

June 23, 1931.

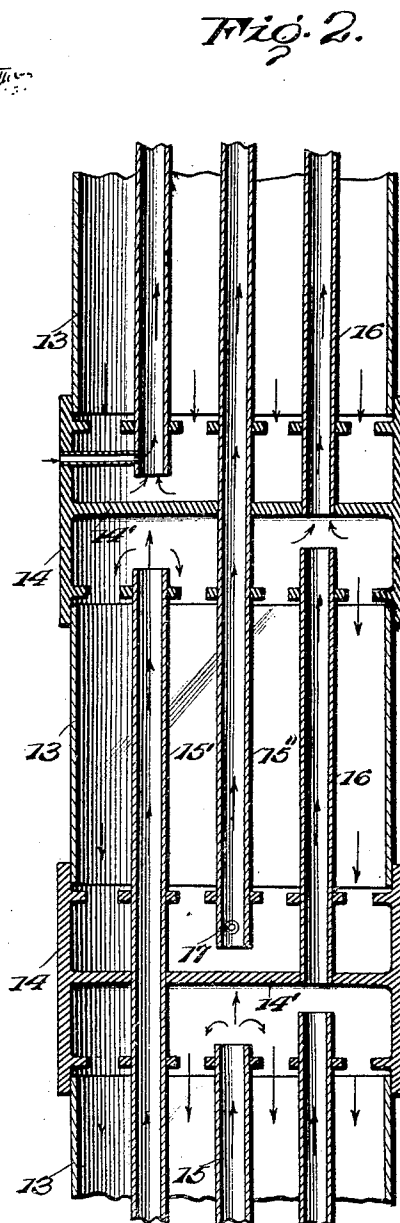
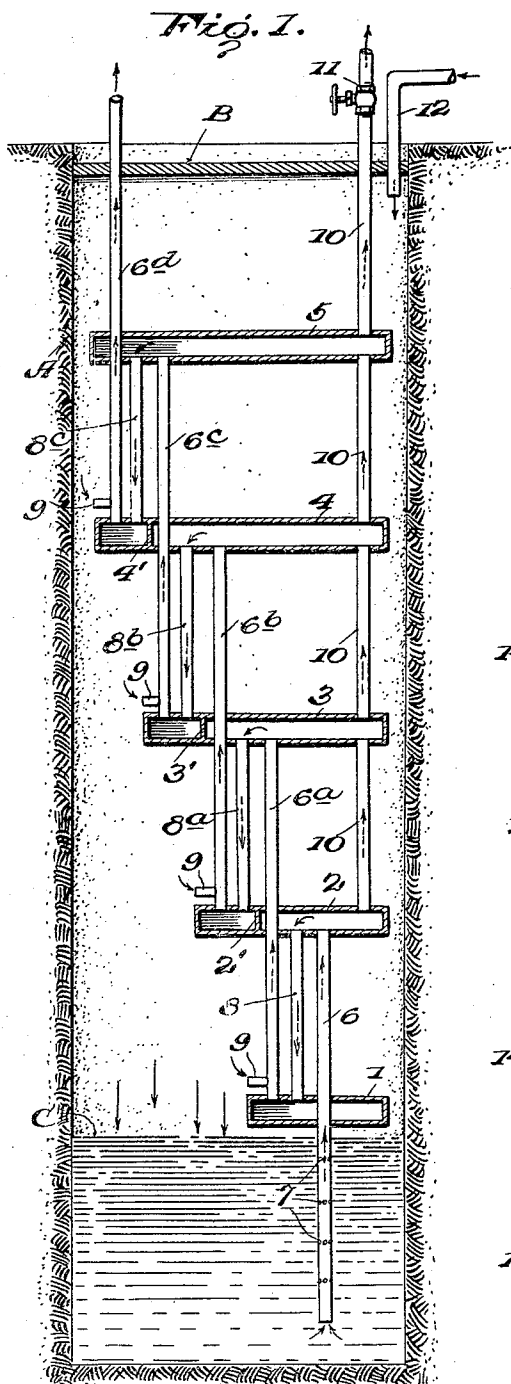
G. BLOW

