

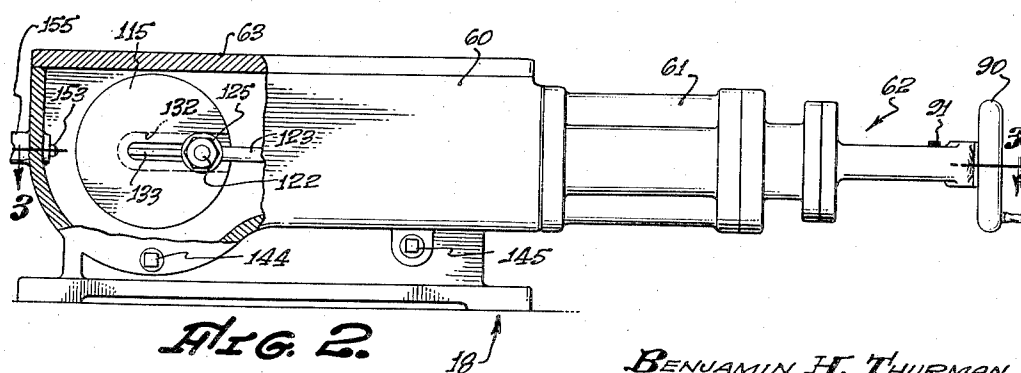
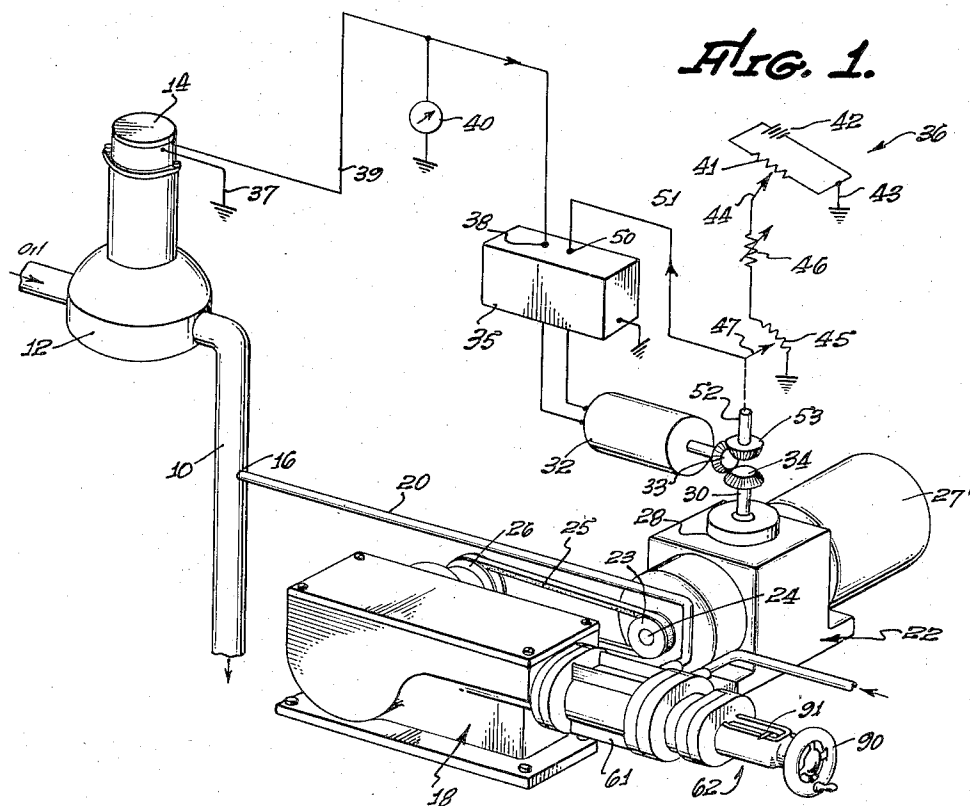
Dec. 9, 1958

B. H. THURMAN
PROPORTIONER

2,863,471

Filed Oct. 11, 1955

2 Sheets-Sheet 1



BENJAMIN H. THURMAN,
INVENTOR.

BY HIS ATTORNEYS.

HARRIS, KIECH, FOSTER & HARRIS.

