No. 834,040. PATENTED OCT. 23, 1906.

A. BAYER.

APPARATUS FOR GAS ANALYSIS.

APPLICATION FILED MAR. 10, 1905.

3 SHEETS—SHEET 1.

Fig. 1.

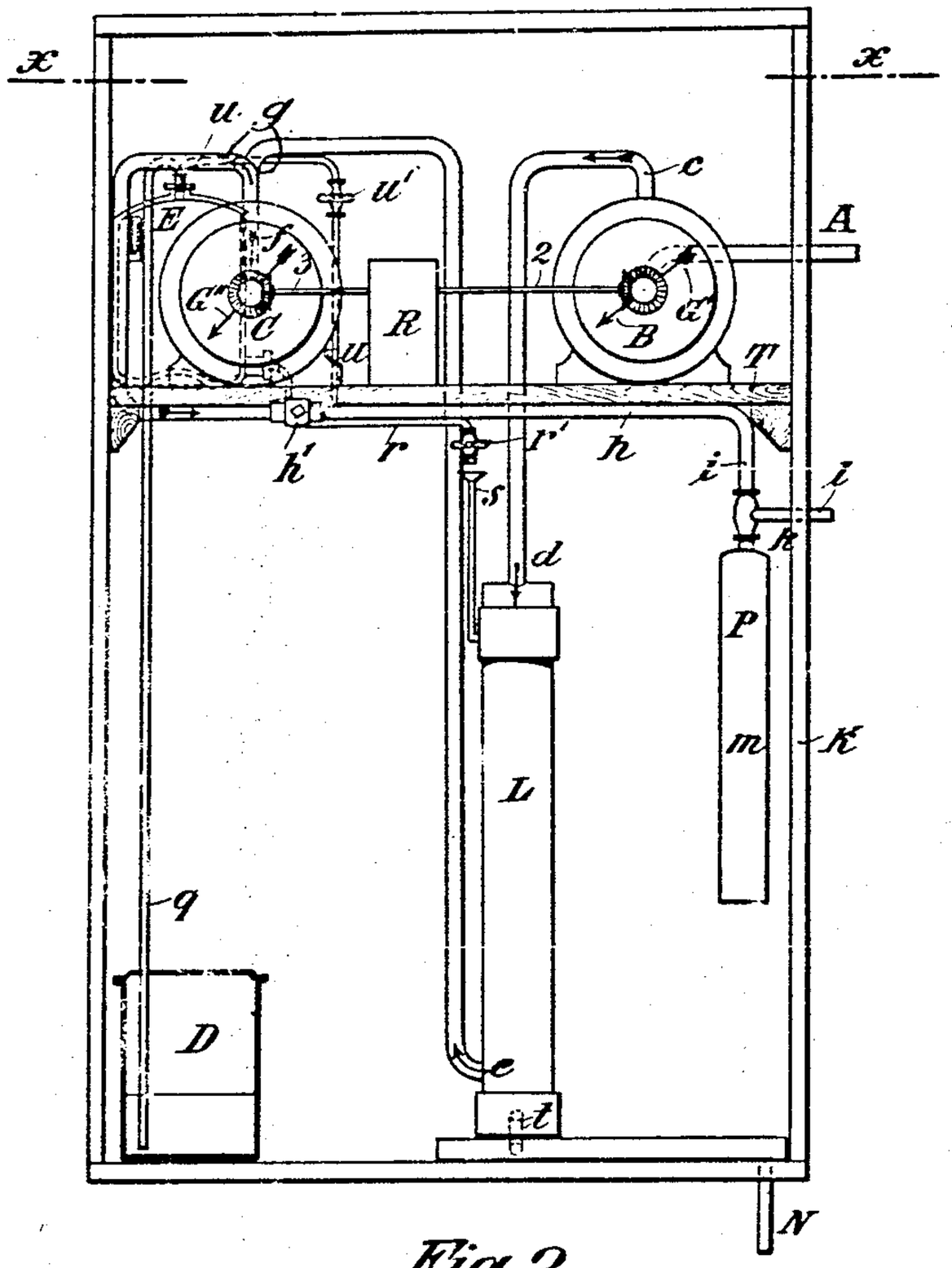
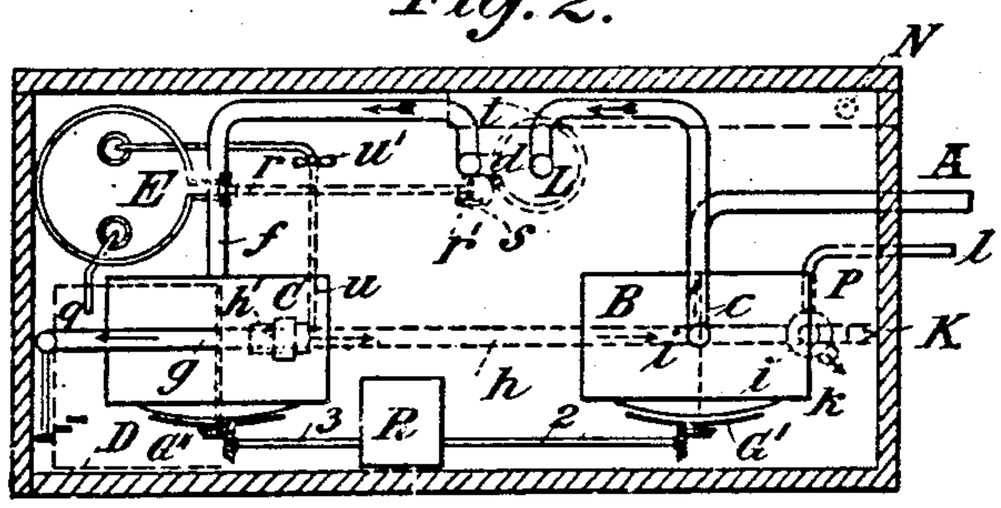