1,811,295

AIR LIFT PUMP

Filed May 28, 1926

3 Sheets-Sheet 1



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3 Sheets-Sheet 2

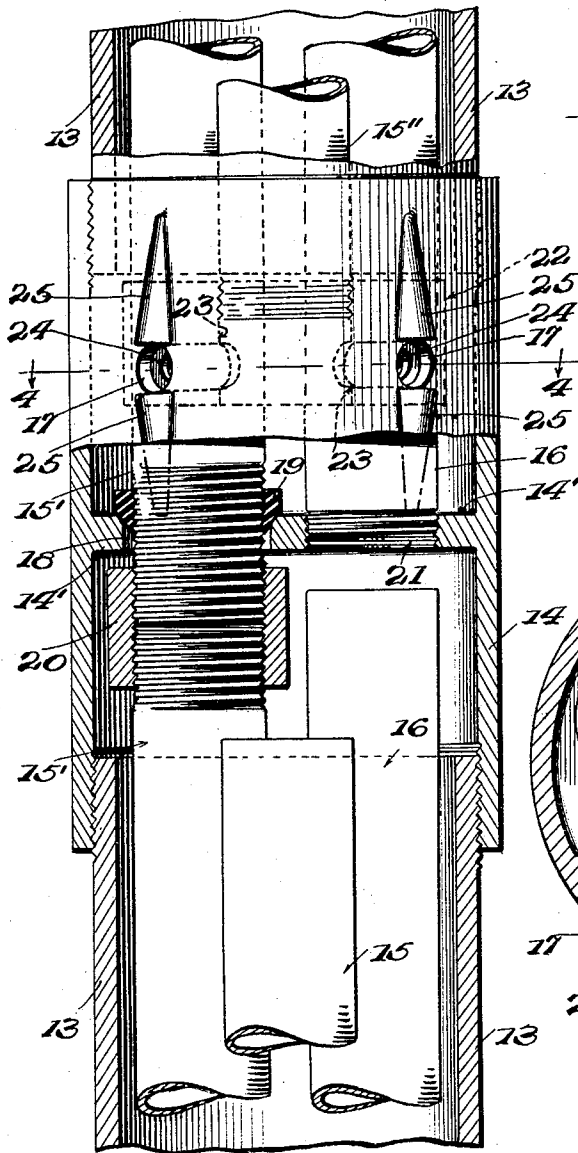


Fig. 3.

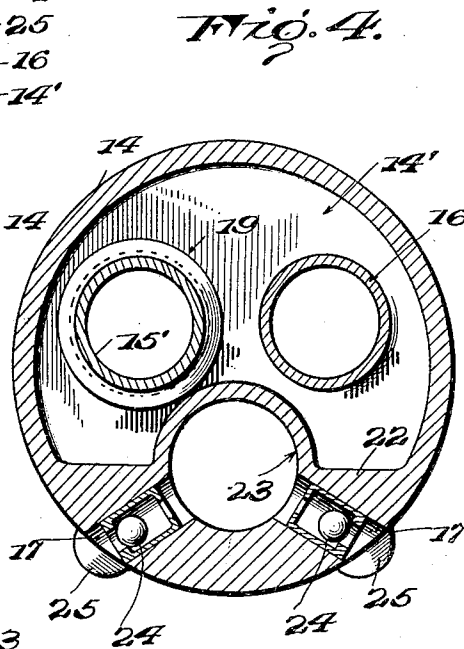


Fig. 4.

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Fig. 5.

