No. 725,533. PATENTED APR. 14, 1903.

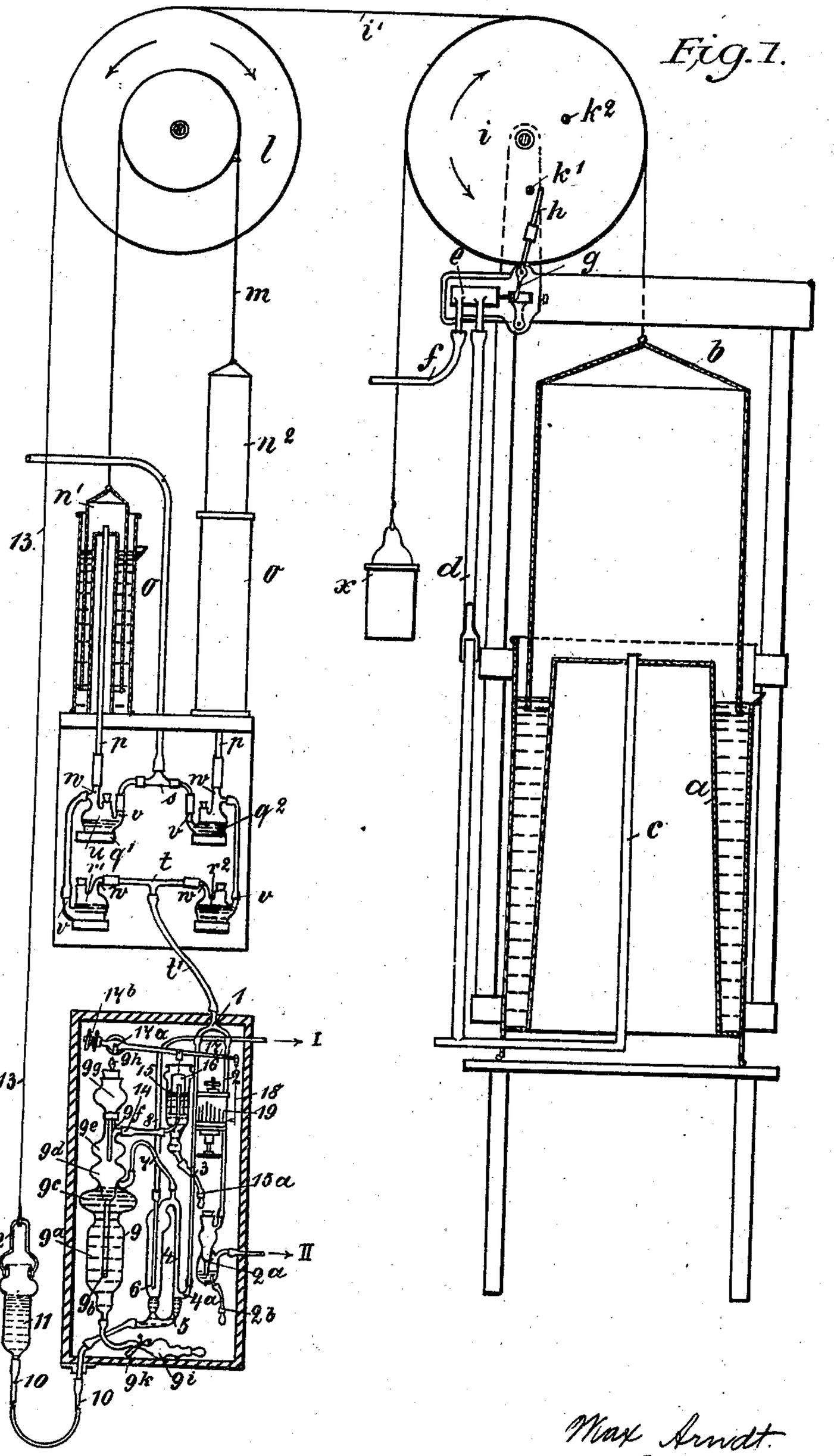
M. ARNDT.

APPARATUS FOR ANALYZING GASES.

APPLICATION FILED APR. 22, 1901.

