J. A. CALDWELL.

APPARATUS FOR THE ANALYSIS OF GASES.

APPLICATION FILED NOV. 16, 1907.

906,687.

Patented Dec. 15, 1908.

3 SHEETS—SHEET 1.

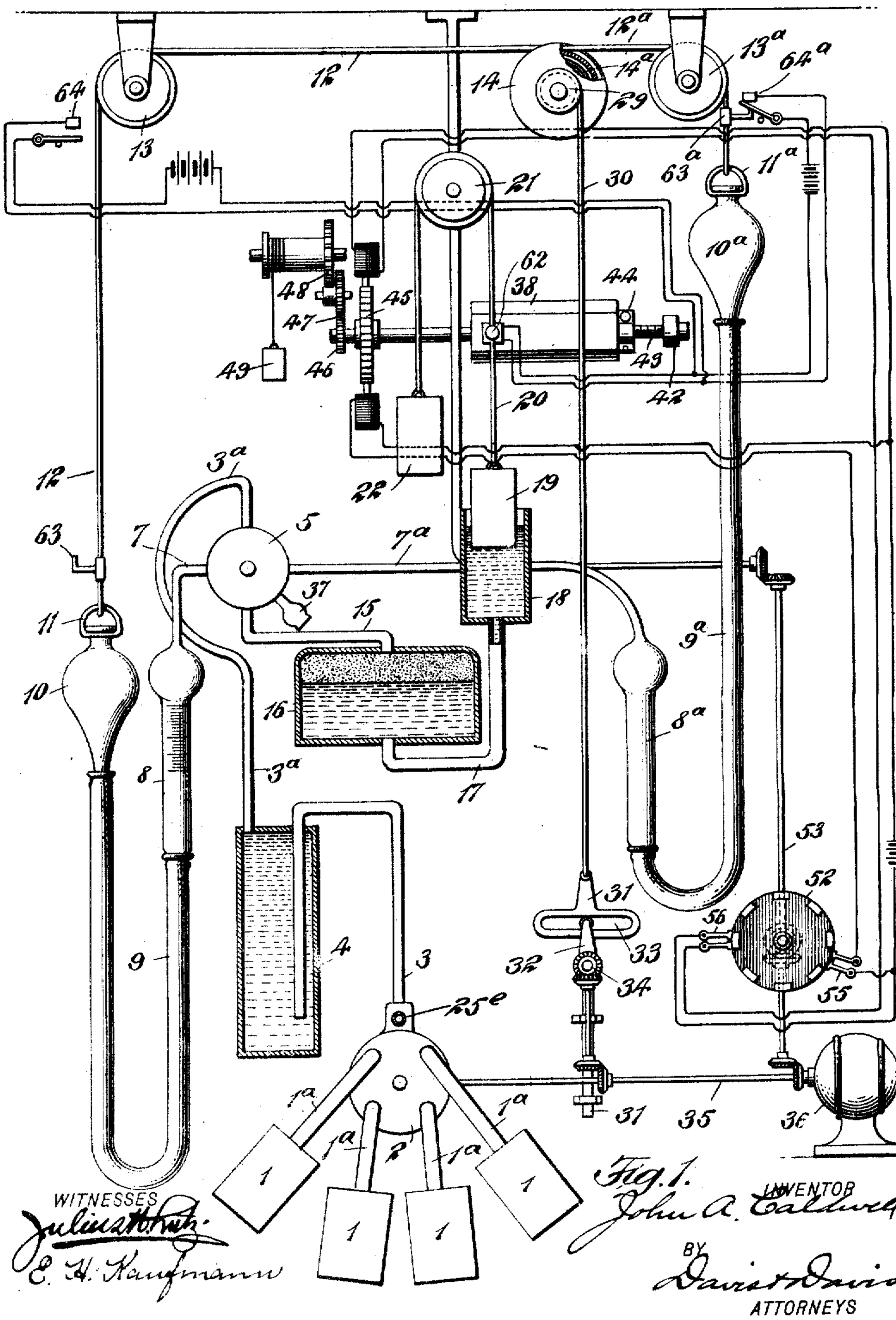

Fig. 1.

WITNESSES

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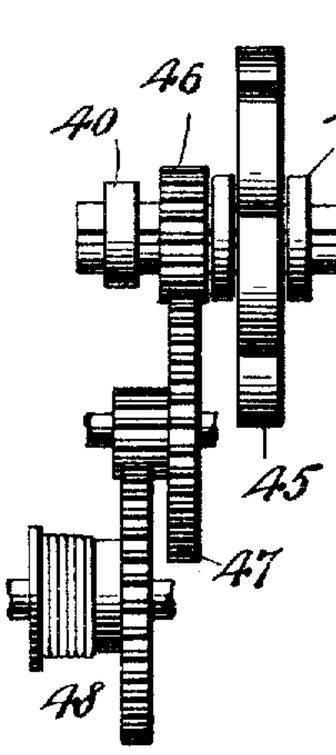
3 SHEETS—SHEET 2.

Fig. 2.



