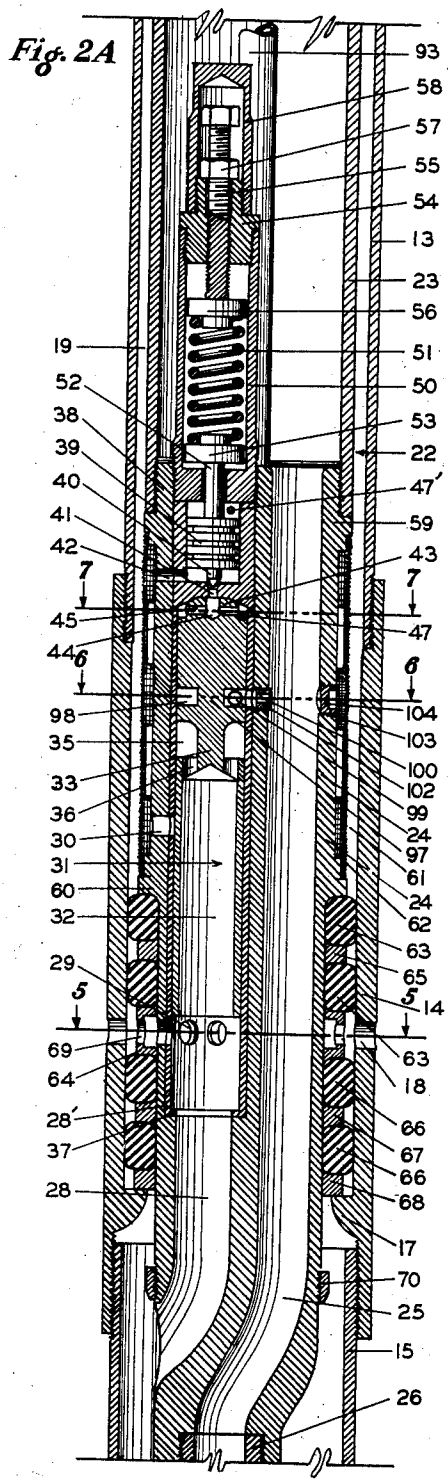
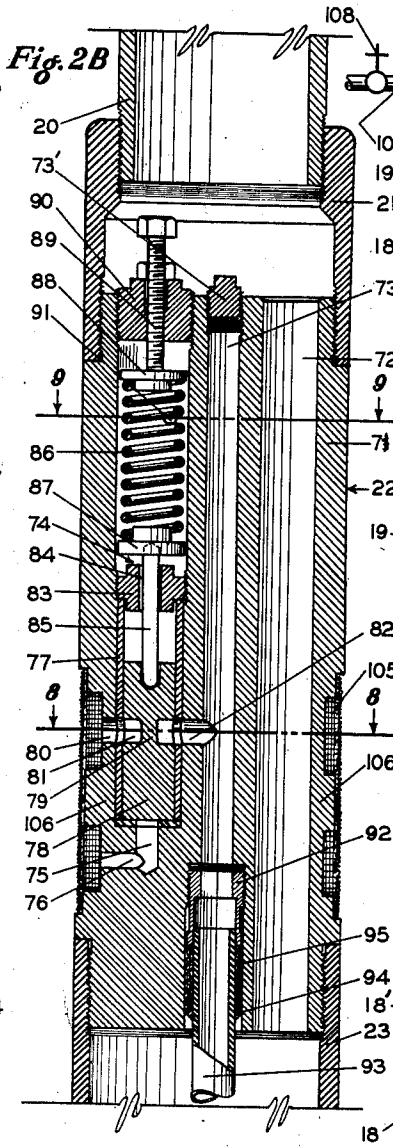
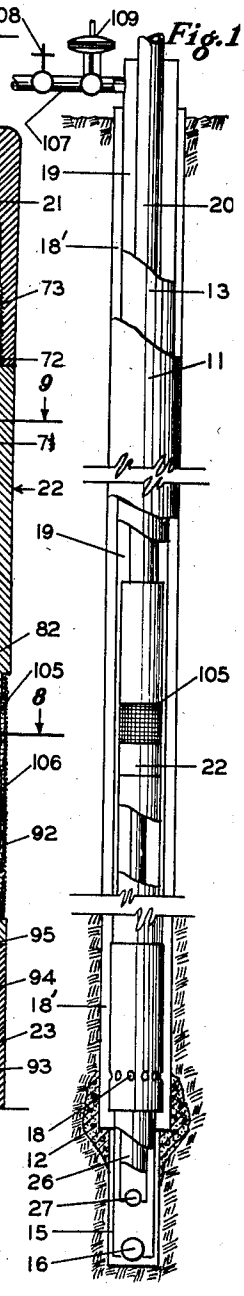
Jan. 3, 1939. J. P. STEPHENS ET AL 2,142,485

