

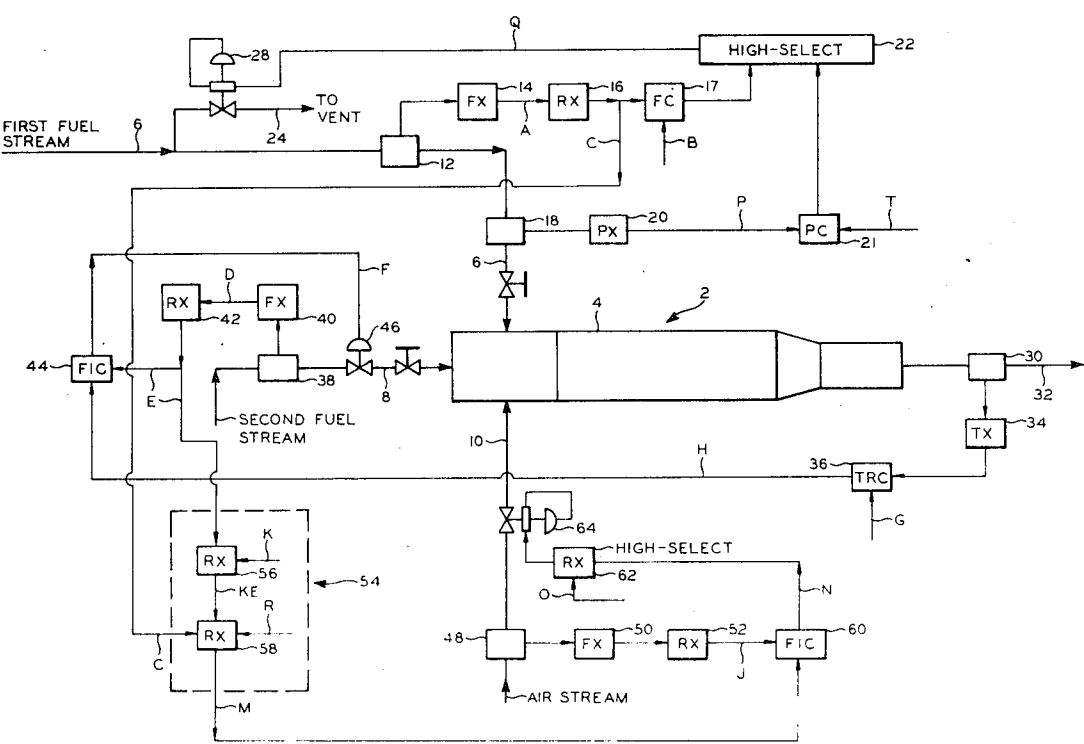
[54] **BURNER CONTROLLING APPARATUS AND METHOD**
[75] Inventor: **Carl L. Osburn**, Bartlesville, Okla.
[73] Assignee: **Phillips Petroleum Company**, Bartlesville, Okla.
[22] Filed: **July 13, 1971**
[21] Appl. No.: **162,057**
[52] U.S. Cl. **431/12**
[51] Int. Cl. **F23c 1/00**
[58] Field of Search **431/12, 162; 137/6, 137/7, 90; 236/14, 15 E**