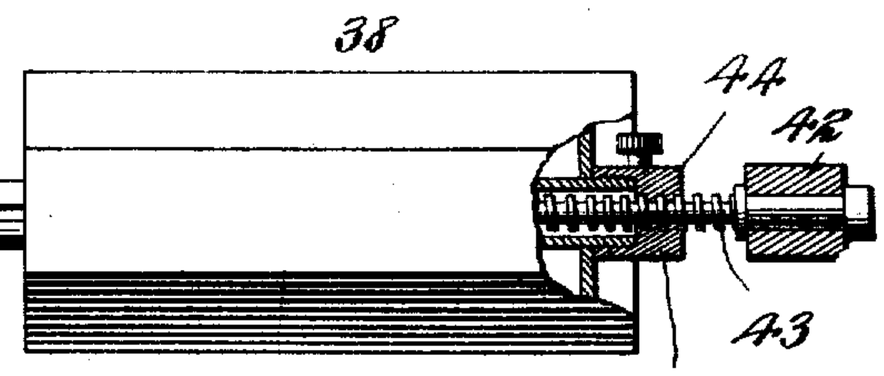


Fig. 2a.

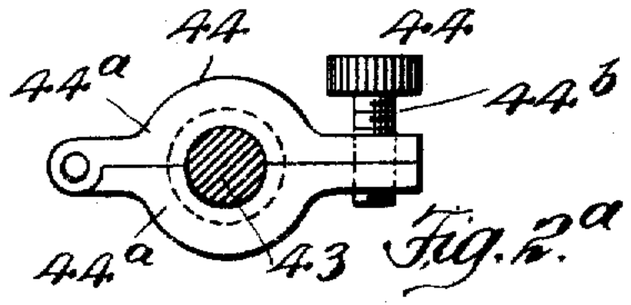