GAS-LIFT PUMP

Filed Nov. 10, 1936 2 Sheets-Sheet 1







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Jan. 3, 1939. J. P. STEPHENS ET AL 2,142,485

GAS-LIFT PUMP

Filed Nov. 10, 1936 2 Sheets-Sheet 2

Fig. 3

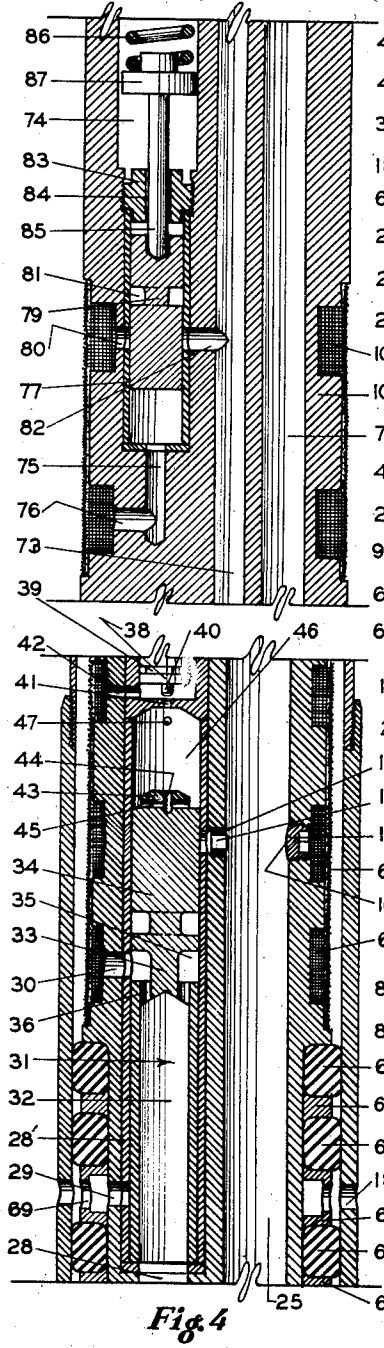


Fig. 4

Fig. 5

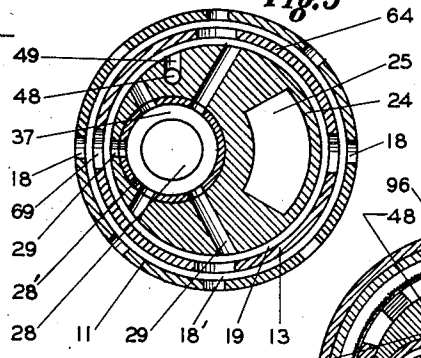


Fig. 7

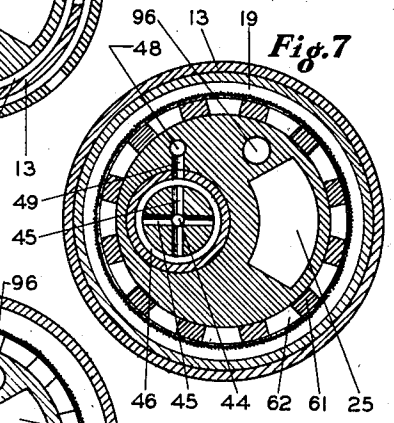


Fig. 6

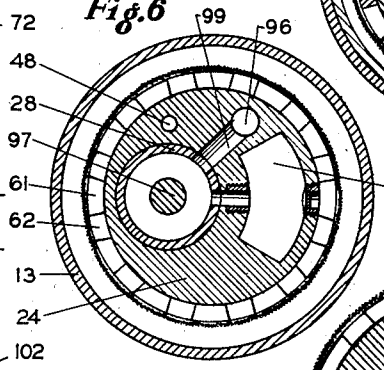


Fig. 8

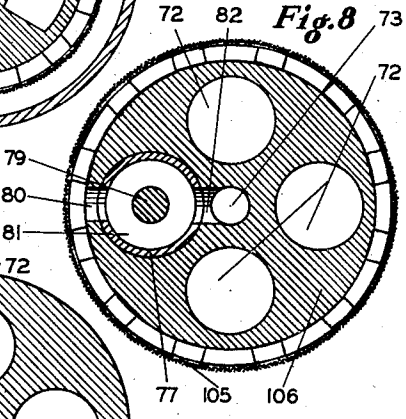
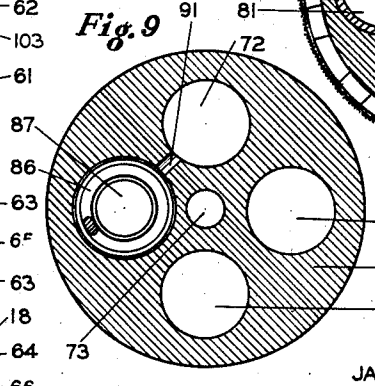


Fig. 9



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Patented Jan. 3, 1939 2,142,485

UNITED STATES PATENT OFFICE

2,142,485

GAS-LIFT PUMP

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Application November 10, 1936, Serial No. 110,164

11 Claims. (Cl. 103—231)

This invention relates to devices for raising fluids from wells.

More specifically, the invention relates to devices for raising liquids from wells in which the actuating medium is a gas under pressure.

An object of the present invention is to provide a device for raising well fluids to the surface.

An additional object of the present invention is to provide a device which will operate with a satisfactory gas-oil ratio.

A further object of the invention is the provision of a device which will be simple, compact, and economical in operation, easy to install and remove, and contain few moving parts.

A still further object of the present invention is the provision of a device operable by varying the operating gas pressure.

Another object of the present invention is the provision of a device operable in accordance with the pressures existing in the liquid eduction column.

