E. H. PEABODY.

AUTOMATIC GAS ANALYZING APPARATUS.

APPLICATION FILED SEPT. 21, 1906.

**944,274.** Patented Dec. 28, 1909.

3 SHEETS—SHEET 1.

*Fig. 1.*

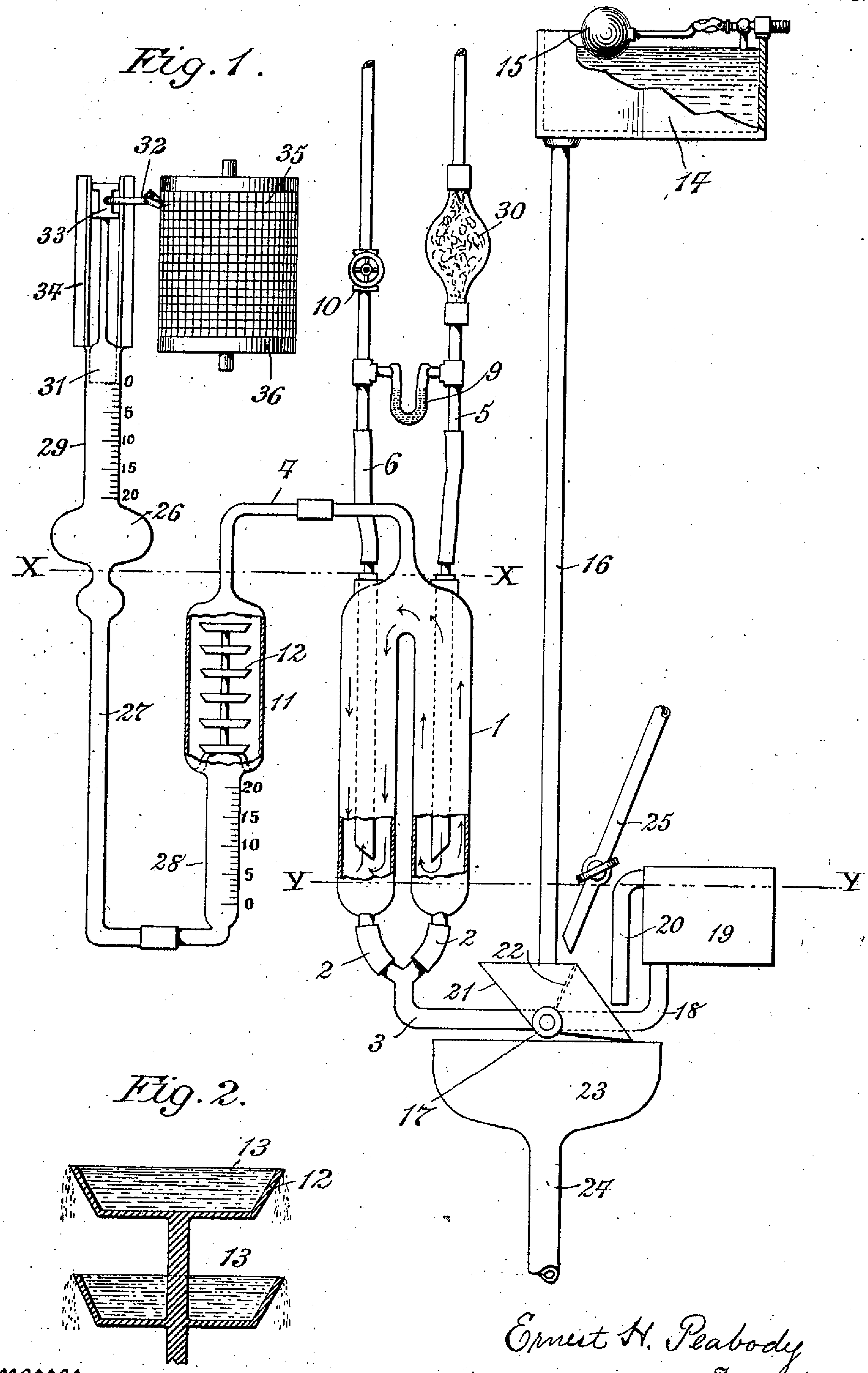



*Fig. 2.*

Witnesses
Edward Rowland.
Kathryn B. Cheevers.