NO MODEL. 2 SHEETS—SHEET 1.

Fig. 1.



Witnesses:
B. Hyler
B. L. Sommers

Max Arndt.
Inventor
by Munn & Co
Attorneys.

No. 725,533. PATENTED APR. 14, 1903.

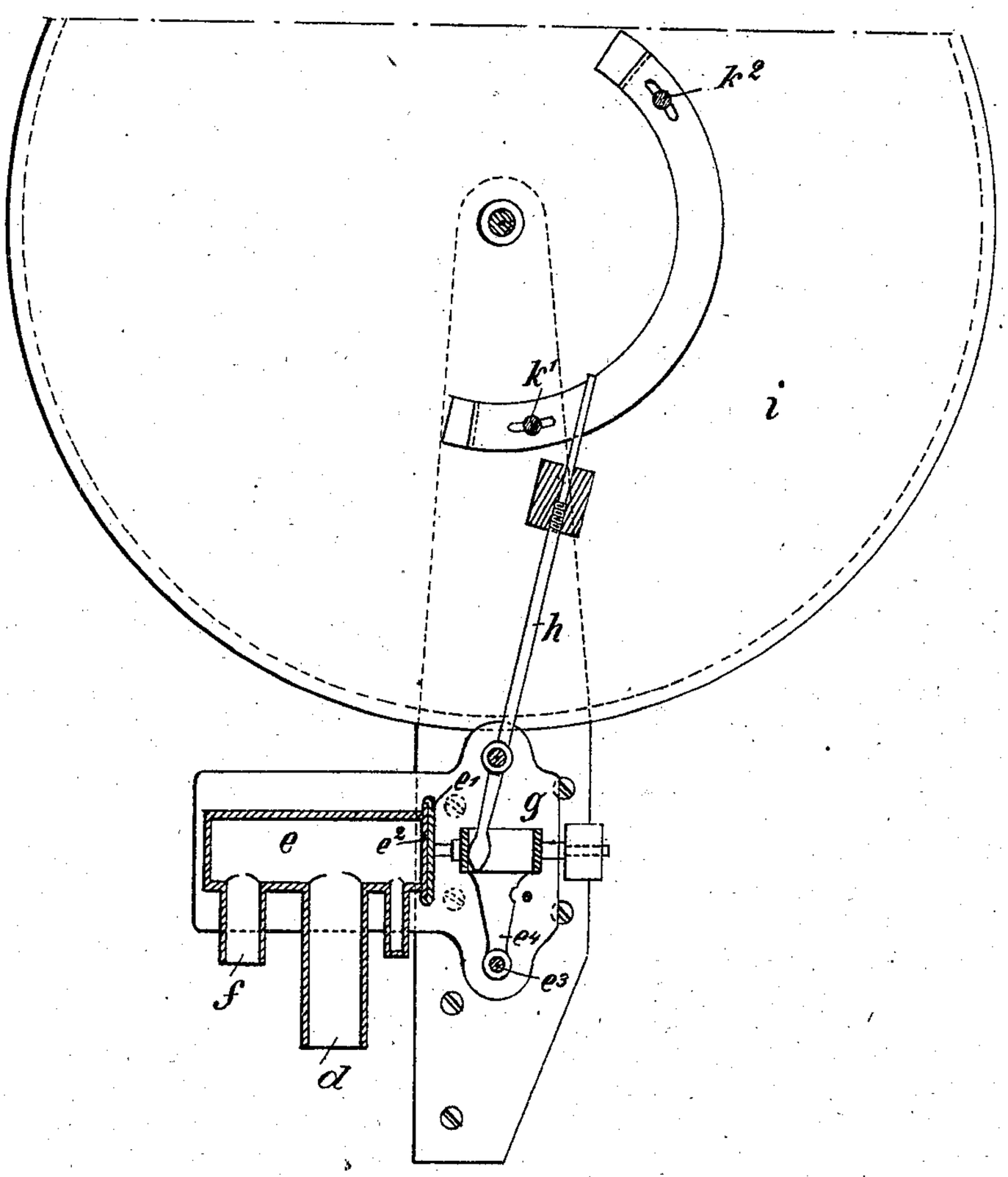
M. ARNDT.