Other objects of the invention will be apparent from a consideration of the detailed description, claims and drawings.

This application is a continuation in part of application Serial Number 32,798, filed July 23, 1935.

In the drawings, in which like numerals are employed to designate like parts, throughout the same,

Fig. 1 is a schematic showing of the device in a well hole,

Fig. 2—A is a longitudinal section through the lower part of the device of the invention,

Fig. 2—B is a longitudinal section through the upper part of the device of the invention, omitting the tubing string shown in Fig. 2—A,

Fig. 3 is a longitudinal section similar to part of Fig. 2—B but showing the valve in another position,

Fig. 4 is a longitudinal section similar to part of Fig. 2—A but showing the valves in other positions,

Fig. 5 is a cross sectional view taken on the line 5—5 of Fig. 2—A,

Fig. 6 is a cross sectional view taken on the line 6—6 of Fig. 2—A,

Fig. 7 is a cross sectional view taken on the line 7—7 of Fig. 2—A,

Fig. 8 is a cross sectional view taken on the line 8—8 of Fig. 2—B, and

Fig. 9 is a cross sectional view taken on the line 9—9 of Fig. 2—B.

Throughout this specification the term "gas" is intended to include any expansible fluid. Those passages serving to conduct the gas under pressure from the source to the surface of the oil in the accumulation chamber are herein termed gas induction conduits or passages. Those passages serving to exhaust the gas under pressure from the accumulation chamber to the surface of the ground are called exhaust passages. Those passages serving to conduct the oil or liquid from the bottom hole to the surface of the ground are termed liquid eduction conduits or passages.

