O. RODHE.

PUMP DRIVEN BY MEANS OF COMPRESSED OR RAREFIED GAS.

APPLICATION FILED APR. 6, 1909.

947,533. Patented Jan. 25, 1910.

3 SHEETS—SHEET 1.

Fig: 1.

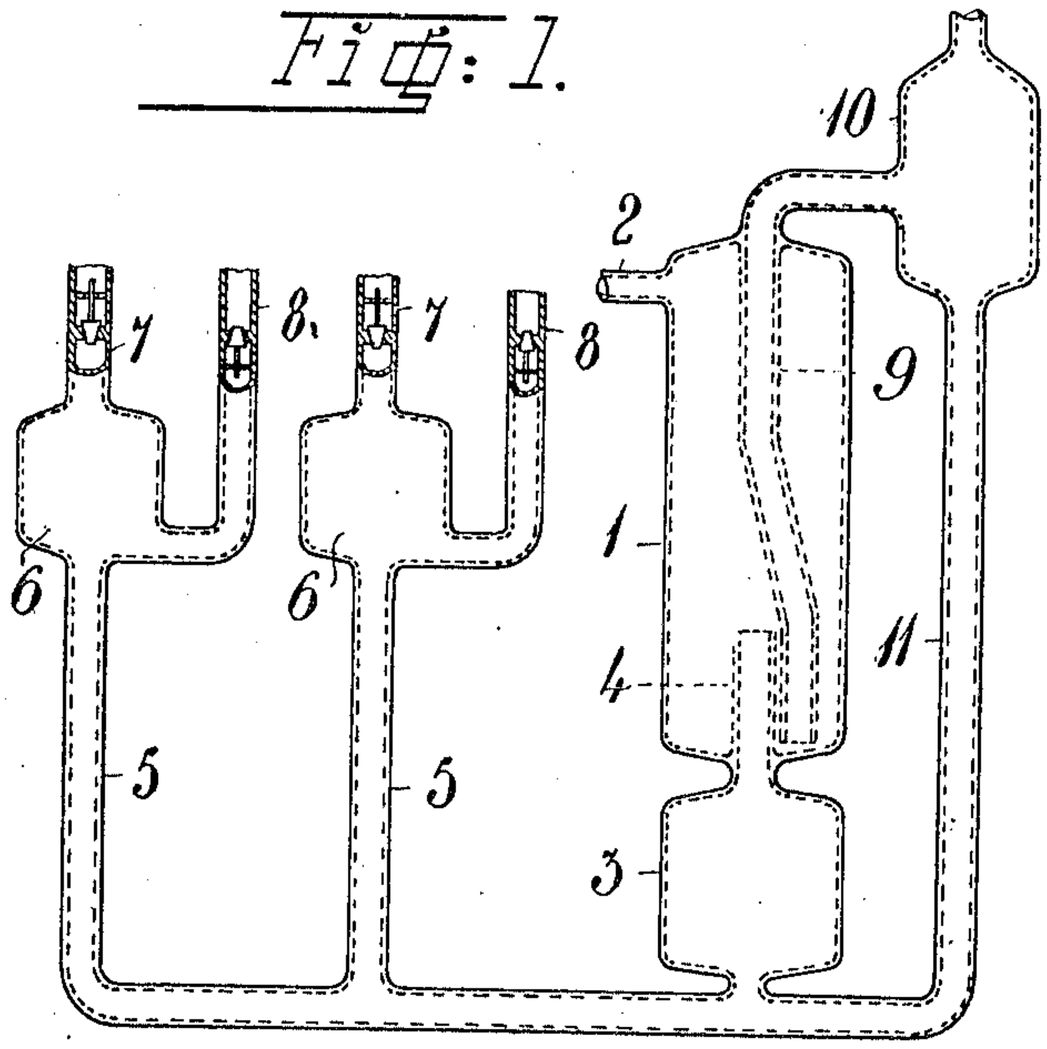


Fig: 3.

