

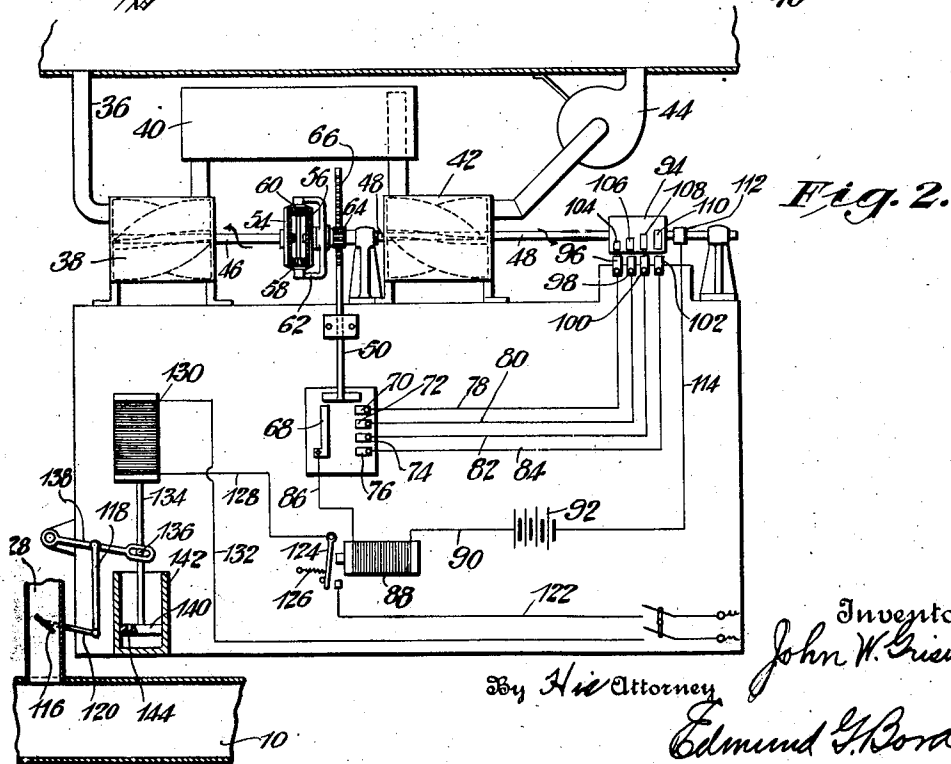
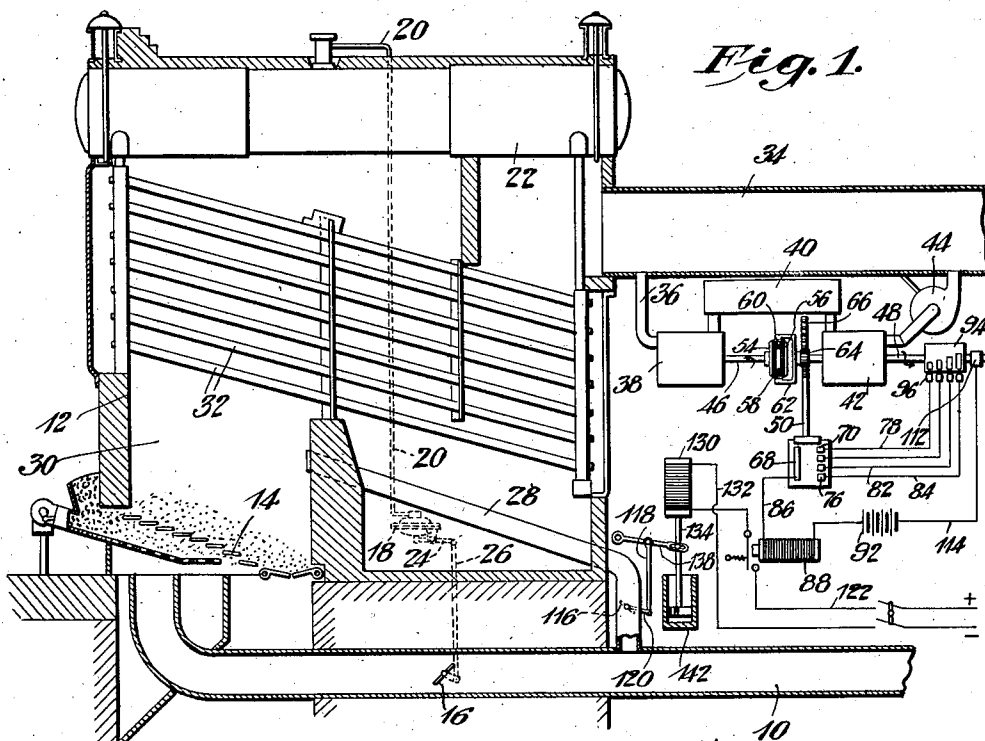
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J. W. GRISWOLD