Referring to the drawings, a well hole is indicated lined with casing 11 which is cemented to the bore at 12 in the neighborhood of the producing formation. Within casing 11 is a tubing string 13 screw threaded at its lower end to a nipple 14 which in turn is screw threaded to an accumulation chamber 15 having its lower end closed by a standing valve 16. This chamber is submerged in the liquid in the bottomhole. The nipple 14 has a shoulder or ledge at 17 and exhaust ports at 18 opening into the space 18' formed between the casing and the tubing string. Within the tubing 13 is positioned a flow string 20 which is screw threadedly connected through adapter 21 to a pump indicated generally by reference numeral 22, to form a flow string assembly.

The pump body 22 is composed of two body members joined by nipple 23. The lower body member 24 has extending through it a liquid discharge or eduction conduit 25 screw threadedly connected at its lower end to the discharge tube 26 which is closed at its lower end by a check valve 27. The eduction conduit 25 opens at its upper end on the interior of nipple 23. The lower pump body member further includes a bore designated generally at 28, being lined in part by liner 28' formed of hard metal, and opening at its lower end in the top of accumulation chamber 15. Bore 28 includes exhaust ports 29 which open on space 19 between the flow string assembly and tubing string in the neighborhood of ports 18 in tubing string 13, and intake or induction ports 30 opening on the same space. Slideably mounted in bore 28 is a main valve 31 consisting of a hollow cylindrical member 32 integrally joined through a reduced portion 33 to a piston head 34. The annular space 35 around reduced portion 33 is in communication with the inside of cylindrical member 32 through openings 36. Movement of this valve in bore 27 is limited by a stop 37 and a partition formed by the closed end of cylindrical sleeve 38 which is fixed in the upper end of bore 28. Slidable in cylindrical sleeve 38 is a pilot valve 39 in the form of a piston having

a valve head 40 adapted to close an orifice 41 in the closed end of cylindrical sleeve 38. A port 42 connects the space between the valve piston 39 and the valve head 40 with the exterior of pump body 24. To achieve a distributed pressure, while presenting a large impact surface to sleeve 38, valve 31 has a valve face 43 on piston head 34 (see Fig. 4) which is axially bored at 44 and radially bored at 45, 45, the last mentioned bores being in communication with bore 44 and bore 44 registering with orifice 41 when the valve 31 is in its uppermost position. An annular space 46 is formed between sleeve 38 and the body of piston head 34 around the valve face 43, bores 45, 45, opening on this space. A port 47 connects this annular space with a bleeder passage 48 which in turn connects with port 49 opening on space 19 (see Figs. 5 and 7). Bleeder passage 48 extends upwardly beyond port 47 to open into port 47' in the upper end of sleeve 38 above the upper face of piston valve 39. The extreme upper end of bore 28 is closed by a cylindrical plug fitting 50 having screw threaded connection therewith. Thus bore fitting 28 from this plug fitting down to stop 37 constitutes a valve chamber. The plug fitting 50 houses a spring 51 which biases pilot valve 39 downwardly through valve stem 52. Spring 51 acts on valve stem 52 by means of a spring retainer 53. The upper end of fitting 50 is closed by a plug 54 having a set screw 55 in screw threaded relation therewith. This set screw engages spring 50 through spring retainer 56. A lock nut is shown at 57. The plug 54 is capped at 58. Annular shoulders 59, 60, and projections 61 serve to retain a screen 62 in spaced relation over the various ports in the body member 24. The exhaust ports 18 and 29 are isolated from the upper reaches of space 19 by a packer or gasket comprising a pair of resilient rings 63 held between shoulder 60 and an annular channel member 64 and spaced by a ring 65. The exhaust ports are also isolated from the accumulation chamber by a similar pair of gaskets or packers 66 spaced by ring 67. Below the lowest packer 66 is a ring 68. The packers, rings, and annular channel member are slidably mounted on pump body member 24 for movement below shoulder 59. It will be apparent that the weight of the flow string and pump resting on shoulder or ledge 17 through ring 68 will compress the gaskets 63, 66, into sealing engagement with nipple 14. Annular channel member 64 has openings 69 permitting communication between ports 29 and 18. A ring 70 is screw threaded on the lower extremity of body member 24 to prevent the packer structure from sliding off while the pump is being lowered into position.

