July 9, 1929. C. D. ZIMMERMAN 1,719,864

APPARATUS FOR GAS ANALYSIS

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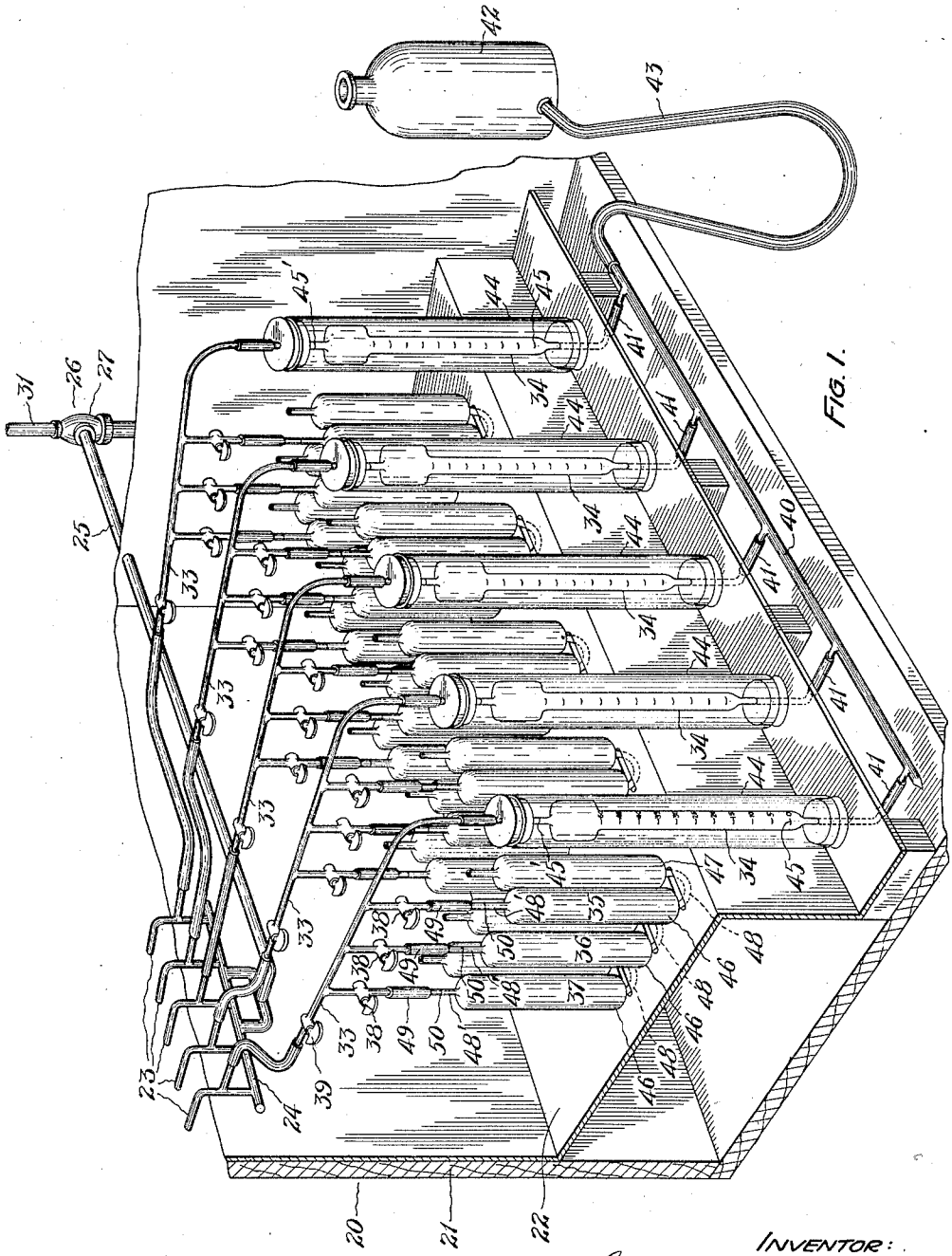


Fig. 1.