Fig. 2.



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3 SHEETS—SHEET 2.

Fig. 3.

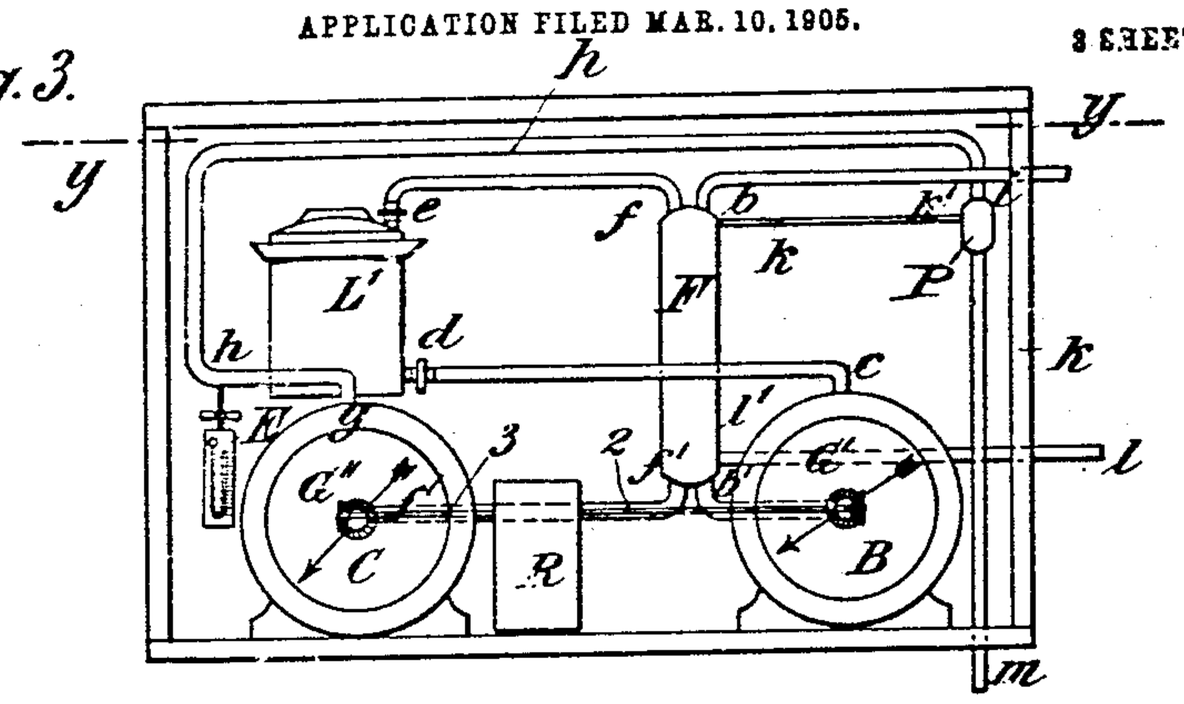


Fig. 4.