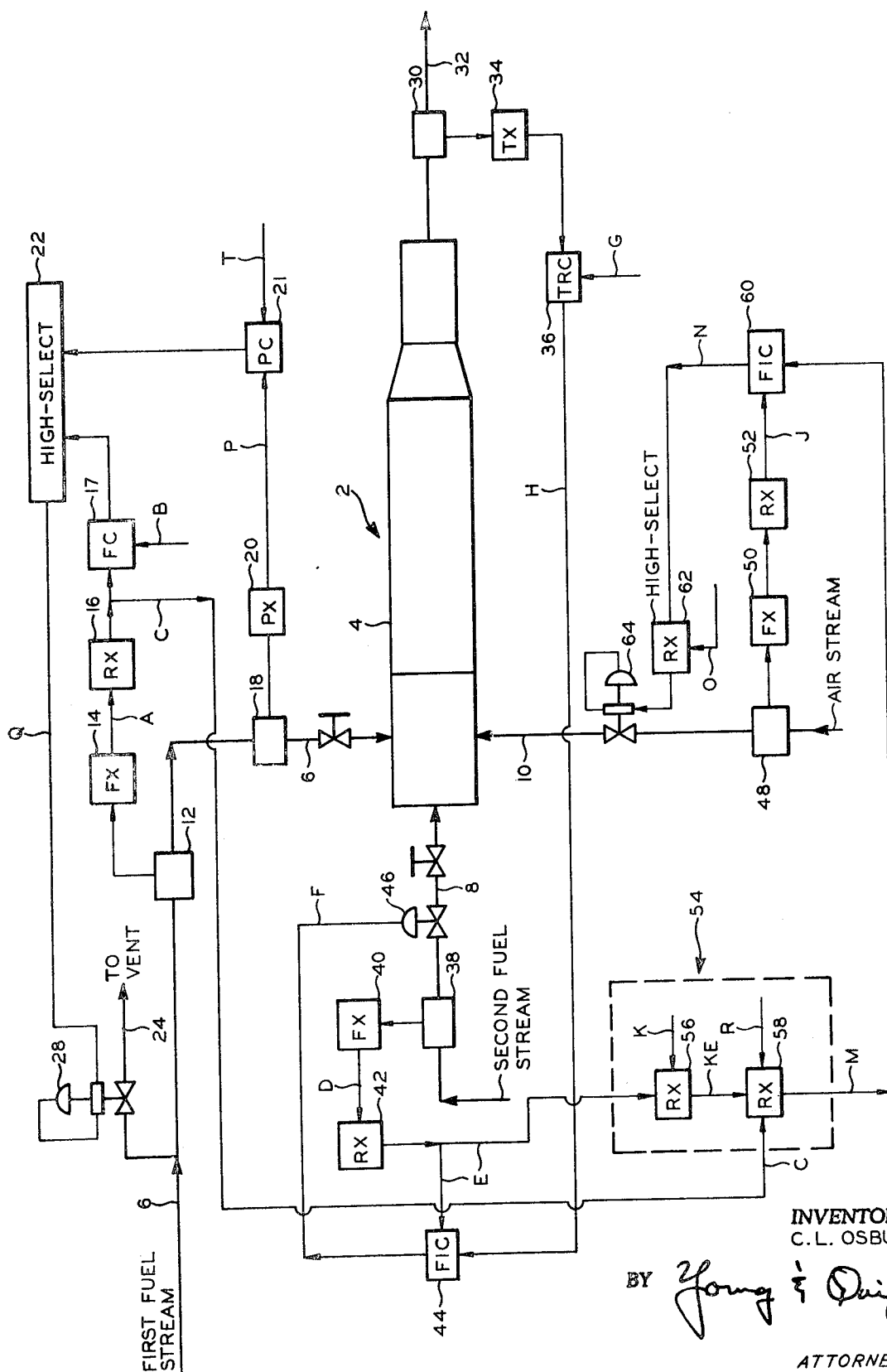
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Primary Examiner—William F. O'Dea
Assistant Examiner—William C. Anderson
Attorney—J. Arthur Young and Donald J. Quigg

[57] **ABSTRACT**
A method and apparatus for controlling the relative flow rates of first and second fuel streams and an air stream to a burner. The first fuel stream has a lower calorific value than the second fuel stream and the streams are controlled to maintain the burner combustion gas temperature above a preselected value, pass the first fuel into the burner at a maximum rate, pass the second fuel stream into the burner at a rate relative to the temperature of the combustion gas and provide a sufficient air stream flow rate for efficient combustion of the combined fuel streams.