Fig. 3.

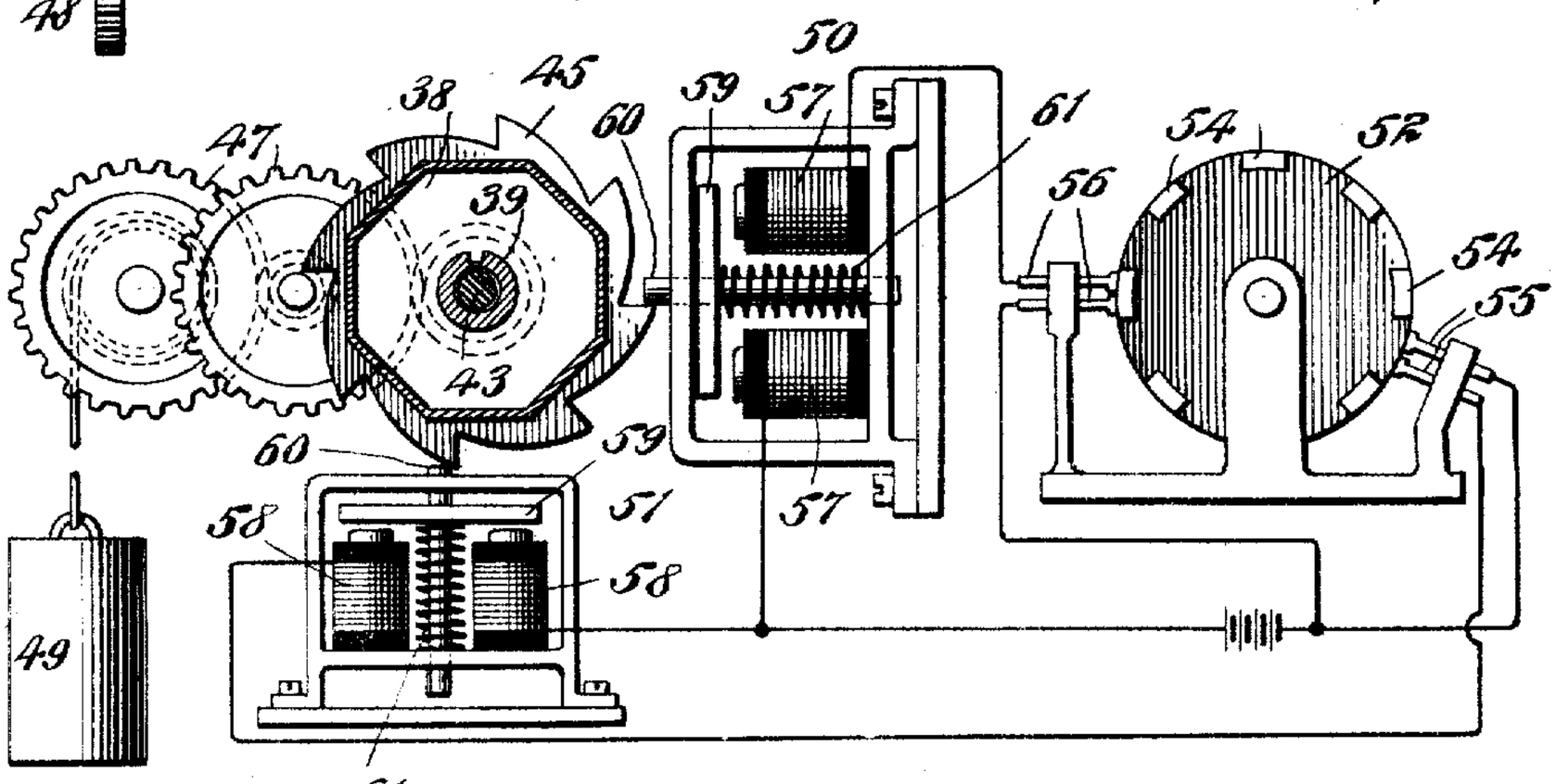
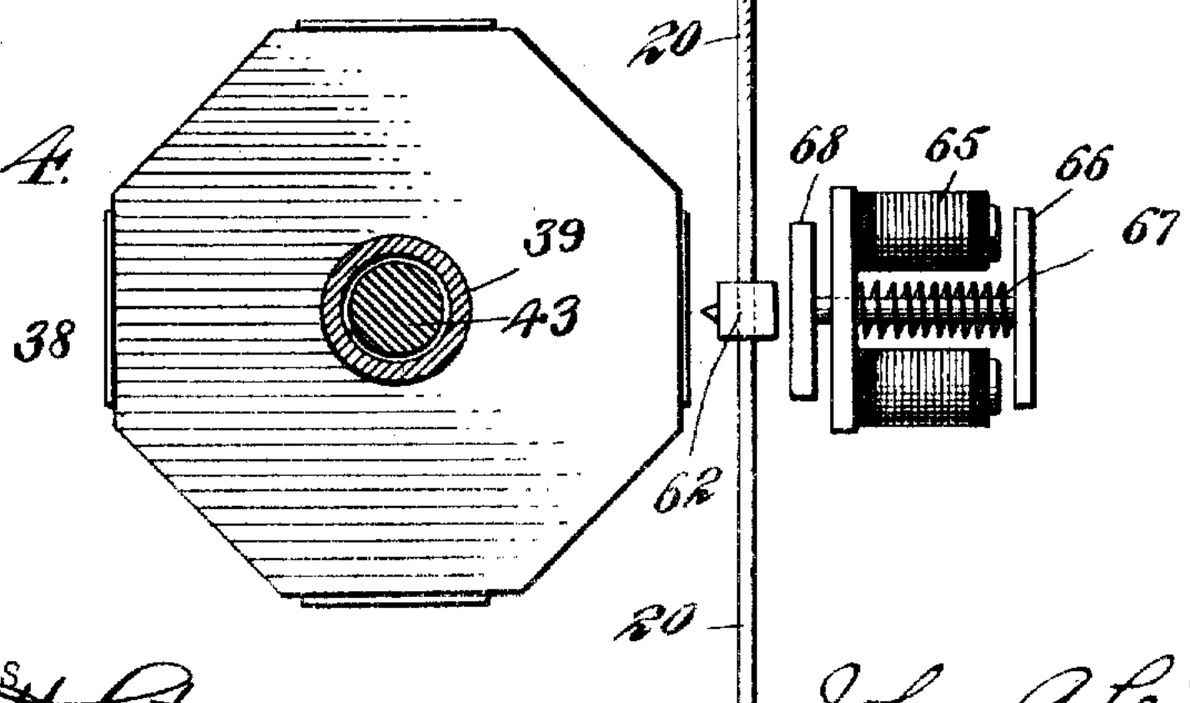