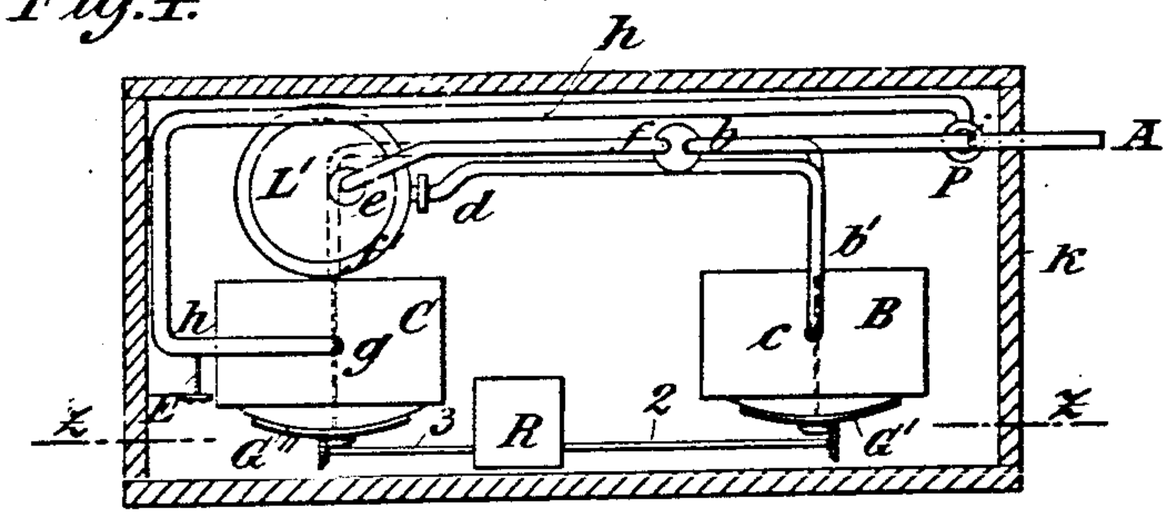


Fig. 5.

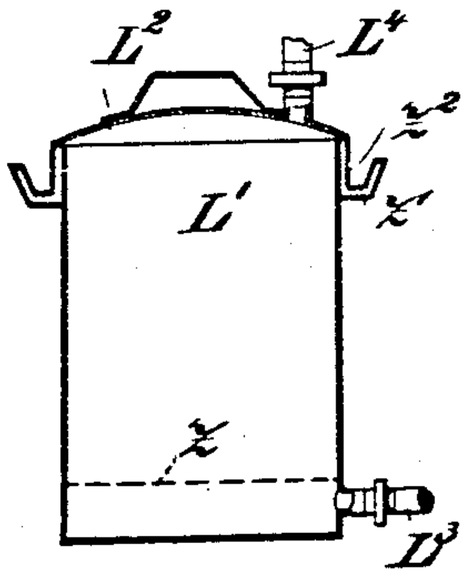


Fig. 6.

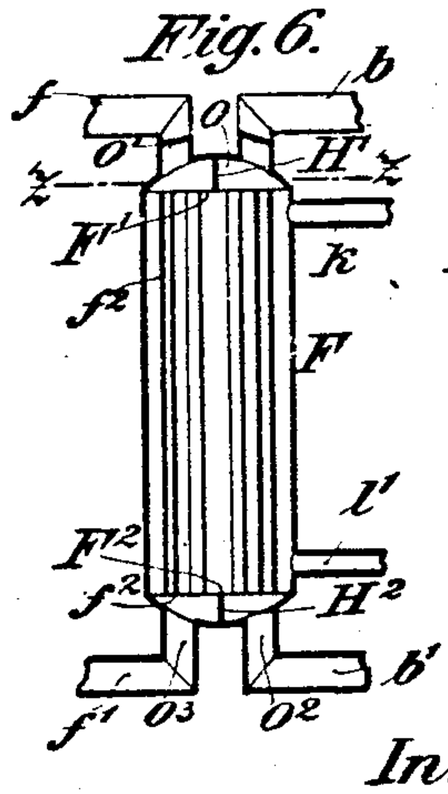
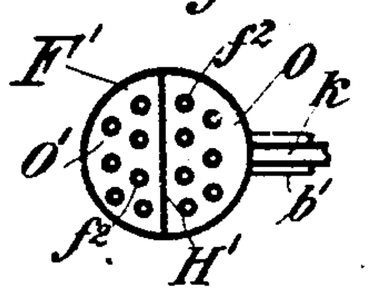


Fig. 6ª.



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APPARATUS FOR GAS ANALYSIS.

APPLICATION FILED MAR. 10, 1905.

