

Jan. 9, 1968

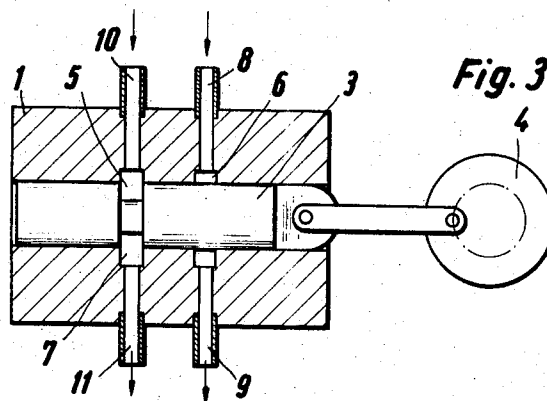
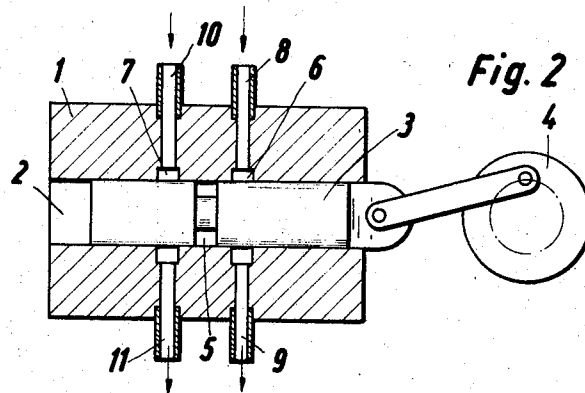
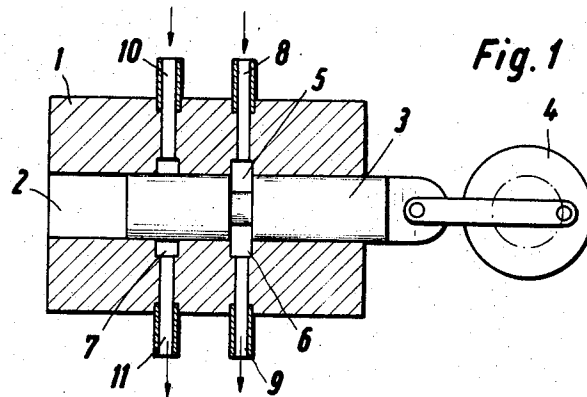
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GAS ANALYSIS APPARATUS WITH PROPORTIONING MEANS

Filed April 21, 1964

5 Sheets-Sheet 1



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Jan. 9, 1968

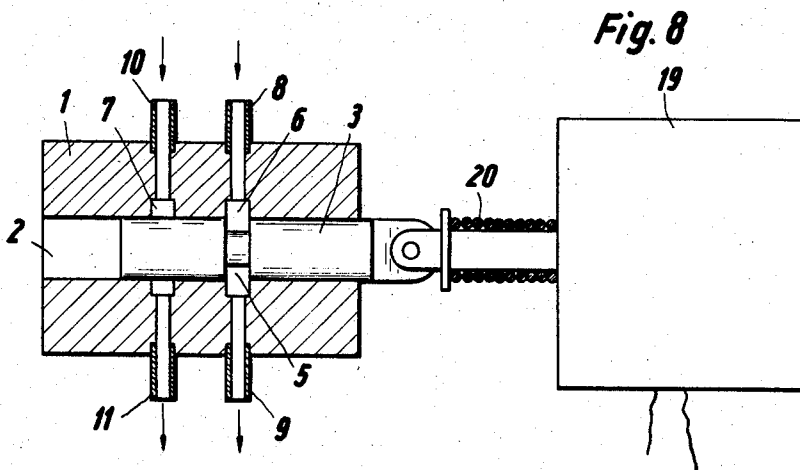
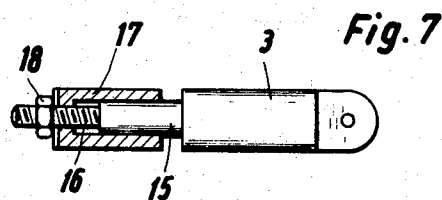
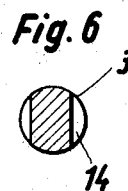
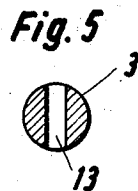
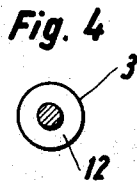
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GAS ANALYSIS APPARATUS WITH PROPORTIONING MEANS

