July 2, 1935. A. BOYNTON 2,006,909

AUTOMATIC HEADING DEVICE

Filed Oct. 21, 1932 2 Sheets-Sheet 1

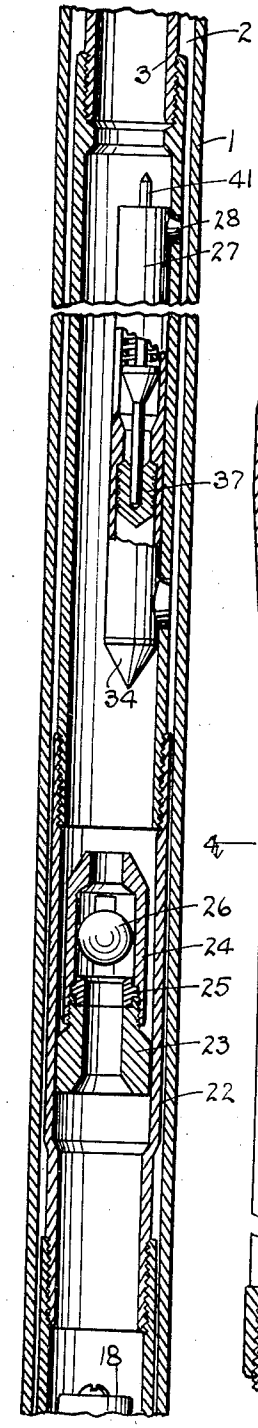


Fig. 1.

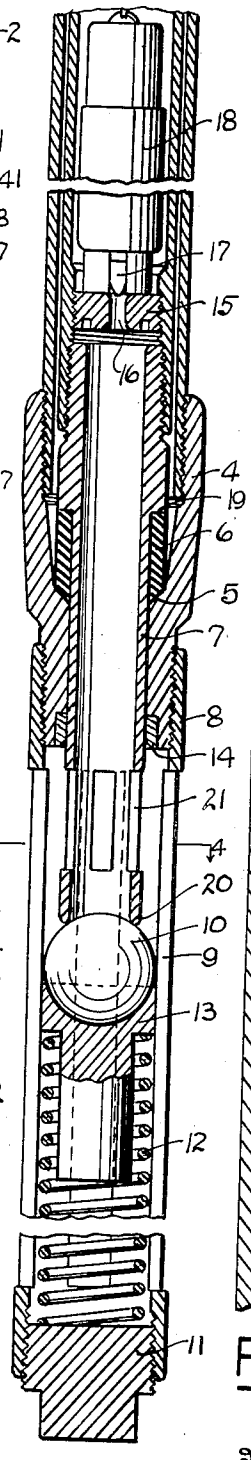


Fig. 2.

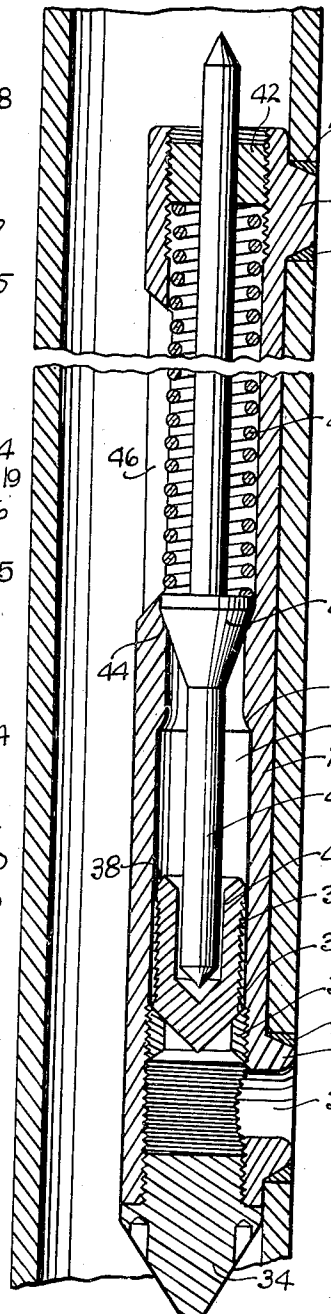


Fig. 3.