3 SHEETS—SHEET 3.

Fig. 7

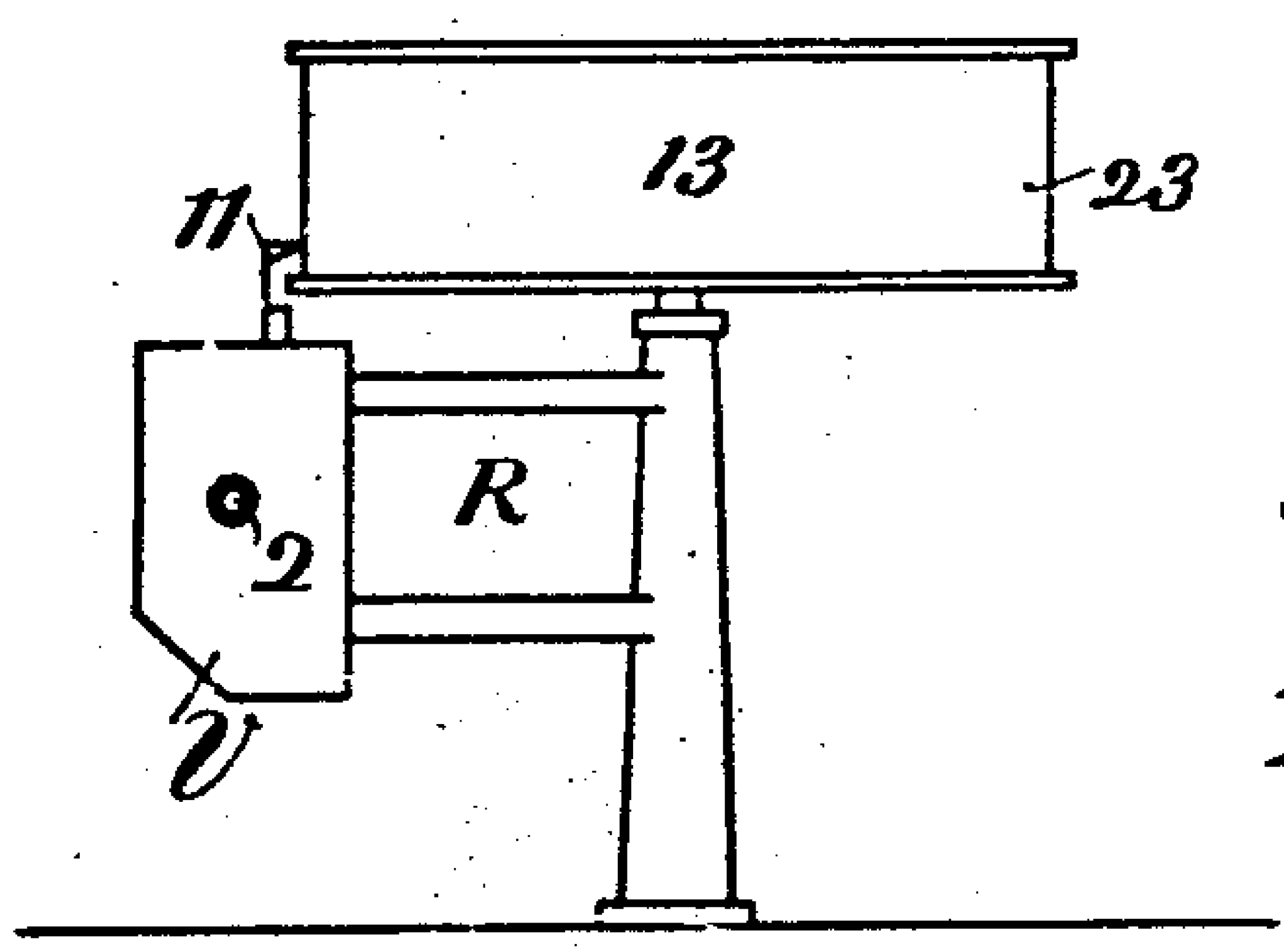


Fig. 9

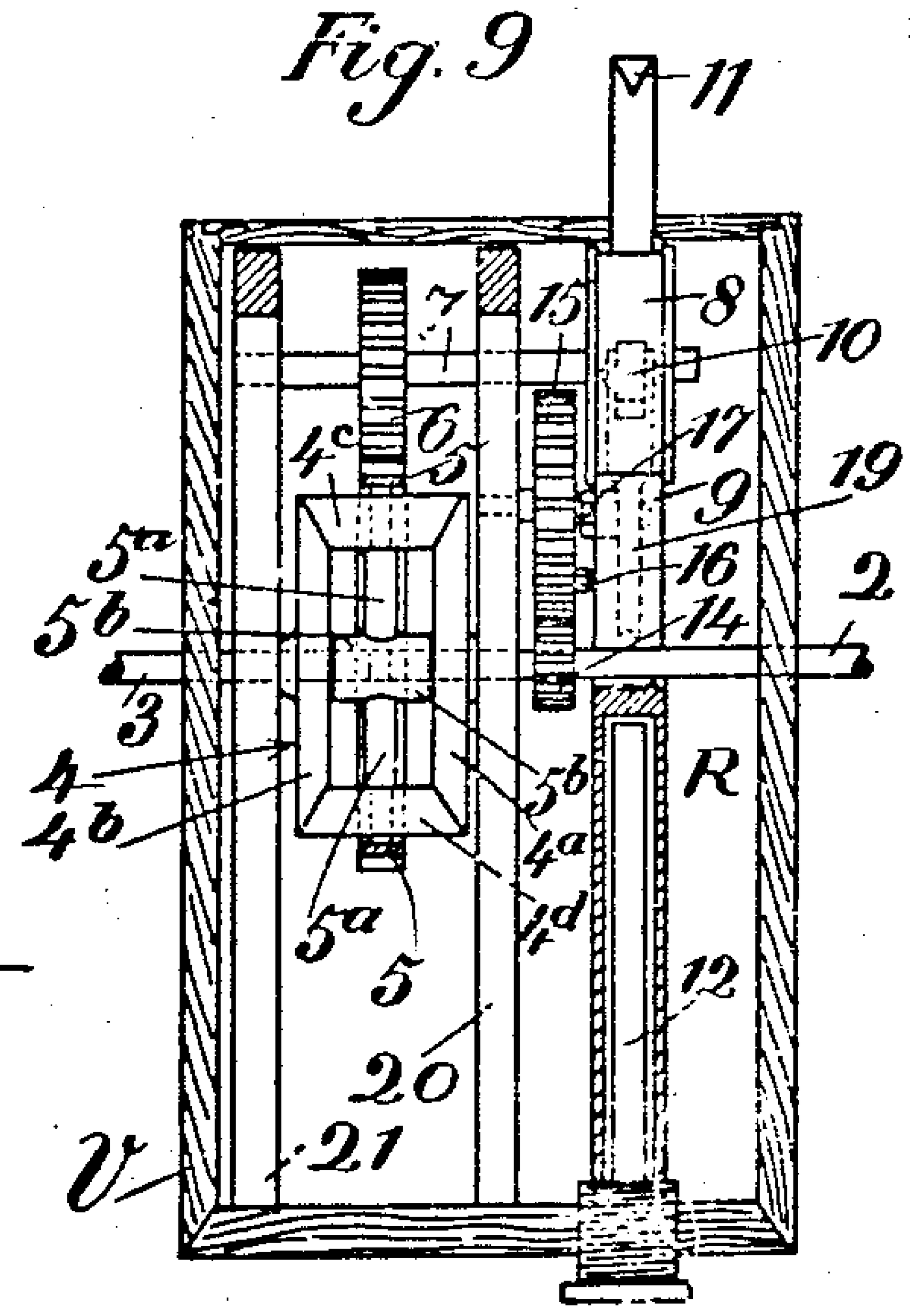