Fig. 4.



WITNESSES

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3 SHEETS—SHEET 3.

Fig. 5.

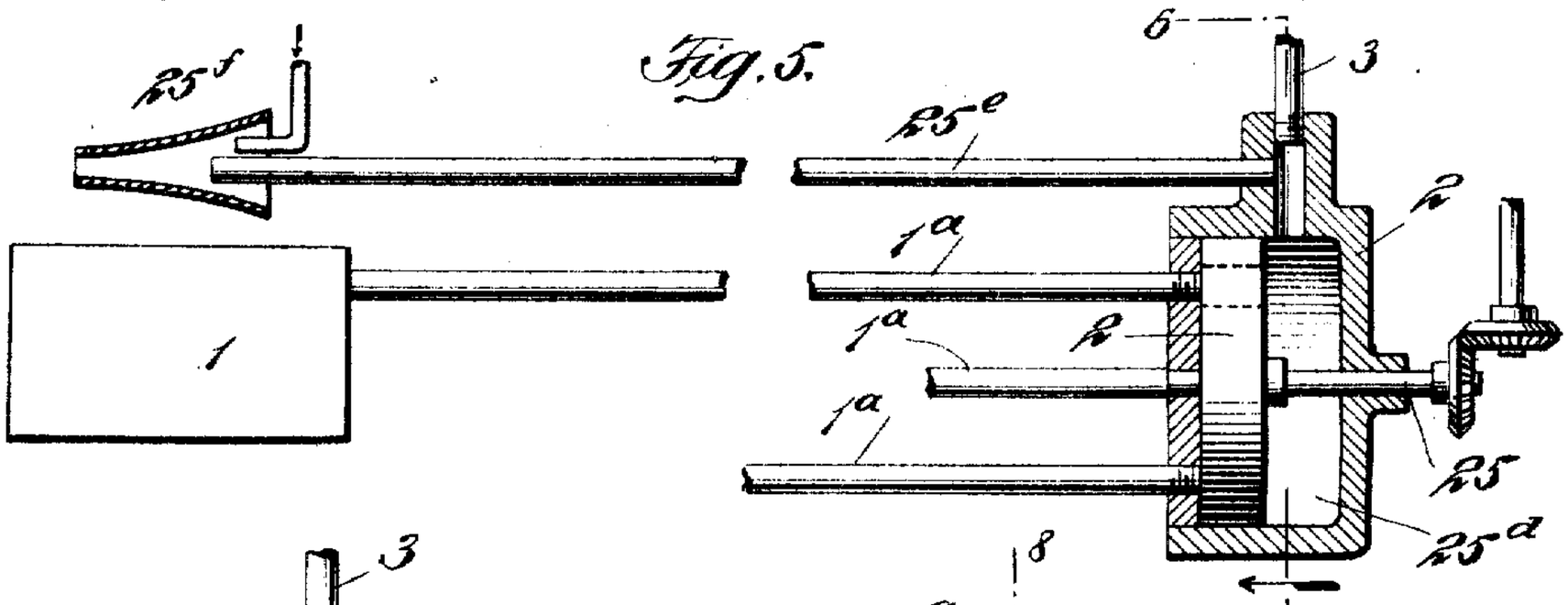


Fig. 6.

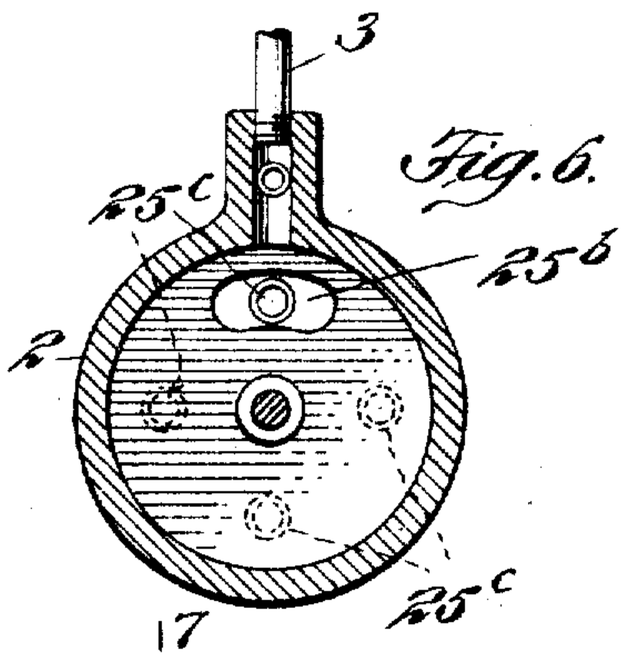


Fig. 7.

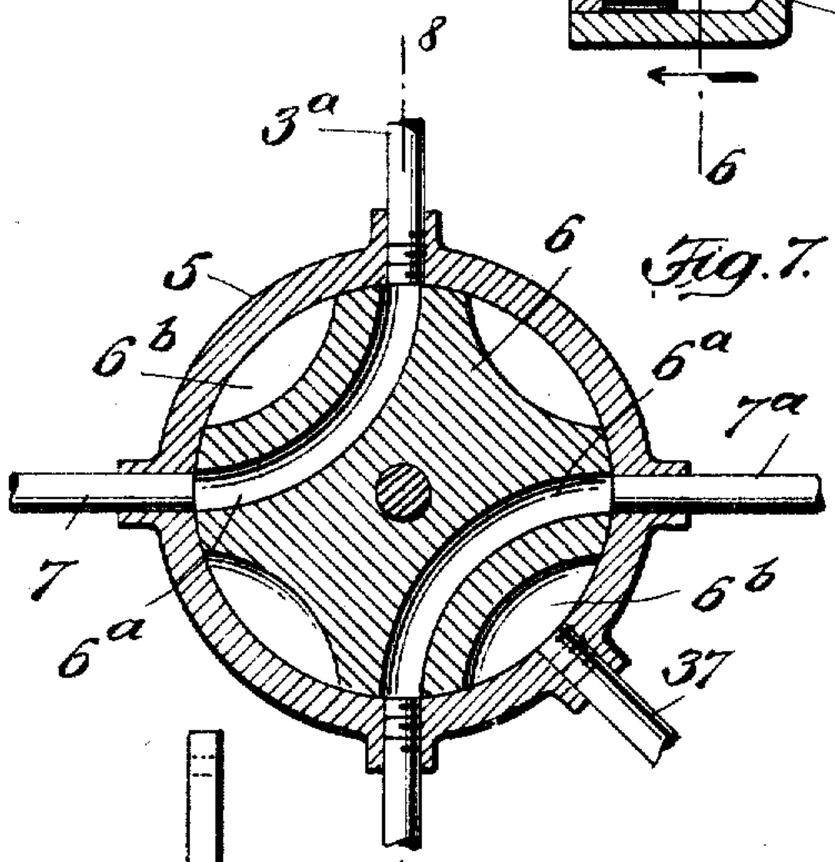


Fig. 8.

