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[54] CRUDE PETROLEUM TRANSMISSION SYSTEM

4 Claims, 1 Drawing Fig.

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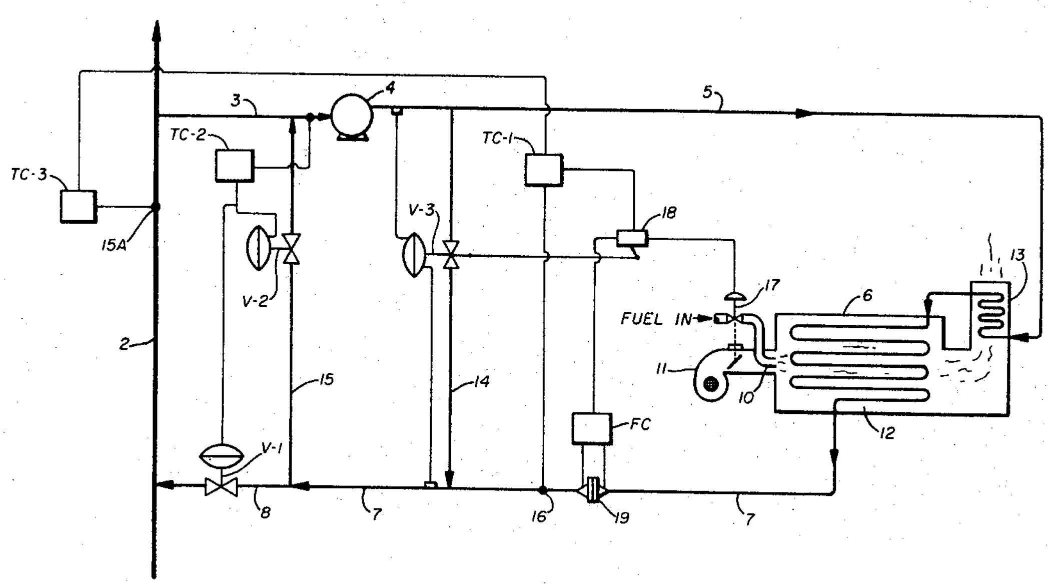
ABSTRACT: A heater having an oil or gas fired burner is shown, tubes are extended through the heater to conduct crude petroleum through the heating zone and lower the viscosity of the petroleum. Conduits connect the heater tubes to a section of transmission line arn are valved to blend the heated petroleum with the petroleum in the line, the resulting mixture being then transmitted a great distance.