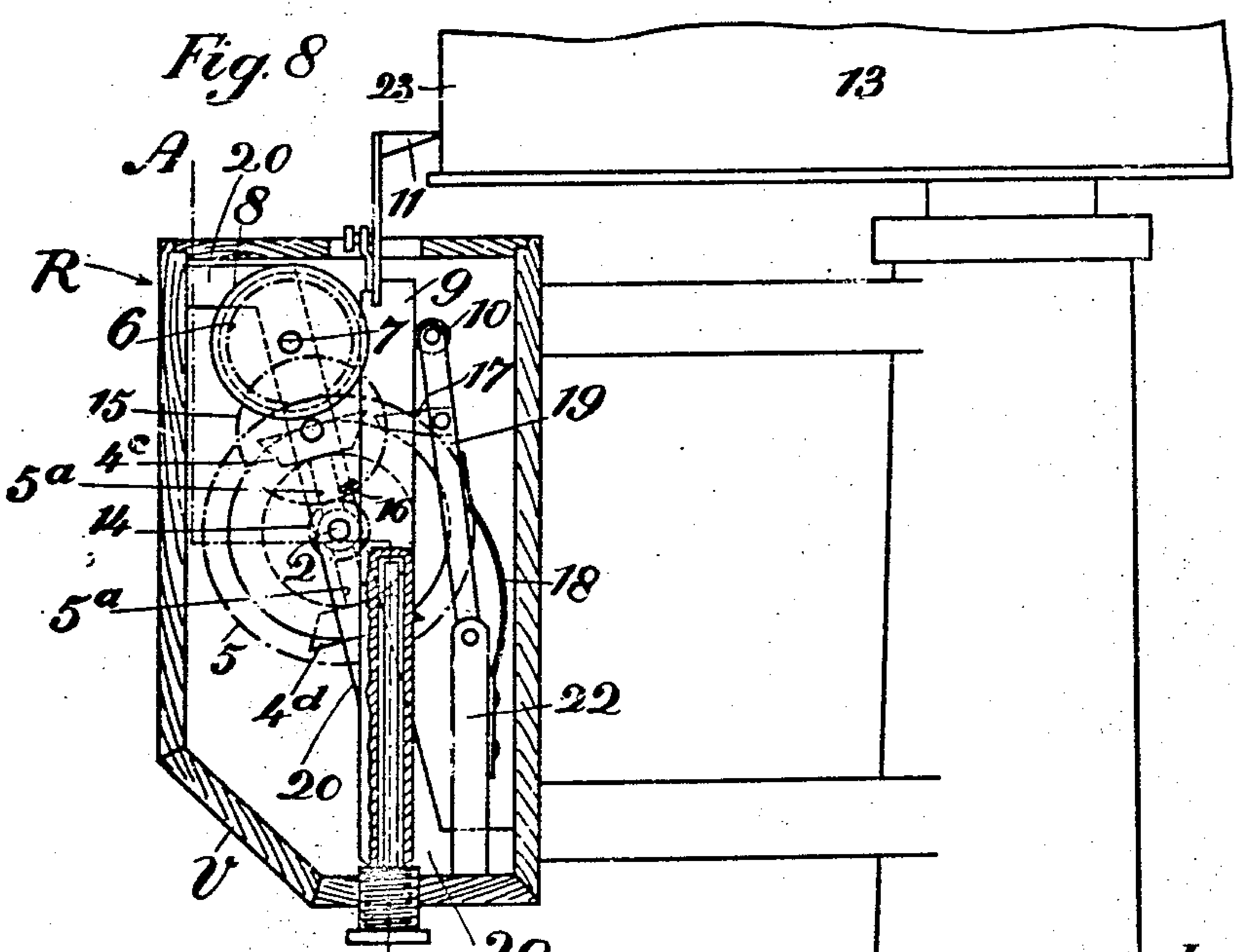


Fig. 8



B

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UNITED STATES PATENT OFFICE.