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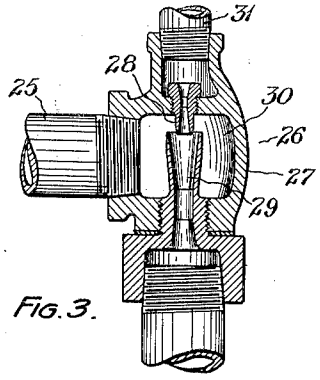


FIG. 3.

FIG. 2.

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UNITED STATES PATENT OFFICE.

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APPARATUS FOR GAS ANALYSIS.

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This invention relates to improved apparatus for taking and analyzing samples of gas, such as flue gas or the like, the apparatus being adapted to determine the exact percentage amount by volume of each constituent present in the samples analyzed.

Generally speaking, the chief object of the invention is the provision of improved apparatus adapted simultaneously to draw samples of gas from different gas passages or different parts of a single gas passage, of gas generating, holding or conducting apparatus, and simultaneously to effect the desired analysis of the said samples.

For purposes of explanation and illustration, I have in the accompanying drawings shown my improved apparatus arranged for use in connection with a steam boiler furnace to analyze the flue gases thereof, but it will be understood that the apparatus is adapted for use under a great variety of circumstances and conditions.

In the drawings,

Fig. 1 is a perspective view of the apparatus for analyzing flue gases or the like, the casing for the apparatus being shown as partly broken away and partly in section.

Fig. 2 is a perspective view showing a boiler furnace and two applications of my analyzing apparatus in use.

Fig. 3 is an enlarged sectional view of a steam jet aspirator forming a part of the apparatus.

I have shown in Fig. 2 a water tube boiler of the bent tube type which is baffled for five gas passages arranged and connected in series between the grate and the stack of the furnace. In connection with this boiler and furnace I have shown two sets of my improved apparatus, each set illustrating a particular method of use. Both sets of the apparatus may be permanently installed in relation to the furnace in the manner shown, or if preferred, one apparatus only may be used successively for the respective applications, as well as to serve any number of furnaces or other forms of apparatus with which the analytical apparatus may be used.

The reference character 1 indicates the furnace in its entirety. The interior of this furnace is indicated by 2 and will be referred to for the sake of clearness as the gas chamber thereof. In the upper portion of the chamber 2 are located a plurality of boiler headers 3, 4 and 5 which are connected by means of a plurality of water tubes 6 to a lower header 7. Baffles 8 are so arranged with respect to the gas chamber 2 and the tubes 6 as to form a series of five gas passages 9. These passages communicate with each other at their ends to form a continuous gas passage from the burners or grates (not shown) to the stack 10. The construction of the burners or grates, as the case might be, and operation thereof as well as the construction and operation of the entire boiler and furnace is well known to those skilled in the art and a more detailed description is deemed unnecessary.

In the application of my apparatus designated by the reference character A in Fig. 2, the apparatus is being used to draw samples of gas from the separate sections of the gas passage 9 in the chamber 2, so that the amount of leakage or infiltration of air into the chamber can be both located and determined in amount from an analysis of the separate samples taken. The conduits 11 extend into their respective gas passages to an equal distance so as to tap a given stratum of gas at different points in its passage through the gas chamber. As. stated, these conduits should extend into the furnace passage to the same depth, as it is well known that gas entering the first passage of the boiler in stratified streams, possibly of different gas composition, maintain these streams more or less throughout the furnace. The same stratum must be analyzed in order to correctly determine the infiltration of air. By taking samples at different depths in the passages the entire wall structure can be tested for leakage of air.

The application of my apparatus shown at B is used to secure an accurate average analysis of the flue gas in the entire gas chamber 2. The conduits 12 are shown as taking samples of gas from points spaced apart in substantially the same plane across a gas passage 14. This gas passage 14 communicates at its lower end with the upper end of the last of the series of gas passages 9. The several analyses of the different samples can be averaged in order to determine the average analysis of the gas in the entire passage. This application also determines the combustion conditions of the furnace as an analysis of the gas entering the several conduits 12 to the apparatus 20 is separately obtained before averaging as will be presently described.