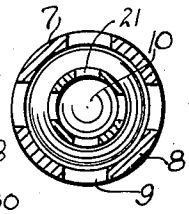


Fig. 4.

Inventor
Alexander Boynton
By Jesse R. Stone
& Lester B. Clark
Attorneys

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AUTOMATIC HEADING DEVICE

Filed Oct. 21, 1932 2 Sheets-Sheet 2

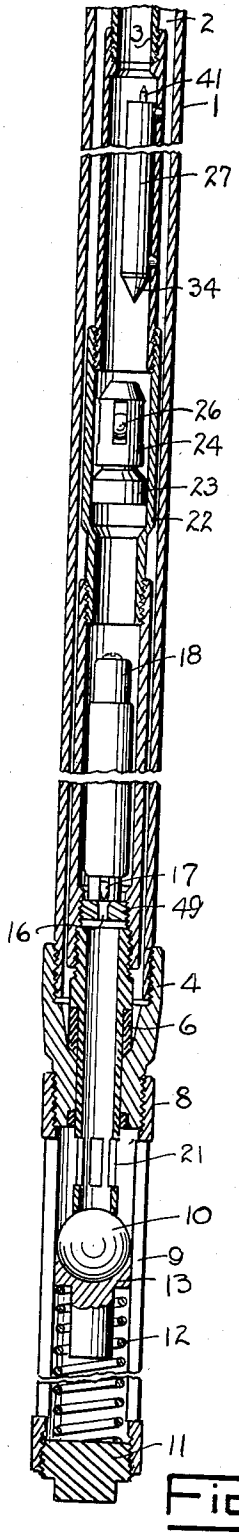


Fig. 5

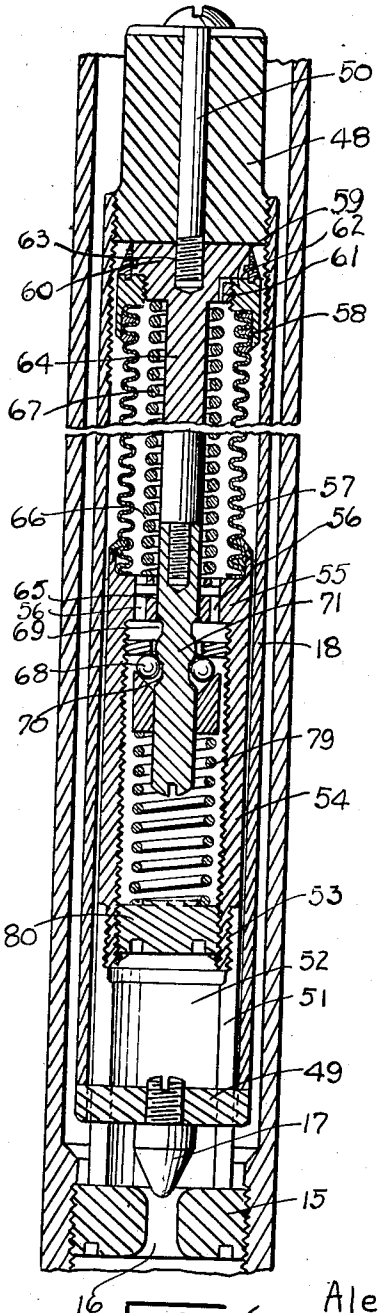


Fig. 6.

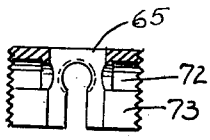


Fig. 7

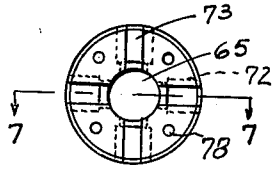


Fig. 8

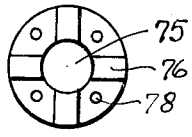


Fig. 9.