The upper body member 71 of the pump has three large passages 72 and one small passage 73 therethrough. The large passages constitute a liquid discharge or eduction conduit and the small one a gas passage, the purpose of which will be later described. A bore, indicated generally at 74, is also located in this body member, terminating at its lower end in a gas passage 75 which opens on space 19 through port 76. The lower portion of bore 74 is lined with a hard metal liner 77 within which a supplemental valve 78 travels. Intermediate its ends piston valve 78 has a reduced portion 79 forming an annular space 80 which in the lowest position of the valve coincides with a port 81 opening into space 19 and a port 82 opening into passage 73. The upper end of liner 77 is closed by a plug 83 having a clearance bore 84 through which passes valve stem 85 of valve 83. In the upper portion of bore 74 is a spring 86 exerting pressure on valve stem 85 through spring retainer 87 and held at its upper extremity by spring retainer 88. The spring is tensioned by a set screw 89, screw threaded into a plug 90 which is itself screw threaded into the open end of bore 74. In the neighborhood of the spring, bore 74 has a port 91 opening into a liquid eduction passage 72. Passage 73 is closed at its upper end by plug 73' and is screw threaded near its lower end to receive gland packing nut 92. A pipe 93 has at its upper end a shoulder 94 between which and the packing gland nut 92 is positioned a packing 95. The lower end of pipe 93 is connected to a passage 96 which in turn opens through port 99 on bore 28 below the closed end of sleeve 38. Valve 31 has a second reduced portion 97 forming a second annular space 98 which when the valve is in its uppermost position registers with port 99. In this position annular space 98 also registers with a port 100 opening into liquid eduction passage 25. A bushing 102 is shown in port 99. An opening 103 is necessary in the wall of this body member to drill port 99. This opening is closed by plug 104. A screen 105 is shown covering the ports 76 and 80 and spaced away from them by projections 106. It is to be understood that nipple 23 completes the liquid eduction conduit through the pump.

At the surface space 19 is closed and connected by pipe 107 to a source of gas under pressure (not shown). In pipe 107 is a control valve 108 and an intermitter 109. Space 18' between tubing string 13 and casing 11 may be open to the atmosphere or closed and connected with a source of gas utilization at low pressure.

In the operation of the device, with no gas pressure applied to space 19, herein termed an induction or intake passage or conduit, oil in the bottom hole will flow past standing valve 16 into accumulation chamber 15 due to gravity. Assume that valve 38 will be in the position shown in Fig. 2—A leaving the accumulation chamber 15 open to the pressure existing in space 18', which is usually around atmospheric pressure, through the exhaust passage or conduit 28, ports 29, openings 69, and ports 18. The oil in chamber 15 will seek the level of the oil in the bottom hole. When the oil in the bottom hole has been given sufficient time to enter the accumulation chamber, the intermitter 109 opens to allow gas under pressure to enter induction or intake passage 19. As pressure builds up in this passage it is applied through port 42 to the lower face of the piston of pilot valve 39. Spring 51 has previously been tensioned by means of set screw 55 so that a predetermined pressure on the lower face of valve 39 is necessary to move it and thus move valve head 40 away from the orifice 41. Upon this happening, the gas pressure will be applied through orifice 41 and bores 44, 45 to annular space 46, forcing the valve 31 downwardly into engagement with stop 37, as shown in Fig. 4. Valve 31 in this position closes exhaust port 29 and uncovers intake port 30 so that gas pressure is admitted from induction passage 19 through port 30, annular space 35, openings 36, the cylindrical portion of valve 31, and the passage or conduit formed by the lower end of bore 28, to the surface of the oil in the accumulation chamber. With this pressure acting upon the oil, the valve 16 closes and the oil is forced past valve 27 and up discharge tube 26, discharge or eduction conduit 25, nipple 23, eduction con-