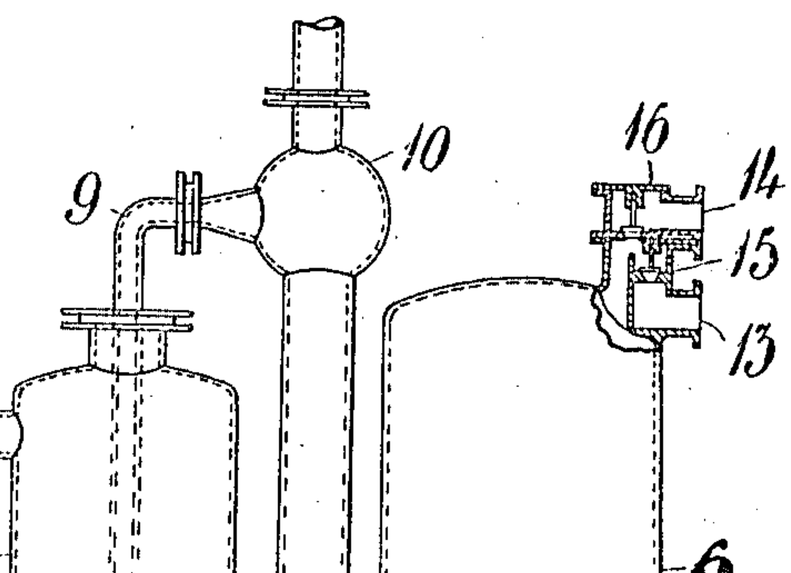
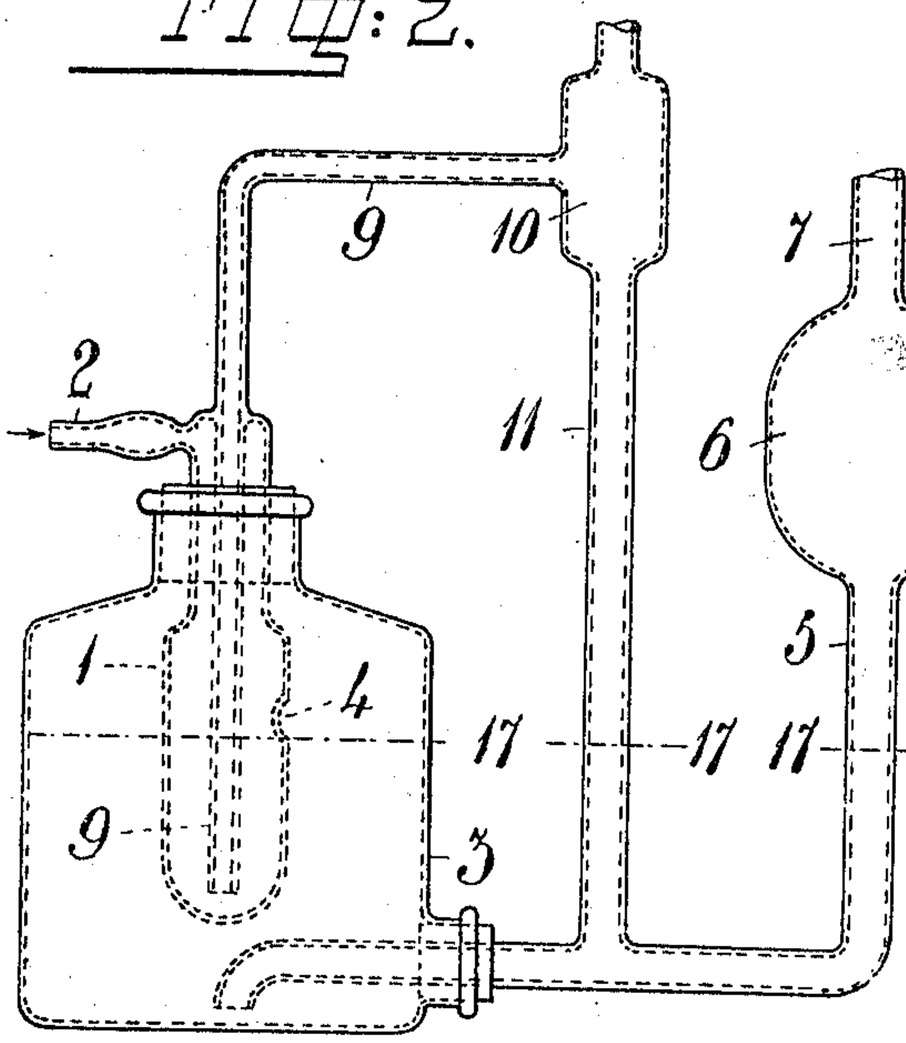


Fig: 2.



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3 SHEETS—SHEET 2.

Fig: 4.

