

[54] CONTROLLING APPARATUS AND METHOD

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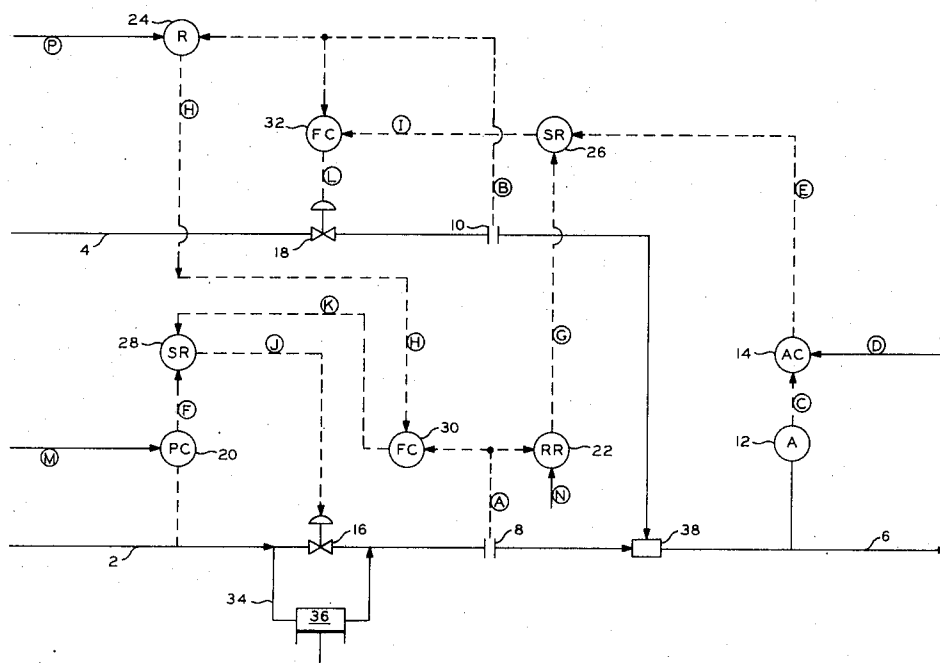
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[57] ABSTRACT

This invention resides in a method and apparatus for controlling the flow of first and second fluid streams together to form a composite stream having a preselected composition range. Said composition range is maintained by the controlling apparatus and method during fluctuation of the supply of one or both of said fluid streams.

10 Claims, 1 Drawing Figure



CONTROLLING APPARATUS AND METHOD

It is often desirable to provide apparatus and method for controlling the flow rates of first and second fluid streams for providing a composite stream having preselected properties. An example of where such control is desirable is in the blending of air with a hydrocarbon fuel gas to lower the calorific value of the resulting blend and maintain said calorific value in a preselected range during fluctuations in the supply of one or both of the gases. It should be understood, however, that the apparatus and method of this invention can be used in controlling the blending of many materials in a wide variety of applications for providing a composite stream having certain preselected properties.

Other aspects, objects, and advantages of the present invention will become apparent from a study of the disclosure, the appended claims, and the drawing.

The drawing is a diagrammatic view of the first stream, the second stream, the composite stream, and the controlling equipment associated therewith.

Referring to the drawing, first and second fluid streams 2, 4 are joined one with the other to form a composite stream 6. A first flow measuring element 8 and a second flow measuring element 10, such as for example conventional orifice meter runs, are associated with their respective first and second fluid streams 2, 4 for measuring the flow rates of the streams. The first flow measuring element 8 delivers a signal A representative of the measured flow rate of the first stream 2 and the second flow measuring element 10 delivers a signal B representative of the measured flow rate of the second stream 4.

It is preferred in this invention that the signals delivered by the various apparatus described herein be pneumatic signals for providing a controlling system that is easy to install and maintain, is of quick response and provides safety with simple construction. The controls can however be electrical, electronic or other types. It is also preferred that the various functions of the apparatus be performed continuously by analog apparatus, but it is within the scope of this invention that said functions such as measurements, signal deliveries, signal comparisons, analyses, etc., or a portion thereof can be conducted intermittently, such as by direct digital control, as opposed to continuously.