duit 72, to the flow string 20. The intermitter 108 continues the application of the gas pressure until all the oil in the accumulation chamber above the lower end of discharge tube 26 is forced out. Usually further pressure is continued until a slug of gas is forced up the discharge tube behind the oil. At this point the intermitter shuts off the supply of gas pressure and as the pressure in space 19 falls, spring 51 forces valve 39 downwardly to close orifice 41. The residual pressure in accumulation chamber 15 returns valve 31 to the position shown in Fig. 2—A, the gas trapped above valve 31 bleeding off through port 47, bleeder passage 48, and ports 49, 69, and 18 to the exhaust space 18'. Although port 47 is always open it is so small that it does not materially reduce the pressure on piston 31 during the pressure cycle. The same applies to port 47' which allows any gas leaking past piston valve 39 to escape. With valve 31 in its uppermost position against sleeve 38, exhaust ports 29 are opened allowing gas in the accumulation chamber to exhaust through ports 29, openings 69 and ports 18 to space 18'. As the pressure in the accumulation chamber falls, valve 31 is held in its uppermost position against cylindrical sleeve 38 by the residual pressure at port 30 forcing the valve against the opposite wall of the valve chamber. With the pressure in the accumulation chamber 15 reduced, valve 16 will open to admit oil into the chamber from the bottom hole and the pump is again ready for the pressure cycle.

When the pump is first lowered into the well if valve 31 is down against stop 37 as shown in Fig. 4 gas pressure in the accumulation chamber due to the hydrostatic head of the oil in the bottom hole will raise it. In case it does not, or in the case where the pump has been in the well not operating and valve 31 is down, gas entering port 30 will build up pressure in the accumulation chamber which will force the valve 31 up since no pressure is being applied to its upper face.

It is evident that the pump could be operated by timing the intermitter so that the admission of gas to the accumulation chamber and up the flow string behind a slug of oil could be continued until enough gas had been admitted to the flow string to establish the proper gas-oil ratio. In the applicants' present device, however, a supplemental valve is furnished to admit this quantity of gas directly from the gas induction passage 19 to the flow string through liquid eduction conduit 25 while the accumulation chamber 15 is exhausting. This means that the accumulation chamber need be used only for accumulating oil and forcing the accumulated oil up the flow string, instead of operating a substantial part of the time as a part of the gas admission circuit. Of course some gas will be forced up the flow string from the accumulation chamber behind the oil slug to force the oil slug past port 100 so that gas entering liquid eduction conduit 25 from this port during the exhaust cycle will not enter and mix with the oil to break up the continuity of the oil slug. Admission of this gas into the column during the exhaust cycle allows the accumulation chamber to be filling while the oil slug is being further speeded toward the surface permitting the chamber to fill oftener and preventing deceleration of the oil slug.

The supplemental valve 78 accomplishes these purposes by the following mode of operation. The valve is exposed on its under side to the pressure in gas induction passage 19 through port 76 and passage 75 and on its upper side to the pressure in liquid eduction conduit 72 through port 91, bore 74, and clearance bore 84. The pressure in eduction conduit 72 is aided by spring 86 in opposing upward movement of the valve. Spring 86 is so tensioned that the valve 78 is held in its upper position (see Fig. 3) by gas pressure in gas induction passage 19 until a sufficient head of oil is present in flow string 20 in which case it will be forced into its lower position as shown in Fig. 2—B. In this position annular space 81 registers with ports 80 and 82 to permit the gas under pressure to enter passage 73, pipe 93, to passage 96. If valve 31 is in the pressure cycle position (see Fig. 4) port 99 is blocked but if valve 31 is in the exhaust cycle position (see Fig. 2—A) recess 98 connects port 99 and port 100, venting the gas under pressure into liquid eduction conduit 25. The bore in bushing 102 is designed to have the proper cross section for the condition present. When some oil is unloaded at the surface, the pressure or head in flow string 20 is decreased and the pressure on the lower or under face of valve 78 overcomes the column pressure plus the spring pressure to move the valve upwardly to cut off the flow of gas into the column.