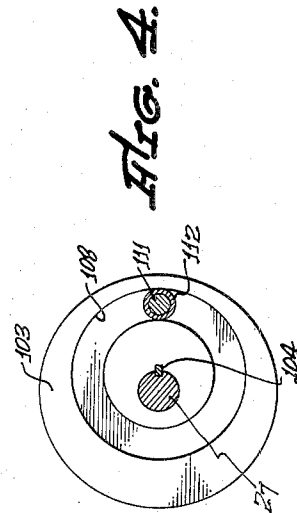
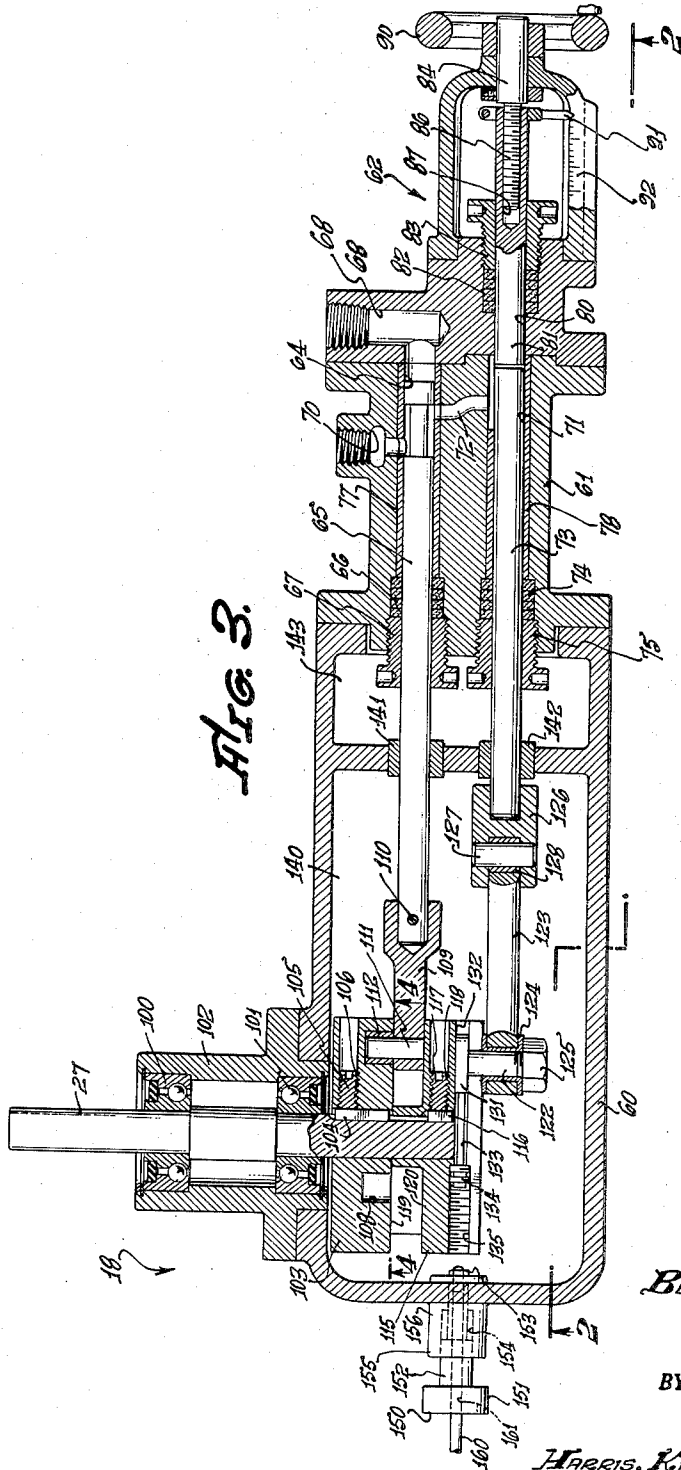
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PROPORTIONER

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Application October 11, 1955, Serial No. 539,780

4 Claims. (Cl. 137—101.21)

This invention relates to a proportioner including a pump and associated control apparatus for mixing two fluids in a fixed ratio when this fixed ratio is an extremely small figure.