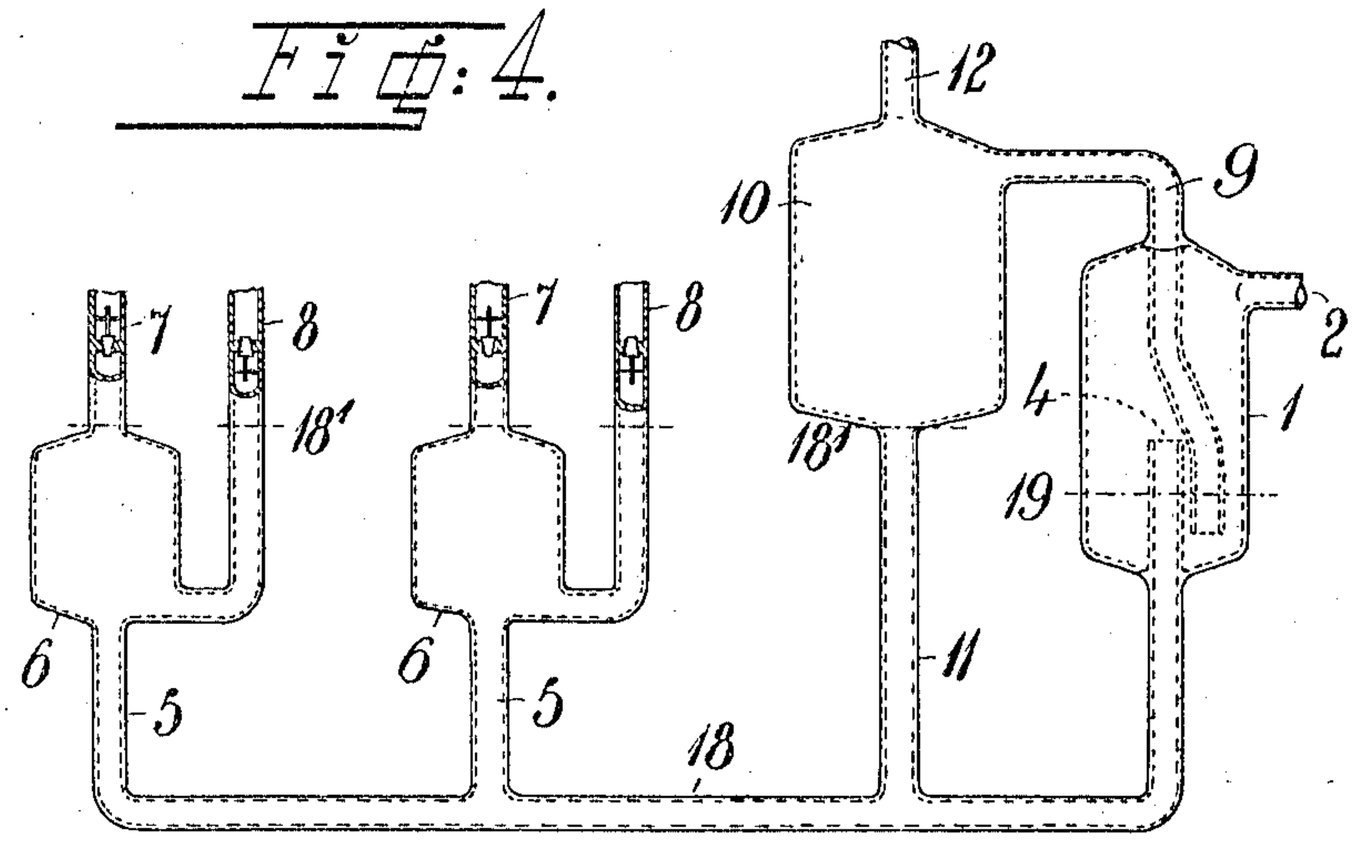
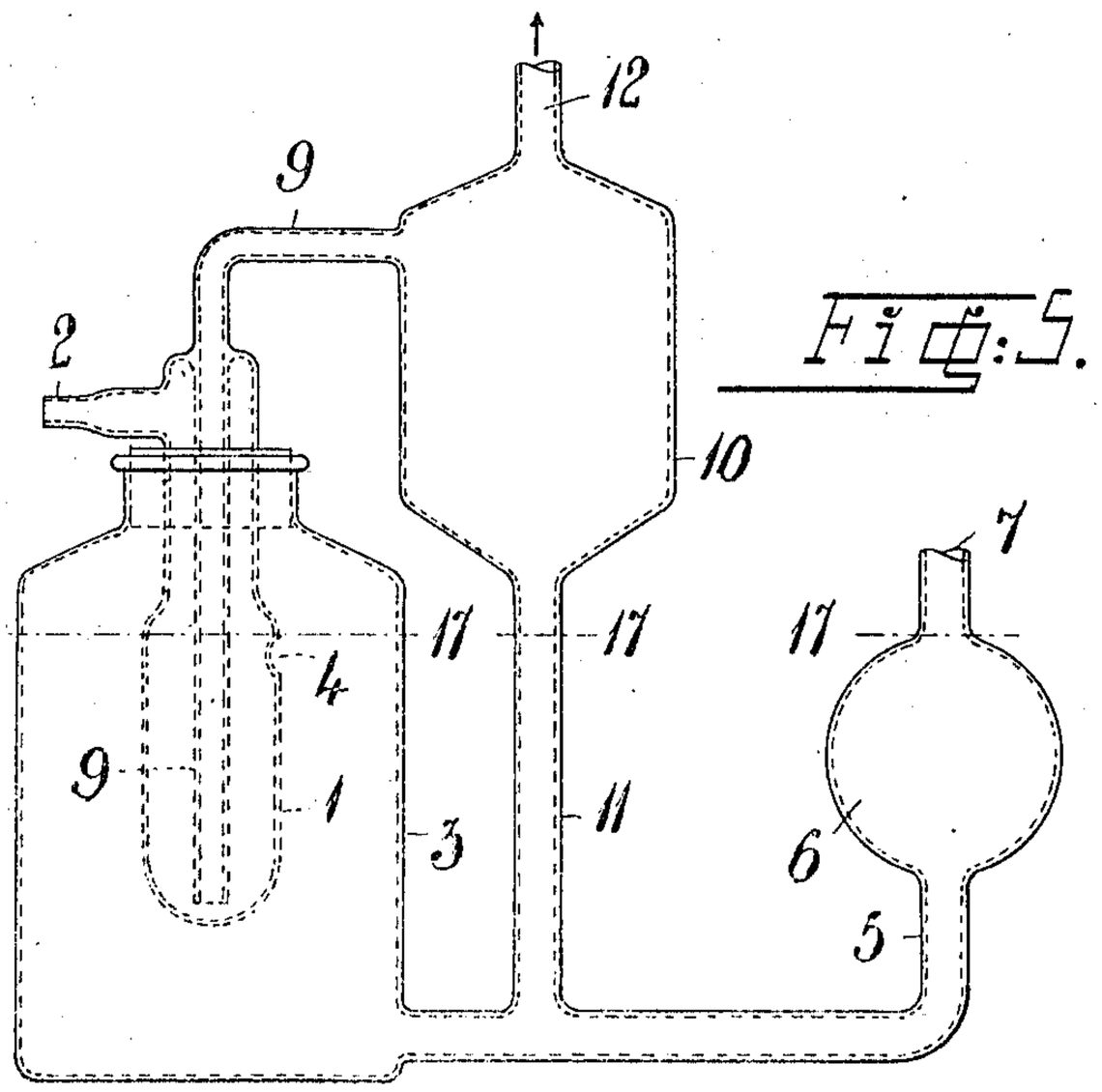