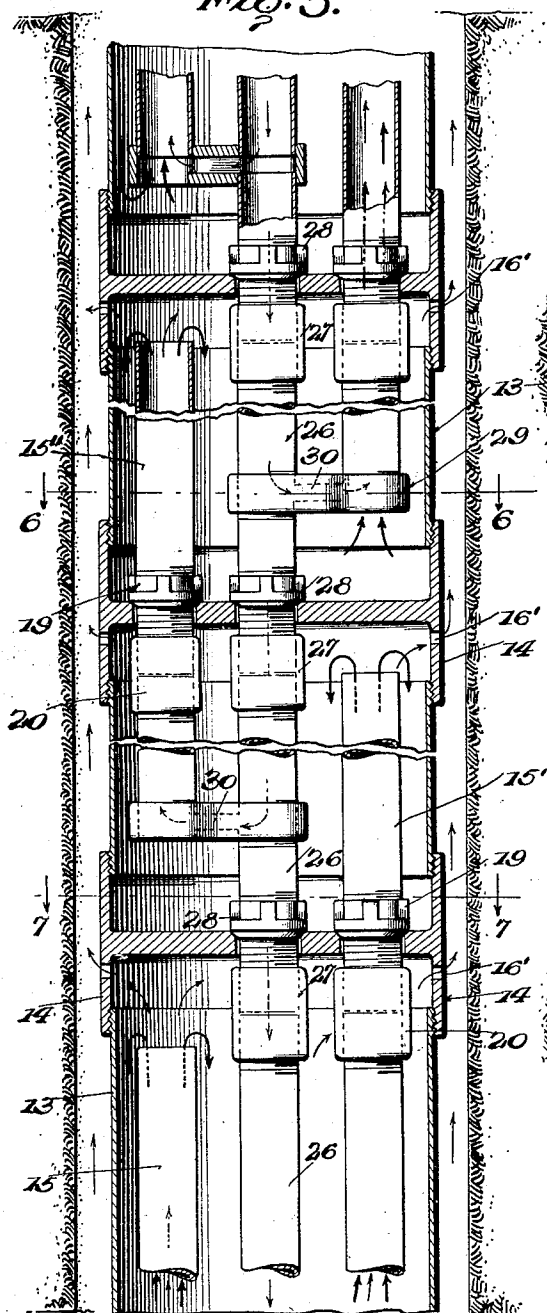


Fig. 6.

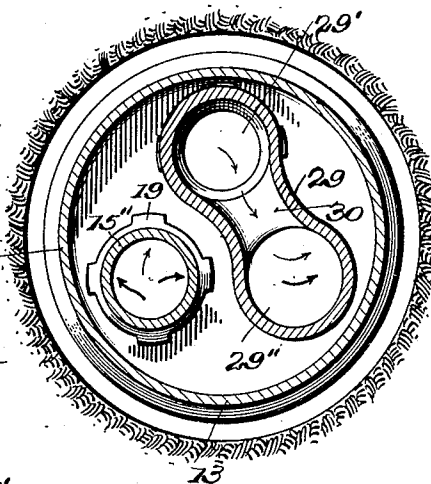
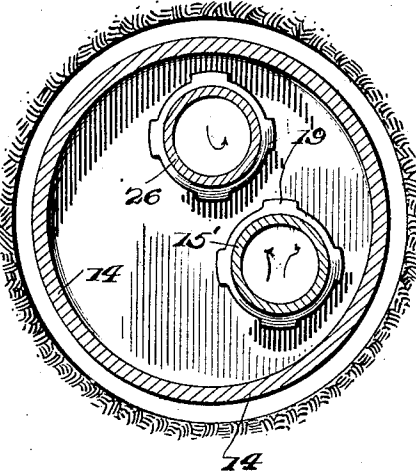


Fig. 7.



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AIR LIFT PUMP

Application filed May 28, 1926. Serial No. 112,405.

This invention relates to air-lift pumps, and has for its objects to provide a pump of this type which can be operated to pump a well of any depth with any pressure of air or other gas; which shall be operable to pump oil wells by utilizing the natural pressure of the gas which is given off with the oil in said wells; which shall be operable at either high or low pressure of the operating air or gas without change in installation, to the end that the pump when once installed in an oil well may continue to operate during the life of the well, notwithstanding the declining gas pressure therein; which shall be operable independently of the depth of submergence; in which fluid containing grit, sand, etc., may be pumped without injury to the pump; and which shall be so constructed that there shall be no wearing of parts, replacements or renewals. Furthermore, it is an object of the invention to provide a pump of this type which may be utilized either in pumping oils from wells, water from mines or other fluids in other locations of great depth. Further objects of the invention will appear hereinafter.

With these objects in view, the invention comprises an outside pipe to be lowered into the well, mine or other location containing the liquid to be pumped, which pipe preferably is composed of sections of suitable length, coupled together by a stage coupling having a transverse partition extending entirely across the same and dividing it into two portions or sections. The interval between adjacent couplings is determined by the pressure available, the pressure, of course, being the controlling factor. Such pressure may, as above indicated, be the natural pressure of the gas given off with the oil in an oil well. Extending down through the lowermost stage coupling, which is located near the surface of the liquid to be pumped, is a "riser" pipe provided with means for admitting air or other gas therinto from the exterior, and this riser pipe extends upward through the first stage coupling and is coupled, as by screw-threading or otherwise, into the second stage coupling on one side of the transverse partition therein. The air or gas

under pressure entering this pipe aerates the liquid column therein, whereby said column is rendered lighter than the column of liquid exterior to the riser pipe, and causes the liquid to rise in the riser pipe to the second stage coupling, whence it overflows back to the first stage coupling and is caught and retained thereby.