ALEXANDER BAYER, OF BRÜNN, AUSTRIA-HUNGARY.

APPARATUS FOR GAS ANALYSIS.

No. 834,040. Specification of Letters Patent. Patented Oct. 23, 1906.

Application filed March 10, 1905. Serial No. 249,426.

To all whom it may concern.

Be it known that I, ALEXANDER BAYER, chemist, a subject of the Emperor of Austria-Hungary, and a resident of 4 Roseggergasse, Brünn, in the Empire of Austria-Hungary, have invented certain new and useful Improvements in Apparatus for Gas Analysis, of which the following is a specification.

The subject of my invention is an apparatus for analyzing gases which enables the various constituents of a gas to be determined in succession and graphically registered. For the purpose in view I employ a special combination of vessels for absorbing the various constituents of the gas and improved registering mechanism. Solid absorbents are found to be most suitable for use in this connection, and as their use, owing to the chemical reaction, occasions the generation of so much heat that the measurement of the gases is rendered inaccurate I provide means for cooling the heated gases or gas residues, so that the measurements are all made at the same temperature.

My invention is illustrated in the accompanying drawings, which show two forms of construction of the new apparatus.

Figure 1 is a front elevation with the front wall removed of the apparatus adapted for liquid absorbents. Fig. 2 is a section on the line *x x* of Fig. 1. Fig. 3 is a front elevation with the front wall removed of the apparatus adapted for solid absorbents. Fig. 4 is a section on the line *y y* of Fig. 3. Fig. 5 is a vertical section of the vessel for solid absorbents. Fig. 6 is a vertical section of the cooler. Fig. 6ª is a section through such cooler on the line *z z* of Fig. 6. Fig. 7 is a side elevation of the registering apparatus. Fig. 8 is a vertical section of the same drawn to an enlarged scale, portions of the drum and stand being broken away to save space. Fig. 9 is a section through the registering apparatus, taken on the line A B of Fig. 8.

Referring more particularly to Figs. 1 and 2, the apparatus consists of a case or box K on the shelf T, in which two gas-meters B C are placed. Instead of only two several meters may naturally be employed. The meters communicate with each other through pipes *cd*, vessel L, and pipe *ef*. Above the shelf T a pipe A conducts through the side of the case K to the meter B.

P is a hydraulic air-pump, *l* being the water-supply pipe to the same. The pump is connected with the meter C by piping *ihq*. At the bottom of the case K a vessel D is located, into which there dips a pipe *q*, the upper end of which enters a closed vessel E, which stands on the shelf T. The vessel E is connected by a pipe *u*, provided with a cock *u'*, with the pipe *h*, furnished with a cock *h'*. It is also provided with a pipe *r*, terminating with a cock *r'*, which is located over the funnel-shaped top end of a pipe 5, which communicates with the upper part of the vessel L

Suppose, now, that it is desired to determine quantitatively the percentage of carbonic acid in certain gases of combustion or in the gases from a lime-kiln. The cylinder L is first filled with coke moistened with soda-lye and the cock *u'* of the pipe *u* closed. The air-pump P is then worked and the gas to be analyzed conducted through the pipe A. The gas flows through the meter B and causes the indicator G' to rotate at a certain rate (*v*). The gas from the meter B passes through the pipe *cd* into the cylinder L, in which the carbonic acid is absorbed by the soda-lye. The gas thus deprived of its carbonic acid flows out of the cylinder L through the pipe *e* to the second meter C, where it actuates the indicator G'' with decreased velocity.

A third meter may be connected with the meter C in similar manner, together with another absorbent-container, &c., for the purpose of determining the amount of a second constituent of the gas, and so on.

The measured gas is sucked out of the meter C (or in the case of three or more meters out of the last one) through the piping *ghi* by the air-pump P and escapes through the aperture *k'* in the latter. The water for working the pump P leaves the latter after performing its work through a suitable exit *m*.

To run lye into the vessel E, the cock *h'* is closed and the cock *u'* opened, whereby by means of the pipe *uhi* a vacuum is produced in the vessel E, so that lye flows from the vessel D into the vessel E. The lye runs out of the latter in a slow continuous stream through the pipe *r* and cock *r'* (opened to the desired extent) and descends through the pipe S into the vessel L. The waste liquids flow out of the latter vessel through the pipe *t* into the duct N.

The absorbent liquid can, if desired, be contained in the meters in place of the sealing liquid, (water,) in which case the vessel L can be dispensed with.