In a number of present-day oil refining processes, successful refining operation is dependent upon the addition of extremely small and critical amounts of reagent to the crude oil. This is especially so in the refining of vegetable oils, as when employing alkali refining or re-refining agents in critical proportions. In such processes, the required amount of reagent will be in the range of $\frac{1}{2}$ to 5% of the oil and it is necessary to maintain the particular ratio to a maximum variation of less than 5%.

Accordingly, it is an object of the invention to provide a proportioner which will pump a stream of reagent into a continuous flow of oil and maintain the proportion of reagent and crude oil substantially constant. Another object of the invention is to provide such a proportioner in which the ratio of reagent to oil may be varied over the range as wide as 1:20 to 1:200.

Another object of the invention is to provide a proportioner having a reagent pump or minor-stream pump operated by a variable speed drive which is controlled by the difference between a preset quantity and a second quantity which is a function of the flow of oil or other major stream. A further object of the invention is to provide such a proportioner in which the proportioning ratio may be adjusted by changing the preset quantity and by changing the stroke of the pump.

The invention also comprises novel details of construction and novel combinations and arrangements of parts which will more fully appear in the course of the following description. However, the drawings merely show and the description merely describes a preferred embodiment of the present invention, which is given by way of illustration or example.

In the drawings:

Fig. 1 is a schematic diagram of a proportioner embodying the features of the invention;

Fig. 2 is a side view shown partially in section of the pump of Fig. 1;

Fig. 3 is an enlarged sectional view taken along the line 3—3 of Fig. 2; and

Fig. 4 is a partial sectional view taken along the line 4—4 of Fig. 3.

The crude oil being refined in the apparatus of Fig. 1 is transported through a pipe line 10 having a flow meter 12 inserted therein. A signal generator 14 which may be of the electrical tachometer type is mounted on the flow meter 12 and coupled thereto, the tachometer producing an electrical output which is a function of the rate of flow of the crude oil through the pipe 10. Reagent is introduced and mixed with the oil in the pipe 10 at a junction 16 therein, the reagent being supplied to the junction by a pump 18 through a small pipe 20. The pump 18 is preferably of the positive displacement or piston type so that reagent will be pumped through the pipe 20 at a fixed rate, this rate being a function of the

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cylinder volume, the length of stroke of the pump and the number of strokes per unit of time. The pump 18 is driven by a variable speed drive 22 through a sprocket 23 mounted on an output shaft 24 of the variable speed drive, a chain 25 and a second sprocket 26 mounted on a drive shaft 27 of the pump 18. The output shaft 24 of the variable speed drive 22 is driven by an electric motor 27' through a speed changing transmission 28, of the variable speed drive 22. The transmission ratio is infinitely adjustable by turning a shaft 30.

The variable speed drive output is varied in speed by a reversible control motor 32 coupled to the shaft 30 through the second of a pair of bevel gears 33, 34, the motor 32 being driven by the output from a differential amplifier 35. The differential amplifier functions as a comparison unit producing an output signal for controlling the control motor 32 when input signals to the amplifier from the generator 14 and a reference signal source 36 are not equal. One terminal of the electrical output from the generator 14 is connected to circuit ground by a conductor 37, the other terminal of the output being connected to an input terminal 38 of the differential amplifier 35 by a conductor 39. A meter 40 is connected across the output of the generator 14 to provide a visual indication of the rate of flow of crude oil.

The reference signal source 36 includes a potentiometer 41 connected across a fixed potential source such as a battery 42, one junction point between the potentiometer 41 and the battery 42 being connected to circuit ground at point 43. A moving arm 44 of the potentiometer 41 is connected to one end of the resistance winding of a second potentiometer 45 through a variable resistance 46, the other end of the winding of the potentiometer 45 being connected to circuit ground. A moving arm 47 of the potentiometer 45 is electrically connected to an input terminal 50 of the differential amplifier 35 through a conductor 51, the moving arm 47 being mechanically coupled to the control motor 32 by a shaft 52 and bevel gear 53.