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5 Sheets-Sheet 2



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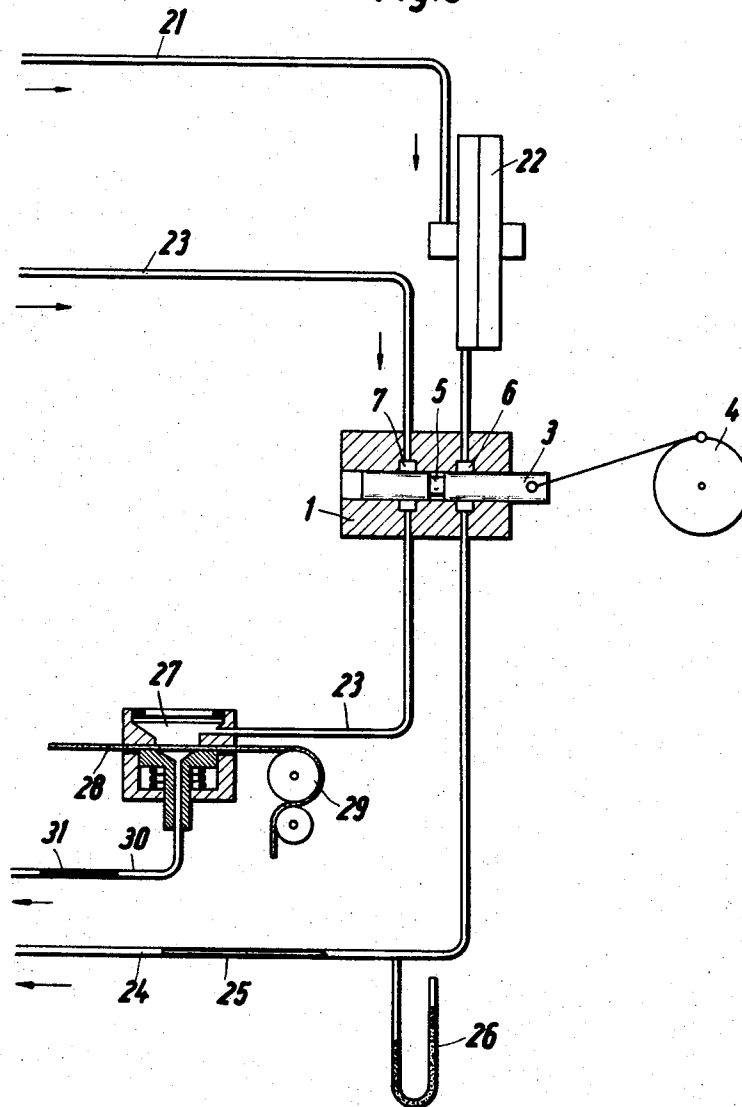
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GAS ANALYSIS APPARATUS WITH PROPORTIONING MEANS