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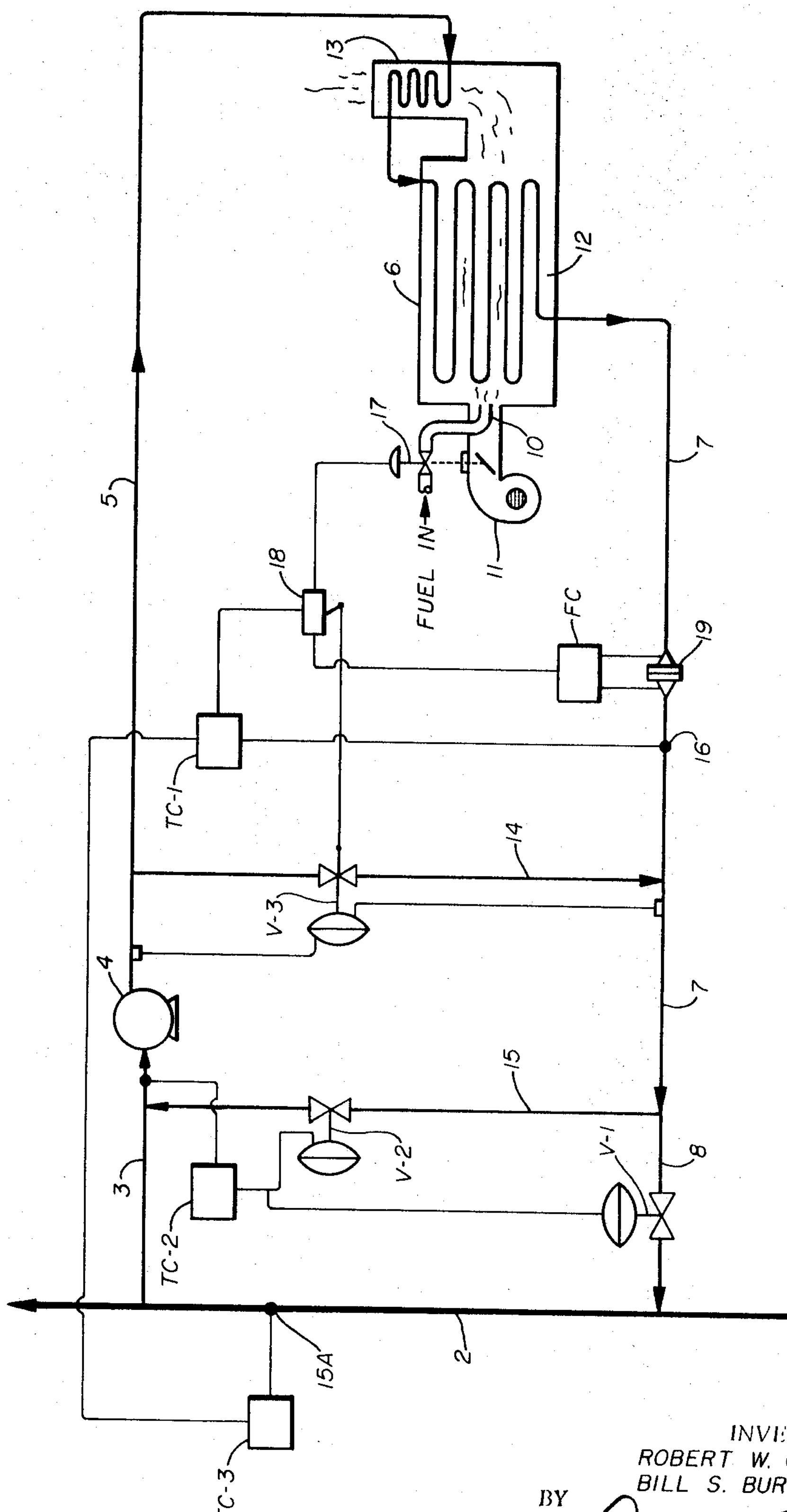

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CRUDE PETROLEUM TRANSMISSION SYSTEM

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to controlled heating to reduce the viscosity of crude petroleum oil in order to facilitate its movement. More particularly, the present invention pertains to apparatus for manipulating fluids in a program of heating and blending which will reduce their viscosity quickly without the overheating which results in petroleum fluids being cracked.

2. Description of the Prior Art

The production of low gravity, high viscosity crude petroleum has always been a problem. Once produced, the transport of this material to the refinery causes a further range of problems to descend.

Generally, a pipeline is favored over trucking in crude transport. It is cheaper. However, the pressure differential required to move low gravity, high viscosity crude through a pipeline has been either too expensive or mechanically impractical.

In general it is an old practice to heat crude fluids to lower their viscosity. Also, in general, it is old to either immerse a fired tube in the fluids or pass the fluids through tubes exposed to products of combustion.

The immersed fired tube is the less attractive choice because of the immediate danger of having coke formed on its surface which will promote the overheating of local wall areas with eventual rupture of the wall. Conducting the fluids through the tubes of a direct fired heater is the selected technique. However, there are several unique and severe problems associated with hating apparatus of this type.

