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GAS ANALYZER

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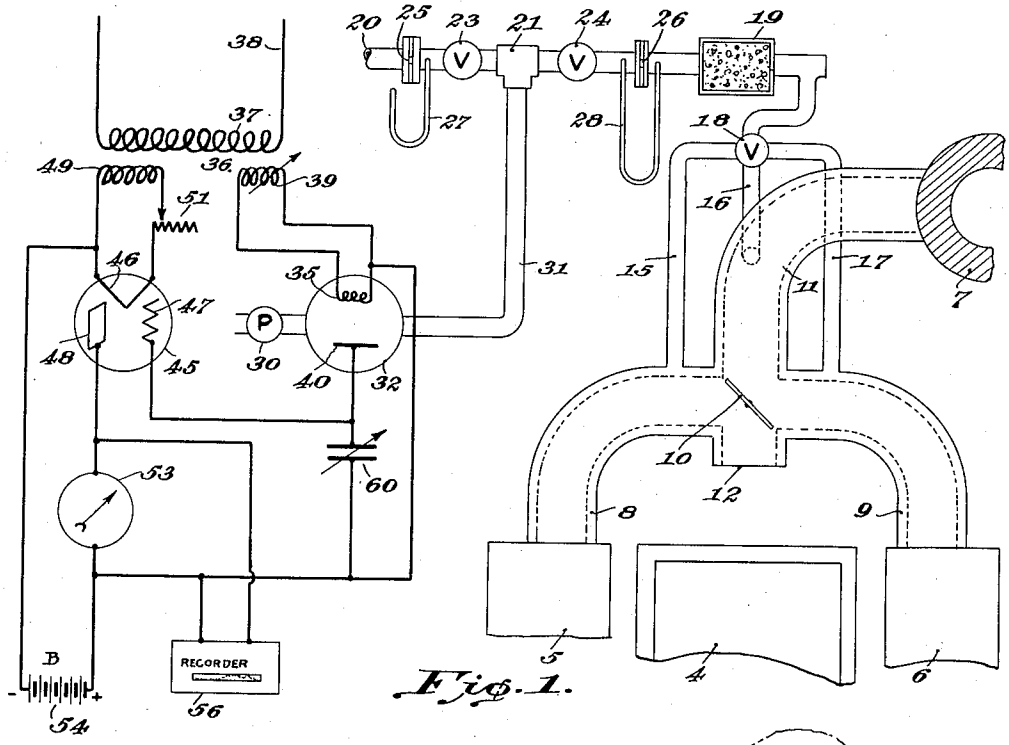


Fig. 1.

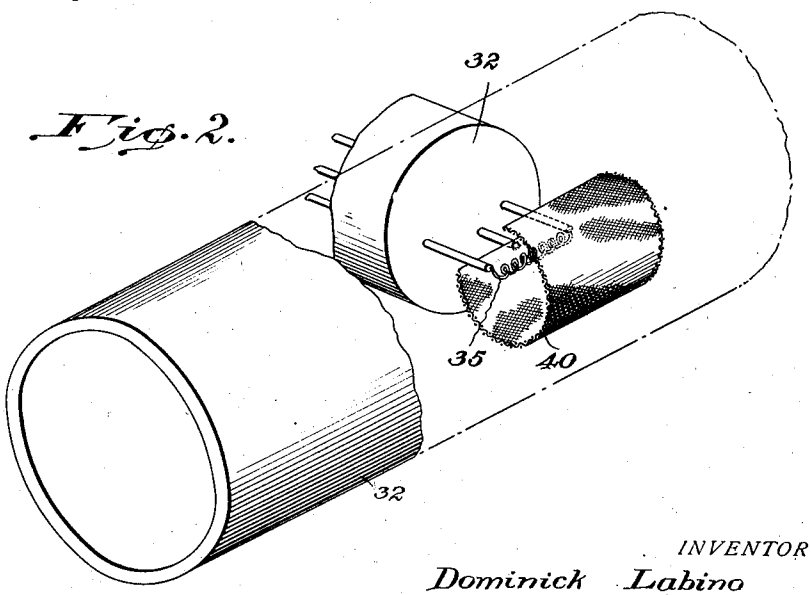


Fig. 2.

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GAS ANALYZER

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7 Claims. (Cl. 23—232)

The present invention relates to a method and apparatus for detecting the presence of and degree of combustion, and more particularly for analyzing automatically and continuously the combustible gas content of waste gases emanating from a gas fired furnace.