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Fig. 9



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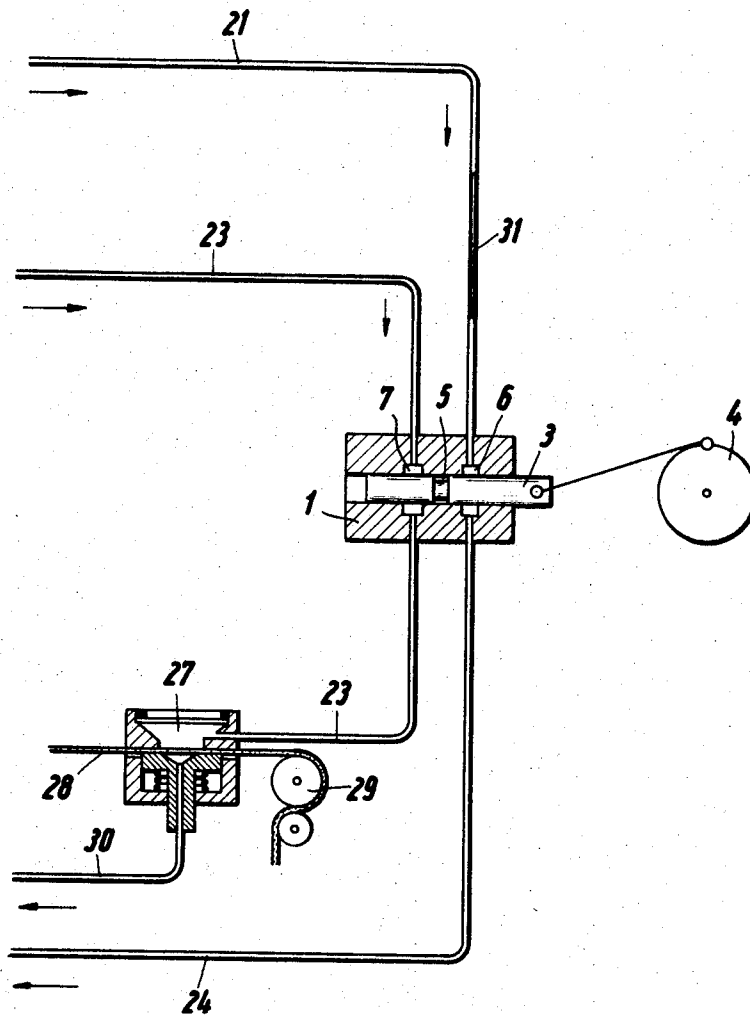
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GAS ANALYSIS APPARATUS WITH PROPORTIONING MEANS

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Fig. 10



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GAS ANALYSIS APPARATUS WITH PROPORTIONING MEANS

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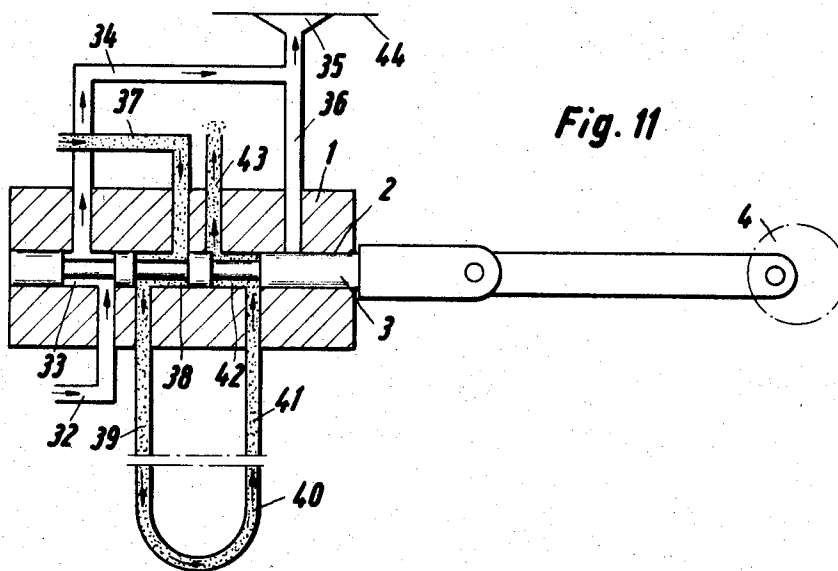