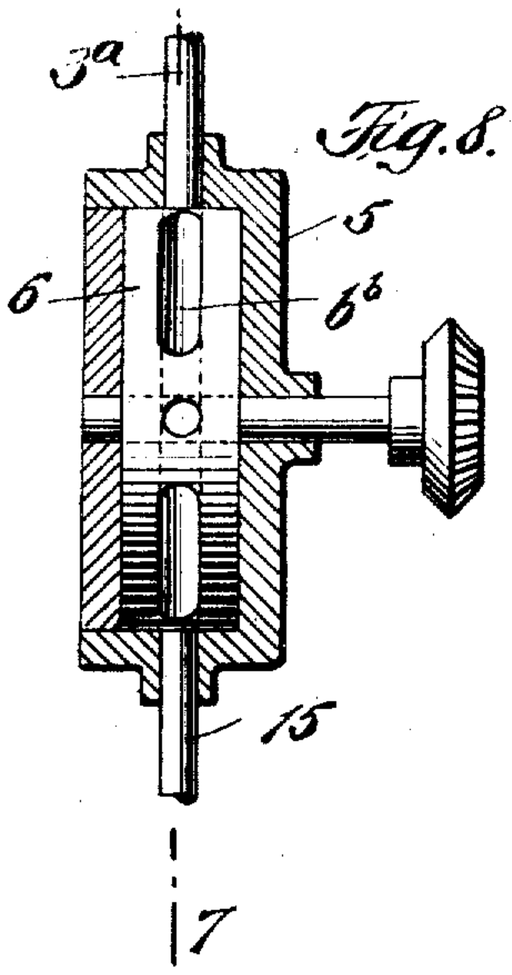
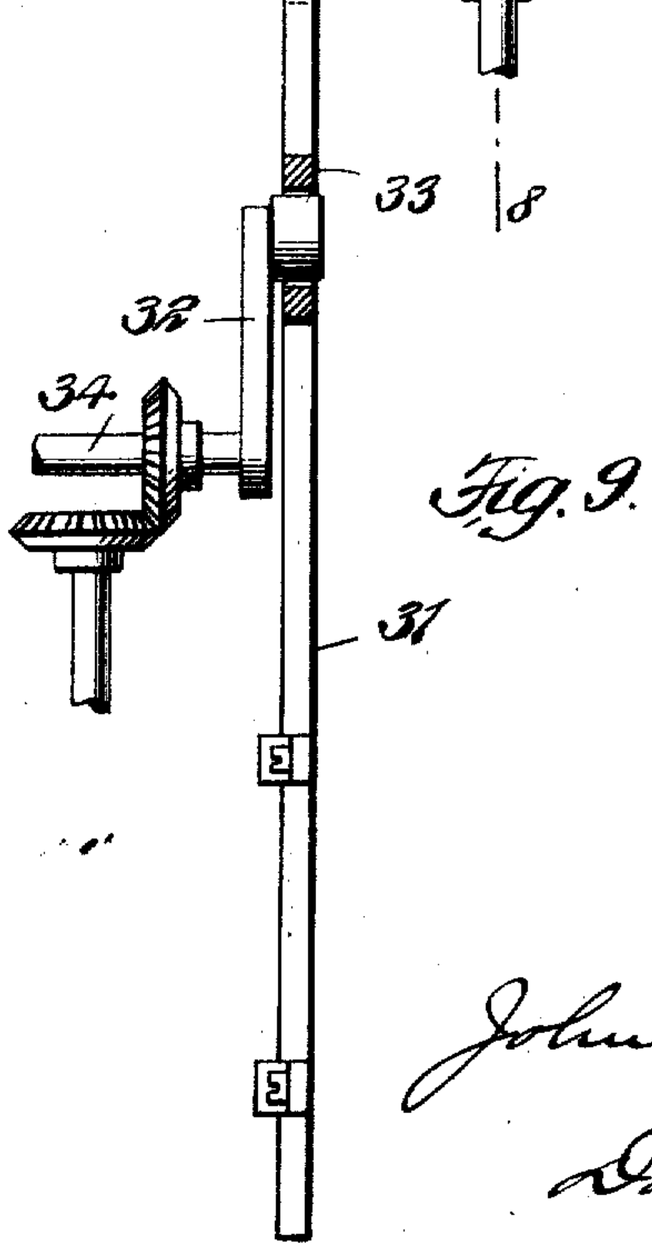


Fig. 9.



WITNESSES

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UNITED STATES PATENT OFFICE.

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APPARATUS FOR THE ANALYSIS OF GASES.

No. 906,887. Specification of Letters Patent. Patented Dec. 15, 1908.

Application filed November 16, 1907. Serial No. 402,379.

To all whom it may concern:

Be it known that I, JOHN A. CALDWELL, a citizen of the United States, residing at Montclair, in the county of Essex and State of New Jersey, have invented certain new and useful Improvements in Apparatus for the Analysis of Gases, of which the following is a specification, reference being had therein to the accompanying drawings, in which—

Figure 1 is a diagrammatic view of the apparatus, portions being shown in section; Fig. 2 a plan view of the rotatable record card holder and the motor for operating it; Fig. 3 an end elevation thereof, the record card holder being shown in sectional view; Fig. 4 a detail view showing the octagonal card holder and the marking device; Fig. 5 a detail view of the means for taking gas from a furnace; Fig. 6 a detail view of the selective valve for taking gas from a series of furnaces in succession; Figs. 7 and 8 detail views of the valve for controlling the movement of the gas from the furnace to the measuring chamber and to the absorption chamber; and Fig. 9 a detail view of the means for drawing the gas from the furnaces.

This invention has relation to a mechanical means whereby a practically continuous record is automatically produced showing the percentage of carbonic acid present in furnace gases, so as to provide a permanent and reliable indication of the condition of combustion for the guidance of engineers.

One of its many objects is to provide simple, accurate, and reliable apparatus for analyzing gases from a series of furnaces, and for producing a permanent individual card record showing the conditions of combustion in each furnace.