One of the objects of the invention is to provide a method and apparatus for indicating and recording the combustible gas contents such as carbon monoxide, hydrogen, hydrocarbons, or the like, that are found by test in the canals of gas fired furnaces, such as a glass furnace, or the like. These gases in percentage should be very low at all times, and, for highest efficiency, none of these gases should be present. However, the percentage of carbon monoxide alone shown by Orsat analysis ranges generally from about zero to two or three per cent or sometimes more. By continuously indicating and recording the percentage of combustibles in the waste gases, adjustments may be made to keep the combustibles as low as possible, and at the same time avoid an excess of air over the optimum proportions.

Heretofore various means have been provided for electrically analyzing the combustibles present in stack gases, as, for example, by registering the ohmic resistance of a platinum wire which is raised to ignition temperature, and is placed in a cell in which samples of the stack gases are continuously passing. This method I have found to be inaccurate and unreliable after a short period of time owing apparently to the attack of the gases upon the platinum wire which seems to be changed in its catalytic behavior. It is an object of the invention to overcome these difficulties and to provide an instrument which will continuously and accurately record the percentage of combustibles present, and to do this for a long period of time.

Another object of the invention is to provide an apparatus for this purpose which is extremely simple and inexpensive, and may be constructed and put into operation at a cost far below that which has heretofore been found possible for this type of apparatus. In this connection I aim to eliminate the use of chemicals or other expensive substances which have heretofore been used as, for example, those used in an Orsat apparatus to analyze the waste gases.

Other objects and advantages of the present invention will become apparent from the following description taken in conjunction with the drawing in which:

Fig. 1 is a diagrammatic view of my apparatus indicating an electrical hookup used and the manner of connection with a conventional gas fired furnace; and

Fig. 2 is a perspective view shown partly in section of an arrangement of elements within my analyzing cell.

Generally speaking, my invention contemplates conducting a clean sample of the stack gases at a predetermined rate and at a predetermined temperature, and mixed with a predetermined quantity of atmospheric air, through a cell composed of a heated filament and a target or plate adapted to receive electrons from the heated filament at a rate which varies directly with the amount of combustibles present in the gases passing therethrough. The heated filament causes combustion of the said combustible gases with the oxygen in the admixed air, causing it to ionize the gaseous particles and facilitate the transmission of electrons from the filament to the target or plate.

As the electrons impinge upon the target or plate, they cause the voltage or current to vary in accordance with the rate of impingement. This voltage or current variation may then be amplified in any suitable manner, its value registered, and, if desired, recorded continuously.

Referring now more particularly to Fig. 1, reference character 4 designates a gas fired furnace such as a regenerative glass furnace having checkerwork regenerators 5 and 6 which alternately communicate with a stack 7 through the regenerator canals 8 and 9, a reversing valve 10, and a stack canal 11. At predetermined intervals the reversing valve 10 is reversed, first, to admit air through the air intake 12 through, for example, regenerator canal 8, to the regenerator 5, during which interval the exhaust gases pass through regenerator 6, the regenerator canal 9, the stack canal 11, and the stack 7; and then, after a suitable interval, when the reversing valve 10 is reversed, the air is admitted into regenerator 6, and the exhaust gases pass through regenerator 5 out through the stack 7.

It is the purpose of the present invention to analyze the exhaust gases passing through the canals 8, 9, and/or 10, and accordingly suitable conduits 15, 16 and 17 may be provided communicating with these canals respectively, these conduits leading to a selector valve 18, and then through a suitable filter and drier 19. This drier may be supplied with calcium chloride or other suitable substance adapted to remove the water from the gas sample. The removal of water and foreign particles protects the internal parts of

the apparatus from corrosion or clogging as well as preventing faulty readings.

The sample may then be mixed with a suitable quantity of oxygen or air which may be drawn through the inlet means **20** and mixed in the mixing chamber **21**. The exact proportion in which the air and gas sample may be intermixed may be regulated by means of the valves **23** and **24**, respectively. Orifices **25** and **26** and accompanying manometers **27** and **28**, respectively, may be provided to indicate the relative rates of admixture of the gases and the proportions thereof.

From the mixing chamber **21**, the sample is drawn by means of a suitable vacuum pump or exhausting means such as an aspirator **30** through the conduit **31** and through the ignition cell **32**.