APPARATUS FOR ANALYZING GASES.

APPLICATION FILED APR. 22, 1901.

NO MODEL. 2 SHEETS—SHEET 2.

Fig. 2.



Witnesses
B. F. Oberlin
R. H. Sommers

Inventor:
Max Arndt,
per Attorney:
Henry Otto Atty.

UNITED STATES PATENT OFFICE.

MAX ARNDT, OF AIX-LA-CHAPELLE, GERMANY.

APPARATUS FOR ANALYZING GASES.

SPECIFICATION forming part of Letters Patent No. 725,533, dated April 14, 1903.

Application filed April 22, 1901. Serial No. 56,929. (No model.)

To all whom it may concern:

Be it known that I, MAX ARNDT, a subject of the King of Prussia, German Emperor, residing at the city of Aix-la-Chapelle, in the Kingdom of Prussia, Germany, have invented a new and useful Improved Apparatus for Analyzing Gases, of which the following is a specification.

My invention relates to an apparatus for automatically and continuously making and recording tests of a gaseous mixture contained in a gas chamber or space whereby a certain gas is removed from the gaseous mixture through being absorbed by chemical means and the percentage volume of the removed or absorbed gas recorded.

According to the nature of the chemical absorbing medium or liquid employed in the apparatus of the invention the percentage volume of carbonic acid, or oxygen, or carbonic oxid contained in a gaseous mixture can be continuously recorded when in the first case the absorbing liquid is potash lye, in the second case pyrogallate, and in the last case cupric chlorid. The apparatus can therefore be used for widely-varying purposes—for example, for controlling the saturating-gases in sugar-factories, or the chamber-gases in sulfuric-acid factories, or for determining the presence of fire-damp in mines, &c.; but it is chiefly designed for the control of steam-generator furnaces by the continuous indication of the average contents of carbonic acid in the smoke-gas, which contents of carbonic acid serves, as is known, for determining the quantity of air required for the economical combustion of the fuel. It also allows of the stoking operations being controlled and supervised in accordance with the recorded contents of carbonic acid in the smoke-gas.

The invention consists in the combination of a small motor, driven by the chimney-draft, with a gas-supplying or gas-feeding mechanism and with a gas-absorbing apparatus provided with a recording mechanism, the gas-absorbing apparatus being supplied by the gas-feeding mechanism with the gaseous mixture to be tested, or the invention consists in the combination of a gas-feeding mechanism, provided with a hydraulic valve device, with a gas-absorbing apparatus fed by said mechanism and having recording mechanism and with a small motor operated by a partial vacuum—for example, that caused by a chimney-draft—all the operations of the combined apparatus being effected from said motor.

In the accompanying drawings, Figure 1 is an elevation, partly in section, of an apparatus embodying my invention; and Fig. 2 is a fragmentary sectional elevation, drawn to an enlarged scale, of a portion of the apparatus, illustrating the organization of the draft-controlling valve.

a is a vessel supplied with a liquid into which dips a suspended bell-shaped receiver *b*. *c* is an air-tube opening underneath said receiver. A flexible tube *d* connects the air-tube *c* with an air-chamber *e*, from which a tube *f* leads to the chimney (not shown) of a furnace. The chamber *e* is closed at one end and on its open opposite end seats a valve e', provided with a facing e^2 of a suitable packing material to form a fluid-tight joint, the stem *g* of said valve being slotted longitudinally and connected to a rock-lever e^4, pivoted at e^3. Into the slot of said valve-stem projects one end of a weighted lever *h*, actuated by two studs k' k^2 on the face of a pulley *i*, so that as said pulley oscillates in one direction the stud k^2 acts on lever *h* and swings the same to the left, thereby unseating the valve e', while stud k' acts on said lever to seat said valve, as will be readily understood. Inasmuch as the lever *h* is weighted, the studs k' k^2 need not continuously act on the lever, but only for a sufficient time to move said lever in one or the other direction to and slightly beyond its dead-center.