Fig. 11

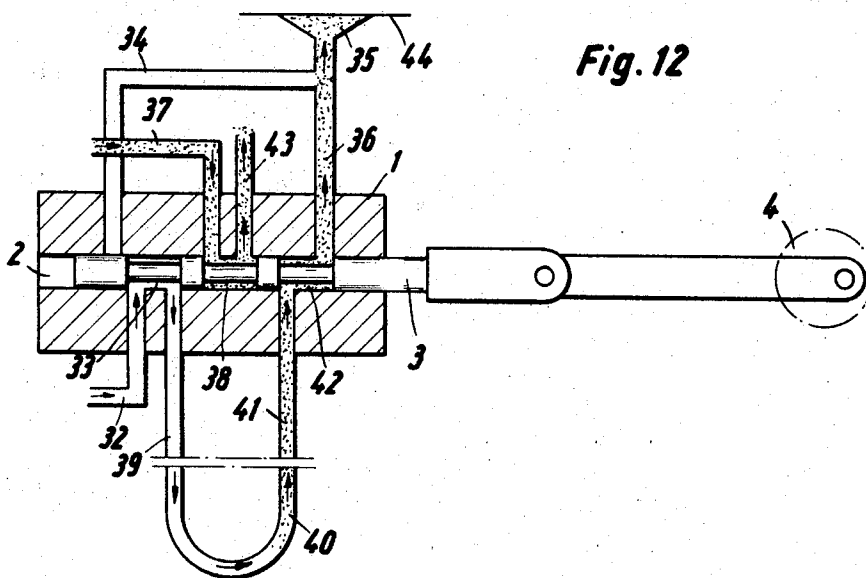


Fig. 12

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GAS ANALYSIS APPARATUS WITH PROPORTIONING MEANS

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7 Claims. (Cl. 73-422)

ABSTRACT OF THE DISCLOSURE

A gas analysis apparatus comprises a piston slide valve which includes a piston reciprocating in a complementary bore of a casing. The piston has at least one recess which constitutes proportioning means. The casing has inlet means and outlet means for gas to be analyzed and leading into and from, respectively, the bore of the casing. Additional inlet means and outlet means for scavenging gas and leading into and from, respectively, the bore of the casing. The respective inlet and outlet means are spaced apart along the axis of the piston and the recess of the latter coincides with the respective inlet and outlet means in the dead center positions of the piston during its reciprocation.

The present invention relates to a gas analysis apparatus with proportioning means in order that gases may be perfectly examined analytically also with higher concentrations than hitherto.

A known gas analysis apparatus, particularly for the determination of low traces of hydrogen sulphide in gases of any kind and in air, operates according to the following principle: a narrow paper strip saturated with a reagent which reacts to the particular gas, for example hydrogen sulphide, and is stained under the influence of the gas more or less depending on the concentration of the gas, is moved at constant speed successively through a comparison chamber and through a measuring chamber. The comparison chamber contains air, whereas a constant volume of the gas to be analyzed is fed to the measuring chamber. The reagent paper strip in both chambers is radiated by one common lamp. The paper brightness acts on two light-sensitive elements. The first of the two elements receives the light from the white paper strip in the comparison chamber, while the light emitted by the more or less blackened paper inside the measuring chamber is directed towards the second of the light-sensitive elements. The resulting differential current is proportional to the gas content, for example to the content of hydrogen sulphide, of the gas to be analyzed and is measured by means of a measuring instrument.

Such a gas analysis apparatus has a normal measuring range of 0 to 25 milligrams of hydrogen sulphide per standard cubic metre (mg. H_2S/Nm^3) with a flow rate of measuring gas of 100 cm^3/min . A four-fold range may be achieved by reducing the gas flow rate to 50 cm^3/min . and by doubling the paper transport speed. Such conditions occur in trace measurements, for hydrogen sulphide for example, when contaminations are to be determined in a cleaned gas. High concentrations, however, are no longer measurable because the quantity to be measured exceeds the measuring range of the analysis apparatus. Such cases occur particularly when measuring H_2S in uncleaned gases when the concentrations of the uncleaned gas to be measured may exceed the measuring range of the analysis apparatus for example by the factor 1000 and more.

In such cases it has hitherto been usual to add a meas-

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uring gas volume compatible with the measuring range of the analysis apparatus to a metered volume of air, inert gas or other gas not interfering with the analysis.

For proportioning or making gas mixtures it is known to use reciprocating pumps with two pistons of different diameters which moreover may have different lengths of stroke and also different stroke cycles per time unit. Perfect proportioning is however no longer ensured if the mixing ratio exceeds a certain amount, for example 1:100, because owing to the arrangement of the necessary valves the detrimental space of the small proportioning piston becomes too large related to the stroke volume.