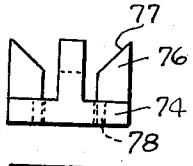


Fig. 10.

Inventor
Alexander Boynton

By Jesse R. Stone
Lister B. Clark
Attorneys

Patented July 2, 1935 2,006,909

UNITED STATES PATENT OFFICE

2,006,909

AUTOMATIC HEADING DEVICE

Alexander Boynton, San Antonio, Tex., assignor to Chas. A. Beatty, San Antonio, Tex.

Application October 21, 1932, Serial No. 638,859

10 Claims. (Cl. 103—234)

My invention relates to a device for lifting liquid from wells, and is particularly adapted for operating in deep oil and water wells. It pertains more particularly to devices whereby the liquid is raised through pneumatic pressure exerted below a load of liquid.

It is an object of my invention to provide automatic means for admitting to the eduction tube a predetermined load of liquid and closing off the inlet of further liquid when the proper amount has entered.

I employ in combination with the liquid weight controlling device, a means for controlling the inlet of air or gas under pressure beneath the liquid thus admitted.

I have, as a further object, the provision of an air or gas intake valve which will automatically close when enough air or gas has been admitted into the eduction tube to expel the load of liquid, and which will remain closed until another load of liquid has passed into the lower end of the tube.

I provide separate control devices for the liquid inlet and the air inlet which combine to operate so as to admit a predetermined load, and to open the air or gas inlet before the liquid inlet is closed and to assist in the closing of the liquid inlet through the pressure of the air or gas admitted by the air or gas inlet valve.

In the drawings herewith, Fig. 1 illustrates a central longitudinal section through the pressure tube and eduction tube, adjacent the lower end of the well and illustrates the position of the air or gas intake control and the check valve.

Fig. 2 is a similar longitudinal section taken immediately below the structure shown in Fig. 1, and showing the lower extremity of the eduction tube.

Fig. 3 is an enlarged detail illustrating the construction of the air or gas inlet control device.

Fig. 4 is a transverse section taken on the line 4—4 of Fig. 2.

Fig. 5 is an assembly view in central longitudinal section of my invention.

Fig. 6 is an enlarged sectional view of the liquid control valve.

Fig. 7 is a sectional detail of the ball retainer in my latch member.

Fig. 8 is a bottom plan view of said retainer.

Figs. 9 and 10 are top plan and side elevation views, respectively, of the ball rider.

My device is adapted to be used in a well properly equipped with well casing, casing head, and the like, such as is disclosed in my copending application Serial No. 637,710; filed October 14, 1932.

It is to be understood that the outer tube 1 is extended upwardly into the casing head and has connection at the upper end with inlet for air or gas under pressure to the space between the pressure tube and the inner eduction tube 3. The eduction tube has a fluid seal with the pressure tube at the upper end and has an outlet to a place of liquid storage. The pressure fluid employed in my apparatus may be either air or gas and where air is referred to in the description and claims in this specification, it is to be understood that either air or gas, or both together, is intended.

The pressure tube is connected at its lower end to a swaged coupling 4, which is reduced in diameter at its lower end and provided with an inner tapered shoulder 5 upon which the seal ring 6, upon the lower section 7 of the eduction tube, may seat. The eduction tube may thus be supported in the coupling 4 and a seal will be formed at the seat 5, which will prevent the passage of pressure fluid beyond this point.

Below the coupling 4 is a tubular extension 8 upon the pressure tube, which is slotted longitudinally at 9 to provide a cage for a check valve. The lower end of the valve cage is closed by a plug 11, which furnishes a support for a spiral spring 12, which in turn supports a valve retaining member 13. The said valve retainer is concaved on its upper end to receive the ball valve 10, said spring and retainer acting to move the check valve upwardly toward the valve seat 14, fitted in the lower end of the coupling member 4.