Fig: 5.



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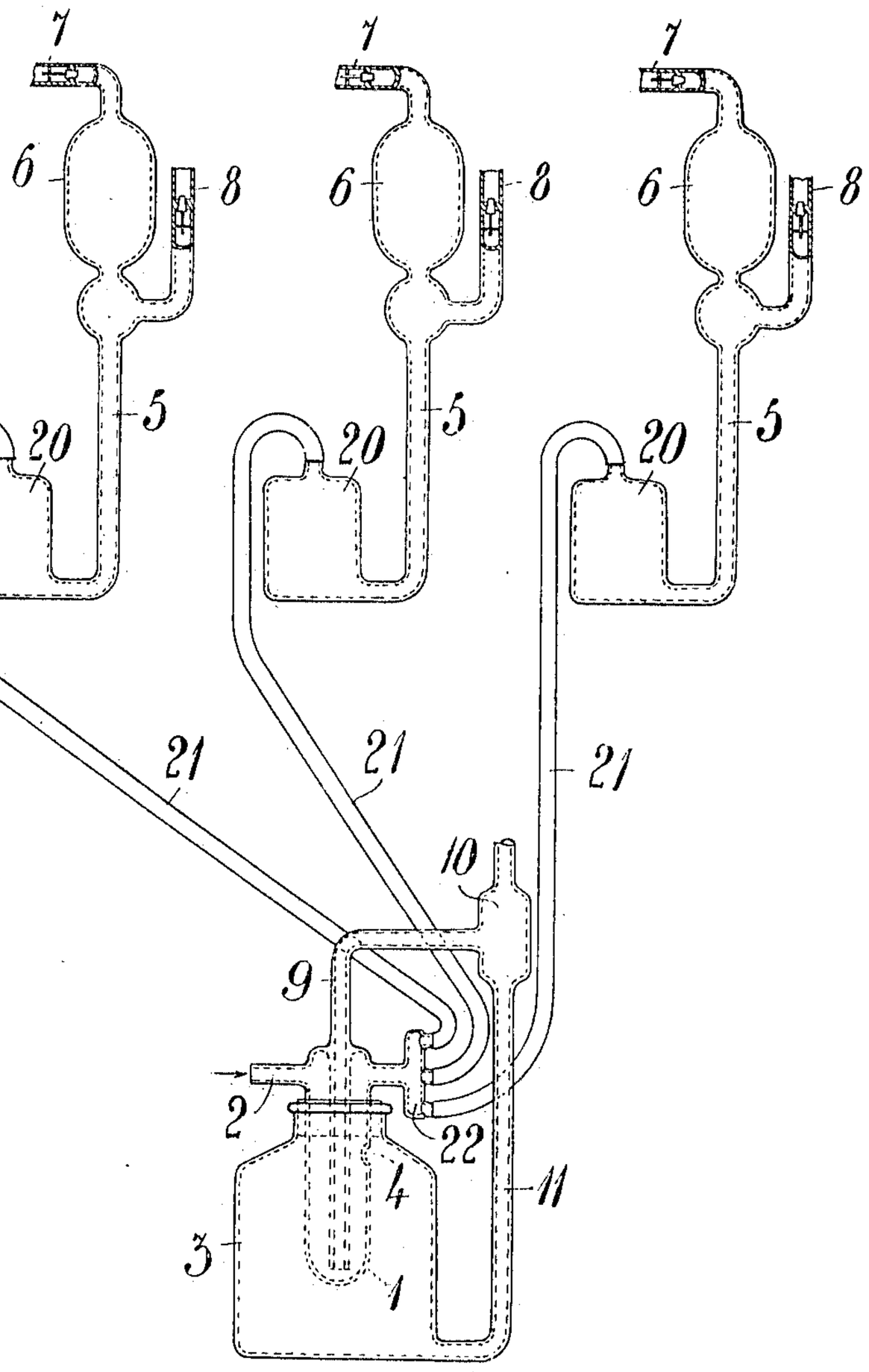
3 SHEETS—SHEET 3.