[56] **References Cited**
UNITED STATES PATENTS
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11 Claims, 1 Drawing Figure





INVENTOR.
C. L. OSBURN

BY *Young & Quigg*

ATTORNEYS

BURNER CONTROLLING APPARATUS AND METHOD

In the operation of burners which utilize first and second fuels of different calorific values, it is often desirable to utilize as large a quantity of one of the fuels as possible while maintaining the heat of combustion within a preselected range. In order to prevent waste of valuable fuels, it is also desirable, especially where the flow rates of the first and/or second fuel streams vary, to provide controls to supply air to the burner at a flow rate which will permit efficient combustion of the fuels.

This invention therefore resides in a method and apparatus for controlling the flow rates of first and second fuel streams to a burner at flow rates relative one to the other such that the temperature of the burner combustion gases is maintained above a preselected value, the first fuel, which is of lower calorific value than the second fuel, is passed to the burner at maximum controlled rate and the air stream is delivered to the burner at a flow rate sufficient for efficient combustion of the combined fuel streams.

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 burner and the control apparatus of this invention.

Referring to the drawing, an incinerator 2, for example, has a burner 4 operably connected to first and second fuel streams 6, 8 and an air stream 10.

A first flow measuring element 12 is positioned in the first fuel stream 6 for measuring the first stream's flow rate into the burner 4. A first flow rate transmitter 14 is connected to the first flow measuring element 12 for delivering a signal A representative of said measured differential pressure. A first computing relay 16 is connected to the first flow rate transmitter 14 for receiving the signal A, computing the square root thereof, and delivering a signal C representative of the volumetric flow rate of the first fuel stream 6. This flow rate signal C is applied to flow controller 17 where it is compared with maximum allowable flow rate set point B and a first control signal is produced responsive to this comparison. It is preferred that the set point B to the first flow controller 17 be a manually variable set point in order that the flow rate of the first fuel stream 6 into the burner can be adjustably limited thereby as described below.

A pressure measuring element 18 is associated with the first fuel stream 6. A pressure transmitter 20 is connected to the pressure measuring element 18 for delivering a signal P representative of said measured pressure. Signal P is applied to pressure controller 21 where it is compared with maximum allowable pressure set point T and a second control signal is produced responsive to this comparison. A high-select relay 22 is connected to flow controller 17 and pressure controller 21 receiving the first and second control signals therefrom, comparing said signals one to the other and delivering as signal Q the larger of said control signals.

A by-pass conduit 24 is connected in fluid communication with conduit 6 through which the first fuel stream flows to the burner 4. A control valve 28 is positioned in the by-pass conduit 24 and is connected to the high-select relay 22 for receiving the signal Q and controlling the rate of venting a portion of the first fuel stream 6 in the event that either or both of the measured flow rate C and conduit pressure P exceed their

respective set point values B and T thereby to operate incinerator 2 at or below its combustion capacity.

A temperature measuring element 30 is associated with the stream 32 of combustion gases discharging from the incinerator 2 for measuring the temperature of the combustion gases which result from burning of the fuels. A temperature transmitter 34 is connected to the temperature measuring element 30 for delivering a signal representative of said measured temperature. A temperature controller 36 is connected to the temperature transmitter 34 for delivering a control signal H responsive to the difference between the measured temperature and a preselected temperature set point G, such as, for example, within the range 1600°-2000°F.

A second flow measuring element 38 is associated with the second fuel stream 8. A second flow rate transmitter 40 is connected to said second flow rate measuring element 38 for delivering a signal D representative of the measured differential pressure of the second fuel stream 8 into the burner 4. A second computing relay 42 is connected to the second flow rate transmitter 40 for receiving the signal D, extracting the square root thereof, and delivering a signal E representative of the volumetric flow rate of second fuel stream 8.

A flow controller 44 is connected to the second computing relay 42 and the temperature controller 36 for receiving signals E and H, comparing said signals E and H one to the other, and delivering a signal F responsive to the difference between said signals E and H. A control valve 46 is positioned in the second fuel stream 8 and connected to the flow controller 44 for receiving the signal F and controlling the flow rate of the second fuel stream into the burner 4 in response to said signal F.