Ernest H. Peabody
Inventor

By his Attorney H. S. MacKaye

E. H. PEABODY.

AUTOMATIC GAS ANALYZING APPARATUS.

APPLICATION FILED SEPT. 21, 1906.

944,274.

Patented Dec. 28, 1909.

3 SHEETS—SHEET 2.

*Fig. 3.*

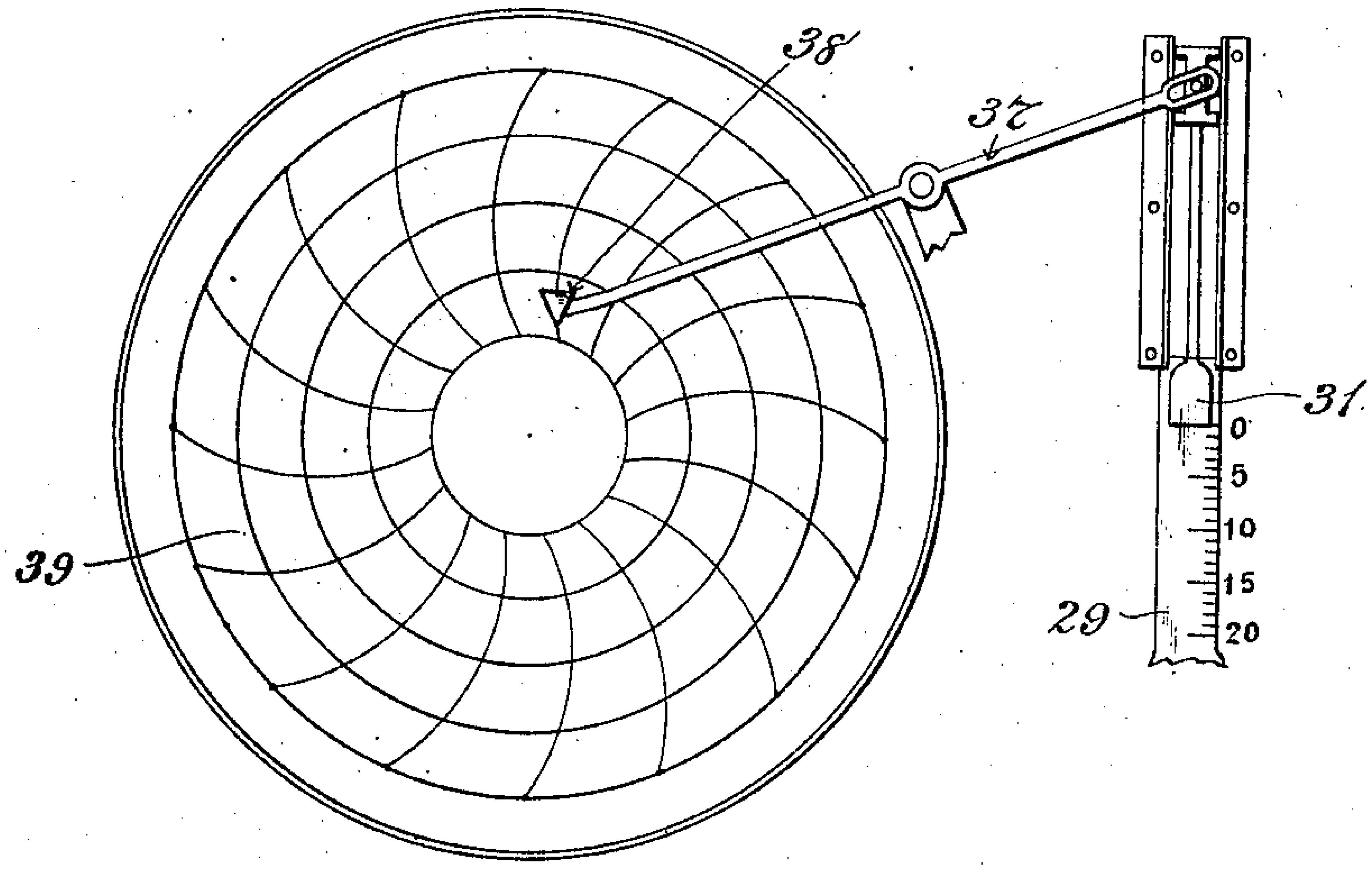
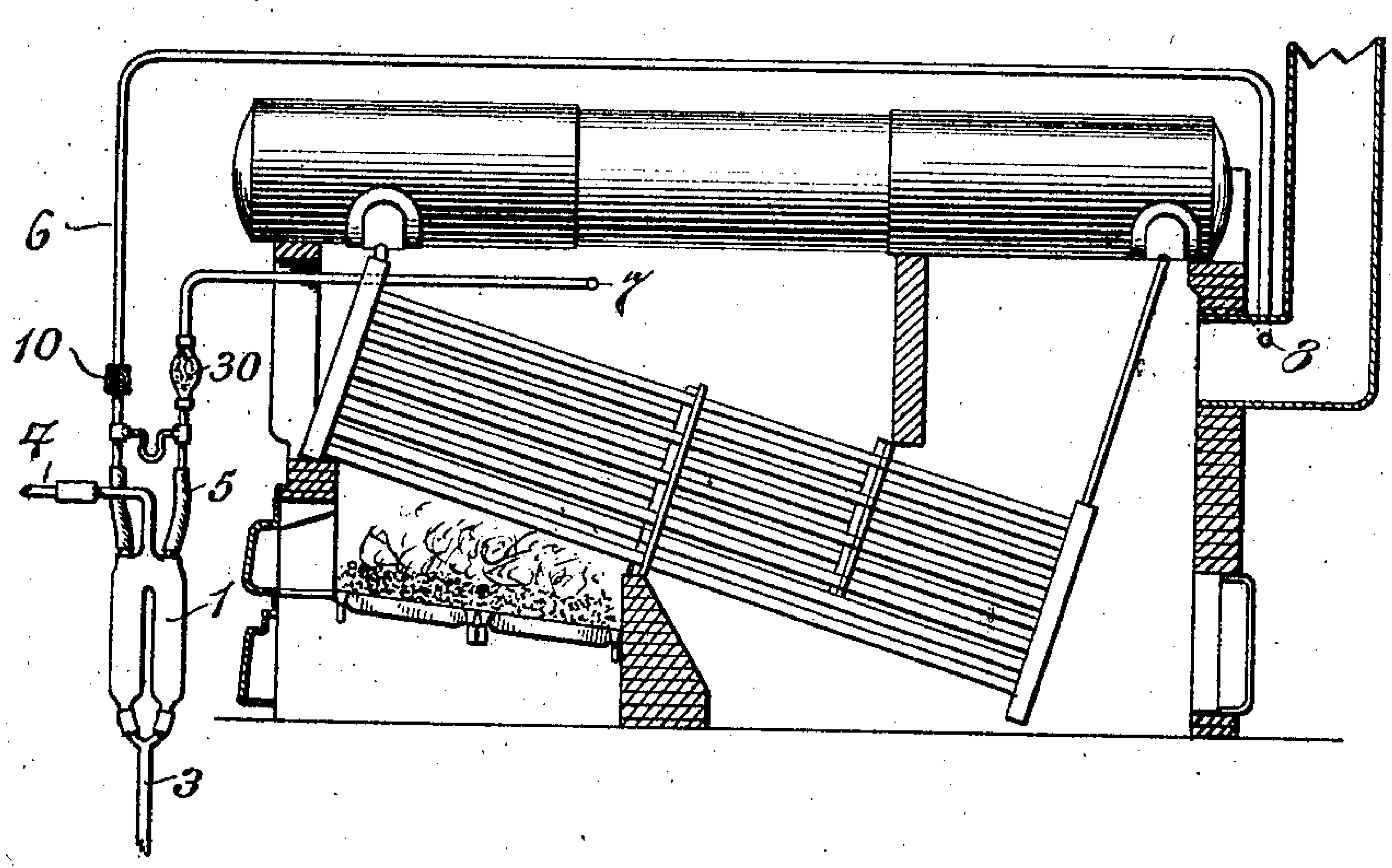