With the valve e' closed the draft of the chimney extends through tube *f*, chamber *e*, and tubes *d c* to underneath the receiver *b* and acts to draw this downward until the valve is opened from the stud k^2. A counter-weight *x*, suspended from the end of a cord passing over the pulley *i*, then raises the receiver *b*, whereupon the latter draws in outside air through chamber *e* and tubes *d c*.

The movements of the pulley *i* occasioned by those of the receiver *b* and weight *x* are transmitted through a cord or chain i' to a second pulley *l* from a cord or chain *m*, on which are suspended two bell-shaped receiv-

ers n' n^2, dipping into a sealing liquid—oil, for instance—supplied to the vessels o.

p represents gas-tubes opening underneath the receivers n' n^2, so that each of these latter in its ascent draws in gas through its corresponding tube p and in its descent forces back the same.

Each of the gas-tubes p is connected with a suction-valve q' or q^2 and with a delivery-valve r' or r^2. A suction-tube s connects both suction-valves q' q^2 with the space from which the gas to be analyzed is taken—for example, the flue of a steam-generator furnace. Further, the delivery-valves r' r^2 in addition to being connected each with a suction-valve are connected together by a delivery-tube t, through which the gas supplied from the receivers n' n^2 is conducted to a gas-absorbing apparatus. The valves q' q^2 and r' r^2 are each in the form of a casing having at the lower part a gas-inlet orifice v and at top a gas-outlet orifice w, and all these valves are so far charged with a sealing liquid—glycerin, for instance—that with the apparatus in a state of rest it stands about half an inch high in each gas-inlet orifice.

The gas-inlets v of the suction-valves q' q^2 are connected with the gas-suction tube s, the outlets w of the same valves each with the gas-inlet of a delivery-valve r' or r^2, and the gas-outlets w of both delivery-valves r' r^2 with the tube t.

The gas is fed to the gas-absorbing apparatus in the following manner: When one of the two gas-receivers—say n'—rises, it draws in gas only through the inlet v of its suction-valve q', because in the gas-inlet of its delivery-valve r', as also in that of the suction-valve q^2 of the other (descending) receiver n^2, liquid columns rise, so as to prevent the back suction of gas out of these valves. Simultaneously the descending receiver n^2 forces the gas previously (in rising) drawn in by it through the gas-outlet of its valve q^2 and through the gas-inlet of its valve r^2, as also through the gas-outlet of this latter and tube t, to the gas-absorbing apparatus by reason of the rising of liquid columns in the gas-inlet of its suction-valve q^2 and in the gas-outlet of the delivery-valve r' of the other (rising) receiver n', which liquid columns prevent the return of gas out of these valves. Consequently the return of gas once drawn in and the mixing of the same with atmospheric air are impossible. As one of the two receivers n' or n^2 is always rising and drawing in gas, while the other is falling and forcing out gas there will of the four valves q' q^2 and r' r^2 be only two—q' r^2 or q^2 r'—placed diagonally to one another which allow gas to pass through them. Therefore when the left-hand receiver n' rises and the right-hand one n^2 falls the left-hand suction-valve q' and the right-hand delivery-valve r^2 are operating, and inversely, so that gas is forced continuously through tube t' to the gas-absorbing apparatus.

The gas-absorbing apparatus is furnished with a gas-inlet 1, to which the tube t' is attached and which branches out into two gas-tubes 2 3, the former leading to a siphon 2^a, supplied with a liquid—glycerin, for instance—to a height somewhat above the open lower end of its dipping tube and serving for the discharge of the fed gas in the direction of arrow II to the atmosphere when the gas-tube 3 is during a gas-absorbing process hydraulically shut off at the tubular bend 4^a, whereupon the gas-pressure overcomes the resistance of the liquid column in the siphon 2^a. 2^b is an emptying-tube for said siphon. The gas-tube 3 communicates past the bend 4^a with the gas-tube 4, leading to the top of a gas-holder 6, and with the bend 5 of said gas-tube 4. The bend 5 communicates with the lower part of the gas-holder 6 and through a flexible tube 10 with a vessel 11, charged with a sealing liquid (glycerin) and suspended from the pulley l by means of a frame 12 and cord or chain 13, therefore taking part in the movements of said pulley and of the receiver b, whereby it is alternately raised and lowered, and thus in consequence of the analogous movements of the sealing liquid therein performs or brings about all the functions of the gas-absorbing apparatus automatically.

