 41 into the conduit 94. Thus, when the charge stock is switched from paraffinic to naphthenic oil, the oil flowing in the conduit 41 will be automatically cut off from the one of the conduits 92 or 93 into which it is flowing and start flowing into the conduit 96 when the specific gravity of the oil in the conduit 41 passes through the value set in the comparator 103, and then when the specific gravity of the oil in the conduit 41 passes through the value set in the compara-
ator 104, the oil flowing in the conduit 41 will automatically be cut off from the conduit 96 and start flowing into the conduit 94.

Thus, whenever there is a switch in charge stock from paraffinic oil to paraffinic oil or vice versa, all the oil that is produced purely from paraffinic oil flows into one of the conduits 92 or 93, all the oil which is produced purely from naphthenic oil flows into the conduit 94, and the oil which is produced partly from paraffinic and partly from naphthenic oil and which is insufficiently pure to be mixed with the raffinate obtained purely from either the paraffinic or naphthenic charge stocks flows into the conduit 96. In this manner the amount of slop oil that results from switching between paraffinic and naphthenic charge stocks is reduced to a minimum.

A gravitometer 135 senses the specific gravity of the charge stock being fed to the extraction tower 21 and applies a signal representing this specific gravity to a yield calculator 137. The output signal of the gravitometer 49 representing the specific gravity of the waxy raffinate in conduit 41 is also applied to the yield calculator 137. From the applied signals the yield calculator continuously determines yield and performs periodic summation of yield.

The principles of the present invention can be used in an extraction unit which is not automatic. For example, the valves 75, 76 and 82 and the temperature controllers 66, 71 and 72 can be controlled manually in accordance with the specific gravity indicated by the gravitometer 49 instead of being controlled automatically by the parameter controls 51 and the valve controls 53. Instead of obtaining a signal representing the specific gravity of oil flowing into the conduit 41, the system could be operated in response to the refractive index of oil flowing in the conduit 41 or the azeotropic point of the oil flowing in the conduit 41. Both of these properties correlate with the viscosity index of the raffinate after it is dewaxed. The invention is not limited to any specific type of extraction equipment but may be used in conjunction with extraction towers containing nests of packing, towers containing rotating discs and stationary baffles, centrifugal extractors, and mixer settler type extractors. Moreover it may be employed with extraction units using phenol, Duro Sol, propane, sulfur dioxide, nitrobenzene, chloroform, etc. as a solvent instead of furfural. These and many other modifications may be made to the above described specific embodiment without departing from the spirit and scope of the invention, which is defined in the appended claims.

What is claimed is:

1. In a process for producing lubricating oil including an extraction process for producing waxy raffinate which is dewaxed to provide the lubricating oil, the improvement comprising detecting the specific gravity of said waxy raffinate, and controlling at least one parameter of said extraction process to obtain a wax raffinate of a predetermined specific gravity whereby said extraction process is controlled in response to the specific gravity of the waxy raffinate to control the viscosity index of the dewaxed lubricating oil.
2. The improvement in an extraction process as recited in claim 1 wherein the step of changing at least one of the parameters of the extraction process is carried out automatically in response to changes in the specific gravity.
3. In a process as recited in claim 1 the further improvement comprising causing said waxy raffinate to flow in a first path and switching said waxy raffinate from flowing in said first path to flow in a second path when the specific gravity of said waxy raffinate changes a predetermined amount.
4. In a process as recited in claim 1 the further improvement comprising causing said waxy raffinate to flow in a first path, switching said waxy raffinate from flowing in said first path to flow in a second path when the specific gravity of said waxy raffinate changes a first predetermined amount, and then switching said waxy raffinate from flowing in said second path to flow in another path when the specific gravity of said waxy raffinate changes a second predetermined amount.
5. The improvement in an extraction process as recited in claim 1 wherein the step of changing at least one parameter of the extraction process when the specific gravity of said waxy raffinate changes includes changing the temperature at which said extraction process is carried out.
6. The improvement in an extraction process as recited in claim 1 wherein the step of changing at least one parameter of the extraction process when the specific gravity of said waxy raffinate changes includes changing the ratio of solvent to charge stock utilized in the extraction process.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,285,846
November 15, 1966
William H. King et al.

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 2, line 18, for "altomated" read -- automated --; column 5, line 11, after "61" insert a comma; column 6, line 59, for "control" read -- controls --; column 7, line 66, for "form" read -- from --; column 8, line 27, for "passer" read -- passes --; column 9, line 9, after "produced from" insert -- the former --; line 32, for "circuit" read -- conduit --; column 11, line 52, for "reaffinate" read -- raffinate --; column 12, line 4, for "wax reaaffinate" read -- waxy raffinate --; column 12, line 7, for "reaffinate" read -- raffinate --; line 9, for "proces" read -- process --; lines 14 and 15, for "reaffinate", each occurrence, read -- raffinate --; same column 12, line 33, for "proces" read -- process --.

Signed and sealed this 12th day of September 1967.

(SEAL)
Attest:

ERNEST W. SWIDER
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