The heated, conducting tubes of the direct fired heater are generally divided into one group in the main body of the heater which absorbs heat of burner combustion by radiation, principally, and a second group in the exhaust stack which absorbs heat by convection, principally. The heat flux (BTU/square foot) on the surface of the tubes must not be so great that heated fluid next the internal wall will crack and coke on the wall surface. The velocity of the heated fluids could be increased to avoid over heating but viscosity becomes a factor in developing an economical limit to the differential pressure required to increase the velocity. Until the viscosity is reduced a predetermined amount, the heat flux must be kept within predetermined limits.

SUMMARY OF THE INVENTION

The present invention contemplates raising the velocity of the heated fluids to a maximum, limited by the economics of differential pressure generation, and firing the burner of the heater within a first low range until the differential pressure reduces a predetermined amount. The viscosity of the fluids will lower as they are heated. Their flow will then change from a laminar form into a turbulent form. One result is a more even distribution of these fluids within their individual tubes. Fewer tube passes will be required in the heater; distribution of the fluids among fewer tube passes will tend to be more even with respect to the heat flux. As the differential pressure reduces to the predetermined minimum amount, the burner is fired within a second high range to reach the temperature ultimately desired for the heated fluids.

The heat input program for the heater shifts the burner operation from a low range to a higher range as quickly as possible. The initial heat output range for the burner keeps the temperature of the discharged flue gases from the stack in, or very close to, the range where corrosive condensation will probably occur. Generally, 400° F. is regarded as the minimum desirable temperature for these flue gases; a lower temperature will result in condensation of liquids containing highly corrosive sulfur compounds. It is desirable that the convection group of the heated tubes be kept in the lower temperature range for as short a time as possible.

The present invention limits the operation of the burner to the low range for as short a time as compatible with the viscosity reduction at the maximum throughput of heated fluids under the available pressure differential. A bypass of the heated tubes is provided to control the differential reducing below a predetermined value. The heating is shifted into a predetermined upper range in order to maintain the maximum heat flux on the tubes at the maximum throughput flow capacity while raising the exhaust temperature of the heater to a range including a minimum of substantially 400° F.

The present invention further contplates a conduit loop including a section of pipeline and a section heated by a source. The heat source is bypassed for the reasons set forth above. The pipeline section is bypassed for the time required to raise the temperature of the fluids to their ultimate desired value. The heat source is operated within a plurality of ranges coordinated with the bypassing of the heat source and the pipeline section to avoid a heat flux which will crack the petroleum fluids heated yet will reach the on-stream condition quickly.

BRIEF DESCRIPTION OF THE DRAWINGS

The drawing is a simple, schematic diagram of a heater with a conduit system between the heater and a section of pipeline including the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The drawing prominently features a pipeline **1** which transports petroleum fluids from a source not shown to a destination also not shown. There are pumps for the pipeline fluids at stations between the source and destination. There is no point in representing such pumps on the drawing. It is sufficient to recognize that they are necessary and that they consume enormous amounts of expensive power in moving petroleum fluids in pipeline **1** when the gravity of the fluids is low and their viscosity high. An embodiment of the present invention will reduce this power and will start up quickly, automatically and with a minimum of attendance.

BASIC CONDUIT LOOP

Apparatus in which invention is embodied is characterized by a conduit for the fluids and which includes a section of pipeline **1**. Pipeline section **2** is to be taken with conduit section **3** forming the input to pump **4**.

The pump **4** delivers fluids to conduit section **5** which forms the input to heater **6**. The heated conduits in heater **6** are the heated section of the loop and from this section the heated fluids are discharged into conduit section **7**.

Conduit section **7** connects to conduit section **8** to deliver heated fluids to pipeline section **2**. The loop is completed for withdrawing fluids from the pipeline **1**, pumping them through heater **6** and delivering them, properly heated, to pipeline **1**. The heated fluids can then mix with the colder fluids of the pipeline to form a mixture having a viscosity which will enable the undisclosed pumps of the pipeline to move the material economically through the pipeline.