*Fig. 4.*




Witnesses
Edward Rowland.
Kathryn B. Chevers

Ernest H. Peabody
Inventor

By his Attorney H. McKaye

E. H. PEABODY.

AUTOMATIC GAS ANALYZING APPARATUS.

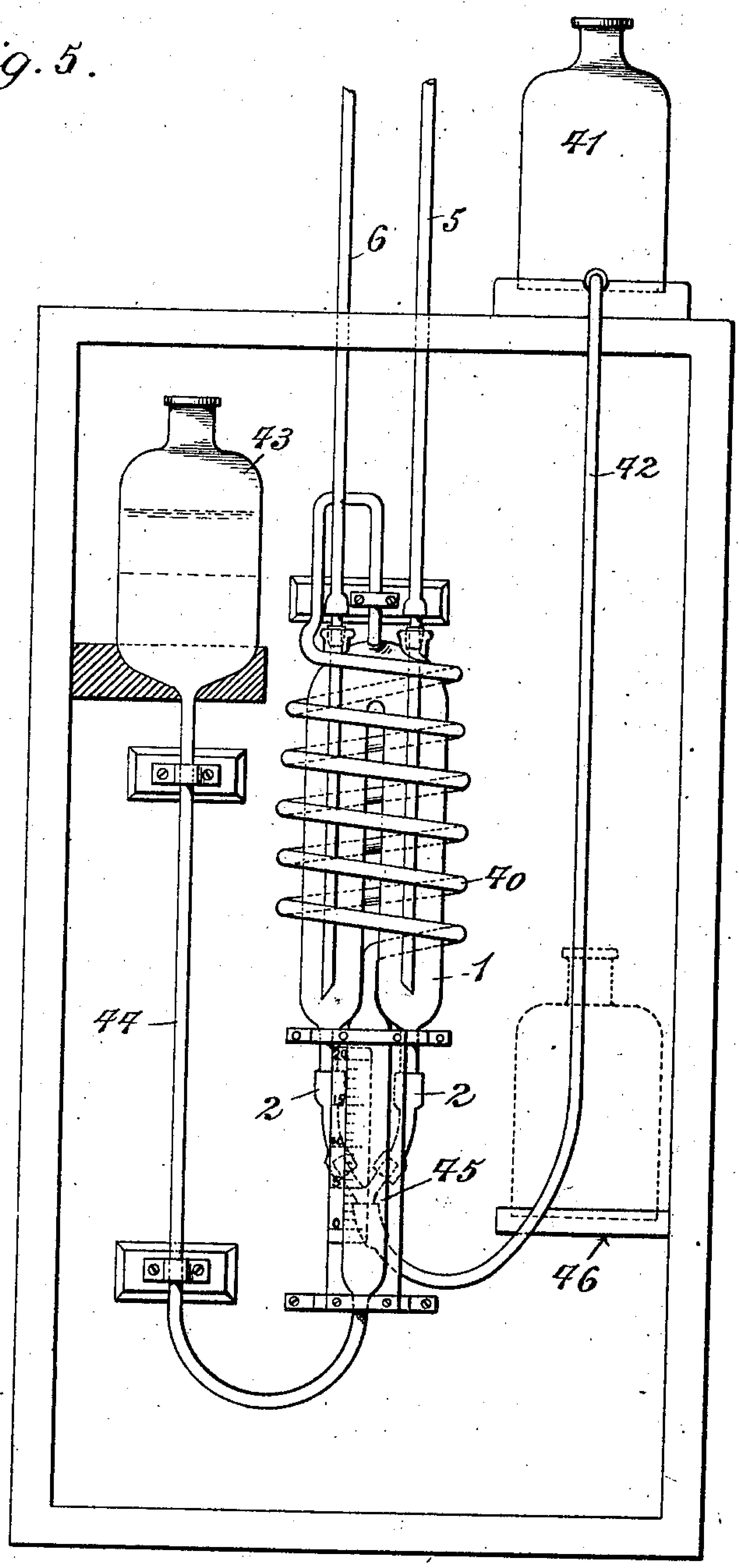
APPLICATION FILED SEPT. 21, 1906.