A third flow rate measuring element 48 is associated with the air stream 10 for measuring the differential pressure of said air stream into the burner 4. A third flow rate transmitter 50 is connected to said third flow rate measuring element 48 for delivering a signal representative of the measured differential pressure of said air stream 10.

A third computing relay 52 is connected to flow transmitter 50 for extracting the square root of the measured differential pressure and delivering a signal J representative of the volumetric flow rate of air through conduit 10.

A computing means 54, such as fourth and fifth pneumatic computing relays 56, 58, is connected to first and second computing relays 16 and 42 for receiving signals C and E therefrom, multiplying signal E times a set point K, adding signal C to the resultant product, multiplying this product by gain or calibration factor R, and delivering a signal M responsive to the summation and multiplication.

A flow controller 60 is connected to the third computing relay 52 and to the computing means 54 for receiving signals J and M, comparing said signals J and M one to the other, and delivering a signal N responsive to the difference between said signals J and M. A second high-select relay 62 is connected to flow controller 60 for receiving signal N, comparing said signal with a limiting, low value of air flow control valve position O, and delivering the higher of signal N or the low limit O to control valve 64.

Control valve 64 is positioned in the air stream 10 and is connected to the second high-select relay 62 for receiving signal N or O and controlling the flow rate of

the air stream into the burner 4 in response to one of said signals.

In the operation of this control equipment, the flow rate of the first fuel stream 6 is maintained in a range sufficient to utilize as large a quantity of the first fuel as possible while maintaining the temperature of the combusted gases above a preselected minimum value. Where the apparatus is an incinerator, for example, and the first fuel will not efficiently combust at conditions wherein the combustion gases have a temperature lower than about 1600°F, for example, it is then necessary to supply a sufficient flow rate of the second fuel stream 8 in order to produce the desired combustion conditions. In order to protect the equipment, however, by-pass valve 28 and its associated controlling equipment is utilized for venting any portion of the first fuel stream 6 in excess of the maximum flow rate or conduit pressure that can be utilized. This feature is particularly advantageous where the supply of the first fuel stream varies to rates in excess of the maximum capacity of the burner, for example, where the first fuel stream is carbon black plant off-gas.

By controlling the temperature of the combusted gases through manipulation of the flow rate of the second fuel stream 8 and computing the combustion air required for the totalized fuel for the burner, the air flow rate therefor can be based on the B.t.u. heating values of the streams and their relative proportions, thereby automatically operating the burner at high combustion efficiency under varying fuel flow rates and heating values of the off-gas stream.

Controller set points B, T and G, and relay set points K, O and R are manually adjustable for the purpose of initial and periodic calibration and tuning of the system, as are the conventional gain, integral and derivative control modes of the above-described components.

To achieve mathematical consistency as regards computer 54, shown here as two computing relays 56 and 58 (but combinable into one computer if desired), set point K to relay 56 may be described as (1) the ratio of the air flow required per volume of second fuel stream to the air flow required per volume of first fuel stream, or (2) the ratio of the relatively constant calorific values of the second fuel stream to that of the first fuel stream. Signal KE thus is the hypothetical volume of first fuel stream that is equivalent to the measured second fuel stream volume. In relay 58 this value is added to the measured volume of first fuel stream C and this total is multiplied by the air volume required per volume of first fuel stream, shown as set point or gain value R. The thus-computed, totalized air volume M is then applied as the set point to air flow controller 60. Similarly, the computations performed by relays 56 and 58 may be described as totalizing the combustion value (BTU per hour) contributions from the two fuel streams and, by virtue of the calibration of relay 58, calculating the air required for efficient combustion and controlling the air flow therefrom.

The process measurement, transmission, signal modification, controlling, signal selecting and computing equipment described above is available from several manufacturers among whom are The Taylor Instrument Division of Sybron Corporation, Moore Products Company, and The Foxboro Company of Foxboro, Massachusetts, in whose Bulletin 13-18D, dated January 1965, equipment capable of these functions may be found described.

The more-recently-developed techniques of direct digital control may also be employed, whereby the mathematical and logical operations performed above may be programmed within a digital computer, which, on receiving the appropriate measurements produces signals to be applied to the various control valves to regulate this process and others within the same plant (for example a carbon black plant) on a time-shared basis.