Another known proportioning device operates with a mechanically rotatable cock in which the bore of the plug is used as proportioning volume. The cock body is provided with two bores disposed at angles of 90° to each other, the plug of the cock being provided with only one passage bore the size of which is adapted to the proportioning volume. After rotation by 90° the gas delivered into the bore of the cock plug through one bore in the cock body is blown out of the plug bore by the gas to be added and both gas volumes are combined and conducted to the analysis apparatus. Also this device has a limited proportioning capacity only, because the bore of the cock plug may not be selected too large in view of the sealing requirements—there must be sufficient overlapping between the bores—while at the same time also a certain minimum value must be reached if proper filling is still to be ensured during the few angular degrees where the bores of the plug and of the cock body face each other as the plug is turned. Another drawback appears in the course of time because scores readily develop on the continually turned cock plug which may result in leakage and consequent falsification of the proportioning volume.

Moreover, the proportioning of low gas volumes easily creates the risk of a delay in indication because a current cannot form in the piping from the sampling point to the proportioning device. For this purpose a T was installed upstream the proportioning device to allow a certain volume of the gas to be analyzed continuously to flow out. Although such an arrangement eliminates the delay caused by a long sampling line, yet the volume of the connecting line between the T and the proportioning means is still large in relation to the small proportioning volume thus causing a noticeable undesired delay in the indication.

It is one object of the present invention to provide a gas analysis apparatus with proportioning means which overcomes the drawbacks mentioned above.

It is another object of the present invention to provide a gas analysis apparatus with proportioning means which includes a piston slide having at least one recess and reciprocating in a casing to be used for proportioning the gas, which by means of its recess or recesses provides for the delivery of the gas to be examined from the gas sampling line into the proportioning means, when the piston slide valve has reached one of its two dead center positions and for conveying the gas to be analyzed by means of scavenging gas out of the proportioning means into the measuring chamber of the gas analysis apparatus, when the piston slide has reached the other of its two dead center positions.

It is still another object of the present invention to provide a gas analysis apparatus with proportioning means, wherein the piston slide itself is used for proportioning and is provided with a recess as proportioning chamber in its center for this purpose. Annular grooves are provided in the casing at both ends of the piston slide travel at the location of the proportioning chamber. The gas to be analyzed (measuring gas) flows through one of the annular grooves of the casing, while scavenging gas or air continuously flows at constant speed through

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the other of the annular grooves. During its stroke the piston slide carries a predetermined volume of measuring gas in its proportioning chamber from one annular groove to the other annular groove from where the measuring gas is delivered to the measuring chamber of the gas analysis apparatus. This embodiment is suitable for proportioning relatively small volumes of up to 1.5 mm.³.

It is yet another object of the present invention to provide a gas analysis apparatus with proportioning means, wherein the piston slide merely serves for controlling a proportioning device, the proportioning chamber of which consists of an exchangeable tube mounted on the outside of the casing. The piston slide is provided with several controlling edges, for example with three grooves for controlling the various gas ways. One groove controls the entry of the scavenging gas into the proportioning tube, the second groove controls the entry of the measuring gas into the proportioning tube, and the third groove controls the exit of the measuring gas from the proportioning tube. This embodiment is well suited for proportioning relatively high proportioning volumes of up to 10 cm.³.

The gas analysis apparatus with the proportioning means designed in accordance with the present invention offers the advantage that the proportioning means are easy to manufacture. Piston, casing and proportioning tube are preferably made of the same hardened material, for example stainless steel, so that these parts will not be attacked by the gas to be measured, for example hydrogen sulphide. Furthermore, the piston slide ensures a good overlapping between the recess or recesses in the piston and the openings in the casing serving as gas inlets and outlets thus maintaining a satisfactory sealing. Furthermore there is a possibility of wide variation in the proportioning volume by appropriate selection of the piston diameter, the size of the proportioning chamber, the size of the proportioning tube, and of the number of strokes per unit of time.

Furthermore there is no delay in indication because in the first embodiment of the proportioning means the gas to be analyzed and proportioned continuously flows through one of the annular grooves in the casing and the proportioning volume defined by the proportioning chamber in the piston is immediately carried along by the flow of scavenging gas upon entry into the other annular groove leading to the measuring chamber of the gas analysis apparatus. Finally, owing to the low speed of movement there is enough time available for filling the proportioning chamber when the piston slide valve reaches its dead center position. In the second embodiment of the proportioning means the flow conditions are even more favorable for the formation of the proportioning chamber proper as a tube of small inside diameter ensures a satisfactory blowing out of the metered measuring gas by the scavenging gas.