Suitable proportions of air to waste gas for relatively low percentage of combustibles, as, for example, less than about three per cent combustibles, may be about 1 to 1. The rate of passing the gases through the cell **32** may be any desired rate, although I have found that a total of 500 cc. per minute, or 250 cc. of air and 250 cc. of waste gas per minute to be satisfactory. The air needs only be added to the sample in the event that there is no excess air in the waste gas issuing from the furnace. If there is sufficient air or free oxygen present in the waste gas sample, the appartus will continue to record the combustibles present in the gas.

The cell **32** is provided with a filament **35**, which is preferably composed of a noble metal such as platinum or alloys thereof, owing to its catalytic properties and to the fact that it has a much higher melting temperature compared to other elements which oxidize at elevated temperatures in the presence of oxygen. A variable transformer **36** consisting of a primary **37** communicating with a power line **38**, and a secondary **39**, communicating with the filament **35**, supplies sufficient current for the filament **35**.

The cell **32** is also provided with a target, plate or element **40** to which electrons travel from the filament **35**, and cause a fluctuation of the voltage or current of plate **40**.

The plate **40** is directly connected to an amplifying means comprising a tube **45** consisting of a filement **46**, a grid **47** to which the plate **40** is electrically connected, and a plate **48**. The filament **46** may be energized by an individual secondary **49** of the transformer **36** operating from the same primary **37** as the secondary **39**. A resistor **51** may be provided between the secondary **49** and the filament **46** for adjustment purposes. The plate **48** is also electrically connected to the secondary **49** of the transformer through a voltage indicator **53** and a B battery **54** which may supply any suitable voltage.

I have found satisfactory results may be obtained with a voltage of about 45 volts in the B battery **54** when the voltage of the power line **38** is about 110 volts. A recorder **56** may also be provided in connection with the indicator **53** in order to continuously record the voltage fluctuations of the plate **48** as registered by the indicator **53**. The voltage fluctuations recorded may be from 0 to about 50 millivolts.

From the particular characteristics of the tube **45**, the plate voltage should preferably be adjusted by means of the resistor **51** so that, with minimum changes in grid voltage **47**, a straight line grid voltage to plate current **48** is obtained, whereby the percentage of combustibles is directly, although not necessarily uniformly, proportional to the plate current. In other words, the plate voltage should be adjusted so that a fairly uniform scale may be obtained. Ordinarily, the range of the indicator **53** and recorder **56** in per cent combustibles as expressed in millivolts, indicated and recorded, will determine the voltage to be used at the plate **48**.

In order to adjust the indicator **53** to zero in per cent of combustibles, I preferably provide a variable condenser **60** having any suitable range of capacitance, generally in the range of about .001 microfarad, as a bypass around the cell **32**. Thus, the condenser **60** may be electrically connected between the plate **40** and the filament **35**.

For a detailed view of cell **32**, showing a preferable embodiment thereof, reference may be had to Fig. 2 in which the filament **35** is in the form of a small coil composed of a platinum wire, and the plate or target **40** is in the form of a small screen disposed cylindrically around the filament **35**. The element or plate **40** may be composed of any suitable metal such as brass or nickel or a suitable alloy. The operating temperature of the plate **40** is relatively cold compared to the temperature of the filament **35**. Ordinarily, the plate **40** may be relatively small as, for example, one inch square or so, in order to produce satisfactory results, although the size may be varied as desired within wide limits. The cell **32** may be enclosed in any suitable vessel such as a glass container or the like.

In operating the device, the sample of gas to be analyzed is cleaned and intermixed with a constant proportion of air, and is fed through the cell **32** at a constant rate by means of the vacuum pump **30**. As the gas passes through the cell **32**, it is ignited by the filament **35** which is heated to the ignition temperature of at least about 1250 to 1400° F. which is sufficiently high to ignite the various combustible constituents which may be present in the gas. Among these, the most important is generally carbon monoxide, although hydrogen, ethane, methane, and other constituents may be present. The filaments should be sufficiently hot in order to ignite any of the gases which may pass through the cell **32**. As the combustibles are ignited by the filament **35**, the conductivity of the gaseous medium between the filament **35** and the element **40** increases in direct proportion to the percentage of combustibles present. In other words, the gaseous medium between the filament **35** and the element **40** is ionized in direct proportion to the percentage of combustibles present in the gas which are caused to ignite by the heat of the filament **35**. The change in electron flow passing through the cell **32** from the filament **35** to the element **40** changes the potential at the grid **47** in the tube **45**, this change being amplified on the plate **48** and from there indicated by the indicator **53**, and if desired, recorded by the recorder **56**. The indicator may be a sensitive volt meter recording the voltages from about 0 to about 50 or 100 millivolts, and these millivolts may be calibrated against percentage of combustibles present.