METHOD OF AND APPARATUS FOR CONTROLLING COMBUSTION

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METHOD OF AND APPARATUS FOR CONTROLLING COMBUSTION.

Application filed February 12, 1920. Serial No. 358,018.

To all whom it may concern:

Be it known that I, JOHN WILLIAM GRISWOLD, a citizen of the United States of America, residing at Warren, in the county of Warren, State of Pennsylvania, have invented certain new and useful Improvements in Methods of and Apparatus for Controlling Combustion; and I do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same.

This invention relates to a method of and an apparatus for controlling the combustion of fuel in a furnace, and more particularly to a method and apparatus for controlling the combustion of fuel in accordance with the composition of the flue gases leaving the furnace.

To obtain perfect combustion of fuel, it is essential that sufficient air or other source of oxygen be supplied to a furnace to provide the oxygen necessary for burning all of the fuel. In utilizing the heat of combustion of fuel in a commercial furnace, it is very desirable that all of the products of combustion shall be burned before passing out of contact with a heat transferring surface and that unburned combustible gases shall not be carried out of the furnace with the exhaust products. Although the use of a large excess of air for combustion in a furnace might insure a complete combustion of the fuel, such an excess is not desirable because it tends to cool the flame temperature and the combustion zones and acts to carry a large quantity of unabsorbed heat out of the furnace with the exhaust products. The ideal conditions for combustion, accordingly, may be obtained when the minimum of air necessary to effect complete combustion of the fuel is supplied to the furnace. In the practical operation of a furnace, however, in order to insure that there shall be an adequate supply of air, it is advisable to provide a slight excess of air over that necessary for complete combustion, as indicated by the existence in the flue gases of a small percentage only of free oxygen.

The presence of free oxygen or unconsumed combustible gases in the products of combustion may, in certain cases, be indirectly detected by a determination of the amount of carbon dioxide in the flue gases and a

knowledge of the empirical relation between the percentage of carbon dioxide and the quantity of unconsumed combustion gases. For instance, in the combustion of a fuel which is practically pure carbon, nearly all of the oxygen of the air would combine with the carbon to form carbon dioxide and the percentage of carbon dioxide in the flue gases when perfect combustion is obtained would accordingly be the same as the percentage of oxygen in the air. A rough control of the combustion of the furnace may, therefore, be obtained by analyzing samples of the flue gases and regulating the air supply to the furnace to maintain a uniform carbon dioxide content in the flue gases. However, if the composition of the fuel is changed, or if a fuel having a varying proportion of carbon and hydrogen is used, the regulation of combustion by the percentage of carbon dioxide in the flue gas would accordingly be rendered unreliable.

The primary object of the present invention is to provide a process of regulating the combustion of fuel in a furnace in which the supply of air to said furnace is controlled directly by the quantity of free oxygen in the products of combustion from said furnace.

Another object of the invention is to provide an apparatus for regulating the combustion of fuel in a furnace by which the supply to said furnace of air for supporting combustion is controlled directly by the quantity of free oxygen in the products of combustion from said furnace.

A further object of the invention is to provide a method of regulating the combustion of fuel in a boiler furnace, in which the rate of combustion of the fuel is controlled by the boiler pressure, and the character of combustion is controlled by the amount of free oxygen or combustible gases in the products of combustion in the furnace.