An analyzing element 12 is associated with the composite stream 6 for measuring at least one constituent of said composite stream and delivering a signal C representative of the concentration of said constituent. The type of analyzer utilized is dependent upon the type of first and second streams desired to be mixed one with the other to form the composite stream and the property of the composite stream that is desired to be maintained within the preselected range. Where the first stream 2 is a hydrocarbon fuel gas and the second stream 4 is air and the calorific value of the composite stream is desired to be maintained within a preselected range, for example, it is then preferred that the analyzer 12 be a paramagnetic oxygen analyzer such as manufactured by Hays Corporation, Michigan City, Indiana, adapted to deliver a signal representative of the concentration of oxygen contained in the composite stream 6. One skilled in the art after studying the construction and method of the invention can determine the particular analyzer and signal for the constituent he desires to control.

A controller 14 having a set point D is available from many manufacturers such as The Foxboro Co., Foxboro, Massachusetts and Sybron Corporation, Taylor Instrument Process Control Division, Rochester, New York, and is connected to the analyzing element 12 for receiving the signal C therefrom, comparing said signal C to its set point D and delivering a signal E responsive to the difference between the set point D and the signal C.

A first process control valve 16 is provided in the first stream 2 for regulating the flow rate of the first stream 2 in response to a hereinafter-described signal J. A second control valve 18 is positioned in the second stream 4 for regulating the flow rate of the second stream 4 in response to a hereinafter-described signal L.

A pressure control means 20 having a set point M, such as is commercially available, is associated with the first stream 2 at a location upstream of the first control valve 16 for measuring the supply pressure of the first stream 2, comparing said measurement to its set point M, and delivering a signal F responsive to the difference between the set point value and the pressure measurement of the first stream 2.

A first ratio relay 22 having a set point N is connected to the first flow measuring element 8 for receiving the signal A therefrom, multiplying said signal A by its set point N, and delivering a signal G representative of said product of multiplication. A second ratio relay 24 having a set point P is connected to the second flow measuring element 10 for receiving the signal B therefrom, dividing said signal B by its set point P, and delivering a signal H representative of said quotient of division. The first ratio relay 22 can be, for example, Foxboro Series 556-8-80 Ratio Computing Relay available from The Foxboro Co., Foxboro, Massachusetts. The second ratio relay 24 can be, for example, Foxboro Series 556-9-80 Ratio Computing Relay.

It should also be understood that in the specific example of this controlled blending process, the division or multiplication performed by these ratio relays 22, 24 can utilize set points P and N calibrated in terms of air-to-gas ratio or percent air (or oxygen) as desired in blended stream 6. The signal G delivered from the first ratio relay 22 is therefore responsive to the requirements of the first stream 2, and the signal H delivered from the second ratio relay 24 is therefore responsive to the requirements of the second stream 4.

The first selective relay 26 is connected to the first ratio relay 22 and the controller 14 for receiving signals G and E therefrom, comparing said signals G and E one to the other, and delivering a signal I representative of the lower one of said signals G and E.

A first flow controller 30 is connected to the second ratio relay 24 and the first flow measuring element 8 for receiving signals H and A therefrom, comparing signals H and A one to the other, and delivering a signal K responsive to the difference between signals H and A to the second selective relay 28. The second selective relay 28 is connected to the first flow controller 30, and to the pressure controller 20, for receiving signals K and F, comparing signals K and F one to the other, and, in response to the comparison, delivering the higher of said signals as signal J to the valve for controlling the flow rate of the first stream 2 relative to one of the flow

rate of the second fluid stream 4 or the supply pressure of said first stream 2. A second flow controller 32 is connected to the first selective relay 26 and the second flow measuring element 10 for receiving signals I and B therefrom, comparing I and B one to the other, and delivering a signal L responsive to the difference between signals I and B to the second control valve 18 for controlling the flow rate of the second fluid stream 4 relative to one of the flow rate of the first stream 2 or the analysis of the composite stream 6.