The pump 18 includes a main housing 60, a cylinder block 61, a cylinder head assembly 62, and a cover plate 63 for the main housing. The cylinder block 61 includes a first chamber 64 having a valve piston 65 therein, one end of the chamber 64 being closed by packing 66 and a locknut 67, the valve piston 65 sliding through the packing in the locknut. The other end of the chamber 64 communicates with a reagent inlet passage 68 in the cylinder head assembly 62, a reagent outlet passage 70 being provided in a wall of the chamber 64. A second chamber 71 is provided in the cylinder block 61 having its longitudinal axis parallel to the longitudinal axis of the chamber 64, the two chambers being interconnected by a passage 72. A pump piston 73 is positioned in the chamber 71, one end of the chamber being closed by packing 74 and a locknut 75, the pump piston 73 passing through the packing and locknut. The chambers 64 and 71 are provided with linings 77 and 78, respectively, composed of Nylatron, a nylon and molybdenum sulphite compound having very high antifriction properties.

A chamber 80 in alignment with the chamber 71 is provided in the cylinder head assembly 62, a control piston 81 being positioned in the chamber 80 and passing through packing 82 and a locknut 83 which enclose one end of the chamber 80. A shaft 84 rotatably mounted in the cylinder head has a threaded section 86 at one end thereof engaging a mating threaded opening 87 in an end of the control piston 81. The shaft 84 may be rotated manually by a handwheel 90 mounted thereon, the rotation of the shaft 84 causing the control piston 81 to move relative to the aligned chambers 71 and 80. A pointer 91, mounted on the control piston 81, traverses

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a scale 92, thereby indicating the relative position of the piston 81 in the chambers 71 and 80.

The shaft 27 rotates in a pair of bearings 100, 101 mounted in a bearing boss 102 extending from a side of the main housing 60. A plate 103 is mounted on the shaft 27 within the housing 60 by a key 104, the components being held in place by a setscrew 105 inserted in a threaded opening 106 in the plate 103. An eccentric groove 108 in a face 119 of the plate 103 provides a reciprocating drive for the valve piston 65, the valve piston being coupled to the groove by an arm 109 which is attached to the piston by a pin 110 and engages the groove 108 with a pin 111, the pin 111 having an anti-friction bushing 112 thereon.

The plate 115 is mounted on the shaft 27 by a key 116 and a setscrew 117, the setscrew being inserted in a threaded opening 118 in the plate 115. The plates 103 and 115 have parallel surfaces 119 and 120, respectively, the groove formed by these two parallel surfaces acting as a guide for the arm 109 and maintaining the crankpin 111 in engagement with the cam groove 108. A crankpin 122 is slidably mounted in the plate 115, a connecting rod 123 having a bushing 124 on one end thereof being clamped on the crankpin 122 by a retaining nut 125. The other end of the connecting rod 123 is pivotally mounted in a sleeve 126 on a pin 127 and a bushing 128, one end of the pump piston 73 also being fixed in the sleeve 126 by a suitable means such as a pin, not shown.

An enlarged head section 131 of the crankpin 122 rides in a T-shaped slot 132 in the plate 115, the clamping nut 125 maintaining the pin fixed in any predetermined position with respect to the plate. A shaft 133 having a threaded portion 134 at one end thereof is positioned in a threaded opening 135 colinear with the T-shaped slot 132. The end of the shaft 133 opposite the threaded portion 134 is rotatably fixed to the head 131 of the crankpin 122 so that rotation of the shaft 131 will move the crankpin 122 in the slot 132 when the retaining nut 125 is loosened.

All of the rotating parts of the pump are positioned in a large chamber 140 in the main housing 60, this chamber being filled with a lubricating oil. The valve piston 65 and the pump piston 73 pass from the large chamber 140 through support bushings 141 and 142, respectively, into a small chamber 143 of the main housing 60 and then into the cylinder block 61. The small chamber 143 does not contain any oil and serves as a trap to prevent lubricating oil which leaks from the large chamber 140 from getting into the cylinder block 61 and also prevents any crude oil which gets through the packing 66 and 74 from contaminating the lubricating oil. Drain plugs 144 and 145 are provided at lower portions of the chambers 140 and 143, respectively.