Rising from the first or lowermost stage coupling is a second riser pipe which passes through the second stage coupling to the third stage coupling. Suitable means are provided for admitting air or gas under pressure near the base of this second riser pipe, whereby liquid in said pipe is aerated and the liquid raised to the third stage coupling, whence it overflows to the second stage coupling by which it is caught. At each coupling, as the liquid emerges from the top of the riser pipe, the liquid and the air or gas separate, the liquid, as before stated, falling back to the next stage coupling below, while the air or gas is conveyed through a suitable "vent" to the top of the well, where it is permitted to escape, preferably under control of a back pressure valve, to the end that the pressure in the system may be regulated for a purpose that will be hereinafter explained. By this means, and by supplying the requisite number of stage couplings suitably spaced, liquid can be raised from a mine or well of any depth, and by placing the stage couplings at such a distance apart that the available air or gas pressure is slightly greater than the pressure due to "submergence", a continuous flow of liquid, as of oil from an oil well or water from a mine, can be maintained without the presence of any movable parts within the well or mine, and at either high or low pressure, as circumstances may require.

The vent may take the form of a pipe consisting of sections open at each end, with the lower end of each section secured in one stage coupling and passing upward to the next stage coupling. The liquid delivered from the top of each stage riser pipe overflows into the outside pipe, and is caught by the next lower stage coupling. Each of the riser pipes is provided with means near its

base for admitting air or gas under pressure. Such means may assume the form of ports controlled by ordinary ball valves provided with means for protecting the entrance port and, if desired and under some conditions, as where a return pipe is provided for the liquid flowing downward from one stage coupling to the next below, a pipe conveying air or gas under pressure to the bottom of each riser pipe may be employed.

The inventive idea is capable of receiving a variety of mechanical expressions, some of which, for the purpose of illustrating the invention, are shown in the accompanying drawings, but it is to be expressly understood that the invention is not limited to the particular construction shown in the drawings, reference being had to the appended claims for this purpose.

In said drawings:

Fig. 1 is a diagrammatic view illustrating the application of my stage air-lift pump to a well closed at the top;

Fig. 2 is a diagrammatic view showing the stage couplings with the pipe sections employed;

Fig. 3 is an enlarged vertical section through one form of stage coupling and the outside pipe, with the interior pipes shown in elevation for the purpose of illustrating the means of coupling the various pipes;

Fig. 4 is a horizontal section on the line 4—4 of Fig. 3;

Fig. 5 is a vertical transverse section showing another embodiment of the invention;

Fig. 6 is a horizontal transverse section on the line 6—6 of Fig. 5; and

Fig. 7 is a like section on the line 7—7 of Fig. 5.

Referring to the drawings, in which like reference characters indicate like parts throughout the several views, and first to the diagrammatic Fig. 1, A is a well sealed at its top by a suitable closure B, and C indicates the surface of the liquid in the well. Supported within the well in any suitable manner, and suitably spaced, is a series of stage couplings 1, 2, 3, 4, 5. While, for the purpose of illustration, five such stage couplings are shown, it will be understood that any desired number may be employed, depending upon the depth of the well and the desired spacing of said stage couplings. Each of the stage couplings here shown is in the form of a chamber, and each of them, except the top and the bottom one (1 and 5 as here shown), is divided into two chambers as by the partitions 2', 3' and 4'.

6 is a riser pipe extending downwardly through the stage coupling 1 into the liquid to be pumped for a suitable "submergence" distance, and opens at its top into the stage coupling 2, its bottom end being open for the admission of liquid as indicated by the arrows. This riser pipe 6 is provided with

means for the admission of air or gas under pressure, here shown in the form of a ring of small holes 7, several such rings being provided at different heights in the pipe. Extending between the stage couplings 1 and 2 is a return pipe 8, and leading upwardly from stage coupling 1 through stage coupling 2 and into the stage coupling 3 is a second riser pipe 6^a. Extending downwardly from the riser coupling 3 to the riser coupling 2 is a second return pipe 8^a, which pipe connects with the coupling 2 on the opposite side of the partition 2' from the point where the return pipe 8 connects therewith. In like manner, riser 6^b extends from stage coupling 2 through stage coupling 3 to stage coupling 4; riser 6^c extends from stage coupling 3 through stage coupling 4 to stage coupling 5; and riser 6^d extends from the stage coupling 4 through stage coupling 5 and outward through the seal B to the point of discharge; also return pipe 8^b extends from stage coupling 4 to stage coupling 3, and return pipe 8^c extends from stage coupling 5 to stage coupling 4, the return pipes in each instance connecting with the respective stage couplings on opposite sides of the partitions 2', 3' and 4'.