944,274.

Patented Dec. 28, 1909.

3 SHEETS—SHEET 3.

Fig. 5.




Witnesses
Edward C. Rowland
Kathryn B. Cheever

Ernest H. Peabody Inventor

By his Attorney H. S. MacKaye

# UNITED STATES PATENT OFFICE.

ERNEST H. PEABODY, OF NEW YORK, N. Y.

## AUTOMATIC GAS-ANALYZING APPARATUS.

944,274. Specification of Letters Patent. Patented Dec. 28, 1909.

Application filed September 21, 1906. Serial No. 335,643.

*To all whom it may concern:*

Be it known that I, ERNEST H. PEABODY, a citizen of the United States, residing in the city, county, and State of New York, have invented a certain new and useful Improvement in Automatic Gas-Analyzing Apparatus, of which the following is a specification.

My present invention relates to an improved apparatus for the analysis of gases, and more particularly to means for determining the proportion of carbon dioxid in furnace gases.

In order to properly regulate the air and fuel supply in furnaces for boilers and other devices it is important to ascertain from time to time the chemical constitution of the furnace gases. These are ordinarily composed of three constituents, namely—nitrogen, oxygen, carbon dioxid, and possibly a fourth:—carbon monoxid. Where the air supply is insufficient, monoxid and an excess of carbon dioxid will be found, and where this supply is too great, oxygen will be in excess. It has been found by many tests made under varying circumstances that, in properly constructed boilers and furnaces, the percentage of carbon dioxid in the furnace gases is by itself a reliable indication as to the proper conditions of the draft. It is therefore clear that a check can be kept on the conditions of fuel supply and of air supply by employing means for rapidly indicating the percentage of carbon dioxid alone, and the present invention has relation to a simple and reliable device whereby determinations of this kind can be rapidly made.

In its preferred embodiment my invention includes means whereby a substantially continuous record may be automatically produced showing the percentage of carbon dioxid present in the furnace gases at frequent and regular intervals of time.

The various separable elements of improvement found in the complete invention are, among others, a novel means for bringing the gases to the measuring apparatus and disposing of the dead gases after each operation, novel means for transferring the gases to be analyzed in measured quantities to the absorbing apparatus and a novel construction of absorbing apparatus.

An illustrative form of my invention is shown in the accompanying drawings wherein—

Figure 1 is a front elevation of an entire automatic recording device embodying the present invention, Fig. 2 is an enlarged view in elevation of a portion of the absorbing apparatus, Fig. 3 is an elevation of a modified form of recording means, Fig. 4 shows in diagram the relation of the receiving and measuring chamber to the furnace of a common type of boiler, and Fig. 5 shows in front elevation a simplified form of device comprising a modified gas-transferring means.