This control system thereby provides for maintaining the burner operation at high efficiency under varying fuel flow conditions and provides the flexibility for easily changing fuel types or altering the relative proportions of the streams passing to the burner.

Other modifications and alterations 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.

That which is claimed is:

1. A controlled burner having a combustion air stream and first and second burner fuel streams passing into the burner and a combustion gas stream discharging from said burner, comprising:

- first means for measuring the flow rate and pressure of the first fuel stream and delivering a signal Q representative of the larger of said measurements;
- second means for controlling the flow rate of the first fuel stream at a preselected value in response to said signal Q;
- third means for measuring the temperature of the combustion gas stream;
- fourth means for measuring the flow rate of the second fuel stream;
- fifth means for controlling the flow rate of the second fuel stream relative and in response to the temperature of said combustion gas stream;
- sixth means for measuring the flow rate of the air stream; and
- seventh means for controlling the flow rate of the air stream relative to the flow rates of the first and second fuel streams into the burner.

2. An apparatus, as set forth in claim 1, wherein the third, fourth, and fifth means comprises:

- a temperature measuring element associated with the combustion gases of the burner for measuring the temperature of said gases;
- a temperature controller connected to the temperature measuring element for delivering a signal H representative of the difference in the measured temperature in a preselected temperature range;
- a second flow rate measuring element associated with the second fuel stream;
- a second flow rate transmitter connected to said second flow rate measuring element for delivering a signal D representative of the differential pressure of the second fuel stream;
- a second computing relay being connected to said flow transmitter for receiving the signal D, extracting the square root thereof and delivering a signal E representative of the volumetric flow rate of the second fuel stream;
- a flow controller connected to the second computing relay and the temperature controller for receiving signals E and H, comparing said signals E and H, and delivering a signal F representative of the difference between said signals; and

a control valve associated with the second fuel stream and connected to the flow controller for receiving the signal F and controlling the flow rate of the second fuel stream in response to said signal F.

3. An apparatus, as set forth in claim 1, wherein the first and second means comprises:

a first flow measuring element in the first fuel stream;
a flow rate transmitter connected to the flow measuring element for delivering a signal a representative of the flow rate of the first fuel stream;

a first computing relay connected to the flow rate transmitter for receiving the signal A, computing the square root of signal A and delivering a signal C representative thereof;

a flow controller having a set point B and being connected to the first computing relay for receiving the signal C comparing said signal C to the set point B and delivering a first control signal representative of the difference between the flow rate of the first fuel stream and the set point B;

a pressure measuring element associated with the first fuel stream;

a pressure transmitter connected to the pressure measuring element for delivering a signal P representative of the pressure of the first fuel stream;

a pressure controller having a set point T and being connected to the pressure transmitter for receiving signal P therefrom, comparing said signal P to said set point T and delivering a second control signal responsive to said comparison;

a high-select relay connected to the pressure controller and the first flow controller for receiving first and second control signals, comparing said signals one to the other, and delivering a signal Q representative of the larger of said first and second control signals;

a by-pass conduit associated with the first fuel stream; and

a control valve positioned in the by-pass conduit and connected to the high-select relay for receiving the signal Q and controlling the flow rate and pressure of the first fuel stream in response to said signal Q.

4. An apparatus, as set forth in claim 3, wherein the set point B of the flow controller is a variable set point.

5. An apparatus, as set forth in claim 1, wherein the sixth and seventh means comprises:

a third flow rate measuring element associated with the air stream;

a third flow rate transmitter connected to said flow measuring element for delivering a signal representative of the differential pressure of said air stream;

a third computing relay connected to the third flow rate transmitter for receiving the signal therefrom, extracting the square root of said received signal and delivering a signal J in response thereto;

a fourth computing relay being connected to the fifth means for receiving a signal E from the fifth means representative of the volumetric flow rate of the second fuel stream, multiplying said signal E by a set point K, and delivering a signal KE representative of the resultant product;