The eduction tube is spaced within the pressure tube to provide an annular space at 2 for the passage of air or gas to the lower end of the eduction tube. Said lower end is provided with an inlet for liquid from the well upwardly into the tubing. This inlet is formed through a plate 15 screwed within a lower section of the eduction tube and provided with an axial passage 16, the upper end of which forms a seat for a valve 17.

In Fig. 6 I have shown the construction of the liquid inlet valve. The member 17 is secured to a cross-bar 49 connected with the lower end of the housing 18. The upper end of said housing is closed by a plug 48 having a central opening therethrough to receive the bolt or screw 50. The cross-bar 49 in which the valve 17 is mounted is slidable vertically within a slot 51 in a sleeve 52 secured to the plate 15.

The upper end of the sleeve 52 is threaded at 53 to engage with the lower end of a barrel 54, the upper end of which is closed by a partition

55 except for passages 56 therethrough. Above the partition 55 a bellows diaphragm member 57 is secured by welding material or solder so as to hermetically seal the connection between the barrel and the bellows.

Said bellows member is of thin sheet metal formed with transverse corrugations which may be annular or spiral as desired.

The upper end of the bellows diaphragm is connected at 58 to a ring 59 threaded internally to engage to head 60 which closes the upper end of said ring. The connection at 58 between the diaphragm and the ring 59 is of welding material or solder to form a tight seal as in the connection at the lower end thereof.

There is a small passage indicated at 61 from the lower end of the plug 60 which enables the fluid within the diaphragm to escape therefrom in original adjustment of the device. However, when the diaphragm is in position the connection between the ring 59 and the plug 60 is made a tight seal by a bond of welding material 62 which is engaged in grooves in the ring and plug as will be noted. The upper end of the plug is provided with a threaded socket 63 into which the bolt 50 is screwed.

The lower end of the plug 60 is formed into a shaft 64 which extends downward axially through the bellows diaphragm 57 and through a central opening 65 in the partition 55. Said shaft is jointed at 66 for purposes of assembly.

Within the diaphragm and encircling the shaft 64 is a coil spring 67 which bears at its upper end against the lower side of the plug 60, and at its lower end against the partition 55. It thus exerts downward force upon the barrel 54 and tends to extend the bellows diaphragm 57 upwardly.

My bellows diaphragm may be latched in compressed or in extended position by means of latching balls 68 engaging the lower extension of shaft 64. Said extension of the shaft is provided adjacent the balls with recesses 69 and 70 between which the shaft is rounded at 71. The latching balls 68 are adapted to engage in either of the grooves 69 or 70 and when the lower groove as shown in Fig. 6, tend to retain the shaft in its upper position with the bellows extended. When balls 68 are in the upper groove 69 the bellows is releasably latched in its lower position by the balls contacting the upper portion of the spherical part 71.

The latching means includes a cage shown best in Fig. 7, and said cage is cylindrical in general outline having an opening 65 therethrough to receive the shaft 64. There are four radial openings 72 leading to the central passage 65 and below these openings there is a downwardly extending slot 73. The balls 68 are housed in the radial passages 72 and when the cage is screwed within the barrel 54 the balls are retained from moving outwardly by face 77. Below the cage is the ball retainer shown in Figs. 9 and 10. There is a lower plate 74 having a central opening 75 to receive the shaft and there are four upwardly extending arms 76 the inner sides of which are beveled at 77 to engage the balls. There are longitudinal openings 78 through the cage to allow the passage of the fluid. The ball retainer is held resiliently upward against the balls by a spring 79 supported at its lower end upon the plug 80. Said plug is screwed tightly within the lower end of the barrel and hermetically seals said barrel by means of the threads and bond of solder or welding 62a so that fluid within the barrel and the diaphragm may not escape. While four balls, four drilled passages 72, four slots 73, and four prongs 76 are shown, it is to be understood that two, three or more than four of these members may be used and the applicant reserves the right to so modify the construction.