Means are provided in the pump housing 60 for adjusting the length of stroke of the pump piston 73 by rotation of the shaft 133. An alignment knob 150 having three cylindrical surfaces, 151, 152 and 153, of progressively decreasing diameters is slidably positioned in an opening 154 in a boss 155 on the pump housing 60. A spring 156 urges the alignment knob outward from the pump housing 60. An adjustment tool 160 is slidably positioned in an opening 161 through the alignment knob 150, the end of the adjustment tool 160 being adapted to engage the threaded end 134 of the shaft 133 in driving relationship.

In the embodiment of the invention described above, the amount of reagent being mixed with a crude oil may be controlled by varying the number of pump strokes per unit of time and by varying the length of stroke of the pump piston. Hence, it would be possible to provide the proper amount of reagent for any desired ratio of reagent to crude oil by varying the transmission ratio in the variable speed drive to control the number of strokes per unit of time; but this method is not practical for very small ratios since at a low rate of

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strokes per unit of time the reagent is not mixed uniformly with the crude oil, the reagent appearing at the mixing point 16 in discrete units so that one portion of the crude oil receives entirely too much reagent and the following portion receives none. In the operation of the invention, the length of stroke of the pump piston is adjusted to give the desired amount of reagent based on the average rate of flow of the crude oil with an optimum number of strokes per unit of time so that under these conditions the reagent arrives at the mixing point in a substantially steady stream.

This adjustment is made by first rotating the shaft 27 to the position shown in Fig. 3 where the pump piston 73 is at its most extended position. A ratchet coupling may be provided between the sprocket 26 and the shaft 27 so that the shaft 27 can be rotated counter to its normal direction of rotation to enable this alignment to be easily accomplished. When the shaft 27 is in the correct position, the alignment knob 150 may be pressed into the housing 60 and the cylindrical surface 153 will engage the opening 135. The nut 125 is loosened and the tool 160 may be used to rotate the shaft 131 to move the crankpin 122 in the slot 132. The exact position of the pump piston 73 may be determined by moving the control piston 81 to engage the pump piston 73 and noting the pointer indication on the scale 92. This control of the position of the control piston 81 also permits the volume of the pump piston chamber 71 to be accurately adjusted.

With the stroke of the pump set at a particular value, the ratio of reagent to crude oil may be varied by changing the reference voltage supplied to the terminal 50 of the differential amplifier. The potentiometer 41 may be used as a ratio setting control with the variable resistor 46 serving as a calibration adjustment for the ratio setting control. With the length of stroke set at a known value and the ratio potentiometer set at a known value, the calibration control is adjusted to give a desired ratio of reagent to crude oil. Then, while the system is in operation, the ratio of reagent to crude oil may be changed by changing the setting of the ratio potentiometer 41 without having to shut down the proportioning operation.

After the system has been adjusted to give the desired proportion of reagent and crude oil, this proportion will be maintained automatically although the rate of flow of crude oil through the pipe 10 varies. The voltage produced by the generator 14 and appearing at the terminal 38 of the differential amplifier will be the same as the voltage produced by the reference voltage source 36 appearing at the terminal 50 of the differential amplifier when the rate of flow of oil through the pipe 10 is at a particular value. Under these conditions, the output of the differential amplifier to the control motor 32 will be zero. If the rate of flow of crude oil increases for any reason whatever, the voltage output from the generator 14 will also increase, thereby creating a difference between the signals appearing at the terminals 38 and 50. The resulting output from the differential amplifier will drive the control motor 32 to vary the speed changing transmission 28 and increase the number of strokes per unit time of the pump 18. The control motor 32 will continue to run, increasing the pump output until the voltages appearing at terminals 38 and 50 are again equal. The control motor 32 also drives the arm 47 of the potentiometer 45 through the shaft 52 and gear 53 to increase the voltage appearing at the terminal 50. When the voltage at terminal 50 has been increased to correspond to the voltage at the terminal 38, the control motor will stop, leaving the pump operating at the increased number of strokes per unit time with the ratio of reagent to crude oil being the same as before the rate of flow of crude oil increased because of the corresponding increase in the amount of reagent supplied to the mixing point 16. When the rate of flow of crude oil changes again, either increasing or decreasing, corresponding changes in the rate

of flow of reagent are accomplished as described above, maintaining the ratio of reagent to crude oil constant.