It is to be understood that the form of our invention, herewith shown and described, is to be taken as a preferred example of the same and that various changes in the shape, size, and arrangement of parts may be resorted to without departing from the spirit of our invention, and further that the theories of operation set out, although believed to be accurate are not to be considered as the sole basis of operativeness of our device but that our device does operate successively, whether or not upon the principles described herein, our invention to be limited solely by the appended claims.

We claim:

1. In a pump comprising a body, a liquid eduction conduit extending through said body, a main valve and a supplemental valve in said body independently movable, said main valve serving to operate said pump, a gas passage extending between said liquid eduction conduit and the exterior of said body, said supplemental valve having a portion coacting with said gas passage to close or open the same.

2. In a gas lift system, a tubing string having a liquid accumulation chamber adjacent its lower end, a flow string within said tubing string and spaced therefrom, terminating in a pump body having a discharge tube within said accumulation chamber, said pump body including an eduction conduit connecting said discharge tube and said flow string, valve means associated with said pump body, a source of gas under pressure connected to the space between said tubing string and said flow string, means operable by the gas under pressure controlling said valve means, said valve means operating to cause the gas under pressure to act on liquid in said accumulation chamber to force said liquid up said discharge tube and eduction conduit to said flow string, a passage connecting said space and said liquid eduction conduit, and valve means in said passage exposed on one side to the pressure in said space and on the other side to the pressure in said liquid eduction conduit for closing and opening said pasage.

3. In a pump comprising a body, a liquid educ-

tion conduit extending through said body, a main valve and a supplemental valve in said body independently movable, a gas passage extending between said liquid eduction conduit and the exterior of said body, said main valve and said supplemental valve each having portions coacting with said gas passage to close or open the same.

4. In a pump comprising a body, a liquid eduction conduit extending through said body, a main valve and a supplemental valve in said body independently movable, a gas passage extending between said liquid eduction conduit and the exterior of said body, said main valve and said supplemental valve each having portions defining a part of said passage in one position, and having further portions closing said passage in another position.

5. In a pump comprising a body, a liquid eduction conduit extending through said body, a main valve and a supplemental valve in said body independently movable, intake and exhaust ports in said body, said main valve having a portion coacting with said ports to close and open said ports upon movement of said main valve, a gas passage extending between said liquid eduction conduit and the exterior of said body, said main valve and said supplemental valve each having portions coacting with said gas passage to close or open the same.

6. In a pump adapted to be connected at its upper end to a flow string and at its lower end to a discharge tube, comprising a body having gas induction and exhaust means and a liquid eduction conduit, a main valve movable for controlling induction and exhaust of gas, means including a supplemental valve exposed on one side to the pressure in said liquid eduction conduit, a passage connecting the exterior of said body with said liquid eduction conduit, said supplemental valve in one position having means for closing said passage and in another position for opening said passage.

7. In a pump adapted to be connected at its upper end to a flow string and at its lower end to a discharge tube, comprising a body having gas induction and exhaust means and a liquid eduction conduit, a main valve movable for controlling induction and exhaust of gas, means including a supplemental valve exposed on one side to the pressure in said liquid eduction conduit, a passage connecting the exterior of said body with said liquid eduction conduit, said main valve and said supplemental valve each in certain positions having means for closing said passage and in other positions for opening said passage.

8. In a gas lift system, a tubing string having a liquid accumulation chamber adjacent its lower end, a flow string within said tubing string and spaced therefrom terminating in a pump body having a discharge tube within said accumulation chamber, said pump body including an eduction conduit connecting said discharge tube and said flow string, valve means associated with said pump body, a source of gas under pressure connected to the space between said tubing string and said flow string, said valve means operating to cause the gas under pressure to act on liquid in said accumulation chamber to force said liquid up said discharge tube and eduction conduit to said flow string and additional valve means independently movable relative to said first mentioned valve means and cooperating with said first mentioned valve means to periodically admit the gas under pressure directly into said eduction conduit.