Referring now to the apparatus designed for use with solid absorbents and shown in Figs. 3 and 4, the gas to be analyzed before entering the first meter B passes through a cooler F, fully described hereinafter, and after leaving the meter B flows through the pipe *cd* into the vessel L′, equally described hereinafter, containing the absorbent, which it leaves through the pipe *ef* and passes through the cooler F and through the pipe *f′* into the second meter C. This latter meter is connected with the air-pump P′ by the piping *ghi*. This pump may be of the simplest construction, since there is no very considerable vacuum to produce. Cooling-water is supplied to the cooler F by the pipe *l l′* and leaves by the pipe *k* *k′* to the pump P to cause a suction in the pipe *h*. As shown in Fig. 5, the said vessel L′ consists of a pot provided with an exit L^3 and having a perforated or sieve-like false bottom *z*, upon which the solid absorbent medium rests. At the top of the vessel is an annular gutter or trough *z′*, into which fits the like-shaped rim z^2 of the cover L^2, which is provided with an outlet L^4. The gutter *z′* is filled with vaseline, soft soap, or other suitable fatty medium for the purpose of effecting an air-tight joint between pot and cover. As shown in Fig. 6, the said cooler F consists of a cylinder of sheet metal provided with two finely-perforated partitions F′ F^2 and pipes f^2, extending from each hole in the one partition to the corresponding hole in the other partition. (See also Fig. 6^a.) Above the partition F′ and below the partition F^2 vertical walls H′ H^2 are provided, so that above two chambers O O′ are formed and below two chambers O^2 O^3.

The pipe *b* enters the chamber O, and the pipe *f* enters the chamber O′. From the chamber O^2 there conducts the pipe *b′* and from the chamber O^3 the pipe *f′*. The pipe *l′* leads into the space or chamber intermediate of the two partitions F′ F^2, and a pipe *k* conducts from this chamber. The cooling-water can thus enter at *l′*, flow through the entire cooler, and leave at *k*.

The gas to be analyzed enters the chamber O by the pipe *b*, passes through the pipes f^2 into the chamber O^2, and leaves the latter through the pipe *b′*, flowing thence to the meter B. The warm gas leaving the vessel L′ enters the chamber O′ at *f*, flows through the pipes f^2, leading to the chamber O^3, and passes through *f′* to the second meter C. In this manner both gases are reduced to the same temperature and are therefore measured at a like temperature.

The registering mechanism R, as shown in Figs. 1 to 4, is connected by bevel-gear and shafts 2 3, rotating in opposite directions, with the gas-meters. This apparatus is illustrated in Figs. 7 to 9 and is comprised of the following details of construction: There is a differential gearing 4 of well-known construction, the purpose of which is to convert the opposing, slow, and irregular movements of the shafts 2 and 3 into a rotary motion representing the difference between the angular velocities of such shafts. The latter are mounted in the respective sides of the casing V, in which the working parts are contained, and in bearing-arms 20 21, disposed therein. The said latter motion is transmitted to the toothed rim 5, which is connected with the differential gearing. To such end the bevel-wheels 4^c 4^d of the differential gearing 4, which gear with the bevel-wheels 4^a 4^b, keyed to the shafts 2 3, respectively, are individually rotatable at the opposite ends of an axis 5^a. This axis is held in position by the ends of the shafts 2 3. For this purpose it is furnished with a nave 5^b, in which the said ends are engaged. To the axis 5^a the said toothed rim 5 is secured, so that its center coincides with the axis of the shafts 2 and 3.

The rim 5 meshes with the toothed wheel 6, keyed to the shaft 7, mounted in the bearing-arms 20 21. At the end of this shaft a pulley 8 is secured, against which is pressed by a friction-roller 10 a bar 9, suitably guided below at 12, so that it may be raised by the pulley 8. The bar 9 carries a style 11 at the top, so that as the bar is raised the style 11 makes an almost vertical stroke on the drum 13. This drum carries, as is well known with such recording arrangements, a sheet of paper 23 and is driven by clockwork (not shown) about a vertical axis.

The friction-roller 10 is carried by an arm 19, pivoted to a suitable support 22 and engaged by a spring 18, fixed to such support, Fig. 8, so that for the purpose stated the roller 10 is pressed against the bar 9. The length of the line which the style thus draws depends upon the period during which the rod 9 is pressed against the pulley 8 and, further, upon the circumferential velocity of the pulley 8. If now a certain interval of time—say three minutes— is regarded, then during such period, depending upon the variation of the circumferential velocity of the pulley 8, the style 11 will draw lines of different length.