It is to be noted that the interior of the diaphragm and the barrel are filled with a lubricating liquid before the upper plug 60 is hermetically sealed in position. The diaphragm is then compressed to slightly beyond the limit to which it will be subjected in use and liquid within the diaphragm in excess of the amount necessary to then fill the same will find a vent through the passage 61.

Slightly above this lowest compressed position, the balls 68 should lie in the position of the groove 69 and this groove will be formed at that point. The bellows will then be allowed to expand and air will be drawn inwardly through the vent 59 to fill the place of the discharged liquid if an air filled pocket is desired above the liquid. The upper end of the bellows will then be hermetically sealed. Even better results may be obtained, under some conditions, by sealing the bellows before expulsion, thus to provide a vacuum above the liquid filler; and in still other cases the bellows should be sealed after only a partial expulsion in order to provide a partial vacuum above the liquid filler.

In the operation of the device the liquid passing upwardly through the opening 16 and about the diaphragm will exert a pressure thereon depending upon the head of liquid rising in the eduction tube. When this head of liquid is high enough to compress the bellows sufficiently the bellows will be contracted and will force the shaft 64 downwardly past the latching balls 68 so that said balls will snap abruptly into the upper groove 69. The valve 17 will thereby be forced to closed position. As long as the head of liquid or combined force of liquid plus air or gas pressure, admitted by valve 37, Fig. 1, is sufficient to hold the bellows compressed, the valve will remain closed. However, when the pressure around the bellows decreases sufficiently, due to expulsion of liquid from the eduction tube, the force of the spring 67 will throw the shaft abruptly upwardly so as to latch it in position with the valve 17 open. Below the inlet 16 is the nipple 7, previously referred to. The seal ring 6 may be of lead or other packing material fitting below a shoulder 19 on the nipple 7 and fixed thereto. The nipple extends downwardly through the coupling and the valve seat 14 and its lower end 20 contacts with the ball valve 10 to move said valve downwardly away from said seat. The eduction tube extension thus provided is slotted at 21 to allow the free entrance of liquid above the check valve.

In assembling the device in the well, the pressure tube will be inserted first, and in the absence of the eduction tube the check valve 10 will be seated in the seat 14 and will close off the entrance of liquid to the pressure tube. When the eduction tube is inserted, however, and is moved downwardly to fit within the said seat 5, the check valve 10 will be moved from its closed position, and an entrance will be provided for liquid upwardly to the inlet 16.

Above the liquid inlet, I may provide a swaged nipple 22, within which is fitted a standing valve. Said standing valve includes a base member 23, a cage 24, a seat 25, and a ball valve 26. This is

a common construction. The standing valve will act to prevent back pressure of liquid or gas downwardly into the well when the load is being lifted.

Above the standing valve is the inlet for the air or gas. The control device, in the form of a differential pressure-operated valve, is housed within a cylindrical housing **27**, the upper end of which is provided with a lateral projection **28**, tapered outwardly and fitting within an opening **29** in the wall of the eduction tube. A bond of welding material **30** tends to close the opening and secure the projection securely within the tube, so as to hold the housing rigidly in position.

The lower end of the housing **27** for my differential valve is also provided with a lateral projection **31**, tapered and fitting within an opening **32** and welded in that position. Said projection **31** has a central opening **33**, which extends radially inward to communicate with the interior of the housing.

The lower end of the housing is closed by a threaded plug **34**. Above the inlet opening **33** is a valve seat ring **35**. This is a threaded ring-shaped member screwed within the inner wall of the housing and formed with an upper valve seat **36** to receive the piston valve plunger **37**. The chamber **47** within the housing is preferably tapered very slightly in an upward direction to limit the passage of air as the valve plunger moves toward its upper seat, but this chamber need not necessarily be tapered.