The first and second flow controllers 30, 32 are available from many manufacturers, such as The Foxboro Co., Foxboro, Massachusetts, and Sybron Corporation, Taylor Instrument Process Control Division, Rochester, New York. Control valves 16, 18 are likewise available from many manufacturers and in the specific example described are desirably of the normally closed (pneumatic pressure opens) type. The selective relays 26, 28 can be respectively, for example, Moore Products Selective Relays Model 61F for low signal pressure selection and Model 58S for high signal pressure selection. Both are made by Moore Products Company, Spring House, Pa.

A conduit loop 34 is provided with said loop being in communication with the first fluid stream 2 on opposed sides of the first control valve 16 and with said loop 34 having a compressor 36 therein for increasing the pressure of said first fluid stream 2. In order to obtain a more accurate measurement of the flow rates of the first and second streams 2, 4, it is preferred that the first flow measuring element 8 be located downstream of the first control valve 16 and downstream of said compressor 36, and the second flow measuring element 10 is located downstream of the second control valve 18. Further, in the preferred embodiment of this apparatus, particularly where the first fluid stream 2 is a hydrocarbon gas and the second fluid stream 4 is a fluid utilized for lowering the calorific value of the gas, it is preferred that the set points of the first and second ratio relay 22, 24 are values sufficient for maintaining the composite stream within a preselected calorific value, for example in the range of about 970 to about 1040 Btu/standard cubic foot at 60° F. and 14.65 psia.

In the method of this invention in addition to that described above with respect to each element of the apparatus, after the operator has selected the first and second fluids and the constituent of the second stream desired as a representative constituent for controlling the composite stream, the various corresponding set points D, M, N, P are selected for the control system. The second flow controller 32 and its associated signals thereto provide for controlling the second stream flow rate at a maximum value for producing the composite stream with a maximum concentration of said second stream during periods when the first fluid stream 2 is in limited supply, and the first flow controller 30 by way of second selective ratio relay 28 maintains the first stream flow rate at a maximum value for producing the composite stream with the minimum concentration of said second stream during periods when the second fluid stream 4 is in limited supply.

The control signal E from controller 14 by way of selective relay 26 can be utilized for limiting the flow rate of the second stream when the analysis indicates that a preselected high oxygen concentration of the composite stream has been reached.

By controlling the mixing of the first and second streams 2, 4 by the method and apparatus of this invention, the composite stream is automatically maintained within a preselected composition range, in a specific example between 11 to 15 percent air in natural gas, during periods when one or both of the first and second flow streams flow rates are fluctuating due to supply-demand relationships. The resultant composite stream is therefore of a more uniform and safe composition and better suited for the purpose for which said composite stream is utilized. A conventional mixer 38 may be inserted at the junction of first stream 2 and second stream 4 to insure thorough mixing of said streams.

Other modifications and alternations of this invention will become apparent to those skilled in the art from the foregoing discussion and accompanying drawing, and it should be understood that this invention is not to be unduly limited thereto.

What is claimed is:

1. An apparatus for separately regulating the flow rates of first and second fluid streams joining one with the other to form a composite stream for maintaining said composite stream within a preselected composition range, comprising:

first flow measuring means for measuring the flow rate of the first stream and delivering a signal A representative of that flow rate;

second flow measuring means for measuring the flow rate of the second stream and delivering a signal B representative of that flow rate;

an analyzing means associated with the composite stream for measuring at least one constituent of said composite stream and delivering a signal C representative of the relative amount of said constituent;

control means having a set point D and being connected to the analyzing means for receiving the signal C therefrom, comparing said signal C to the set point D and delivering a signal E responsive to the difference between the set point D and the signal C;

a first control valve positioned in the first stream for regulating the flow rate of the first stream in response to a received signal;

a conduit loop in communication with the first stream on opposed sides of the first control valve;

a compressor positioned in the conduit loop;

a second control valve positioned in the second stream for regulating the flow rate of the second stream in response to a received signal;

a pressure control means associated with the first stream at a location upstream of the first control valve for measuring the pressure of said first stream, comparing said measurement to a set point, and delivering a signal F responsive to the difference between the set point value and the pressure measurement of the first stream;

a first ratio relay means having a set point and being connected to the first flow measuring means for receiving the signal A therefrom, multiplying said signal A by the set point, and delivering a signal G representative of said multiplication;

a second ratio relay means having a set point and being connected to the second flow measuring means for receiving the signal B therefrom, dividing said signal B by the set point and delivering a signal H representative of said division;