GENERAL CONTROL OF HEATER 6

Heater **6** is fired with a burner **10** and supply of combustion air from blower **11**. The firing equipment is contemplated as conventional, burning gas or oil to produce products of combustion for contact with the heated conduit section which extends through heater **6**. The control of fuel and air can be embodied in many different arrangements; a single valve in this disclosure represents all such elements which respond to a control system sensitive to primary elements established in the basic conduit loop.

The input to the heater must be carefully controlled within a plurality of ranges. Ultimately, this heater input is adjusted to maintain a desired temperature for the mixture of fluids in the pipeline section **2**. In approaching this goal, the heater input must be staged and coordinated with bypass programs for the sections of the basic conduit loop to bring the complete system into full, "on-line" operation as quickly and efficiently as possible.

GENERAL PROBLEMS OF HEATER 6

Heater **6**, as a separate structure, is shown as having its burner **10** controlled to produce heat into a radiant section and a convection section. The radiant section **12** is the main body of the heater and the tubes mounted in this section are exposed to principally radiant heat of combustion.

BEfore they reach the radiant section, the fluids to be heated flow through tubes mounted in the exhaust stack of heater **6**. This convection section **13** is exposed to the heat of the combustion which is principally convective. The products of combustion from the burner discharge into the radiant section and then flow through the convection section. The fluids to be heated are first heated in section **13** and then section **12**.

Heaters of the size contemplated for this pipeline heating are expensive. Any reduction in this size is, of course, very desirable. If the basic problems of cracking the fluids heated, distributing the fluids within the heater tubes and corrosion of the heated tube surface can be controlled, the heater will not only resist deterioration, but can be built in smaller sizes than otherwise possible.

The first problem could be considered one of corrosion. The heat extracted from the flue gases should not lower their temperature to the neighborhood of 400° F. At 400° F. and below, condensation of sulfur-bearing compounds becomes a corrosive threat. Certainly the heater **6** should be operated to maintain the flue gas temperature in section **13** within this corrosive range for as short a time as possible.

The second problem considered is the danger of cracking the petroleum fluids heated within the tubes of section **12**. If the heat flux on the tube surface is high enough, and the absorption by the fluids low enough, the thin outer layer of fluids in the tubes will overheat and break down. Turbulence of the fluids heated is the answer.

Heat will destroy laminar flow of low gravity oils by promoting turbulence, resulting in an increase in heat transfer into the fluids. However, this heating and viscosity reduction to obtain turbulence takes a finite period of time. The heat flux must be controlled within a predetermined low range with the fluid flow maintained at a maximum as set by the economically available pressure differential for maintaining flow. Once the differential pressure reduces to a predetermined level, the heat input is shifted into high gear without danger of cracking the fluids and the temperature in the convection section is raised above the condensation level.

HEATER BYPASS OPERATION

On initial startup of the system, the tubes of the heater **6** will offer a tremendous resistance to the flow of fluid. Pump **4** will develop a differential pressure between conduit section **5** and conduit section **7** which causes the flow. This differential is controlled by extending a bypass conduit **14** between conduit section **5** and conduit section **7** with a valve V–3 regulating flow and responsive to the differential pressure.

Flow is established through the heated tubes in heater **6** under the differential pressure set by The remainder of the output of pump **4** is shuttled around the heater, through bypass conduit **14**.

As heat is added to the production fluids the differential pressure begins to reduce. Less fluids are bypassed until valve V—3 closes. Thereafter, all the pumped fluids flow through heater **6**.

PIPELINE SECTION BYPASS

The bypass of heater **6** controls the differential pressure across the heater while the viscosity of the heated fluids reduces and generates turbulence in the fluids being heated. Until this viscosity is lowered, turbulence generated and the temperature level raised a significant amount, the fluids in the conduit loop are not properly prepared for introduction into the pipeline **1**.

The heating and recirculation with bypasses, are brought about in overlapping stages. First, the heater bypass is operated as set forth. Next, the pipeline section **2** is bypassed, then gradually fed heated fluids until the viscosity of the pipeline **1** fluids is under control. Bypass conduit **15** is connected between conduit section **7** and conduit section **3** to form the basic conduit loop into a reservoir of heated fluids from which the fluids can be blended into the cold fluids of pipeline section **2** in a desired program.