Said piston valve is approximately cylindrical in shape, having its lower end tapered to fit the seat **36** and having its upper end beveled at **38** to fit within an upper seat **39** formed on the interior wall of the housing. It may be slightly tapered upwardly, if desired, in accordance with the taper of the chamber. Said piston valve is formed with an axial recess **40** at its upper end, said recess extending short of the lower end and being adapted to receive a guide stem **41**. The outer surface of the piston valve is serrated with grooves, the lower walls of which are inclined downwardly and outwardly, the upper walls being horizontal, and said serrations being adapted to be acted upon by fluid entering the chamber within the housing, and to receive sand or other particles entering the housing and which may engage therein as the clearance is decreased when the plunger approaches its upper seat in the upwardly tapered chamber.

The guide stem **41** extends longitudinally of the housing and projects through a threaded plug **42** at the upper end thereof. It is provided between its ends with a downwardly tapering valve member **43**, which fits within a seat **44** in the housing. Above this valve member is a compression spring **45**, which bears upon the head of the valve **43** and tends to hold it downwardly within the seat **44**. Both the valve plunger **37** and the valve **43** become check valves when the eduction tube is withdrawn from the well, thereby preventing liquid from escaping into the pressure tube. These members also act as check valves whenever there is not enough pressure in the pressure tube to lift the slug of liquid, thereby preventing the escape of liquid from the eduction tube into the pressure tube at such times.

The side wall of the housing above the valve **43** is provided with a slotted opening **46** to allow the passage of air or gas to the interior of the eduction tube. The air or gas will preferably be delivered to the pressure tube in a constant flow and the pressure of the air below the valve will tend to hold the said valve elevated to the position shown in Fig. 1 with the spring **45** under compression.

The term differential as herein used has reference to the difference between the relatively higher pressure of air in the pressure tube and the relatively lower pressure of liquid in the flow tubing at the same level and at the same time.

Increasing differential caused by a lowering of the liquid head in flow tubing or increasing pressure in the pressure tube, urges the plunger toward its upper seat upon which it will seal off against the admission of air or gas into the flow tubing whenever the pressure in the flow tubing at the air inlet device, plus the expansive force of the valve plunger spring, is less than the force in the pressure tube. During all other times the valve plunger is below its upper seat, thereby allowing air or gas to pass from the pressure tubing into the flow tubing. As the differential diminishes, the plunger recedes further from its upper seat until it finally rests upon its lower seat at no differential (maximum load).

The adjustment of the liquid intake valve must be such that it will close at a pressure somewhat higher than the differential required to open the differential valve. The differential valve, therefore, opens before the liquid intake valve closes. The differential at which the differential valve opens, therefore, determines the weight of the slug to be expelled at any given pressure in the pressure tubing. As the liquid intake valve is adjustable the intake valve is caused to open after the differential air or gas valve closes if a heading operation is desired as is primarily intended. If, however, the liquid intake valve is adjusted to open before the air or gas valve closes, both valves will remain open after the well starts, and a continuous flow will result, thereby changing the device from an intermittent heading device to a constant flowing device.

Reducing the pressure in the pressure tube will shorten the length of the slug to be expelled because this will reduce the differential. For example, with 200 pounds pressure in the pressure tube and 100 pounds plunger spring compression, 100 pounds in eduction tube will open the air or gas valve, but if the pressure in the pressure tube be reduced to 150 pounds, then 50 pounds in the eduction tube will open this valve.

Compressed air or gas so admitted does not exert back pressure on the producing formation of the well because when the gas is admitted into the eduction tube, it will instantly close the standing valve or exert the pressure on the bellows and close the liquid intake valve.

The weight of the slug of liquid to be expelled and its physical properties determines the pressure that should be used to lift it from a certain depth through a certain size of tube.

The weight of the slug and the pressure being determined, the differential assembly should be adjusted to admit the proper amount of air or gas to expel the slug by the most economical use of the power (compressed air or gas). This differential is obtained by maintaining proper pressure in the pressure tubing and providing for proper compression of the plunger spring when plunger engages its upper seat, little or no compression being held in the plunger spring when plunger is on its lower seat. The amount of compressed air or gas to be admitted is then determined by the amount of clearance around the plunger.