Advantageously the piston slide of the proportioning means is also driven by the clockwork for transporting the reagent paper strip of the measuring device, so that the piston slide valve will positively be moved in synchronism with the transport. But it is also possible to actuate the proportioning means by an electromagnet with pull-back spring, thereby making possible to provide for an intermittent proportioning with a program suited for the particular application of the gas analysis apparatus.

With these and other objects in view which will become apparent in the following detailed description, the present invention will be clearly understood in connection with the accompanying drawings, in which:

FIGURE 1 is an elevation, partly in section, of the proportioning means with the piston slide and the proportioning chamber in the supply line of the gas to be examined;

FIG. 2 is an elevation, partly in section, of the proportioning means with the piston slide and the proportioning chamber in central position;

FIG. 3 is an elevation, partly in section, of the propor-

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tioning means with the piston slide and the proportioning chamber in the measuring line;

FIG. 4 is a sectional view of the piston slide with an annular groove serving as proportioning chamber;

FIG. 5 is a sectional view of the piston slide with a bore serving as proportioning chamber;

FIG. 6 is a sectional view of the piston slide with milled faces;

FIG. 7 is an elevation of a piston slide valve with an adjustable proportioning chamber;

FIG. 8 is an elevation of the proportioning means, as driven by an electromagnet;

FIGS. 9 and 10 are diagrams of a gas analysis apparatus with proportioning means;

FIG. 11 is an elevation of a proportioning device with a proportioning tube fitted to the outside of the casing with the piston slide shown in the position in which the proportioning tube fills with measuring gas; and

FIG. 12 is an elevation of the proportioning device of FIG. 11 with the piston slide shown in the position in which the metered volume of measuring gas is pressed out of the proportioning tube by the scavenging gas.

Referring now to the drawings, and in particular to FIG. 1, the apparatus comprises a casing 1 provided with a cylindrical bore 2 in which a piston 3 is reciprocated by a crank drive 4. The piston 3 is provided in its center with a groove 5 extending all around the piston 3 and forming the proportioning chamber or proportioning volume. The reciprocating motion of the piston 3 defines a certain path for the proportioning chamber 5. Annular grooves 6 and 7 are provided in the casing 1 at both ends of the path. The gas to be analyzed and proportioned flows through an inlet sleeve 8 into the annular groove 6, passes through the latter and leaves the groove 6 through the outlet sleeve 9. Air, for example, is fed in through an inlet sleeve 10 and, after flowing through the annular groove 7, leaves again through the outlet sleeve 11 from where it is conducted to the measuring chamber.

Referring now again to the drawings, and in particular to FIG. 2, piston 3 has reached its center position after 90° rotation of the crank drive 4, the proportioning chamber 5 now being located between the two annular grooves 6 and 7. The proportioning chamber 5 has taken out of the annular groove 6 the volume of gas to be analyzed, which volume is predetermined by the size of the proportioning chamber 5. The proportioning chamber 5 is now sealed by the overlapping casing 1. As the piston 3 is moved towards the annular groove 7, the volume of gas enclosed in the proportioning chamber 5 is also conveyed thereto. The gas to be analyzed continues to flow through the inlet sleeve 8, the annular groove 6 and the outlet sleeve 9, while at the same time air continues to flow to the measuring chamber through the inlet sleeve 10, the annular groove 7 and the outlet sleeve 11.

As indicated in FIG. 3, piston 3 has reached the other dead center position of the piston path after further rotation of the crank drive 4 by 90°. The volume of the gas to be analyzed enclosed in the proportioning chamber 5 has now reached the annular groove 7 where it is taken along by the air flow and conveyed to the measuring chamber of the gas analysis apparatus. The gas to be analyzed continues to flow through the inlet sleeve 8, the annular groove 6 and the outlet sleeve 9.