Valve V–2 regulates the flow in bypass conduit **15** and valve V–1 regulates the flow in conduit section **8**. As one valve opens the other closes, thereby determining how much of the heated fluids flow into pipeline section **2**. In general, the valves are arranged responsive to the temperature of all heated fluids pumped through the loop. As this temperature approaches a desired value, valves V–1 and V–2 open and close to inject more the heated fluids into pipeline section **2**.

SUMMATION OF FLOW PATTERN IN THE LOOP

The overall purpose of heating the basic conduit loop is to provide a source of heated fluids which can be fed into a pipeline to control the viscosity of the pipeline fluids into an economic pumping range. Once "on-stream" this system is easily understood. Fluids are continually withdrawn, heated and fed back into the pipeline upstream of the draw-off point. The heating of the side stream is regulated from the temperature attained in the pipeline. What is not obvious, and readily understood, is the internal workings of the heated basic conduit loop upon startup and when there is a change in the viscosity of the material in the pipeline.

At startup, the conditions met by the system are severe. The entire loop is charged with the fluids of the pipeline. They lack the desired characteristics for pumping or heating. A large amount of heat must be introduced, but the low heat conductivity of such fluids necessitates that this heat must be added at a lower than what might be regarded as a normal rate in order to avoid extreme temperature differences across their contact surface with the products of combustion in the heater.

Heat is needed to break up the laminar flow of these fluids with turbulence which will increase the absorption of heat by the fluids and reduce the pressure drop required to move the fluids.

To speed the development of turbulence in the fluids they are heated in a recirculation circuit of the loop which is isolated from the pipeline. Bypass conduit **15** completes the recirculation circuit with sections **5** and **7**. Within this recirculation circuit a bypass is maintained with conduit **14** while the fluids are heating to a predetermined viscosity.

HEATING CONTROL

The eventual, on-line, control of the firing of burner **10** is set by the temperature of the fluids in pipeline section **2**. A primary element **15A** is placed in section **2** and in contact with these fluids. TC–3 is connected to **15A** as an instrument which develops a control signal which can be sent some distance. TC–1 receives the TC–3 signal and modifies it by a signal generated by a temperature sensitive primary element at **16**. This modified control signal is applied to combustion control valve **17** when selected by switch **18**.

Switch **18** receives the modified temperature signal from TC–1 as well as a signal representative of flow in conduit section **7**. Switch **18** is shown as mechanically actuated by valve V–3 so that the operation of combustion valve **17** is placed under either the influence of fluid flow from heater **6** or the temperatures of the fluids heated by the heater.

The startup control of the system can now be more comprehensively analyzed. As explained heretofore, the differential across the heater **6** keeps valve V–3 open a first. When open, valve V–3 positions switch **18** to apply the output of FC to combustion valve **17** while the heater is partially bypassed through valve V–3. At such period, the heat input is logically geared to the actual flow of fluid through the heater. Orifice **19** sets the output signal of FC and the heat is matched to the amount of medium absorbing the heat.

Once valve V–3 has closed (the differential has decreased below a predetermined value) the system is shifted to temperature control. The temperature at **15A** is the final guide. However, the temperature at **16** is an important immediate guide to the operation of heater **6**. This temperature at **16** must not exceed a predetermined maximum, regardless of the ultimate temperature condition of **15A**. Therefore, the signal from **16** is led to TC–**1** to modify the TC–**3** (**15A**) signal if necessary to control the temperature of the fluids from heater **6**.

CONCLUSION

When designed under the concepts of the present invention, the pipeline heater **6** is an efficient, compact direct fired heater. Staged heating, with bypassing, enables the heater to bring low gravity, high viscosity oil up to temperature with the minimum number of heated tube passes.