A further object of the invention is to provide an apparatus in which the supply of air for supporting combustion is continuously under the control of the composition of the flue gases.

With these and other objects in view, the invention consists in the process and apparatus described in the following specification and defined in the claims.

The various features of the invention are

illustrated in the accompanying drawings, in which:

Fig. 1 is an elevation partly in section, showing a preferred embodiment of the invention; and

Fig. 2 is a detailed sectional view of the combustion controlling mechanism.

In the present invention the rate of combustion is controlled by the steam pressure in the boiler, and the completeness of combustion is controlled by the quantity of free or unconsumed oxygen in the products of combustion leaving the furnace. To this end, a primary draft of air is admitted beneath and forced upwardly through the fuel bed and the rate of combustion is regulated by increasing or decreasing the draft. To insure the complete utilization of this primary supply of air, a comparatively thick bed of fuel is used which acts similarly to a gas producer to form carbon monoxide in the upwardly passing gases. The primary air as it leaves the fuel bed, therefore, carries with it a considerable amount of unburned combustible gases. To complete the combustion of the unburned gases, a secondary supply of air slightly in excess of that sufficient to insure complete combustion is introduced into the combustion chamber above the fuel bed.

The quantity of secondary air supplied to the furnace is controlled directly by the quantity of free oxygen in the products of combustion passing from the furnace. To this end a small portion of the products of combustion is continuously withdrawn from the furnace flue through a gas meter which measures the rate of flow of the gas withdrawn. From the meter the portion of flue gas passes through an absorption chamber which is filled with an oxygen absorbing substance to completely remove any free oxygen contained in the products of combustion, and from the absorbing chamber passes through a second gas meter. If there is no free oxygen in the products of combustion, there will be no change in the volume of gas passing through the absorption chamber and the two meters placed at opposite sides of said absorption chamber will be rotated at substantially the same rate of speed. When the flue gas contains free oxygen, the volume of the gas passing through the absorption chamber will be decreased by the absorption of the oxygen and the second gas meter will be rotated at a slower rate of speed than the meter through which the gas passes to the absorption chamber. The two gas meters are connected to a differential gearing which remains stationary when the speed of rotation of the gas meters is equal, but which is rotated to close an electric draft regulating circuit when the meters rotate at different speeds due to absorption of free oxygen in the absorption chamber. The

electric circuit is arranged to control a draft regulating damper to decrease the supply of secondary air to the furnace when the quantity of free oxygen in the flue gases rises above a maximum amount.

If liquid or gaseous fuel is used, the supply of fuel, and accordingly the rate of combustion, may be controlled directly by the steam pressure of the boiler, and the entire quantity of air supplied to the furnace, and accordingly the character of combustion, may be controlled by the oxygen content of the fuel gases.

A combustion regulator applied to an ordinary coal fired steam boiler is shown in Fig. 1. In this arrangement, air for supporting combustion is forced through an air supply pipe 10 and enters a furnace 12 under a fuel grate 14. The quantity of air passing through the pipe 10 to the space under the grate 14 controls the rate of combustion of fuel in the furnace and is governed by a damper 16, the position of which is controlled by the steam pressure of the boiler.

To this end the furnace is provided with a pressure diaphragm 18 which communicates through a connecting conduit 20 with a steam drum 22 of the boiler. The movement of the diaphragm 18 with variations in steam pressure of the boiler is transmitted through a lever 24 and a connecting rod 26 to the damper 16. As the pressure in the steam drum 22 of the boiler increases, the diaphragm 18 is depressed and transmits its movement through the lever 24 and connecting rod 26 to move the damper 16 toward closed position. Conversely, when the steam pressure in the drum 22 falls, the diaphragm 18 rises and the damper 16 is moved toward open position.

The combustion of the unburned combustible gases leaving the fuel bed is completed by means of a secondary air supply introduced by a branch pipe 28 leading from the pipe 10 to a combustion chamber 30 above the grate 14. From the combustion chamber 30 the products of combustion pass back and forth in contact with a bank of water tubes 32 and leave the furnace through a flue 34.