Fig: 6.



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PUMP DRIVEN BY MEANS OF COMPRESSED OR RAREFIED GAS.

947,533. Specification of Letters Patent. Patented Jan. 25, 1910.

Application filed April 6, 1909. Serial No. 488,244.

To all whom it may concern:

Be it known that I, OLOF RODHE, engineer, subject of the King of Sweden, residing at Stocksund, in the Kingdom of Sweden, have invented new and useful Improvements in Pumps Driven by Means of Compressed or Rarefied Gas, of which the following is a specification.

The present invention relates to pump devices of the class in which to effect the pumping action, one of two vessels or pipes communicating with each other and containing a liquid, are connected with a pipe for compressed or rarefied gas (for example air or carbonic acid), so that the column or columns of liquid in the other vessel or vessels by means of the action of the said gas, rises or sinks, respectively, to any desired degree, whereupon, by means of automatically actuated valves the passage for the compressed or rarefied gas is closed and the vessel or pipe first mentioned is put into communication with the atmosphere so that the pressure in the said vessel returns (*i. e.* falls or rises) to the outer pressure. In this way the columns of liquid assume once more their original levels, in doing which, the said valves are automatically closed, so that pressure or vacuum in the first named vessel once more occurs, and is again interrupted in the same way, and so on, so that the columns of liquid receive a periodically rising and falling movement, and in doing so act as pump pistons.

In the apparatus of this kind hitherto known, the communication of the said vessel, connected with the pipe for compressed or rarefied gas, with the atmosphere has been effected by means of mechanical valves, actuated by floats connected therewith and floating on the rising and sinking columns of liquid, contained in said vessels and mechanical valves have also been arranged in said pipe for compressed or rarefied gas which valves during the work have been opened and closed alternately with the closing and opening of the valves through which the communication of said reservoir with the atmosphere is effected.

The object of the present invention is to obviate the use of mechanical valves and floats for the said purpose, as mechanical valves and floats very easily get out of order, whereby much trouble may be caused, especially when the pumping device or apparatus is intended to work without personal control, as for instance when used for operating automatically acting apparatus for analyzing gases. The said disadvantages are, according to the present invention, obviated by the use of liquid seals for opening and closing communication between the said reservoir and the atmosphere, instead of mechanical valves and the floats operating the same. By means of the liquid seals, the reservoirs or vessels, connected with the pipes for compressed or rarefied gas are automatically put into connection with the atmosphere for a sufficiently long time, whereupon the liquid-seals are again automatically closed, without any use of mechanical parts and without any danger of said liquid-seals leaking or getting out of order. By the use of liquid-seals for said purpose, no valve in the pipe for the compressed or rarefied gas needs to be operated during the working of the apparatus.

In order to illustrate the invention there are shown as example in the accompanying drawings several different forms of construction of the same.

Figures 1, 2 and 3, show diagrammatically three different forms of construction of the invention and which are intended to be driven by means of compressed gas. Figs. 4 and 5 show in the same way two other forms of construction intended to be driven by rarefied gas (suction). Fig. 6 illustrates diagrammatically a method of connecting several pumps to one common driving device, which in accordance with this example, is shown to be arranged for working by means of compressed gas.