My complete apparatus comprises five principal elements, namely:—A measuring chamber into which the mixed gases are initially conveyed. An absorption chamber into which said gases are transferred in measured quantities when the apparatus is used. Means for transferring the gas as aforesaid. A reservoir into and out of which the absorption liquid is forced from and to the absorption chamber during each operation, and means for determining the position of the absorption liquid at the end of each operation.

In the embodiment of my device which is shown in Fig. 1, the measuring-chamber into which the mixed gases are initially introduced takes the form of an inverted U-shaped tube, 1, the lower ends of which are made narrow and are joined, as by branch tubes 2, to a supply pipe 3. From the top of the measuring chamber the capillary tube 4 leads to the absorption chamber.

The inlet and outlet tubes 5 and 6 extend down into the two legs of the chamber 1 as shown in dotted lines in Fig. 1, and their lower orifices are placed at such a level that, when a suitable liquid enters the chamber and rises high enough to close said orifices, the volume of gas imprisoned in the chamber will be a convenient predetermined number of units, as for instance 100 c. c.

The inlet tube 5 is preferably connected, as at 7 in Fig. 4, to a point near the fire box in the furnace, while the outlet tube 6 is connected to the outgoing flue as at 8, where the pressure is considerably lower. The precise points of connection, 7 and 8, may vary through wide limits, so long as they correspond to locations of material difference of pressure in the path of the products of combustion. At 9 is shown a simple pressure gage, whereby an indication of this difference of pressures is constantly given, so as to provide a means of ascertaining the degree of suction acting at any time to feed the apparatus. A valve 10 may be introduced to control the degree of pressure in operation.

The term "furnace" as used in my claims applies to the entire heating device including the chimney itself.

The absorption chamber is shown at 11, and may be of any appropriate construction, but I prefer the arrangement illustrated; wherein one or more wide and shallow pans 12 are supported within the chamber 11, so that, as the absorbing liquid flows in, the contents of said pans are renewed and they are left brimful when the absorbing liquid is withdrawn. By this arrangement an extended absorbing surface is afforded by the contents of the pans, shown at 13 in Fig. 2.

The means for transferring the gas from the measuring chamber to the absorption chamber 11 may take many forms, and I have shown two of these which are within the scope of the present invention. That one of the means shown which is preferred for continuous automatic operation is shown in Fig. 1. Here a supply reservoir 14 is used which is kept filled with water or other suitable displacing liquid at a constant level by automatic means, such for instance, as those indicated at 15. A supply pipe 16 communicates by a three-way valve 17 with the pipe 3 on one side and, on the other side, with the pipe 18, leading to the overflow tank 19. The level here is kept constant, as at *y—y* by the overflow pipe 20. The valve 17 is automatically operated to place the pipe 3 in communication alternately with the pipes 16 and 18, in a manner familiar in the use of three-way valves. While my invention covers any convenient means adapted to this operation, I have shown for illustrative purposes a motor operating continuously under the influence of a continuous stream of water. For this purpose, there is mounted upon the rotary member of the valve 17 a tilting receptacle 21, divided into two sections by the partition 22. This is so shaped and located that, when the valve 17 is turned as far as it will go in one direction one section empties itself into the basin 23, whence the water is led away by the pipe 24. In the meantime water flowing continuously from the pipe 25 into the other section of the receptacle 21, finally fills it to such a point as to tilt it back and bring the valve 17 to its opposite extreme position. The water is again emptied into the basin 23 and water from the pipe 25, filling the first emptied section of 21, causes repetition of the above described cycle of operation.

The fourth principal element of my device is the reservoir for the absorption liquid. I may use any liquid capable of efficiently absorbing carbon dioxid, and preferably a solution of caustic potash. This is contained in a reservoir 26 and in the tube 27 which is connected to the absorption chamber 11. In connection with, and virtually forming a part of the reservoir, I use one or two gage glasses as desired. These are shown at 28 and 29 occupying respectively the initial and the terminal end of the total reservoir. These gage glasses are graduated, preferably to indicate percentages of carbon dioxid in the gas analyzed, and they should be calibrated with due regard to the differences of level of the absorption liquid in the reservoir during the operation hereinafter described. Either of these gage glasses may be suppressed, and indeed, where the external recording means are employed as herein shown, neither gage glass is indispensable.