In testing the products of combustion passing through the flue 34 for free oxygen, a small portion of the products of combustion is withdrawn from the flue 34 through a tube 36 and passed through a wet gas meter 38 to determine the rate at which the gas is withdrawn. From the gas meter 38, the sample of flue gas flows through an absorption chamber 40 which is filled with phosphorous or other material capable of selectively absorbing free oxygen without affecting the other constituents of the flue gas. An alkaline solution of pyrogallol may be used, but in that case it will be necessary to

intermittent energizing of the solenoid 88, the switch 124 is closed for definite intervals and a lifting force exerted on the rod 134 through the energizing of the solenoid 130. In this manner a series of lifting impulses is exerted on the lever 138 to close the damper 116. If this closing action does not suffice to bring the free oxygen content of the flue gases back to the desired maximum limit, the contact 50 will continue to move downwardly and to connect the plate 68 successively with the branch circuits 80, 82 and 84 and to thereby lengthen the periods of time during which current is sent through the solenoid 88. The effect of increasing the length of time during which the solenoid 88 is energized is to increase the length of time during which the switch 124 is closed and the current is sent through the solenoid 130. In this manner, a more prolonged lifting action is exerted on the rod 134 until the damper 116 is closed sufficiently to bring the oxygen content of the gases in the flue 34 below the desired maximum limit. When this point is reached, the volume of the sample of flue gases is substantially undiminished in passing through the absorption chamber 40 and the meter shaft 48 is rotated at a slightly greater rate of speed than the shaft 46 and the contact 50 is thereby lifted into its uppermost position.

When the contact 50 is in its uppermost position, the switch 124 is continually held open by the spring 126 and the circuit through the solenoid 130 is continually open. The weight of the damper operating lever mechanism acts on the link 118 to slowly open the damper 116 until the oxygen content of the gases in the flue 34 rises to the point at which the contact 50 is operated in the manner described above. The action of the dash pot 142 and the piston 140 retards the movement of the damper operating mechanism to such an extent that a slight change in the position of the damper 116 will affect the draft regulating device before the damper 116 will have moved into extreme positions.

While the invention has been described as applied to a steam boiler in connection with a device by which the rate of combustion is independently regulated, the apparatus described above may be used in other cases without an independent device for regulating the rate of combustion. For example, in brass melting and similar metallurgical furnaces, the rate of combustion is regulated by hand and combustion is controlled to give a maximum temperature. For this purpose, the supply of air must be so regulated that there will be very little if any excess of air supplied and accordingly little or no free oxygen in the products of combustion, since the addition of air

above that necessary for complete combustion reduces the temperature obtained because of the cooling action of the excess air. In this case, therefore, the above described combustion control device is used, without an automatic device for controlling the rate of combustion, to control the total amount of air supplied to the furnace in such a manner that the amount of free oxygen in the combustion products is reduced to the minimum amount necessary to insure complete combustion of the fuel.

The method and apparatus of this invention are similar in certain of their broader aspects to the method and apparatus for controlling the combustion of fuel in a furnace, disclosed in my co-pending application, Serial No. 358,016, filed Feb. 12, 1920. The subject matter common to this application and application, Serial No. 358,016 is claimed in the latter application.

Having described the invention, what is claimed as new is:

1. A combustion regulator for furnaces, comprising means continuously acting to increase the draft to a furnace, means governed by an electric current for intermittently decreasing said draft, a gas absorption chamber, means for drawing a portion of the products of combustion from said furnace through the gas absorption chamber, and means governed by the decrease in volume of the gas in passing through said absorption chamber for controlling said electric current.

2. A combustion regulator for furnaces, comprising means continuously acting to increase the draft to a furnace, means governed by an electric current for intermittently decreasing said draft, means for retarding the speed of said draft increasing and decreasing means, a gas absorption chamber, means for drawing a portion of the products of combustion from said furnace through the gas absorption chamber, and means governed by the decrease in volume of the gases in passing through said absorption chamber for controlling said electric current.