The gas-holder 6 is provided with a gas-discharge tube 8, leading upward to the atmosphere in the direction of arrow I and having its bottom end placed higher than the gas-passage through the bend 4^a. Further, a narrow flexible tube 7 connects the upper part of the gas-holder 6 with the vessel 9, containing the gas-absorbing liquid 9^a.

The vessel 9 has upon it an air vessel formed with two air-spaces 9^d 9^e, the former of which is provided with a tube 9^b, open at the bottom and extending deep down into said vessel 9, and the latter having placed upon it a hopper 9^g for filling in the absorbing liquid. The hopper is closed by a very narrow nozzle 9^h, through which and through a tube 9^f, forming a downward extension of the hopper, the air-spaces 9^d 9^e are in communication with the atmosphere.

The tube 9^f serves to limit the dimensions of the space to be occupied by air within the air vessel. The height at which said tube is set depends upon how much per cent. of the volume of the gaseous mixture is at the maximum occupied by a particular gas whose percentage volume is to be ascertained and recorded by means of the analysis, the tube being set the deeper the larger the quantity of gas to be absorbed.

From the air-space 9^e branches an air-tube 14, the opposite end of which opens underneath a recording air-receiver 16, dipping into a sealing liquid (glycerin) contained in a vessel 15. 15^a is a flexible tube serving for emptying the vessel 15.

In connection with the recording air-receiver 16 is a recording-lever 17, adapted to oscillate on a fixed pivot 17^a and balanced by

a weight 17^b. Said recording-lever has jointed to it a rod 18, carrying a marking-stud which in the recording operation is moved up and down against a paper strip placed on the revolving drum of a clockwork 19.

The gas-absorbing apparatus operates as follows: With the vessel 11 held in a position so low down that the gas-passage through the bend 4^a is open the gaseous mixture, arriving through the tube 3 and filling the tube 4 and gas-holder 6 afresh previous to each analysis, takes its way through the tube 4, gas-holder 6, and tube 8 in the direction of arrow I to the atmosphere. The gas-outlet I I is then closed by the liquid in the siphon 2^a. If now the vessel 11 is raised by the action of the receiver *b*, the liquid in said vessel will first shut off the bend 4^a and then the tube 8, so that there is then intercepted in the tube 4 and gas-holder 6 under atmospheric pressure a quantity of gas that is always of the same volume. As now no more gas can be delivered into the gas-holder 6, it passes, during the time an absorbing process is being performed, through the liquid of the siphon 2^a to the atmosphere in the direction of arrow II. Therefore through the medium of the whole apparatus it is only the gas sample intercepted in the gas-holder 6 and tube 4 that serves for controlling purposes, which gas sample in the further rise of the vessel 11, and therewith of its sealing liquid in the tube 4 and gas-holder 6, is completely driven from these two places and forced through the narrow flexible tube 7 into the vessel 9, so that the absorbing liquid 9^a in the latter is pressed downward, but rises in the same measure in the dipping tube 9^b and in the air-spaces 9^d 9^e, thereby forcing air from these spaces. Simultaneously therewith a gas or absorbing space is formed in the vessel 9 over the sealing liquid 9^a by the gas driven out of the gas-holder 6 and tube 4, so that this gas or gaseous mixture is in immediate contact with the absorbing liquid 9^a. This results in the volume of the gas previously intercepted in the gas-holder 6 and tube 4 being reduced in the absorbing-space 9^c to the extent of the volume of the absorbed gas. Therefore the larger the volume of this latter the smaller is the quantity of absorbing liquid 9^a that rises in the air-spaces 9^d 9^e and of air that is forced out of these spaces by the absorbing liquid. In this operation air is forced out of the space 9^d, which is always smaller than the volume of the gas remaining behind in the space 9^c after the completion of an absorbing process, then through the tube 9^f, hopper 9^g, and nozzle 9^h to the atmosphere, and lends no assistance in the recording operation. So soon, however, as the tube 9^f is hydraulically shut off by the absorbing liquid 9^a, this, continuing to rise, drives a portion, dependent upon the quantity of the absorbed gas, of the air now intercepted in the space 9^e through tube 14 to underneath the receiver 16, so that this latter, raised by the internal air-pressure, also raises the recording-lever 17, and therewith the marking-stud rod 18, thereby drawing upon the paper strip 19 a line which is the shorter the larger the percentage volume of the absorbed gas, the end point of this line therefore representing the result of a now-completed automatic gas analysis. At the same time the stud k^2 on the pulley *i* opens the air-valve *g*, so that the receiver *b* again rises, the vessel 11, with the sealing liquid contained therein, then falling, by reason of which the absorbing liquid 9^a returns to the level of its state of rest, and the recording mechanism is also brought to a standstill by the fall of the receiver 16, the marking-stud then being in front of the lowermost division-line of the paper strip 19, and therefore the absorbing apparatus in readines for a fresh gas analysis. The saturated absorbing liquid 9^a can be drawn off through the flexible tube 9^i, and its spherical compressible enlargement, conjointly with a cock 9^k, serves for adjusting the absorbing liquid to a desired height. These automatic gas analyses can be performed as often as desired, according as the receiver *b* is raised quicker or slower—say once in about every five minutes.