A further object of the invention is to provide a rotatable record card holder adapted to carry a number of cards and to give said holder a step-by-step movement and a longitudinal movement, and to provide means for marking on the cards a permanent record showing the condition of the furnace gases.

There are many other important objects and advantages of the invention which will be particularly described hereinafter.

Referring to the various parts by numerals, 1 designates a series of boiler furnaces, said furnaces being diagrammatically indicated. These boilers are connected to a selective intake valve or device 2 by suitable pipes 1^a. From the valve 2 the gas is led through pipe 3 to a point near the bottom of a suction-regulating chamber 4 filled with water or other suitable sealing liquid. Pipe 3 is open at its lower end and may be extended any suitable distance down into the liquid contained in said chamber, for a purpose which will be hereinafter set forth.

The top of chamber 4 is connected by pipe 3^a to a valve casing 5 containing the rotatable valve 6 having a series of ports. To one of the ports in the valve casing a pipe 7 is connected, the lower end of this pipe being in communication with the top of a stationary measuring chamber 8. To the lower end of this measuring chamber is connected a flexible rubber pipe or tube 9 which extends below the measuring chamber a suitable distance and is then turned and brought upward. A small chamber or bottle 10 is connected to the upper end of tube 9, and carries a ring 11 at its upper end to which the suspending and lifting cord 12 is attached. The cord 12 passes over a suitable pulley 13 and is secured to a drum 14, which serves to support the chamber 10 and the tube 9, and to raise and lower them as will be hereinafter described.

Connected to the valve casing 5 is an outlet pipe 15 which is adapted to be brought into communication with the pipe 7 at the proper point in the rotation of the valve 6, whereby a measured quantity of gas from the chamber 8 will be passed through said pipe as will be hereinafter described. An absorption chamber 16 is connected to the outlet end of pipe 15 so that gas may be delivered from pipe 7 through the valve 6 into said chamber. Within said chamber is arranged any suitable material adapted to absorb carbonic acid. I prefer to use potash, and to place in the chamber a suitable quantity of iron wire netting. Connected to the bottom of the absorption chamber is a pipe 17, which is carried up to a suitable point above the absorption chamber and is connected to the bottom of a displacement chamber 18 in which is contained a suitable liquid. This chamber is open at its top; and arranged to move therein, according to the displacement of the liquid, is a balanced weight 19. This weight is connected to the lower end of a

flexible cord 20 which passes over a suitable pulley 21 and carries at its other end the counter-balance weight 22. The weights 19 and 22 are equal so that the weight 19 will move up and down according to the displacement of the liquid in chamber 18.

Secured to the drum 14 is an actuating drum 29; and wound on said drum is a cord 30 whose lower end is connected to a vertically reciprocating bar 31. This bar is moved vertically by a crank arm 32 which rotates in a yoke 33. The crank arm is carried by a shaft 34 driven by suitable gearing from the main shaft 35 of the motor 36. The crank 32 is of such length and the drum 29 is so proportioned with respect to the drum 14, that the required vertical movement of the chamber 10 is secured, and said movement is predetermined and is constant.

The operation of this portion of my apparatus is as follows:—The chamber 10 and tube 9 is supplied with a suitable quantity of liquid and the upper end of the chamber 10 is open to the atmosphere. When the bar 31 is raised by the crank arm 32, the chamber 10 is lowered. This dropping of the chamber 10 causes a corresponding drop of the liquid in the measuring chamber 8. The lowering of the liquid in the chamber 8 produces a vacuum in the upper part of said chamber and in the pipe 7 so that when said pipe is connected to pipe 3^a gas will be drawn from pipe 3 through the liquid in chamber 4 to pipe 3^a and then through the valve 6 and pipe 7 to chamber 8, thereby filling said chamber with a certain quantity of gas from one of the furnaces connected to the selective valve. At this point the valve 6 rotates cutting off communication with pipe 3^a and placing pipe 7 in communication with pipe 15 leading to the absorption chamber. The crank arm 32 has now made a one-half revolution and is depressing the bar 31 thereby elevating the chamber 10 and the tube 9 connected to it. This causes the liquid in the said chamber and tube to again pass into chamber 8 and to force the gas therefrom into the absorption chamber. When the CO_2 is absorbed, the unabsorbed gas forces the liquid from said chamber into the displacement chamber 18. Any movement of the liquid in the displacement chamber causes a corresponding movement of the balanced weight 19. The larger the percentage of carbonic acid in the furnace gases the smaller will be the amount of liquid displaced by the unabsorbed gas and consequently the shorter will be the movement of the balanced weight 19. When the chamber 10 has reached its maximum height all the gas from the measuring chamber 8 has been driven to the absorption chamber and the unabsorbed gases have lifted the weight 19. Connected to the weight 19 is a marking device whereby the height of the weight will be recorded at the completion of each operation, thereby indicating the amount of CO_2 absorbed in the chamber 16.

It will readily be understood that the movement of the chamber 10 being constant a certain amount of gas will be drawn into the chamber 8 at each movement of the chamber 10, and that said fixed quantity of gas would cause a certain displacement of the liquid in the displacement chamber if all of said gas were forced into the absorption chamber and none of it absorbed. It is, therefore, apparent that the extent of movement of the weight 19 will indicate the amount of gas not absorbed in the potash chamber. When the chamber 10 has been raised to its uppermost position and all of the gas from the measuring chamber 8 has been forced into the absorption chamber the valve 6 places the pipe 15 in communication with the escape pipe 37 so that the unabsorbed gases may pass from the absorption chamber to the atmosphere.