Each of the riser pipes 6^a, 6^b, 6^c and 6^d is provided with suitable means for admitting air or gas under pressure near the bottom thereof, as for example the port indicated at 9.

Extending from the stage coupling 2 out through the seal B is a vent pipe 10, which pipe may be provided with a back pressure valve 11 exterior to the well. This vent pipe is composed of open-end sections in free communication at each end with the respective stage couplings as shown, so that the air or gas is vented at each coupling, and the vent valve 11 affords means for controlling the vent pressure, whereby such pressure may be maintained at atmospheric pressure or above, as may be found desirable.

Air or gas under pressure may be delivered to the well 7 from any suitable source through pipe 12.

In operation, pressure on the surface of the liquid C (as for example the natural gas pressure in an oil well) causes a column of liquid to rise in the riser pipe 6, depressing the surface C of the liquid below the uppermost line of perforations 7, and the air or gas under pressure then enters the riser pipe 6, aerates the liquid therein, causing the column of liquid to rise and be delivered into the stage coupling 2, where the air separates therefrom and rises through the vent pipe 10, while the liquid flows downwardly through the return pipe 8 to the stage coupling 1 until the pipes 8 and 6^a have been filled to the level of the second coupling 2, whereupon the air or gas under pressure admitted through the port 9 causes the liquid to rise and be delivered from the top of the

riser 6^a into the stage coupling 3, where the air or gas separates therefrom and passes thence through the vent pipe 10, while the liquid flows downward through return pipe 8^a to the stage coupling 2 and on the left-hand side of partition 2', as shown in Fig. 1. This operation just described is repeated at each stage coupling until the liquid is raised and discharged from the top of the riser 6^a.

It will be understood that any necessary number of stage couplings may be employed, and that the spacing of these stage couplings may be varied at will to suit the circumstances of each particular case, depending upon the air or gas pressure available or to be employed.

It will be understood, also, that in case the pumping system were set up otherwise than in a sealed well, as for example in an open mine, the air or gas under pressure which is delivered to the several riser pipes would be conducted to the ports where it enters said risers by suitable piping.

One of the important features is the back-pressure valve 11 of the vent pipe 10. When desired, this valve produces a back-pressure in the vent pipe instead of atmospheric pressure. Let it be assumed that the stage couplings are placed at intervals to require fifty pounds pressure to operate, and that the pressure of air or gas in the well is one hundred pounds. In this case the valve on the gas outlet would be set to produce a back pressure of fifty pounds so that there would be a net working pressure of fifty pounds as required. This production of back pressure has the further advantage that the system may be installed with the stage coupling intervals for low pressure and be made to operate without loss under high pressure, a fact which is of much importance in oil wells, since the natural gas pressure gradually declines, and the system may be installed with short stage intervals for the ultimate low pressure, while it may nevertheless be operated under the high pressure existing at the time of installation. Furthermore, the system can be controlled by varying the back pressure so that one installation may be made to serve for the life of the well and operated under the declining gas pressure in the well, all through the proper control of the back pressure.

The foregoing description will enable the principle of operation of my improved stage air-lift pump to be understood. The preferred construction of the stage couplings is illustrated in Figs. 2, 3 and 4, in which there are shown outside pipe sections 13 connected by stage couplings 14, which stage couplings are divided into upper and lower portions by a horizontal partition 14'.

Referring to Fig. 2, 15, 15' and 15'' are the respective risers which deliver the mixed

air and liquid below the partitions 14', the air or gas being vented through the pipe 16, and the liquid passing downwardly around the respective pipes to be caught by the partition 14' in the stage coupling next below and provide the submergence for the next lift. In this case the sectional pipe 13 constitutes the return conduit corresponding to the return pipes 8, 8^a, 8^b, 8^c of the diagrammatic Fig. 1. For example, the liquid delivered from the top of riser pipe 15' will pass downwardly around said pipe as indicated by the arrows and be caught and retained by partition 14', while the air or gas issuing from the riser pipe 15' will find exit through the vent pipe 16. Air or gas under pressure is admitted through the port 17 near the base of riser 15'', resulting in a repetition of the operation.