In Fig. 1, the numeral 1 indicates a reservoir which is connected by the pipe 2 with a compressor or reservoir for compressed gas. 3 is a reservoir for liquid which communicates by means of the pipe 4 with the lower part of the reservoir 1. The reservoir 3 communicates with pipes 5 each of which is connected with or formed into reservoirs 6 which are provided with inlet and outlet 7, 8. From the lower part of the reservoir 1 there proceeds a pipe 9 which projects upward and at its upper part communicates with the enlarged part 10 of a pipe 11 which communicates with the reservoir 3.

The apparatus works in the following way: On the pump being put into motion the liquid reservoir 3 is filled with liquid up to the mouth of the pipe 4, and in the lower part of the reservoir 1 there is a suitable

amount of liquid which reaches to a proper height over the lower mouth of the pipe 9, so that a liquid seal is formed. When the compressed gas streams through the pipe 2 into the reservoir 1 the pressure in this latter is increased, so that the liquid in the reservoir 3 is pressed up through the pipes 5 into the reservoirs 6 and naturally also to the same level in the pipe 11. Simultaneously with this, however, the liquid in the lower part of the reservoir 1 is pressed up into the pipe 9. When the liquid column in that pipe has reached the upper opening 12 of said pipe, then, on compressed gas continuing to flow into the reservoir 1, the liquid in the pipe 9 will be forced out into the part 10 of the pipe 11 which is open at its top so that the reservoir 1 is put into communication with atmosphere by means of the pipe 9, whereby the pressure in the reservoir (practically) sinks to the outer pressure. This has for effect that the liquid pressed up in the reservoirs 6 and the pipes 5, and also the liquid which has been pressed out through the pipe 9 into the pipe 11, sinks back into the reservoir 3, and a part of this liquid flows over the upper opening of the pipe 4 into the reservoir 1, so that the lower opening of the pipe 9 is again closed by the liquid and thus shuts off communication with the atmosphere, or, in other words, the original state of things is restored. On compressed gas continuing to stream in through the pipe 2 into the reservoir 1 the same process is repeated again and so on as long as compressed gas is led into the reservoir 1 through the pipe 2. From what has been said above it is seen that, in this manner a liquid column is made to alternately rise and sink in the pipes 5 or in the reservoirs 6 connected with these pipes. These liquid columns act in the same way as a pump piston. If, for example, in the pipe 8 an inwardly opening or suction-valve is arranged, and if in the pipe 7 an outwardly opening or pressure-valve is arranged—or if the said pipes are provided with liquid seals acting in the same way—then it is plain, that when the liquid column sinks, a suction will arise in the pipe 8 and a corresponding quantity of gas will be sucked into the reservoir 6, while, when the liquid column rises, the same quantity of gas will be pressed out through the pipe 7. The present invention can with advantage be used for the automatic carrying out of analyses of gases, in which case, the pipe 8 is connected with the supply-pipe for that gas which is to be analyzed, and the pipe 7 is connected with a pipette or reservoir containing an absorbing substance.

In the form of construction, which, as an example, is shown in the drawing, there are shown two pipes 5, but it is clear that only one or even more than two such pipes can be arranged, according as circumstances require. The device can also be arranged in such a way that the reservoir 3 is replaced by a pipe which is in the same way connected with the pipes 5, 11 and 4, *i. e.*, the reservoir 3 is contracted to the shape of a pipe. The liquid which will be pressed up into the pipes 5 or reservoir 6 respectively, is, in such a case, collected in the bottom part of the reservoir 1, and is pressed up from there through the pipes 9, and 11 to the pipes 5 in the above stated manner.

In Fig. 2 there is shown another form of construction of the invention which differs from that shown in Fig. 1 chiefly in that the reservoir 1 in this case is arranged inside the reservoir 3 with which it communicates through an opening 4 arranged in the wall of the reservoir 1. This form of construction works in the same way as that illustrated in Fig. 1. Let it be assumed, that the reservoir 3 is filled with a liquid, for example, mercury, up to the level marked by the dotted line 17, *i. e.*, so high, that the liquid can run through the opening 4 into the reservoir 1, which as well as the pipes 11 and 5 are then filled to the same level. Now, when a compressed gas, for example compressed air, is conducted into the reservoir 1 through the pipe 2, the liquid is pressed out of the reservoir 1 up into the pipe 9 and— since the gas in question also streams through the opening 4 into the reservoir 3— out of the reservoir 3 up into the tubes 11 and 5 and the reservoir 6. When the pressure in the reservoir 1 has risen so much that the liquid in the pipe 9 has reached the upper mouth of the same *i. e.*, when the maximum pressure has been reached the liquid rushes from the reservoir 1 up through the pipe 9 into the enlarged part 10 of the pipe 11, so that the lower opening of the pipe 2 becomes exposed, whereupon the gas streams out from the reservoir 1 through the pipe 9 and to the pipe 11, the upper enlarged part of which communicates with the atmosphere so that the pressure in the reservoirs 1 and 3 falls to the outer pressure. The liquid which, during the period of pressure, has been pressed up into the pipes 11 and 5 and the reservoir 6 respectively, to a height, which calculated from the lowest level of the liquid in the reservoir 3, corresponds to the difference of level between the lower and the upper mouths of the pipe 9, now rushes back into the reservoir 3, and a part streams again through the opening 4 into the reservoir 1 and in so doing closes the lower mouth of the pipe 9 and thus cuts off the connection of the reservoir 1 with the atmosphere, while the liquid again assumes (practically speaking, at least) its original level as marked by the dotted line 17. While the compressed gas continues to be led in through the pipe 2, this process also continues to be repeated in the same way. A liquid column thus alter-