The apparatus is shown in detail in Fig. 1

and is enclosed in an outer casing 21. Secured in the interior of this outer casing is a supporting plate 22 constructed to provide separate levels for supporting different parts of my apparatus to be presently described. The outer casing 21 and supporting plate 22 may be constructed of any desired material, as they taken alone form no part of my present invention.

The conduits 23 communicate with conduits 11 (or 12) which lead to the gas chamber 2 in the interior of the furnace 1, shown in Fig. 2. It will be readily understood that the apparatus shown in Fig. 1 is adapted to be used in either application A or B disclosed in Fig. 2, as well as various other applications. These conduits are connected together at their inner end by means of an aspirator manifold 24. This manifold is connected by means of a tube 25 to an aspirator of any well known type. In Fig. 3 I have shown, for the purpose of illustration, an aspirator 26 adapted to be operated by steam which consists essentially of a casing 27 having a steam nozzle 28 secured to one side of the casing, and adapted to direct steam into a venturi-shaped passage 29. The said venturi 29 projects into the interior of the chamber 30 of the casing 27 and is secured to the side thereof opposite to the steam jet. In the operation of the aspirator the steam, entering through the pipe 31 and flowing at high velocity from the nozzle 28 into the venturi-shaped passage 29 just described, causes a suction in the chamber 30 of the aspirator in a well known manner, and this causes gas to flow into this chamber from the tube 25 which communicates with the aspirator manifold 24.

Leading from each one of the conduits 23 are a plurality of pipes which are connected by means of flexible tubing such as rubber or the like to a series of gas manifolds 33. These manifolds are formed of capillary tubing and are five in number, and each one communicates at one end in the manner just described with a corresponding conduit 23, and is in communication at its other end with a measuring burette 34. There are five of these measuring burettes, each one being connected at one end to a corresponding gas manifold 33. I have provided a series of absorbing pipettes 35, 36 and 37 communicating with each of these manifolds 33 by means of capillary tubes, at spaced points intermediate the ends of each manifold 33, as can be seen from Fig. 1. Each of the capillary tubes leading from a gas manifold to a pipette is adapted to be closed off by means of a cock 38.

A three-way cock 39 is located in each one of the gas manifolds 33 between the conduits 23 and the pipettes 37. These cocks are designed to allow communication between each of the gas manifolds and its corresponding conduit when turned to one position; to allow communication between the atmosphere and each of the gas manifolds when turned to a second position; and to cut off communication between the gas manifolds and either the conduits or atmosphere when turned to the third position. These three-way cocks may be of any construction suitable for the purpose stated.

Each of the measuring burettes 34 communicates at its lower end with a water manifold 40 by means of sections of flexible tubing 41. A levelling bottle 42 to contain water communicates with this water manifold 40 by means of a flexible tube 43 so as to permit the raising and lowering of the bottle 42 for the purpose to be presently described. Each of the measuring burettes 34 is enclosed in a casing 44 which is adapted to contain water for cooling the gas samples. Each burette is graduated as shown to contain 100 c. c. of fluid, the 0 c. c. mark being indicated by the reference character 45, and the 100 c. c. mark by the character 45′.