In adjusting the device at the start of operations, the indicator **53** may be made to assume a positive reading, this potential reading resulting from the constants, (1) the capacity of the variable condenser **60**, (2) the filament current in tube **45** adjusted by resistor **51**, (3) the distance between the filament **35** and the plate **40** in cell **32**, and (4) the rate of electron or current flow through the cell when air and no waste gases are passing therethrough. The function of the con-

denser 60 is to adjust the indicator 53 to zero in per cent of combustibles when air and no waste gases are passing through the cell. The number of millivolts then indicated by the indicator 53 becomes zero of combustibles on the scale.

Various other applications may be made with my novel apparatus as, for example, it may be used as a flame indicator or to operate a relay to signal when flames are present in stacks or other parts of gas fired furnaces. In this event, however, of course, no orifice or pumping system is required, and the elements of cell 32 would merely be located in the region requiring observation. However, in this event, the elements in cell 32 should preferably be properly insulated and shielded. When flames are present, the electrical conductivity between the filament 35 and the element 40 increases, and thus permits the presence of flame to be made manifest.

Various modifications and variations may be resorted to without departing from the spirit and scope of the present invention, as, for example, rectified alternating current may be used in place of that supplied by battery 54.

I claim:

1. The method of measuring the degree of combustibles in a gas, which comprises igniting the combustibles in the gas and simultaneously registering the electrical conductivity change in the gas as the said combustibles are ignited.

2. The method of analyzing a waste gas sample to determine the degree of combustibles remaining therein, which comprises admixing sufficient oxygen with said gas to permit complete oxidation of the combustibles therein, raising the gas mixture to ignition temperature of said combustibles to cause combustion of said combustibles, passing an electrical current through said gas as the combustibles are being ignited, and indicating the amperage changes of said current.

3. The method of analyzing stack gas containing combustible gases, which comprises adding to said stack gas sufficient oxygen to permit complete combustion of the combustible gases, passing said mixture of gas between a heated filament and a plate, the temperature of said filament being sufficiently high to permit complete combustion of said combustible material in said gases, passing electrons through said gases from said filament to said plate, and measuring the changes in the electron flow caused by said combustion.

4. The method of analyzing stack gas containing combustible gases, which comprises adding to said stack gas sufficient oxygen to permit complete combustion of the combustible gases, passing said mixture of gas between a heated filament and a plate, the temperature of said filament being sufficiently high to permit complete combustion of said combustible material in said gases, passing an electrical current through said gases between said filament and said plate, amplifying said current changes caused by said combustion, and indicating said amplified current changes.

5. The method of determining the degree of combustible gases in a waste gas sample, which comprises igniting said combustible gases with oxygen in the presence of a catalyst, and registering the electrical conductivity of the gases as the combustible matter is burning, the electrical conductivity varying in direct proportion to the percentage of combustible matter in said waste gases.

6. Apparatus for indicating the percentage of combustible matter in a waste gas sample from a gas fired furnace, which comprises a cell, means for passing a sample of said waste gases through said cell at a constant rate, means for admixing a sufficient quantity of air with said waste gases in said sample prior to entering said cell to cause complete combustion thereof, a filament within said cell, means to energize said filament with alternating current to at least combustion temperatures of said combustible matter, an element spaced apart from said filament and adapted to receive electrons emanating from said heated filament, and means for amplifying and registering the changes in the rate of electron flow from said filament to said element, said means including a detector tube having the grid thereof electrically connected to said element, means for registering the amplified rate of electron flow from said tube, and a capacitance shunting said filament and the electrical connection between said grid and said element.

7. Apparatus for indicating the percentage of combustible matter in a waste gas sample which comprises a cell, means for passing a sample of waste gases through said cell at a constant rate and admixed with sufficient oxygen to oxidize the combustible matter in said cell and cause complete combustion thereof, a filament within said cell, an alternating current source connected to said filament to energize it to at least combustion temperatures of said combustible matter, a target spaced apart from said filament and adapted to receive electrons emanating from said heated filament, a three element detector tube having the grid thereof electrically connected to said target, alternating current energizing means for the filament of said detector tube, means for registering the electrical energy emanating from the plate of said detector tube, and a capacitance shunting the filament within said cell with the electrical connection between said grid and said target.

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