To make a permanent record of the movements of the weight 19 I provide an apparatus which consists of a horizontally mounted octagonal drum 38 mounted on a rotatable tube 39. This tube is rotatably supported at one end in bearings 40 and is formed with a long exterior key-way 41. Mounted in a fixed bearing 42 and extending longitudinally into the tube is a non-rotatable screw rod 43. Secured to the drum is a split nut 44 which engages the screw rod and forces the drum therealong as the tube carrying the drum is rotated. Secured to the tube 39 between the bearings 40, by means of a rib fitting in groove 41 is a ratchet wheel 45, and also connected to said tube between the bearings 40 is a gear wheel 46. This wheel is connected by a train of gears 47, to a drum 48 carrying a weight and cord 49. The ratchet wheel is provided with eight teeth to correspond to the faces of the drum. To permit the ratchet wheel and the drum to have a step-by-step rotative movement I provide two electrically operated pawls 50 and 51 which serve as an escapement device.

To actuate the pawls 50 and 51 I provide a rotating circuit making and breaking device 52 said device being operated from the main motor shaft by means of the shaft 53 and suitable beveled gear connections with the shaft of the circuit breaker. This circuit making and breaking device consists of a disk provided in its periphery with contact plates 54 which, as said disk rotates, complete the circuits between the contact pieces 55 and 56. The contact pieces 56 control the magnet 57 of the pawl 50 and the contacts 55 control the magnet 58 of the pawl 51. The contact plates and the circuit closing device are so arranged that when the circuit is completed through the pieces 56 it will be broken at the pieces 55; and when completed

through 55 it will be broken through 56. The pawls 50 and 51 each consists of an armature 59 carrying a pawl 60, a spring 61 acting against the magnet and maintaining the pawl 60 in the path of the tooth of the ratchet, except when the magnets are energized. The pawls are so arranged with respect to the ratchet teeth that when one pawl is in engagement with the ratchet tooth the other pawl is released therefrom and is resting on the outer surface of a tooth, the object being that when the engaged pawl is released the other pawl will stop the ratchet wheel after it has rotated one tooth. The circuit making device rotates at a constant speed and the drum will make one complete revolution to each revolution of said device, the drum, however, making its rotation by a step-by-step movement.

I prefer to use an octagonal drum when obtaining records of the conditions of the gases in four furnaces, and to secure a record card on every other face of said drum, whereby said cards will have a blank space or side of the drum between them. To make a permanent record on each card I provide an electrically operated marking point 62 which is carried by the cord 20. This marking point is so located on said cord and with respect to the record carrying drum 38 that it will be adjacent one of the faces of said drum when the chamber 10 is in its uppermost position and the balanced weight 19 has reached the length of its upward movement. When the chamber 10 has reached the uppermost point of its movement a finger 63 on the cord 12 will engage two contact points 64 and complete a circuit through magnet 65. This magnet is arranged to attract an armature 66 which is held back by a spring 67. The armature 66 carries a push-plate 68 which is adapted to engage the marking pin 62 and to force said pin against the record card carried by the drum. The drum-moving means is so timed that the drum will be rotated when the chamber 10 is lowered and the absorption chamber is connected to the atmosphere to permit the weight 19 to return to its normal position. The marking point is then below the drum. By this means the drum and the marking point may be arranged close together and the movement of the marking point under the action of the magnet 65 need be very slight.

It will, of course, be understood that the movement of the selective valve 2 must be timed with respect to the movement of the drum, so that the gas analysis recorded on each card will be from the same furnace, that is to say, the analysis of gas from No. 1 furnace will be recorded on No. 1 card during all of the revolutions of the drum, and likewise with respect to all the other furnaces. By this means I obviate the use of a complete analyzing apparatus for each furnace.

The selective valve 2 is mounted on a shaft 25 and is provided with a port 25^b which is adapted to register with the inlet ports 25^c from the furnace. In the valve casing is formed a gas chamber 25^d with which the pipe 3 is connected. To this chamber is also connected a pipe 25^e to the outer end of which is connected a suction exhaust 25^f which tends to cause a vacuum in the chamber 25^d, the suction on pipe 25^e, however, being less than the suction on the pipe 3 whereby pipe 3 will be able to take its supply from the chamber 25^d, notwithstanding the suction on pipe 25^e. It will, therefore, be seen that as the valve 2 rotates and its port is brought in communication with the inlet from the furnaces a supply of gas will be taken from each furnace into the chamber 25^d by reason of the suction on pipe 25^e and that a proper quantity of gas will be taken from the chamber 25^d into the chambers 8 and 8^a. The movements of the valve 2 and the valve 6 are so timed that the port 25^b will admit gas to chamber 25^d from one of the furnaces when the pipe 3^a is connected to either pipe 7 or 7^a; and the rotation of the drum 38 and the valve 2 is synchronous so that each furnace will have an individual card record on said drum.

The nut 44 is split horizontally, its sections 44^a being hinged together. A screw 44^b is provided to hold the two sections of the nut together around the threaded rod 43. The purpose of using said split nut is to permit it to be disengaged from the threaded rod so that the tube 39 and the drum may at any time be moved back to the bearing 42.