The pipettes 35, 36 and 37 contain certain chemical reagents which are adapted to absorb from a gas sample particular constituents. As for instance, the pipettes 35 may contain a solution of caustic potash which will absorb from a given gas sample the carbon dioxide (CO_2) content thereof. The pipettes 36 may contain a pyrogallol solution which is adapted to absorb the oxygen (O_2) content of the gas. Pipettes 37 may contain a hydrochloric acid solution of cuprous chloride which is adapted to absorb the carbon monoxide (CO) content of the gas sample. The absorbing pipettes may be constructed in any form suitable for the purpose. They should afford chambers to hold the reagent solution and from which the latter may be displaced by the entering gas leaving wetted surfaces to contact with the gas in the well-known manner. Each of the pipettes holding the same solution may have its own chamber into which the solution is displaced or all of them may have a common chamber into which the solution is displaced. In the specific construction illustrated the former arrangement is employed and each pipette comprises enlarged tubes 46 and 47 connected in the usual manner at their lower ends by restricted tube 48. The upper end of tube 46 is connected to the conduit leading to the gas manifold by means of a short section of capillary tubing 48′ and flexible connections 49 and the upper end of the tube 47 communicates with the atmosphere, or preferably, in accordance with the common practice, with prior apparatus for flue gas analysis, rubber bulbs (not shown) are fitted on the open upper ends of tubes 47 so that the atmosphere is not admitted to the reagent in the tube. The mark 50 which is shown on the tube 48′ connecting the upper end of tube 46 with its corresponding manifold 33 is for the purpose of indicating the correct height of the reagent

contained in each pipette. Tubes 46 preferably contain pieces of glass tubing or the like to afford large wetted surface areas when the gas being analyzed is forced into the pipette.

The method of operating the apparatus is as follows: suction is started in the manifold 24 by means of the aspirator 26. This will cause gas to flow from the gas chamber 2 through each of the conduits 23. The three-way cocks at 39 are all turned to allow gas to flow into the interior of each of the gas manifolds 33. The levelling bottle 42 is then alternately raised and lowered so that the level of water in the measuring burettes will be alternately raised and lowered. The lowering of the bottle 42 will draw, simultaneously, separate samples of gas from spaced points in the gas chamber into the conduits 23, through the manifolds 33 and into each one of the measuring burettes 34. The raising of bottle 42 will discharge each sample back through the manifolds 33 and into the aspirator manifold 24. This action is repeated until a sample of gas free from air is obtained in each of the measuring burettes 34. Then with the levelling bottle 42 in the lower position such that the water in each burette 34 is below the zero point, the cocks at 39 are closed, thus retaining a sample of something over 100 c. c. of gas in each burette. Each sample is then reduced to exactly 100 c. c. at atmospheric pressure by proceeding as follows with each burette in succession. The rubber tube connecting the lower end of the burette to the water manifold is pinched off by the fingers of the operator, cock 39 is turned to place the burette in communication with the atmosphere and then the water bottle is raised and sufficient water is admitted to the burette to bring the water level therein exactly to zero. Cock 39 is then fully closed. This procedure is repeated for each one of the burettes until a sample of 100 c. c. of gas, at atmospheric pressure, is obtained in each one of the burettes.

This having been done, each one of the cocks at 38 is turned so as to allow communication with each of the pipettes 35 and its corresponding gas manifold. The reagent in each pipette initially must be up to the mark 50. The gas samples are then simultaneously forced into each of the pipettes 35 by raising the levelling bottle 42 and keeping it raised until the water in the burettes 33 reaches the top mark or 100 c. c. mark 45′ of all of the burettes. It might be stated here that in order to obtain a thorough mixture of gas and solution in the pipettes, the levelling bottle might be raised and lowered several times so as to pass the gas back and forth in the pipettes 35. After this raising and lowering of the levelling bottle, the bottle is raised as was stated until the water in each of the burettes reaches the top mark 45′ as was stated above. The gas is allowed to remain in the pipettes for a short period of time during which the chemical reagent in each of the pipettes 35 is absorbing the carbon dioxide (CO_2) content of the gas. The gas is then passed back into the measuring burette by lowering the bottle 42 until the reagent in the pipettes 35 again reaches the mark 50. The cocks 38 of pipettes 35 are then closed. A reading is then made on each burette by placing the surface of the water in the levelling bottle 42 on a level with the water in each burette 34 successively. This reading will indicate the amount of CO_2 content present in each sample of gas. In case the true analysis of all the gas sampled is desired the separate analyses secured, or values determined therefrom directly or by calculation, are averaged.