Great simplicity and reliability in working of the whole combined apparatus is attained by there being no cocks employed, but rather an open system in which only air, gases, and liquids act upon one another.

When the apparatus is employed for controlling fires, the vessel 9 is charged with potash lye 9^a, which possesses the property of absorbing carbonic acid, (CO_2.) In such a case a sample of the smoke-gas is taken in the described manner uninterruptedly from the furnace-flue through the suction-tube *s*, provided with a soot-filter, (not shown,) and of the smoke-gas thus obtained a portion is analyzed, so that on completion of the analysis the end point of the line marked upon the paper strip 19 indicates the average percentage-volume contents of carbonic acid in the smoke-gas.

What I claim as my invention, and desire to secure by Letters Patent, is—

1. The combination with a gas suction and delivery mechanism, of a gas-absorption apparatus arranged to receive gas from said suction and delivery mechanism, and means for automatically operating the suction and delivery mechanism and the absorption apparatus, substantially as described and shown.

2. The combination with a gas suction and delivery mechanism, of a gas-absortion apparatus arranged to receive gas from said suction and delivery mechanism, and air-pressure-operated means for automatically operating the suction and delivery mechanism and the absorption apparatus, substantially as described and shown.

3. The combination with a gas suction and delivery mechanism, of a gas-absorption apparatus arranged to receive gas from said

suction and delivery mechanism, and air-pressure-operated means for automatically operating the suction and delivery mechanism and the absorption apparatus, substantially as described and shown.

4. The combination with a liquid-sealed bell, of a gas-absorption apparatus, and automatic air-pressure-operated means to lift and lower said bell in its sealing liquid and actuate the gas-absorption apparatus, substantially as described and shown.

5. The combination with a gasometer, a liquid-sealed bell provided with an inlet and an outlet for gas, a liquid seal for the gas-inlet and one for the gas-outlet to said bell, of a gas-measuring chamber, and an absorption-chamber containing a suitable chemical connected thereto and a vessel containing a displacing liquid connected to the gas-measuring chamber, and means to operate the gas suction and delivery mechanism and simultaneously the vessel to displace the gas from the measuring into the absorption chamber, substantially as described and shown.

6. The combination with a gasometer, a pipe connecting it to a source of suction to exhaust the air thereunder, a weight arranged to hold the bell of said gasometer normally lifted, a valve automatically operated to vent said pipe to the atmosphere, a liquid-sealed suction and delivery mechanism and a gas-absorption apparatus both operated by the gasometer, substantially as described and shown.