I have thus far described one form of each of the essential elements of the specific invention, and the mode of operation can now be set forth.

Assuming the parts to be in the position shown in Fig. 1, which is that existing just after one complete operation. The tube 3 is in communication with the tank 19 and the displacing water (or other liquid) stands at the level *y—y*, lower than the extremities of the tubes 5 and 6, within the chamber 1. The absorption liquid has filled the chamber 11 and now stands in said chamber and in the reservoir at the level *x—x*. Water is running into the left hand section of the motor-receptacle 21, preparatory to a new operation. Owing to the difference of gas pressures in the two pipes 5 and 6, the furnace gas is flowing freely in through 5 and out through 6 as indicated by the arrows, being preferably cleared of dust by an appropriate strainer 30. The effect of the gas circulation thus produced is to entirely clear out the gas left over in the chamber 1 from the previous operation, and to fill said chamber with new furnace gas. This state of things being produced, as soon as the left hand section of the receptacle 21 is filled, the three-way valve 17 operates to cut off the tank 19 and places tube 2 in communication with the main supply pipe 16. Water from the reservoir 14 is thus admitted to the measuring chamber 1, and, as the level rises therein, it acts first to close the lower ends of the tubes 5 and 6 and then to drive the measured volume of imprisoned gases over into the absorption chamber 11. The gases thus driven over displace the absorbing liquid which rises in the receiving reservoir.

The liquid in the reservoir 14 is kept constantly at such a level that, when said liquid is admitted to the chamber 1, it will rise to the level *x—x*, exactly at the beginning of the capillary tube 4, and neither higher nor lower. When said liquid reaches this point, the opposing pressure of the absorbing liquid, transmitted through the gas in the absorption chamber, acts to arrest it.

The parts are so proportioned that, assuming the gases transferred as above described to contain no elements capable of absorption by the absorbing liquid, this latter will stand in its reservoir with one end at the zero mark in the glass 28 and the other end at the zero mark in the glass 29. Of course, where either of these glasses is dispensed with, the reading will be zero in the other under the circumstances assumed. In practice, however, a certain quantity of carbon dioxid will be present in the gases which have filled the chamber 1 and been transferred as above described, and since this is absorbed by the liquid in the pans 12, the volume of gas will be diminished. This diminution will be shown by the resulting difference in the position of the absorbing column and a reading of either gage glass will serve to measure this difference. By suitable spacing of the marks upon the gage glasses, each space between marks may be made to correspond to a certain proportion borne by the carbon dioxid to the total volume of gas. In the drawing I have illustrated as an example a system of calibration whereby each space between marks on the glasses corresponds to one per cent. of the carbon dioxid, and the glasses read up to twenty per cent., which is beyond any proportion found in practice in boiler furnaces.

Any user of a given furnace should know what percentage of carbon dioxid in the gases corresponds to the best conditions of combustion in that furnace, and, if he observes a departure therefrom one way or the other, he can take the proper steps for correction thereof.

It will of course be understood that, as the right hand compartment of the motor reservoir 21 is filled, the valve 17 is once more operated and the conditions shown in Fig. 1 are again produced.

A practically continuous record of the conditions of combustion may be obtained by using the device illustrated in Fig. 1 or that shown in Fig. 3. In each of these forms a float 31 is supported upon the upper surface of the displaced column of absorbing liquid as it rises and a pen or pencil 32 is carried on an appropriate cross head 33, moving between guides 34.

In Fig. 1 the end of the pen or pencil bears upon the surface of a ruled chart 35 secured upon the periphery of a cylinder 36 which is adapted to revolve slowly and continuously in a well known manner. By properly placing the chart 35 and appropriately spacing the lines thereon, a series of zig-zag lines will be produced, the upper angles of which will indicate on the chart the percentage of carbon dioxid present at each operation of the apparatus. This indicator may be used with or without one or both of the gage glasses.