The analyzing process just described is then repeated for the oxygen (O_2) and carbon monoxide (CO) content in the gas by passing the remaining gas through the pipettes 36 and 37, respectively. It will, of course, be understood that in order to obtain a correct reading for each succeeding analysis that the sum of the preceding readings must be subtracted from the last reading taken.

In using my apparatus in the application designated by the reference character B in Fig. 2, it will be seen that I can obtain a correct average analysis of the total gas present in a gas passage, as the values determined are based upon entirely separate samples taken under uniform conditions at spaced points across the said passage. This is very advantageous as the gas in the passages of large boilers varies in analysis across the passage and also varies with time. If samples at single points are taken in succession a large number of analyses must be made to get a good average and even when this is done the average may be incorrect, since under the prior practice the samples, as a practical matter, must be taken at different times. When a series of simultaneous analyses are taken by one apparatus a more correct average is obtained in about one-half the time required to take and analyze the single samples successively.

The application shown by the reference character B in Fig. 2 has a further advantage in that it has been found that gas entering the first passage of the boiler in stratified streams of different compositions maintain these streams throughout the furnace without much mixing and therefore simultaneous analyses of gas from spaced points across a boiler passage show certain conditions in the furnace which are of great value in combustion work.

The application designated by reference character A in Fig. 2, in which separate gas samples are taken simultaneously from different points spaced apart lengthwise of the current of gas in the furnace chamber, is of

great advantage in locating and determining from time to time the leakage or infiltration of air into the gas chamber of a boiler furnace through its walls. This can be done in less time and with more accuracy by taking simultaneous analyses in one apparatus, than by taking single analyses successively. As is well understood, air leakage causes a decrease in the carbon dioxide (CO_2) and carbon monoxide (CO) content of the flue gas and an increase in the oxygen (O_2) content, and the change in gas analysis, as the flue gas goes through the successive passages of the gas chamber, therefore indicates the amount of air leakage at certain points.

The two specific applications described relate to single furnaces, but obviously the apparatus can be used to analyze simltaneously the flue gases of a plurality of boilers or furnaces, as for example, where the flues of these furnaces lead into a single stack. In this case, the conduits 23 are led, respectively, into the flues of the separate furnaces.

While I have described and illustrated the preferred apparatus and the preferred procedure in the case of two particular applications or uses of my invention and in the last preceding paragraph have specifically mentioned another application, it will be readily understood that these are merely by way of example, that other applications or uses of the invention are contemplated and that there can be wide variations both as to procedure and as to the apparatus and the different applications thereof without departing from the invention as defined in the appended claims.

What I claim is:

1. In apparatus for gas analysis, the combination of a plurality of measuring burettes; a plurality of tubes connected respectively to the upper ends of the burettes and adapted to draw gas simultaneously from different points in a gas passage or passages; means, comprising an absorption pipette connected to the upper end of each burette, for absorbing a constituent of the gas measured in the burette; a manifold connected to the lower ends of the burettes; and a liquid levelling bottle operatively connected to the manifold and adapted when raised to displace gas simultaneously from each of the burettes into its corresponding absorbing means and when lowered to withdraw gas simultaneously from each absorbing means into its corresponding burette.

2. In apparatus for gas analysis, the combination of a plurality of measuring burettes; a plurality of tubes connected respectively to the upper ends of the burettes and adapted to draw gas simultaneously from different points in a gas passage or passages; a manifold connected to said tubes adjacent to the burettes; suction means connected to said manifold; means, comprising an absorption pipette connected to the upper end of each burette, for absorbing a constituent of the gas measured in the burette; a manifold connected to the lower ends of the burettes; and a liquid levelling bottle operatively connected to the last named manifold and adapted, when raised, to displace gas simultaneously from each of the burettes into its corresponding absorbing means and when lowered to withdraw gas simultaneously from each absorbing means into its corresponding burette.

In testimony whereof, I hereunto affix my signature.

CARL D. ZIMMERMAN.