As the crank drive 4 is further rotated by 180° the piston 3 again reaches its starting point, so that the proportioning chamber 5 is again located in the annular groove 6, as shown in FIG. 1. The air contained in the proportioning chamber is displaced by the gas to be analyzed flowing through the inlet sleeve 8 and the annular groove 6 to the outlet sleeve 9, so that the proportioning chamber 5 again fills with measuring gas. Since the gas to be analyzed continuously flows through the proportioning means there will always be fresh gas at the sampling

point, that is in the annular groove 6. A delay in indication is thus excluded.

FIGS. 4, 5 and 6 are sectional views of different embodiments of the proportioning chamber 5. FIG. 4 shows an annular groove 12 the depth and width of which may be varied. FIG. 5 shows the piston 3 with a bore 13 as proportioning chamber, the diameter of which may be varied within certain limits. FIG. 6 shows a proportioning chamber formed by milled recesses 14 on the piston 3. In all these three cases also the outside diameter of the piston 3 may be varied for changing the size of the proportioning chamber.

FIG. 7 discloses a piston having a proportioning chamber adjustable in size. For this purpose the piston 3' is composed of two parts. At the end, remote from the crank drive 4, piston 3' carries a centering shaft 15 with a threaded pin 16 having a bush 17 screwed thereon. The width of the annular groove and consequently the size of the proportioning chamber 5' and the proportioning volume may be varied by shifting the bush 17 on the centering shaft 15. The adjustment of the bush 17 is secured by means of a counter nut 18.

FIG. 8 indicates how the crank drive may be replaced, for example, by an electromagnet 19. In the attracted state of the magnet 19, as shown, the proportioning chamber 5² is located at the level of the annular groove 7, whereas in the currentless state the spring 20 causes the piston 3² with the proportioning chamber 5² to move in front of the annular groove 6², it being of no importance whether the proportioning chamber 5² is filled in the attracted state or in the currentless state of the magnet.

The operation of a gas analysis apparatus with proportioning means will now be described with reference to FIG. 9. The supply line 21 of the gas to be analyzed includes a pressure regulator 22 which provides for the pressure in the proportioning means not to exceed a certain value. It is thus prevented that the gas to be examined overflows in the proportioning means from annular groove 6 to annular groove 7. Substantially, there is a pressure of about 50 to 100 mm. column of water in the measuring line 23 and it is therefore desirable to maintain the same pressure or a slightly lower pressure in the annular groove 6 of the gas to be analyzed. The regulator 22 also comprises a capillary 25 arranged in the discharge line 24 of the gas to be analyzed. The water column 26 indicates the pressure existing in the annular groove 6 of the gas to be analyzed. There must always be the same pressure in the annular groove 6, so that the volume of gas removed by the proportioning chamber 5 will always remain equal. If this is not ensured, the contents of the proportioning chamber 5 will increase or decrease depending on the pressure in the gas line. Operation therefore takes place at a constant overpressure, for example 80 mm. column of water, against the atmosphere.

The volume of gas to be analyzed transported by the proportioning chamber 5 into the annular groove 7 is conveyed by the air used as scavenging gas through the measuring line 23 to the measuring chamber 27. In the measuring chamber 27 the measuring gas acts in known manner on a reagent paper strip 28, which is moved forward by feed means 29, for example a clockwork motor, intermittently, for example with 12 steps for each field at a speed of one step per minute. The air is discharged from the measuring chamber 27 through the line 30 which is preferably provided with another capillary 31 before it is led into the outgoing air shaft in order not to let the pressure in the annular groove 7 fall below the pressure of the annular groove 6 and especially in order to prevent a short-circuit across the outgoing air shaft between the gas discharge lines 24 and 30. The other reference characters refer to the same parts as in the FIGS. 1 to 3.

FIG. 10 shows the same scheme of a gas analysis apparatus with proportioning means as FIG. 9, the only

modification being that the pressure regulator 22 is replaced by a capillary 31' in the supply line 21 of the gas to be analyzed. The capillary 31' provides for a pressure in the proportioning means which is approximately equal to the pressure in the line 30 and does not exceed the pressure in the annular groove 7. An approximately constant pressure is thus ensured in the annular groove 6. The other reference characters refer to the same parts as in FIG. 9.