Commercial equipment embodying the features of the invention has been produced which will mix a reagent with a crude oil over the range of $\frac{1}{2}$ to 5% of reagent to crude oil, and with fluctuations in the particular ratio held to less than plus or minus 2%. Thus, it is seen that the novel features of the invention are capable of mixing a very small amount of one liquid with a very large amount of a second liquid in a continuous process while maintaining the particular proportion of the two liquids substantially constant. The particular proportion of liquids may be changed a small amount by varying the ratio set potentiometer, and may be changed a large amount by changing the length of stroke of the pump, thus permitting variation of the operating ratio over a range of 10 to 1.

Although an exemplary embodiment of the invention has been disclosed and discussed, it will be understood that other applications of the invention are possible and that the embodiment disclosed may be subjected to various changes, modifications and substitutions without necessarily departing from the spirit of the invention.

I claim as my invention:

1. In an apparatus for mixing a first fluid with a second fluid in a fixed small proportion while the rate of flow of the second fluid varies between zero and a maximum, the combination of: a meter for measuring the rate of flow of the second fluid, said meter including means for producing a metering signal that is a function of the flow rate; a reference signal source producing a reference signal; a comparison unit; means coupling said signals to said comparison unit, said comparison unit including means for producing a control signal which is a function of the difference between said metering signal and said reference signal; a variable output power unit actuated by said control signal to vary the output of said power unit between zero and a maximum; pump means for producing a flow of a small quantity of the first fluid; means connecting said power unit to said pump means in driving relationship; and means connecting said power unit to said reference signal source, said means varying said reference signal as the output of said power unit varies.

2. In an apparatus for mixing a first fluid with a second fluid in a fixed small proportion while the rate of flow of the second fluid varies between zero and a maximum, the combination of: a flow meter having an electrical generator actuated by the flow of fluid through said flow meter; pipe means for directing flow of the second fluid through said flow meter; a source of constant voltage; control means connected to said source for selecting a desired portion of said voltage; a differential amplifier; circuit means connecting the outputs of said generator and said control means to said differential amplifier; a power motor; a control motor; a positive displacement pump; a variable speed transmission having a power input, a control input and a power output, said power motor being connected to said power input, said control motor being connected to said control input to vary the magnitude of said power output between zero and a maxi-

mum, and said power output being connected to said pump; and conductors connecting the output of said differential amplifier to said control motor in controlling relationship.

3. In an apparatus for delivering a substantially continuous stream of reagent to a flowing stream of oil and automatically maintaining the ratio of reagent to oil substantially constant, said ratio being very small and adjustable over a wide range, the combination of: flow means for measuring the rate of flow of the oil; first signal generating means coupled to said flow means and producing a flow rate signal which is a function of the rate of flow of the oil; second signal generating means producing a reference signal, said second signal generating means being variable; signal comparison means; circuit means coupling said first and second signal generating means to said signal comparison means, said signal comparison means producing a control signal which is a function of the difference between said flow rate signal and said reference signal; a variable speed transmission having a constant speed input, a control input, and a variable speed output; motor means coupled intermediate said signal comparison means and said control input, said motor means being actuated by said control signal to adjust said variable speed output; means connecting said motor means to said second signal generating means to vary said reference signal; means for manually varying said reference signal independently of said motor means providing a continuous external control of said ratio; and a positive displacement pump driven by said variable speed output, said pump including reciprocating valve means for controlling flow of reagent to and from said pump, means for varying the stroke of said pump, and means for varying the cylinder volume of said pump.

4. In a proportioner, the combination of: a flow meter; an electrical generator coupled to said flow meter; a source of constant voltage; voltage divider means; variable resistance means interconnecting said source of constant voltage and said voltage divider means; a differential amplifier; circuit means connecting said electrical generator and said voltage divider means to said differential amplifier; a variable speed drive having an output variable between zero and a maximum; a control motor interconnecting said differential amplifier and said variable speed drive, said control motor adjusting the output of said drive as a function of the output of said differential amplifier; shaft means coupling said control motor to said voltage divider means; a positive displacement pump; means for adjusting the output per stroke of said pump; and means coupling said variable speed drive to said pump in driving relationship.

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