Not only does the improved distribution of heated oil in the tube passes enable the heater size to be reduced, but the exhaust gas temperature remains in the corrosive range for the minimum time. Finally, the control of the combustion and flow pattern minimizes the danger from coking of overheated oil.

The storage of properly heated oil in the loop is fed into the pipeline as rapidly as feasible, under the guidance from the temperature attained by the fluids in the conduit. The combustion control is shifted from one range to another under indices which protect the heater and ultimately reflect the temperature of the pipeline fluids which are pumped great distances.

The system is simple enough to be readily automated for remote monitoring and adjustment. Temporary shutdowns are followed by smooth startups which bring the pipeline up to full operation in a minimum time with inexpensive equipment.

From the foregoing it will be seen that this invention is one well adapted to attain all of the ends and objects hereinabove set forth, together with other advantages which are obvious and which are inherent to the apparatus.

It will be understood that certain features and subcombinations are of utility and may be employed without reference to other features and subcombinations. This is contemplated by and is within the scope of the invention.

As many possible embodiments may be made of the invention without departing from the scope thereof, it is to be understood that all matter set forth above, or shown in the accompanying drawings is to be interpreted as illustrative and not in a limiting sense.

The invention having been described, what is claimed is:

1. A system for controlling the combustion of a direct fired heater for fluids circulated through tube passes in the heater so as to be exposed to products of combustion, including,
a bypass conduit connected across the heater to bypass fluid around the tube passes of the heater,
a valve in the bypass conduit connected to respond to the differential pressure across the heater tube passes,
means responsive to the flow of fluids through the passes,
means responsive to the temperature of the fluids heated in the passes.
a combustion control system for the heater,
and means connected to the valve to select when the flow responsive mean will be connected to the combustion control system and when the means responsive to the temperature of the fluids heated with be connected to the combustion control system,
whereby, when the heater is started and the valve is open the flow of fluids through the passes regulates the combustion over a first range of operation and when the valve is closed the temperature of the fluids regulates the combustion over a second range of operation.

2. The system of claim **1** wherein,
the fluid heated to blended into a larger body of unheated fluid to form a mixture,
a means responsive to the temperature of the blended fluid mixture generates a control signal,
and the means responsive to the temperature of the fluid heated in the tube passes is connected to modify the control signal of the blended fluid mixture temperature to control the combustion in the heater as the alternate to control by the flow-responsive means.

3. A system for controlling the viscosity of oil well production fluids transported through a pipeline conduit, including,
a loop connected to the conduit at two spaced-apart points and through which a portion of the fluids transported through the conduit are diverted,
a pump included in the loop to force the fluids diverted from the conduit through the loop,
means for heating the fluids flowing through the loop, the means occupying a predetermined portion of the loop and removed from the segment of pipeline conduit defined by its two points of connection with the loop,
a first bypass conduit connecting a point in the loop downstream of the heating means with a point in the loop upstream of the heating means whereby a portion of the heated fluids in the loop may be recirculated,
a valve located in the loop,
means responsive to the temperature of the fluids flowing in the loop, the temperature responsive means located in the loop and connected to the valve so as to control which portion of the heated fluids is recirculated in the loop and which portion of the heated fluids is blended with the fluids being transported through the pipeline conduit,
means in the loop responsive to the flow rate of fluids through the heater passes,
and switching means connected to the flow rate responsive means and the vale of the second bypass conduit to select when the flow responsive means will be connected to a combustion control system of the heater and when the valve of the second bypass conduit will be connected to the combustion control system,
whereby when the heater is started and the valve of the second bypass conduit is open, the heat output of the heating means is established at a predetermined maximum by the flow-responsive means.

4. The system of claim **3**, including,
temperature-responsive means responsive to a combination of the temperature of the fluids in the pipeline conduit at a point downstream of the point at which heated products of the loop are blended into the pipeline conduit and the temperature of fluid in the loop, and connected to the combustion control system through the switching means to regulate the heat output of the heating means when the valve in the second bypass conduit is closed.

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