Figs. 3 and 4 illustrate in detail one form of stage coupling and the manner in which the several pipes are connected therewith. The horizontal partition 14' in the coupling 14 has two openings therethrough, one, the opening 18, through which the through-riser 15' passes. This through-riser has a beveled jamb nut 19 secured thereon which serves to support the pipe on the partition 14' and at the same time effectively seal the opening 18 against the passage of liquid. Below the partition, the riser 15' (if it is desired to form the same in sections) is coupled to a lower section by means of an ordinary coupling 20, as will be readily understood. The other opening 21 in the partition 14' receives the lower end of the section of the vent pipe 16 which projects upward from said partition to a point slightly below the partition in the next stage coupling. The section of the vent pipe 16 just below the opening 21 terminates a considerable distance above the top of the riser pipe 15 but below the partition 14', to the end that air or gas escaping from the riser pipe 15 may be able to enter the vent pipe and pass upwardly as previously described.

Referring now to Fig. 4, the stage coupling has projecting from its inner periphery a riser pipe support in the form of a shelf or bracket 22 through which is provided an opening 23, and the lower end of the riser pipe 15'' is screw-threaded into said opening as shown in Fig. 3. The bracket 22 has a port, or preferably a plurality of ports 17, extending from the outside of the stage coupling 14 to the interior of the opening 23, as clearly shown in Fig. 4, and in each of these openings a ball and cage valve 24 is mounted. For the purpose of protecting the entrance of the ports 17, a guard or shield is provided, which guard or shield preferably takes the form of outwardly extending protuberances 25 formed on the exterior surface of the stage coupling above and below the

ports 17, as will be understood from an inspection of Fig. 4.

The operation of the structure shown in Figs. 3 and 4 will be readily understood from what has already been described in connection with Fig. 2. The liquid passing upward by way of the through-riser 15' overflows at a point just beneath the horizontal partition 14' of the next stage coupling above and descends within the exterior pipe 13 and around the other three pipes, being caught by the partition 14'. The liquid rises in the space surrounding the riser 15' and in the riser 15'', and the liquid within the riser 15'' is aerated through the ports 17, setting up the air-lift operation heretofore described.

Figs. 5, 6 and 7 illustrate a somewhat different arrangement of the several pipes which, however, perform the same functions and operate upon the same principle as heretofore described. In said figures, a continuous pipe 26 extends downwardly from the top of the structure to the bottom thereof. This pipe is made up of sections secured together by ordinary pipe couplings 27, preferably located just below the partition in the stage couplings, and a lock nut 28 is screw-threaded onto each section just above the partition in the coupling and provided with a lower beveled edge portion, to the end that said nut shall not only support the pipes when they rest upon the partitions of the stage couplings, but shall also serve to seal the opening in the partition of the stage coupling through which the pipe 26 passes. Suitably secured upon each section of the pipe 26, adjacent the stage coupling, is a horizontally extending yoke 29. This yoke, as will be understood from an examination of Fig. 6, has at its respective ends vertical openings 29' and 29'' extending vertically therethrough, which openings are connected by a port 30, as will be readily understood from an inspection of Figs. 5 and 6. The pipe 26 is in open communication with said port, preferably by having the sections of said pipe above and below the yoke screw-threaded into the latter but without being inserted far enough to obstruct the port. The bottom of each riser is likewise screw-threaded into the opening 29' in the respective yokes, but without entering far enough thereinto to obstruct the port 30. The opening 29' in the yoke being entirely open at its bottom, the riser is in open communication with the space immediately above the partition in the stage coupling just beneath.

Vent ports 16' are provided through the vertical wall of the stage coupling just beneath the horizontal partition in said coupling.

In this construction, air or gas under pressure is delivered to the pipe 26, and just above the horizontal partition of each stage coupling the air passes through the ports 30 from

said pipe to the base of the riser pipes 15', 15'', etc. It will be seen that in this case the yoke 29 performs the same functions as the shelf or bracket 22 in the form of the invention illustrated in Figs. 3 and 4, to wit, it serves as a support for the base of the riser pipe and contains the port through which air or gas under pressure is conducted to the base of said pipe.