With reference to FIG. 11, the casing 1 is provided with a cylindrical bore 2 in which the control piston 3³ is tightly fitted and is reciprocated by the crank drive 4³. Piston 3³ is provided with three recesses for controlling the various gas ways. Scavenging gas, for example air, enters through the inlet sleeve 32 into the casing 1 of the piston slide 3³, passes into the recess 33 of the piston 3³ leaves the casing 1 through the outlet sleeve 34 and is conveyed to the measuring chamber 35 of the gas analysis apparatus. The branch-off line 36 of outlet sleeve 34 and/or measuring chamber 35 is sealed by the piston 3. The measuring gas to be analyzed enters through the inlet sleeve 37 into the casing 1, flows around the recess 38 in the piston 3 and passes through outlet sleeve 39 into the proportioning tube 40 which it fills with measuring gas and re-enters through inlet sleeve 41 into the casing 1, passes into the recess 42 in the piston 3 and escapes through outlet sleeve 43 to the atmosphere.

FIG. 12 shows the crank drive rotated by 180° out of the position shown in FIG. 11. The outlet sleeve 34 for the scavenging gas is now closed by the piston 3³. The scavenging gas now flows through inlet sleeve 32, recess 33 of the piston 3³, outlet sleeve 39, into the proportioning tube 40, pushes the measuring gas ahead of itself through inlet sleeve 41, recess 42 and outlet sleeve 36 to the measuring chamber 35 of the gas analysis apparatus in which the measuring gas acts in known manner on the reagent paper 44. The measuring gas which continues to flow through the proportioning means passes through the inlet sleeve 37 into the recess 38 of the piston 3³ from where it unobstructedly escapes through the outlet sleeve 43 into the atmosphere.

After rotation of the crank drive 4 by another 180° the position shown in FIG. 11 is reached again. The scavenging gas in the proportioning tube 40 is displaced by the measuring gas and the proportioning tube 40 again fills with measuring gas. The quantity of the proportioning volume is fixed by the length of the exchangeable tube. The proportioning volume may amount up to 10 cm.³ and more.

While I have disclosed several embodiments of the present invention, it is to be understood that these embodiments are given by example only and not in a limiting sense, the scope of the present invention being determined by the objects and the claims.

What I claim is:

1. A gas analysis apparatus including proportioning means comprising

a piston slide including a piston having at least one recess constituting proportioning means,

a casing having a cylindrical bore of a diameter complementary to that of said piston,

said piston reciprocating in said bore of said casing and serving to proportion the gas to be analyzed,

first inlet means for gas to be analyzed leading into said bore,

first outlet means for said gas extending from said bore,

second inlet means for scavenging gas leading into said bore,

second outlet means for said scavenging gas extending from said bore,

said first inlet means and said first outlet means being spaced apart along the axis of said piston from said

second inlet means and said second outlet means, said piston during its reciprocation assuming respective

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end positions and moving said gas to be analyzed accumulated in said proportioning means from said first inlet means to said second inlet means, a measuring apparatus communicating with said second outlet means, and

said casing having annular grooves spaced apart along the longitudinal axis of said piston and surrounding said piston for continuous communication between said first inlet means with said first outlet means and between said second inlet means and said second outlet means, respectively.

2. The gas analysis apparatus, as set forth in claim 1, wherein

said recess in said piston defines an annular chamber, and

said annular chamber communicates with said respective inlet and outlet means in the end positions of said piston.

3. The gas analysis apparatus, as set forth in claim 1, wherein

said recess in said piston defines a crosswise disposed bore, and

said bore communicates with said respective inlet and outlet means in the end positions of said piston.

4. The gas analysis apparatus, as set forth in claim 1, wherein

said recess in said piston defines lateral cut outs, and said lateral cut outs communicate with said respec-

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tive inlet and outlet means in the end positions of said piston.

5. The gas analysis apparatus, as set forth in claim 1, wherein

said piston comprises two parts movable relative to each other and defining adjustably said proportioning means.

6. The gas analysis apparatus, as set forth in claim 1, wherein

said measuring apparatus includes a reagent paper strip, and includes

drive means for said piston and for the transport of said reagent paper strip.

7. The gas analysis apparatus, as set forth in claim 6, wherein

said drive means for said piston comprises an electro-magnet and a pull-back spring operatively connected with said electro-magnet for the return movement of said piston.

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