Another form which the indicator in question may take is shown in Fig. 3. Here the float actuates a lever 37, the extremity of which carries a suitable pen or pencil 38 which bears upon a flat revolving chart 39. Here the up and down movements of the float 31 produced by operation of the device are transmitted in the form of curves to the chart. As the latter revolves, a zig-zag line is produced thereon whose interior angles indicate upon a suitably drawn scale, the percentage of carbon dioxid corresponding to each successive operation of the apparatus.

The means employed for continuous rotation of the charts are well known in connection with indicators in general and therefore I have not shown the same herein.

In Fig. 5 is shown a simpler modification of my broad invention, some elements of which are obviously susceptible of use with certain elements hitherto described, and illustrated in the other views. Here the absorption chamber consists of a spiral tube 40 which may surround the measuring chamber 1. By using a spiral tube as shown, an extended surface wetted by absorbing liquid may be obtained and the vessels 12 be dispensed with. The displacing liquid is contained in a movable vessel 41 connected to the measuring chamber by a flexible tube 42. The absorbent liquid reservoir consists of the vessel 43, the connecting tube 44 and the graduated glass 45 which last may be supported directly beneath the measuring chamber in the form shown, wherein the tube 40 is wound around the chamber 1. The tubes 5 and 6 through which circulation of gas is accomplished enter the measuring chamber as in the form shown in Fig. 1. When the vessel 41 is raised, as shown in full lines, gas is expelled into the absorbing chamber, expelling the absorbing liquid into the reservoir 43 and permitting determination of the percentage of $CO_2$ by reading of the glass 45. When the vessel 41 is lowered to the support 46, as shown in dotted lines, a new supply of gas is introduced in the manner already described.

Many changes may be made in the construction and arrangement of the parts of this apparatus without departing from my invention, and I am not to be understood as limiting myself to the details herein shown and described.

What I claim is—

1. An apparatus for gas analysis comprising an intake chamber, an inlet and an outlet tube for gas terminating therein, a source of displacing liquid, an overflow and a valve adapted to operate in one position to establish communication between said chamber and source of liquid and in another position to establish communication between said chamber and overflow, substantially as described.

2. An apparatus for gas analysis comprising an intake chamber, means for conveying gas thereto, a source of displacing liquid, an overflow and a three-way valve adapted to connect said chamber with said source when in one position and with said overflow when in another position, substantially as described.

3. An apparatus for gas analysis comprising an intake chamber means for conveying gas thereto a source of displacing liquid, an overflow, a valve adapted to connect said chamber alternately with said source and said overflow and means adapted to automatically operate said valve for producing said alternate connections, substantially as described.

4. In combination with a combustion furnace, an apparatus for analysis of gas comprising an intake chamber, and two gas tubes leading therefrom to two points of different pressures in the normal path of movement of the furnace gases, substantially as described.

5. In combination with a combustion furnace, an apparatus for analysis of gas comprising an intake chamber, a tube leading from said furnace at a point relatively near the fire to said intake chamber, and a second tube leading from said furnace at a point relatively near the chimney outlet, to said intake chamber, substantially as described.

6. In combination with a combustion furnace, a measuring chamber, an absorption chamber, means for transferring gas from the former to the latter chamber and an inlet and outlet for the measuring chamber communicating respectively with points of different pressures in the normal path of movement of the furnace gases, substantially as described.

7. An apparatus for gas analysis comprising an absorbtion chamber, a reservoir of absorbing fluid in communication therewith, means for forcing measured quantities of gas into said absorption chamber and a gage glass near each end of said reservoir, substantially as described.

ERNEST H. PEABODY.

Witnesses:

EUGENE P. TERRY,

KATHARINE VAN VALKENBURG.