In this form, as in the other forms heretofore described, the liquid is delivered at the top of the riser pipe, beneath the partition of the stage couplings, and descends to the partition of the stage coupling next below, where it is caught and retained within the pipe 13 until the space within the pipe 13 surrounding the risers and the air or gas pipe 26 is sufficiently filled with the liquid to supply the required submergence, at which time the air or gas passing through the ports 30 aerates the column of liquid in the riser pipe, to effect the air-lift as heretofore described. When the mixed air and liquid leave the upper end of the riser pipe, the liquid, as before described, descends while the air (or gas) separates therefrom and is vented through the vent port 16' (which is located at a higher level than the top of the riser pipe) and rises to the top of the well in the space surrounding the pipe 13, the movements of the air and liquid being clearly indicated by the arrows in the drawings.

It will be observed that the coupling is one of simple construction, lending itself readily to the assemblage of the several pipes to be connected therewith in firm position, and that the entire pumping system is free from moving parts of every description whatsoever within the interior of the well. This is a matter of much importance, since, when the system is once installed, there is no necessity for removal for repair or replacement of parts. Furthermore, it will be seen that, even if the liquid to be pumped contains grit, sand, or other foreign matter, the same cannot interfere with the successful operation of the system, nor can it wear or deteriorate the parts.

It will be further appreciated that no matter to what height the liquid is to be raised, the system is adapted to efficiently function, since the number of stages of the system can be increased or decreased to suit such conditions. It will also be readily appreciated that the system is adapted to operate under widely varying conditions of pressure, since the distance between the stage couplings can be adjusted to conform to the pressure available or desired. As indicated above, the system may be installed with the stage couplings so spaced as to be effectively operated at low pressure and will nevertheless operate at high pressure, and this renders the system peculiarly adaptable to oil wells, wherein the natural pressure of the gas is employed, 13

which pressure is bound to be high when it is first put in operation and bound to decrease during the continued operation of the well.

For the purpose of illustrating the invention, the system has been diagrammatically illustrated and, while preferred forms of stage couplings are shown more in detail, it is to be expressly understood that the invention is not to be limited to such showing and specific construction, since those skilled in the art will readily understand that variations may be made in the arrangement and construction of the parts without departing from the spirit of the invention, the limits of which are to be taken not from such illustration, but from the claims hereto appended.

What is claimed is:—

1. The combination of a sectional exterior pipe, a series of stage couplings connecting the sections thereof, a series of riser pipes delivering liquid to said stage couplings serially, means sealing the upper or outlet end of said exterior pipe, whereby gas under pressure can be retained in said exterior pipe, and means venting the gas passing through the riser pipes to the external atmosphere against pressure exceeding atmospheric pressure.

2. In an air-lift pump, the combination of a series of stage couplings arranged one above the other, riser pipes connecting the alternate couplings, a return conduit between the adjacent couplings, air venting means communicating with the top of each riser, a riser pipe leading from the liquid source to the coupling immediately above the bottom coupling, means supplying air or gas under pressure to the surface of the liquid to be raised, said last-named riser pipe being provided with a series of ports extending down below the surface of the liquid for admitting air or gas under pressure into said riser pipe as the surface of the liquid is lowered.

3. In an air-lift pump, the combination of a series of stage couplings arranged one above the other and each having a partition dividing it into upper and lower sections, a series of riser pipes leading from the upper side of each partition to the under side of the partition of the next higher coupling but one, means conveying liquid from the upper end of each riser to the base of the riser in the coupling next below, means aerating the liquid in each riser, air venting means communicating with the top of each riser, and means controlling the pressure in said air-venting means.

4. In an air lift, a sectional pipe, a coupling for the sections consisting of a transverse partition having two openings there-through, a riser pipe passing through one opening and supported therein by a packing ring secured on said riser pipe, and a section of a vent pipe secured in the other opening.

5. In an air lift, a sectional pipe, a cou-

pling for the sections consisting of a transverse partition having two openings there-through, a riser pipe passing through one opening and supported therein by a packing ring secured on said riser pipe, a section of a vent pipe secured in the other opening, a second riser pipe having its lower end opening immediately above said partition, and means supplying air or gas to the lower end of said second riser pipe.

In testimony whereof I have signed this specification.

GEORGE BLOW.

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