- a first selective relay means connected to the first ratio relay means and the control means for receiving E and G, comparing said signals E and G one to the other, and delivering a signal I representative of the lower of said signals E and G;
- a first flow controller connected to the second ratio relay and the first flow measuring means for receiving signals A and H, comparing signals A and H one to the other and delivering a signal K responsive to the difference between signals A and H;
- a second selective relay means connected to the first flow controller, the first valve and the pressure control means for receiving signals F and K, comparing said signals F and K one to the other, and delivering a signal J representative of the higher of said signals F and H to the first valve for controlling the flow rate of the first stream relative to one of the flow rate of the second stream or the pressure of the first stream; and
- a second flow controller connected to the first selective relay, the second flow measuring means, and the second valve for receiving signals B and I, comparing signals B and I one to the other, and delivering a signal L responsive to the difference between signals B and I to the second valve for controlling the flow rate of the second stream relative to one of the flow rate of the first stream or the analysis of the composite stream.
2. An apparatus, as set forth in claim 1, wherein the analyzing means is a paramagnetic oxygen analyzer.
 3. An apparatus, as set forth in claim 1, wherein the set point of the first ratio relay means is a value representative to the desired flow rate of the second stream divided by the desired flow rate of the first stream and the set point of the second ratio relay means is a value representative to the desired flow rate of the second stream divided by the desired flow rate of the first stream.
 4. An apparatus, as set forth in claim 1, wherein the first flow measuring means is located downstream of the first control valve and the second flow measuring means is located upstream of the second control valve.
 5. An apparatus, as set forth in claim 1, wherein the signals are pneumatic signals.
 6. An apparatus, as set forth in claim 1, wherein the first fluid stream is a gaseous hydrocarbon stream and the second fluid stream is air.
 7. An apparatus, as set forth in claim 6 wherein the set points of the first and second ratio relay means are values for maintaining the composite stream within a

preselected calorific range.

8. An apparatus, as set forth in claim 1, wherein the analyzing means measures the oxygen content of the composite stream and the second fluid stream comprises air.

9. A method for regulating the flow rates of first and second fluid streams joining one with the other to form the composite stream for maintaining said composite stream within a preselected composition range, comprising:

- measuring the flow rate of the first stream;
 - delivering a signal A representative of the flow rate of said first stream;
 - measuring the flow rate of the second stream;
 - delivering a signal B representative of the flow rate of said second stream;
 - measuring at least one constituent of said composite stream;
 - delivering a signal C representative of the relative amount of said measuring constituent;
 - comparing signal C to a set point D;
 - delivering a signal E responsive to the difference between the set point D and the signal C;
 - measuring the pressure of said first stream;
 - delivering a signal F responsive to the difference between a set point value and the pressure measurement of the first stream;
 - multiplying signal A by a set point value;
 - delivering a signal G representative of said multiplication;
 - dividing signal B by a set point value;
 - delivering a signal H representative of the quotient of a division of signal B by an associated set point value;
 - comparing the signals E and G one to the other;
 - delivering a signal I representative of the lower of said signals E and G;
 - comparing signals A and H one to the other;
 - delivering a signal K responsive to the difference between signals A and H;
 - comparing signals F and K one to the other;
 - delivering a signal J in response to the comparison;
 - receiving signal J and controlling the flow rate of the first stream in response to said signal J;
 - comparing signals B and I one to the other;
 - delivering a signal L responsive to the difference between signals B and I;
 - receiving signal L and controlling the flow rate of the second stream in response to said signal L.
10. A method, as set forth in claim 9, wherein the constituent measured is oxygen.

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