3. A combustion regulator for furnaces, comprising a damper for controlling the draft to a furnace, a lever mechanism acted upon by gravity to move said damper into open position, an electromagnetic means acting on said lever mechanism to close said damper upon passage of current thru said electromagnetic means, a gas absorption chamber, means for drawing a portion of the products of combustion from said furnace thru the gas absorption chamber, and means governed by the decrease in volume of the gas in passing through said absorption chamber for opening and closing said electric current through said electromagnetic damper operating mechanism.

4. A combustion regulator for furnaces,

comprising a damper for controlling the draft to a furnace, a lever mechanism acted upon by gravity to move said damper into open position, an electromagnetic means acting on said lever mechanism to close said damper upon passage of current thru said electromagnetic means, a dash pot device acting on said lever mechanism to retard the movement of said damper, a gas absorption chamber, means for drawing a portion of the products of combustion from said furnace through the gas absorption chamber, and means governed by the decrease in volume of the gas in passing through said absorption chamber for opening and closing said electric current through said electromagnetic damper operating mechanism.

5. A combustion regulator for furnaces, comprising means for controlling the supply of air for supporting combustion to said furnace, a gas measuring means, an absorption chamber, a second gas measuring means, means for drawing a portion of the products of combustion from said furnace thru said first gas measuring means, said absorption chamber and second gas measuring means, and means controlled by said gas measuring means for operating the means for controlling the air supply to the furnace.

6. A combustion regulator for furnaces, which comprises means continuously acting to increase the draft to a furnace, means acted upon by the passage of an electric current to decrease said draft, means for directing said current thru one of a series of parallel branch electric circuits, a make and break device arranged to intermittently open and close said branch electric circuits for varying lengths of time, and means governed by the amount of free oxygen in the products of combustion passing from said furnace for connecting said current through the branch electric circuit having the longest period of closing as the oxygen contained in the said products of combustion increases.

7. A combustion regulator for furnaces, comprising a gas meter, a gas absorption chamber, a second gas meter, means for drawing a portion of the gas passing from said furnace successively through said first gas meter, said absorption chamber and said second gas meter, a differential gear driven in opposite directions by the differences in speed of rotation of said meters, a contact moved by said differential gear, a series of parallel branch electric circuits positioned to be separately and singly closed by said contact, means for intermittently opening said separate branch circuits for different lengths of time, a magnetic switch connecting the said branch circuits, a second circuit closed by said magnetic switch, a solenoid in said second circuit and a draft controlling damper operated by said solenoid.

8. A combustion regulator for furnaces, comprising a gas meter, a gas absorption chamber, a second gas meter, means for drawing a portion of the gas from said furnace successively through said first gas meter, said absorption chamber and second gas meter, and means controlled by the difference in speed of rotation of said meters for controlling the draft to said furnace.

9. A combustion regulator for a furnace, comprising means for measuring the rate of flow of gas, an absorption chamber, a second means for measuring the rate of flow of gas, means for drawing a portion of the products of combustion from said furnace successively through said first measuring means, said absorption chamber and said second measuring means, means controlled by said gas measuring means for closing an electric circuit for different intervals of time and increasing the time of each closure as the difference in flow of gas through said meters increases, a solenoid excited by said current in said circuit, a draft controlling damper urged toward open position by a constantly acting force and toward closed position by said solenoid, and means for retarding the motion of said damper.

10. A combustion regulator for furnaces, comprising a gas meter, a gas absorption chamber, a second gas meter, means for drawing a portion of the gas passing through said furnace successively through said first gas meter, said absorption chamber and said second gas meter, a series of parallel branch electric circuits, a contact operated by the difference in volume of gas passing through said meters to separately and singly close said branch electric circuits, means for intermittently opening and closing said branch electric circuits for different lengths of time, a magnetic switch arranged to be closed during the passage of intermittent currents through said branch electric circuits, and means controlled by said second circuit for operating the draft controlling damper of said furnace.

11. A combustion regulator for furnaces, comprising means constantly acting to increase the draft to a furnace, means for constantly testing the quantity of free oxygen in the products of combustion from said furnace, and means acting intermittently for increasingly longer periods of time, as the quantity of free oxygen increases beyond a certain percentage, to decrease said draft.