a fifth computing relay having a set point R and being connected to the first means and the fourth computing relay for receiving a signal C from the first means representative of the flow rate of the first fuel stream, adding signal A to the signal KE, multiplying the resultant sum times the set point R, and

delivering a signal M representative of the computation;

a flow controller connected to the third and fifth computing relays for receiving signals J and M, comparing said signals one to the other, and delivering a signal N responsive to the difference between said signals J and M;

a second high-select relay connected to the flow controller for receiving signal N, comparing said signal with a set point D, and delivering the larger of said signal N and set point D; and

a controlling valve associated with the air stream and being connected to the second high-select relay for receiving the signal therefrom and controlling the flow rate of the air stream in response thereto.

6. An apparatus, as set forth in claim 5, wherein the set point K is a variable set point.

7. A method for regulating the flow of first and second fuel streams and an air stream passing to a burner having combustion gases passing therefrom, said first fuel stream having a lower calorific value than said second fuel stream, comprising:

1. measuring the flow rate of the first fuel stream passing to the burner;

2. delivering a signal C representative of the flow rate of the first fuel stream;

3. comparing signal C to a set point B;

4. delivering a first control signal responsive to the difference between the signal C and the set point B;

5. measuring the flow rate of the second fuel stream passing to the burner;

6. delivering a signal E representative of the flow rate of the second fuel stream;

7. measuring the temperature of the combustion gases of the burner;

8. delivering a signal representative of the temperature of the combustion gases;

9. comparing the signal of step (8) to a set point B;

10. delivering a signal H responsive to the difference between the comparison of signals in step (9);

11. comparing signal E to a set point H;

12. delivering a signal F responsive to the difference between the signal E and the set point H;

13. controlling the flow rate of the second fuel stream in response to signal F;

14. measuring the flow rate of the air stream passing to the burner;

15. delivering a signal J representative of the flow rate of the air stream;

16. multiplying signal E times a constant K;

17. adding signal C to the product of step (16);

18. multiplying the sum of step (17) by a constant R; and

19. delivering a signal M responsive to the computation of step (18); comparing signals J and M;

delivering a signal N responsive to the difference between signals J and M;

comparing signal N with a set point signal O; and controlling the flow rate of the air stream in response to the greater of the signals N and O.

8. A method, as set forth in claim 7, including adjusting the constant K for changing the relative flow rate of the air stream.

9. A method, as set forth in claim 7, including maintaining the temperature of the exhaust gases at temperatures greater than about 1600°F.

7

10. A method, as set forth in claim 7, including measuring the pressure of the first fuel stream passing to the burner;

delivering a signal P representative of the pressure of the first fuel stream;

comparing signal P to a set point T;

delivering a second control signal responsive to the comparison of signal P and the set point T;

comparing the first and second control signals one to

8

the other; and

delivering a signal Q representative of the larger of said first and second control signals; and

removing at least a portion of the first fuel stream in response to the value of the signal Q.

11. A method, as set forth in claim 10, including adjusting the set point signal B for changing the flow rate of the first fuel stream into the burner.

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UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,734,675

Carl L. Osburn

Dated: May 22, 1973

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 4, line 26, after "stream" insert -- , delivering signals relative to said measurements, comparing said signals, --; column 4, line 27, after "said" cancel "measurements" and insert -- signals --. Column 5, line 9, after "signal" delete "a" and insert -- A --. Column 6, line 30, after "B" insert -- and controlling the flow rate of the first fuel stream in response to said first control signal --; column 6 line 39, after "point" cancel "B" and insert -- G --; column 6, line 56, before "comparing" insert -- (20) --; column 6, line 57, before "delivering" insert -- (21) --; column 6, line 59, before "comparing" insert -- (22) --; column 6, line 60, before "controlling" insert -- (23) --.

Signed and sealed this 1st day of January 1974.

(SEAL)
Attest:

EDWARD M. FLETCHER, JR.
Attesting Officer

RENE D. TEGTMEYER
Acting Commissioner of Patents