nately rises and falls in the reservoir 6 and in so doing acts in the above mentioned manner as a pump piston.

The form of construction shown in Fig. 3 differs from that illustrated in Fig. 2 in this way, that according to this form of construction, the pipes 11 and 5 enter the reservoir 3 directly, instead of being connected with the same by means of a pipe. In this figure there are also shown the suction and delivery pipe connections 13 and 14 and their valves 15 and 16 respectively. This form of construction acts in quite the same way as that shown in Fig. 2, for which reason a special description of the same may be considered unnecessary.

In Fig. 4 there is shown a modified form of construction of the arrangement shown in Fig. 1 which is intended to be worked by suction. In this figure 10 is a reservoir which communicates with the reservoirs 6 by means of the pipes 11, 18, 5. In addition to this, the reservoir, 10, is also connected with a suction pipe, 12, in which a suction suitable for the purpose is brought about by the action of some suction device, *e. g.* by the pipe 12 being connected with an evacuated reservoir, or an exhauster, ejector or the like. The reservoir 6 is provided with pressure and suction pipes, 7 and 8, which are provided with pressure and suction valves respectively or with liquid seals acting in the same way. The reservoir 10 also communicates with a reservoir, 1, partly by a pipe 9 which reaches almost to the bottom of reservoir 1 and partly by means of a pipe 4 which is connected with the pipe 18 and enters into the reservoir 1 a little above the lower mouth of the pipe 9. The reservoir 1 also communicates with the atmosphere by an opening 2. This form of apparatus acts in the following way: Let it be supposed that the reservoirs 6 together with the system of pipes in connection with them, are filled with a liquid, *e. g.*, mercury, up to the level which is marked by the dotted lines, 18′, or, in other words, to the same level as the upper opening of the pipe 4 which passes into the reservoir 1, and let us also assume that the amount of liquid introduced into the apparatus is so chosen that there is also a quantity of liquid sufficient for the purpose of working in the lower part of the reservoir 1 so that the liquid in this latter extends some distance above the lower mouth of the pipe 9, for example, up to the dotted line, 19. As soon as the air begins to be sucked out of the reservoir, 10, through the pipe, 12, so that a vacuum arises in the said reservoir, the consequence is that the liquid rises in or is sucked up into, the reservoir 10 and falls within the reservoirs, 6, the consequence of which is, that a suction takes place in the pipes, 8, so that, in the same degree as the liquid sinks in the reservoirs, 6, gas, either from the atmosphere in the form of air or from a gas-reservoir connected with the pipe, 8, streams into these reservoirs, 6, through the said pipe. Simultaneously the liquid is of course sucked from the lower part of the reservoir 1 up into the pipe 9 for a distance corresponding to the vacuum in the reservoir 10. When the vacuum in the reservoir 10 has become so great that the liquid in the pipe, 9, has risen to its upper mouth, *i. e.*, to its entrance into the reservoir, 10, the liquid, while the suction continues, streams out of the reservoir 1 up through the pipe 9 into the reservoir 10, until the level of the liquid in the reservoir 1 has fallen to the lower mouth of the pipe 9 and when this is going on, the air which comes into the reservoir 1 through the opening, 2, streams through the pipe 9 into the reservoir 10, so that the vacuum there ceases to exist. The consequence of this is, that the liquid in the reservoir 10 which has been sucked up, sinks, and rises through the tubes, 11, 18, 5 into the reservoirs 6, the consequence of which is, that the gases sucked through the pipes into these reservoirs are forced out of them by the liquid through the pipes 7, in the course of which process the pipes 8 are closed by the valves which are arranged in them. When the reservoirs, 6, have been filled by the liquid which flows back from the reservoir, 10, the superfluous liquid flows through the pipe 4 into the reservoir, 1, so that the lower mouth of the pipe, 9, by the forming of a liquid-seal is again closed and all the levels of the liquid once more assume their initial positions. While the suction continues in the pipe, 12, the same process continues to be repeated, and goes on as long as the suction continues. The arrangement can, too, be simplified in such a way that the reservoirs 6 are left out, so that only the reservoirs, 10, and 1 which communicate with each other, remain, in which case the reservoir 1 is provided both with a suction valve, and a pressure valve arranged in such a way that on the return of the liquid which has been sucked up into the reservoir 10, to the reservoir 1 through the pipes 11, 4, the gas which has been sucked into the reservoir 1 through the suction valve, is pressed out of the said reservoir through the pressure valve.