12. The method of regulating combustion in furnaces, which comprises continuously removing a sample of the flue gases from a furnace, continuously testing said sample of flue gases for free oxygen, continuously increasing the draft to said furnace when the content of oxygen in the flue gases is below a certain percentage, and decreasing

intermittent energizing of the solenoid 88, the switch 124 is closed for definite intervals and a lifting force exerted on the rod 134 through the energizing of the solenoid 130. In this manner a series of lifting impulses is exerted on the lever 138 to close the damper 116. If this closing action does not suffice to bring the free oxygen content of the flue gases back to the desired maximum limit, the contact 50 will continue to move downwardly and to connect the plate 68 successively with the branch circuits 80, 82 and 84 and to thereby lengthen the periods of time during which current is sent through the solenoid 88. The effect of increasing the length of time during which the solenoid 88 is energized is to increase the length of time during which the switch 124 is closed and the current is sent through the solenoid 130. In this manner, a more prolonged lifting action is exerted on the rod 134 until the damper 116 is closed sufficiently to bring the oxygen content of the gases in the flue 34 below the desired maximum limit. When this point is reached, the volume of the sample of flue gases is substantially undiminished in passing through the absorption chamber 40 and the meter shaft 48 is rotated at a slightly greater rate of speed than the shaft 46 and the contact 50 is thereby lifted into its uppermost position.

When the contact 50 is in its uppermost position, the switch 124 is continually held open by the spring 126 and the circuit through the solenoid 130 is continually open. The weight of the damper operating lever mechanism acts on the link 118 to slowly open the damper 116 until the oxygen content of the gases in the flue 34 rises to the point at which the contact 50 is operated in the manner described above. The action of the dash pot 142 and the piston 140 retards the movement of the damper operating mechanism to such an extent that a slight change in the position of the damper 116 will affect the draft regulating device before the damper 116 will have moved into extreme positions.

While the invention has been described as applied to a steam boiler in connection with a device by which the rate of combustion is independently regulated, the apparatus described above may be used in other cases without an independent device for regulating the rate of combustion. For example, in brass melting and similar metallurgical furnaces, the rate of combustion is regulated by hand and combustion is controlled to give a maximum temperature. For this purpose, the supply of air must be so regulated that there will be very little if any excess of air supplied and accordingly little or no free oxygen in the products of combustion, since the addition of air

above that necessary for complete combustion reduces the temperature obtained because of the cooling action of the excess air. In this case, therefore, the above described combustion control device is used, without an automatic device for controlling the rate of combustion, to control the total amount of air supplied to the furnace in such a manner that the amount of free oxygen in the combustion products is reduced to the minimum amount necessary to insure complete combustion of the fuel.

The method and apparatus of this invention are similar in certain of their broader aspects to the method and apparatus for controlling the combustion of fuel in a furnace, disclosed in my co-pending application, Serial No. 358,016, filed Feb. 12, 1920. The subject matter common to this application and application, Serial No. 358,016 is claimed in the latter application.

Having described the invention, what is claimed as new is:

1. A combustion regulator for furnaces, comprising means continuously acting to increase the draft to a furnace, means governed by an electric current for intermittently decreasing said draft, a gas absorption chamber, means for drawing a portion of the products of combustion from said furnace through the gas absorption chamber, and means governed by the decrease in volume of the gas in passing through said absorption chamber for controlling said electric current.

2. A combustion regulator for furnaces, comprising means continuously acting to increase the draft to a furnace, means governed by an electric current for intermittently decreasing said draft, means for retarding the speed of said draft increasing and decreasing means, a gas absorption chamber, means for drawing a portion of the products of combustion from said furnace through the gas absorption chamber, and means governed by the decrease in volume of the gases in passing through said absorption chamber for controlling said electric current.