In order to render the apparatus rapid in operation I connect a second measuring chamber 8^a to the valve casing 5 by a pipe 7^a, the valve ports being so arranged as to place said pipe 7^a at the proper times in communication with the pipe 3^a and with the absorption chamber through pipe 15. A second rubber tube 9^a is connected to the lower end of the measuring chamber, and chamber 10^a is connected to the upper end of said tube. A ring 11^a is secured to the chamber 10^a and to said ring is secured a cord 12^a which passes upwardly over a pulley 13^a and is wound upon the drum 14 in a direction the reverse of that of cord 12. The two chambers 10 and 10^a and their attached parts balance each other so that very slight force exerted will cause them to be alternately raised and lowered. Within the drum 14 is secured a suitable spiral spring 14^a which moves said drum in one direction when the bar 31 is lifted by the crank 32. When said bar is depressed by the crank 32 the cord 30 will rotate the drum

14 against the tension of the spiral spring therein.

On the cord 12^a is secured a contact finger 43^a which engages a contact 44^a when the chamber 10^a has been raised to its highest position. The contact pieces 43 and 43^a complete the circuits to the magnet 46 which actuate the marking device, said device being operated every time the receptacle 10 or 10^a is raised to its highest point.

The valve 6 is formed with ports 6^a and 6^b. The ports 6^a, as the valve 6 is rotated, connect the measuring chamber to the furnace and to the absorption chamber; while the short ports 6^b connect the absorption chamber to the exhaust pipe 37, this valve being so timed in its rotation that the proper connections are made.

It will thus be seen that when one measured charge of gas is being delivered into the absorption chamber from one of the measuring chambers the other measuring chamber is being charged with gas from the furnace.

I do not claim the specific form of the apparatus for taking gas from the furnace and forcing it into the absorption chamber or the specific arrangement of the two measuring vessels and the means for drawing gas into them alternately from the furnaces as that part of the apparatus is not my invention.

Having thus described my invention, what I claim as new and desire to secure by Letters Patent, is:—

1. A gas analyzing apparatus comprising means for measuring gaseous products of combustion, means for successively connecting said gas measuring means to each of a series of furnaces, whereby a charge of gaseous products of combustion may be taken from each of said furnaces in succession, an absorption chamber, means for delivering the gas from the measuring chamber into said absorption chamber, and a single device for separately indicating the amount of gas absorbed from the products of combustion from each furnace.

2. A gas analyzing apparatus comprising means for taking a measured quantity of gas from each one of a series of furnaces, an absorption chamber to receive said measured quantities in succession, a displacement chamber connected to the absorption chamber, a marking device to indicate the amount of gas absorbed in the absorption chamber, means for holding a record card for each furnace, and means for actuating the marking device to form an individual record for each furnace.

3. A gas analyzing apparatus comprising a selective means for taking a measured quantity of gas from each of a series of furnaces, means for absorbing a portion of each of said measured quantities of gas, a marking means to indicate the amount of gas absorbed, a movable card-holder, means for moving said card holder synchronously with the selective device, whereby a card will be prepared for each furnace indicating the composition of the gaseous products of combustion.

4. A gas analyzing apparatus comprising a selective means for taking a measured quantity of gas from each of a series of furnaces, means for absorbing a portion of the furnace gas from each of said measured quantities, a marking means to indicate the amount of gas unabsorbed, and means for making a permanent record indicating the composition of the gaseous products of combustion in each furnace.

5. A gas analyzing apparatus comprising a selective means for taking a measured quantity of gas from each of a series of furnaces, means for absorbing a portion of each of said measured quantities of gas, a marking means to indicate the amount of gas unabsorbed from each of said measured quantities, a movable record holder, means for moving said record holder synchronously with the selective device whereby a separate record may be kept for each furnace.

6. A gas analyzing apparatus comprising a selective means for taking a measured quantity of gas from each of a series of furnaces, means for absorbing a portion of each of said measured quantities of gas, a marking means to indicate the amount of gas absorbed, a rotatable card holder having a plurality of flat faces adapted to receive record cards, means for rotating said card holder synchronously with the selective device for each successive operation of said device, whereby a card will be marked for each furnace.

7. A gas analyzing apparatus comprising a selective means for taking a measured quantity of gas from each of a series of furnaces, means for absorbing a portion of each of said measured quantities of gas, a marking means to indicate the amount of gas absorbed, a rotatable card holder having a plurality of flat faces adapted to receive record cards, means for rotating said card holder synchronously with the selective device whereby a card will be presented to the marking device for each successive operation of said device, whereby a card will be marked for each furnace, and means for moving the card holder longitudinally.

8. A gas analyzing apparatus comprising a selective means for taking a measured quantity of gas from each of a series of furnaces, means for absorbing a portion of each of said measured quantities of gas, a marking means to indicate the amount of gas absorbed from each of said measured quantities, a rotatable card holder, means for giving said card

holder a step-by-step rotative movement, and means for actuating the marking device between said rotative steps, and means for moving the card holder longitudinally, whereby a card will be prepared for each furnace indicating the condition of the fuel gases.

In testimony whereof I hereunto affix my signature in the presence of two witnesses this 28th day of October 1907.

JOHN A. CALDWELL.

Witnesses:
WM. R. DAVIS,
EMMA H. H. KAUFMANN.