9. In a pump adapted to be positioned within a tubing string, connected at its upper end to a flow string and at its lower end to a discharge tube, comprising a body having a liquid eduction conduit extending therethrough, and a gas induction and exhaust passage opening adjacent one end thereof, said passage having a gas intake port and a gas exhaust port opening on the exterior of said body and in spaced relation along the length of said passage, sealing means for engagement with the tubing string positioned on the exterior of said body between said intake port and said exhaust port, additional sealing means positioned on the exterior of said body between said exhaust port and said passage opening, a movable valve in said body in one position closing said exhaust port and opening said intake port and in another position opening said exhaust port and closing said intake port, a supplemental valve in said body exposed on one end to the pressure in said eduction conduit, and a passage from the exterior of said body to said eduction conduit, each of said valves acting to block said passage in one position and to unblock said passage in another position.

10. In a pumping system, a tubing string having a seat adjacent its lower end, an exhaust port above said seat, and an accumulation chamber below said seat a flow string assembly positioned within said tubing string and spaced therefrom, comprising a flow string, a pump body connected to the lower end of said flow string, and a discharge tube positioned within said accumulation chamber, connected to the lower end of said pump, an exhaust port in said pump body in the neighborhood of said first mentioned exhaust port, an intake port in said pump body above said exhaust port, a sealing member for the space between the tubing string and the flow string assembly positioned between said intake port and said exhaust ports, said space above said sealing member constituting a gas induction conduit, an additional sealing member for the space between the tubing string and the flow string assembly below said exhaust ports, a liquid eduction conduit in said pump body connecting said discharge tube and said flow string, a valve chamber upon which said intake port and said second mentioned exhaust port open, gas induction and exhaust passage means connecting said accumulation chamber with said valve chamber, a source of gas under pressure connected to said gas induction conduit, a main valve in said valve chamber movable by the gas under pressure to close said second mentioned exhaust port while opening said intake port, a supplemental valve chamber, a supplemental valve movable in said supplemental valve chamber, one side of said valve being exposed to the pressure in said gas induction conduit and the other side being exposed to the pressure in said liquid eduction conduit, movement of said valve taking place due to the presence of a pressure differential, a passage between said gas induction conduit and said liquid eduction conduit, said supplemental valve having a portion which in one position of said supplemental valve defines a part of said passage and in another position blocks said passage.

11. In a pumping system, a tubing string having a seat adjacent its lower end, an exhaust port above said seat, and an accumulation chamber below said seat a flow string assembly positioned within said tubing string and spaced therefrom, comprising a flow string, a pump body connected to the lower end of said flow string, and a dis-

charge tube positioned within said accumulation chamber, connected to the lower end of said pump, an exhaust port in said pump body in the neighborhood of said first mentioned exhaust port, an intake port in said pump body above said exhaust port, a sealing member for the space between the tubing string and the flow string assembly positioned between said intake port and said exhaust ports, said space above said sealing member constituting a gas induction conduit, an additional sealing member for the space between the tubing string and the flow string assembly below said exhaust ports, a liquid eduction conduit in said pump body connecting said discharge tube and said flow string, a valve chamber upon which said intake port and said second mentioned exhaust port open, gas induction and exhaust passage means connecting said accumulation chamber with said valve chamber, a source of gas under pressure connected to said gas induction conduit, a main valve in said valve chamber movable by the gas under pressure to close said second mentioned exhaust port while opening said intake port, a pilot valve for applying the gas under pressure to said main valve, said main valve being exposed to the pressure in said accumulation chamber and movable thereby when the gas under pressure is not applied to said main valve to close said intake port and open said second mentioned exhaust port, a supplemental valve chamber, a supplemental valve movable in said supplemental valve chamber, one side of said valve being exposed to the pressure in said gas induction conduit and the other side being exposed to the pressure in said liquid eduction conduit, movement of said valve taking place due to the presence of a pressure differential, a passage between said gas induction conduit and said liquid eduction conduit, said main valve and said supplemental valve each having a portion which in one position of each said main and supplemental valves defines a part of said passage and in another position blocks said passage.

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