3. A combustion regulator for furnaces, comprising a damper for controlling the draft to a furnace, a lever mechanism acted upon by gravity to move said damper into open position, an electromagnetic means acting on said lever mechanism to close said damper upon passage of current thru said electromagnetic means, a gas absorption chamber, means for drawing a portion of the products of combustion from said furnace thru the gas absorption chamber, and means governed by the decrease in volume of the gas in passing through said absorption chamber for opening and closing said electric current through said electromagnetic damper operating mechanism.

4. A combustion regulator for furnaces,

comprising a damper for controlling the draft to a furnace, a lever mechanism acted upon by gravity to move said damper into open position, an electromagnetic means acting on said lever mechanism to close said damper upon passage of current thru said electromagnetic means, a dash pot device acting on said lever mechanism to retard the movement of said damper, a gas absorption chamber, means for drawing a portion of the products of combustion from said furnace through the gas absorption chamber, and means governed by the decrease in volume of the gas in passing through said absorption chamber for opening and closing said electric current through said electromagnetic damper operating mechanism.

5. A combustion regulator for furnaces, comprising means for controlling the supply of air for supporting combustion to said furnace, a gas measuring means, an absorption chamber, a second gas measuring means, means for drawing a portion of the products of combustion from said furnace thru said first gas measuring means, said absorption chamber and second gas measuring means, and means controlled by said gas measuring means for operating the means for controlling the air supply to the furnace.

6. A combustion regulator for furnaces, which comprises means continuously acting to increase the draft to a furnace, means acted upon by the passage of an electric current to decrease said draft, means for directing said current thru one of a series of parallel branch electric circuits, a make and break device arranged to intermittently open and close said branch electric circuits for varying lengths of time, and means governed by the amount of free oxygen in the products of combustion passing from said furnace for connecting said current through the branch electric circuit having the longest period of closing as the oxygen contained in the said products of combustion increases.

7. A combustion regulator for furnaces, comprising a gas meter, a gas absorption chamber, a second gas meter, means for drawing a portion of the gas passing from said furnace successively through said first gas meter, said absorption chamber and said second gas meter, a differential gear driven in opposite directions by the differences in speed of rotation of said meters, a contact moved by said differential gear, a series of parallel branch electric circuits positioned to be separately and singly closed by said contact, means for intermittently opening said separate branch circuits for different lengths of time, a magnetic switch connecting the said branch circuits, a second circuit closed by said magnetic switch, a solenoid in said second circuit and a draft controlling damper operated by said solenoid.

8. A combustion regulator for furnaces, comprising a gas meter, a gas absorption chamber, a second gas meter, means for drawing a portion of the gas from said furnace successively through said first gas meter, said absorption chamber and second gas meter, and means controlled by the difference in speed of rotation of said meters for controlling the draft to said furnace.

9. A combustion regulator for a furnace, comprising means for measuring the rate of flow of gas, an absorption chamber, a second means for measuring the rate of flow of gas, means for drawing a portion of the products of combustion from said furnace successively through said first measuring means, said absorption chamber and said second measuring means, means controlled by said gas measuring means for closing an electric circuit for different intervals of time and increasing the time of each closure as the difference in flow of gas through said meters increases, a solenoid excited by said current in said circuit, a draft controlling damper urged toward open position by a constantly acting force and toward closed position by said solenoid, and means for retarding the motion of said damper.

10. A combustion regulator for furnaces, comprising a gas meter, a gas absorption chamber, a second gas meter, means for drawing a portion of the gas passing through said furnace successively through said first gas meter, said absorption chamber and said second gas meter, a series of parallel branch electric circuits, a contact operated by the difference in volume of gas passing through said meters to separately and singly close said branch electric circuits, means for intermittently opening and closing said branch electric circuits for different lengths of time, a magnetic switch arranged to be closed during the passage of intermittent currents through said branch electric circuits, and means controlled by said second circuit for operating the draft controlling damper of said furnace.

11. A combustion regulator for furnaces, comprising means constantly acting to increase the draft to a furnace, means for constantly testing the quantity of free oxygen in the products of combustion from said furnace, and means acting intermittently for increasingly longer periods of time, as the quantity of free oxygen increases beyond a certain percentage, to decrease said draft.