7. The combination with a gasometer, a pulley, a weight flexibly connected over said pulley to the gasometer-bell, a pipe connected to a chimney and arranged to cause a partial vacuum in said bell by chimney-draft, a valve in said pipe arranged to vent it to the atmosphere, devices on the pulley to open and close the valve, a gas suction and delivery mechanism, and a gas-absorption apparatus operated by the gasometer, substantially as described and shown.

8. In a gas-analysis apparatus, a measuring-chamber, a gas-inlet and a gas-outlet pipe therefor, a liquid-sealed by-pass connected to the gas-inlet pipe, a vessel containing a displacing liquid connected to the measuring-chamber, said liquid sealing the gas inlet and outlet pipes to measure a definite quantity of gas, an absorption-chamber containing a solution of a suitable chemical and connected to the measuring-chamber, an air-chamber liquid-sealed by said solution and provided with a vent, arranged to be liquid-sealed by the solution displaced by the gas and a recording device actuated by the residual air in the air-chamber, substantially as described and shown.

9. In a gas-analysis apparatus, a measuring-chamber, a gas-inlet and a gas-outlet pipe therefor, a vessel containing a displacing liquid connected to said chamber at its lower end, an absorption-chamber containing a solution of a suitable chemical connected to the upper end of said measuring-chamber, an air-chamber liquid-sealed by said solution and provided with a vent to the atmosphere arranged to be sealed by the solution displaced by the gas, a liquid-sealed bell operated by the pressure of the residual air in the air-chamber, and a recording-style actuated by the bell, substantially as described and shown.

10. In a gas-analysis apparatus, a measuring-chamber, a gas-inlet and a gas-outlet pipe near the bottom thereof, a liquid-sealed by-pass connected to the inlet-pipe, a vessel containing a displacing liquid flexibly connected to the bottom of the measuring-chamber, an absorption-chamber containing a solution of a suitable chemical, a tube connecting the upper end of the two chambers, an air-chamber projecting into the absorption-chamber, a tube projecting into the air-chamber and serving to vent it to the atmosphere, and liquid-sealed by the solution displaced by the gas, a bell operated by the pressure of the residual air in the air-chamber, a recording-style actuated by said bell and devices automatically gas-operated to periodically move the vessel and its containing liquid, and to supply fresh quantities of gas to be analyzed, substantially as described and shown.

11. The combination with a pair of gas suction and delivery mechanisms arranged to operate alternately, and liquid-sealed suction and delivery valves for each, of a gas-analysis apparatus, arranged to be fed with gas thereby, a recording device to record the result of such analysis and draft-operated mechanism automatically and periodically actuating both the gas-suction mechanism and gas-analysis apparatus, substantially as described and shown.

12. The combination with a pair of gas suction and delivery mechanisms arranged to deliver quantities of gas alternately, and liquid-sealed suction and delivery valves for each, of a gas-analysis apparatus arranged to measure and analyze a definite quantity of gas delivered by said mechanism, a liquid-sealed by-pass for diverting gas from the gas-analysis apparatus after a definite volume thereof has been measured, means for recording the result of the analysis and gas-operated means for automatically and periodically operating the said suction and delivery mechanisms, the gas-analysis apparatus and recording means, substantially as described and shown.

13. The combination with a pair of gasometers arranged to act as gas suction and delivery mechanisms, a suction-valve for each, a suction-pipe to both of said valves, a delivery-valve connected to each suction-valve and to each other, and a delivery-pipe common to both delivery-valves, of a gas-analyzing apparatus arranged to measure and analyze definite volumes of a gas delivered through said delivery-pipe thereto, and means operated by chimney-draft to automatically and

periodically operate the suction and delivery mechanism and the gas-analyzing apparatus, substantially as described and shown.

14. The combination with a gas suction and delivery mechanism, of a gas-measuring and a gas-absorption apparatus, a device to record the amount of gas absorbed and means for periodically and automatically operating the gas suction and delivery mechanism, and the gas-measuring device, to automatically analyze and record the analysis, to clear the measuring and absorption chambers and take a new charge of gas, substantially as described and shown.

In testimony that I claim the foregoing as my invention I have signed my name in presence of two subscribing witnesses.

MAX ARNDT.

Witnesses:
C. E. BRUNDAGE,
H. QUADFLIEG.