In Fig. 5 there is illustrated how a form of construction which, in other respects, analogous with that shown in Fig. 2, can be modified so as to be worked by suction. In this case, as in Fig. 4, the reservoir 10 is connected with a suction pipe, 12. The construction and method of working of the device ought to appear with sufficient clearness from what has been said above with reference to Figs. 2 and 4.

Pumps, constructed in accordance with the present invention, can be used with advan-

tage for various purposes. The experiments which have been made have shown that these pumps can be employed very advantageously for the driving of automatically acting apparatus for analyzing gases. It ought to be clear, too, that the effect of the periodically occurring compression or increased pressure of gas which takes place in the reservoirs, 1, 3, according to Figs. 1 to 3 and of the periodically occurring rarefaction of air which, according to Figs. 4 and 5, takes place in the reservoir, 10, can also be used in the manner described above, in separate pumps, *e. g.*, in such a way that the said reservoirs are put in connection, by means of suitable pipes, with tubes or vessels communicating with each other and containing a liquid—or cylinders containing suitable pump pistons—so that the above mentioned periodically recurring variations in pressure may act on the said pump pistons so that these are put into reciprocating motion or on the liquid columns in the said vessels or tubes so that the liquid in the same is made to fall and rise like a pump piston. Such an arrangement is illustrated as an example by Fig. 6. In this figure there is shown a compression-device of the same construction as that shown in Fig. 2. The periodical rising and falling pressure which, in the way described above, is brought about in the reservoirs 1, 3, is transmitted in this case by means of pipes 21, which for instance can be connected to the reservoir 1, in a way which is shown in Fig. 6 by means of a branched connection 22 communicating with said reservoir, and each of these pipes, 21, is connected with liquid reservoirs, 20, each of which again communicates with one or several pipes 5 and reservoirs, 6, to which pressure, and suction pipes, 7, 8, are connected. The periodically rising and falling pressure in the reservoirs 1 and 3 respectively will thus act on the liquid in the reservoirs 20 in such a way, that a liquid column will have a rising and falling movement in the pipes 5 and the reservoirs 6 which communicate with said reservoirs, 20, which liquid columns will then act as pump pistons in the manner described above. Such an arrangement as shown in Fig. 6 can, of course, also be arranged for working by means of suction in the way shown in Figs. 4 and 5. The pipes, 21, can of course as above stated instead of being connected to the reservoirs 20 be connected to pump cylinders containing suitably arranged pump pistons which are then brought into reciprocating movement by the action of the rising and falling pressures in the reservoirs 3 and 1.

Having thus described my invention, I declare that what I claim is:—

1. A pump comprising a pair of reservoirs, a pipe connecting the bottoms of said reservoirs, a liquid in said parts, a pipe having one end extending down into the liquid in one reservoir and its other end connected with the atmosphere and the before-mentioned pipe and a pump connected with said reservoir containing the liquid seal pipe.

2. A pump comprising a pair of reservoirs, a pipe connecting the bottoms of said reservoirs, a liquid in said pipe and in the bottom of one of the reservoirs, a pipe having one end extending down into the liquid in one of the reservoirs and its other end connected with the atmosphere and the before-mentioned pipe, and a compression means connected with the reservoir containing the liquid.

3. A pump comprising a reservoir, a second reservoir, situated at a higher level than the first reservoir, a pipe connecting the bottoms of said reservoirs, a pipe having one end extending down into the bottom of the first reservoir and having its other end connected with the atmosphere and with the before-mentioned pipe, a liquid in the first reservoir covering the end of said pipe, said liquid extending into the pipes, and a compression pump connected with the first mentioned reservoir.

4. A pump comprising a reservoir, a casing therein having a hole located above its bottom communicating with the reservoir, a compression pump in communication with said casing, a second reservoir located above the level of the first mentioned reservoir, a pipe connecting the bottoms of said reservoirs, said pipe and first mentioned reservoir containing a liquid, the normal level of which is even with the hole in the casing, a pipe having its lower end reaching to the bottom of the casing and having its upper end communicating with the air and with the before mentioned pipe.

In witness whereof I have signed my name to this specification in the presence of two subscribing witnesses.

OLOF RODHE.

Witnesses:

AUG. OLAGELIN,

A. DENERSSON.