12. The method of regulating combustion in furnaces, which comprises continuously removing a sample of the flue gases from a furnace, continuously testing said sample of flue gases for free oxygen, continuously increasing the draft to said furnace when the content of oxygen in the flue gases is below a certain percentage, and decreasing

ing the draft when the quantity of free oxygen increases above said fixed percentage.

13. The method of regulating combustion in furnaces which comprises continuously removing a sample of the flue gases from a furnace, continuously testing said sample of flue gases for free oxygen, continuously increasing the draft to the furnace when the content of oxygen in the flue gases is below a certain percentage, and intermittently decreasing the draft when the percentage of oxygen increases beyond a fixed percentage.

14. The method of regulating combustion in furnaces, which comprises continuously removing samples of the flue gases from a furnace, continuously testing said samples of flue gases for free oxygen, continuously increasing the draft to said furnace at a slow rate compared to the velocity of the gases, and slowly decreasing the draft to said furnace when the quantity of oxygen in the flue gases rises beyond a fixed percentage.

15. A combustion regulator for boiler furnaces which comprises means governed by the steam pressure in said boiler for controlling the rate of combustion in said furnace, an air supply for completing the combustion of fuel in said furnace, means continuously acting to increase said air supply to said furnace, means governed by an electric current for intermittently decreasing said draft, a gas absorption chamber, means for drawing a portion of the products of combustion from said furnace through said gas absorption chamber, and means governed by the decrease in volume of gas in passing through said absorption chamber for controlling said electric current.

16. A combustion regulator for boiler furnaces which comprises means governed by the steam pressure in said boiler for controlling the rate of combustion in said furnace, an air supply for completing combustion in said furnace, a gas meter, an absorption chamber, a second gas meter, means for drawing a portion of the products of combustion successively through said first gas meter, said absorption chamber and said second gas meter and means governed by the difference in speed of rotation of said meters for controlling said air supply to said furnace.

17. A combustion regulator for furnaces comprising a primary air supply for controlling the rate of combustion of fuel in said furnace, means governed by the steam pressure in said boiler for controlling the rate of supply of said primary air, a second air supply for completing combustion of fuel in said furnace, a gas meter, an absorp-

tion chamber, a second gas meter, means for drawing a portion of the products of combustion successively through said first meter, said absorption chamber and said second meter and means governed by the difference in the speed of rotation of said meters for controlling the supply of secondary air to said furnace.

18. In a furnace having primary and secondary air supplies, a combustion regulator for furnaces comprising an absorption chamber, means for passing a portion of the flue gases from the furnace continuously through the absorption chamber, and means for automatically controlling the supply of secondary air to the furnace in accordance with the amount of gas absorbed in said chamber.

19. A combustion regulator for furnaces comprising an absorption chamber adapted to absorb oxygen only from the furnace gases, means for passing a portion of the gases from said furnace through the absorption chamber, and means for controlling the supply of air to the furnace in accordance with the extent to which the volume of the furnace gases is reduced by the absorption of oxygen from them.

20. A combustion regulator for furnaces comprising means for removing the free oxygen from a portion of the flue gases and means for controlling the supply of air to the furnace in accordance with the ratio of the volume of gases before and after the removal of the oxygen.

21. The method of regulating combustion in furnaces which comprises continuously removing a sample stream of the flue gases from a furnace, effecting a continuous analysis of the chemical composition of said sample, metering the volume of the gases before and after the analysis and automatically governing the draft on said furnace in accordance with the volume change of the sample effected by the analysis.

22. The method of regulating combustion in furnaces which comprises continuously removing a sample stream of flue gases from a furnace, effecting a continuous chemical combination of the free oxygen in said sample, measuring the volume change in said sample produced by said combination and regulating the amount of draft on the furnace in accordance with said volume change.

23. The method of regulating combustion in furnaces which comprises continuously removing a sample stream of the flue gases from a furnace, continuously absorbing the free oxygen content of said sample and regulating the draft to the furnace by a mechanism responsive to the volume change in said sample before and after the absorption.

In testimony whereof I affix my signature.
JOHN WILLIAM GRISWOLD.