The motion of the shaft 2 is constant, since the gas-meter B is operated at the same speed by the original gas. This shaft 2 is therefore employed to bring the style 11 back to its initial position in definite intervals of time. This is necessary, since the bar, owing to its own limited length, can only be raised to a certain extent. For this purpose a pinion 14 is keyed to the shaft 2, such pinion meshing with a toothed wheel 15. To the latter is secured a pin or stud 16, which at

each complete revolution of the wheel 15 strikes a projection 17, secured to the pivotal arm 19. On the pin 16 striking the projection 17 the roller 10 is moved away from the rod 9, and the latter then descends by gravity, whereupon it is again pushed upward, the pin 16 releasing the projection 17, so that the style 11 commences to draw a new line.

Since the drum 13 makes one revolution in twenty-four hours, the drawn lines located one beside the other and whose bases are all on the same level—namely, that corresponding with the lowest position of the bar 9—will by reason of the irregular motion of the drum of the meter C be of different heights, so that their summits will form a day-diagram.

For the purpose of better explanation of the operation and object of the registering apparatus I will now proceed to give a practical example.

If, for instance, through both meters B and C ordinary air is allowed to flow, the drums will be driven at the same speed, the differential gear—*i. e.*, rim 5—will not move, so that the pulley 8 and rod 9 recieve no motion, and the style 11 accordingly makes a horizontal line on the drum. If, now, instead of air a gas containing ten per cent. of carbonic acid is allowed to flow through the meter B, then after absorption of the carbonic acid by an absorbent medium subsequent to passage through the meter B the drum of the meter C will move with a velocity of only 0.9 that of the drum of the meter B.

The differential gearing—*i. e.*, rim 5—will move with a velocity of 0.1—that is to say, the difference between the velocities 1 and 0.9, and this velocity will be transmitted to the style 11.

The gear of the registering apparatus is preferably so arranged that the style 11 is always raised two millimeters when the drum of the meter C has a velocity one per cent. less than that of the drum of the meter B. In the present case, therefore, the style 11 will draw a line twenty millimeters long—that is to say, a line twenty millimeters long indicates that in the gas passing through the meter C ten per cent. less has been measured than in the gas which entered the meter B.

Having thus described my invention, I claim as new and desire to secure by Letters Patent of the United States—

1. In a gas-analyzing apparatus, in combination, gas-meters connected in the gas-pipe, shafts driven in opposite directions by the meters, graphical registering mechanism, and differential gearing transmitting the differing motions of the shafts to the said registering mechanism, substantially as described.

2. In a gas-analyzing apparatus, in combination, gas-meters connected in the gas-pipe, an absorbent-container connected between the two meters, shafts driven in opposite directions by the meters, graphical registering mechanism, and differential gearing transmitting the differing motions of the shafts to the said registering mechanism, substantially as described.

3. In a gas-analyzing apparatus, in combination, gas-meters connected in the gas-pipe, an absorbent-container connected between the two meters, and a cooler divided into two compartments, through one of which the gas passes prior to entering the first meter, and through the other of which it passes after leaving the absorbent-container and prior to entering the last meter, substantially as described.

4. A cooler for gas-analyzing apparatus comprising a vessel having chambers at the ends divided from the remainder of the vessel by perforated partitions, walls dividing each of the said end chambers into two compartments, and pipes extending from the holes in one perforated partition to the corresponding holes in the other partition, said compartments at one end being furnished with gas-inlets, and the said compartments at the other end with gas-outlets, and the central pipe-chamber being provided with a water-inlet at the one end and a water-outlet at the opposite end, substantially as described.

5. In a gas-analyzing apparatus, a solid absorbent-container, comprising a vessel having a gas-inlet near the bottom, and an annular trough at the top, adapted to contain a fatty sealing medium, and a cover having a gas-outlet and a guttered rim fitting into the trough of the vessel, substantially as described.

6. In a gas-analyzing apparatus, in combination, gas-meters connected in the gas-pipes, shafts driven in opposite directions by the meters, a toothed rim, differential gearing transmitting the differing motion of the shafts to the said rim, a third shaft, a toothed wheel mounted thereon and driven by the said rim, a friction-pulley keyed to this shaft, a vertically-sliding bar, guiding means for the latter, spring-actuated means pressing the bar against the friction-pulley, a style carried by the said bar, and a rotary drum marked by the style, substantially as described.

7. In a gas-analyzing apparatus, in combination, gas-meters connected in the gas-pipe, shafts driven in opposite directions by the meters, a toothed rim, differential gearing transmitting the motion of the shafts to the said rim, a third shaft, a toothed wheel mounted thereon and driven by the said rim, a friction-pulley keyed to this shaft, a vertically-sliding bar, guiding means for the latter, a pinion mounted on one of the said first-named shafts, a toothed wheel, the pinion and having a lateral stud, a friction-roller, a spring-

actuated pivoted lever carrying the said roller, and pressing it against the pulley, a projection on the said lever engaged by the said stud on the toothed wheel rotating, a style carried by the said bar, and a rotary drum marked by the style, substantially as described.

In witness whereof I have hereunto signed my name, this 16th day of December, 1904, in the presence of two subscribing witnesses.

ALEXANDER BAYER.

Witnesses:

A. W. DONEGAN,

HERMANN SCHALLINGER.