The statements of the foregoing paragraph

will be clearly understood by the following example where the air inlet valve is closed as shown in Fig. 1. Let it be assumed that the liquid intake valve will close at 150 pounds per square inch pressure; that the slug of liquid at its base exerts a pressure of 100 pounds per square inch when the differential valve opens; that the proper gas pressure to expel the slug is 200 pounds per square inch; and that the clearance around the valve **37** is such that it will admit enough gas to expel the slug. In the case assumed, the differential at the base of the slug is 100 pounds (200 pounds per square inch pressure in the pressure tube minus 100 pounds weight per square inch of the slug). The compression on the valve spring must then be 100 pounds in order to overcome the 100 pounds differential. The valve spring will then force the valve **37** away from its upper seat and admit compressed air or gas into the eduction tube. When 100 pounds per square inch of liquid pressure is exerted in the eduction tube at the differential valve, the valve instantly recedes from its upper seat, because 200 pounds per square inch of gas pressure is expanding under 100 pounds of load. The inertia of the slug is overcome by this expansion. Friction of the slug increases as its momentum increases. The differential therefore decreases; thereby to open the differential valve still wider as the momentum and friction increase until so much of the slug has been expelled from the eduction tube that the portion of the slug still unexpelled exerts less back pressure. This increases the differential, thereby urging the valve **37** upward until it seals off at such differential that the gas remaining under the remaining part of the slug will be sufficient to expel it.

Proper clearance around the valve **37** should be provided to produce this result. After the slug has gained a predetermined momentum it will not move faster because the clearance around the valve limits the amount of gas admitted. Since the velocity of the slug cannot, therefore, exceed that which the limited amount of gas will impart, the lightened slug (after part of it has been expelled) must exert less back pressure upon the differential valve. This increased differential, therefore, urges the differential valve to close until another slug has entered as before, when the operation is repeated, and so on.

The plunger is urged in the direction of its upper seat by the greater pressure that obtains under it. It is forced away from the upper seat by compression of the plunger spring. The amount of force required to compress the plunger spring far enough to permit the plunger to seal off upon its upper seat determines the differential at which the plunger will seal off upon its upper seat at any given pressure in the pressure tube.

It will be seen that, in the operation of my device, the air or gas under pressure will exert a fairly constant pressure at the lower end of the air inlet chamber. The operation of the device will function therefore in accordance with the pressure within the device, tending to balance the pressure of the air on the outside. When the differential between the interior pressure in the eduction tube and that on the exterior comes within the predetermined limit, then the valve will be moved downwardly out of its seat to allow the entrance of the air to the interior. This will assist the head of liquid in closing the liquid inlet, and the slug of liquid will then be raised to the surface. As the liquid is discharged from the tube, and the pressure therein decreased, the differential at the air inlet will decrease and the pressure inlet valve will be closed. My device is operative automatically, and will function without back pressure upon the producing formation, and, as it is simple in construction, it will last for long periods of time without mechanical attention after it has once been adjusted. The advantages of this construction will be obvious to those skilled in the art.

What I claim as new is:

1. In a device of the character described, a pressure tube for wells, an eduction tube spaced inside thereof, a seal between said tubes adjacent the lower end thereof, a valve controlling the entrance of liquid upwardly into said eduction tube, means connected with said valve to close the same responsive to fluid pressure above said valve, an air inlet above said liquid inlet, and a valve in said air or gas inlet, said valve being normally closed by air pressure in said pressure tube, and responsive to a predetermined differential between the relatively less pressure in said eduction tube and the relatively greater pressure in said air or gas tube to open and allow the entrance of air beneath said liquid, said valves being adjustable to operate simultaneously or in succession.

2. In a device of the character described, a pressure tube for wells, an eduction tube spaced inside thereof, a seal between said tubes adjacent the lower end thereof, an adjustable liquid inlet valve controlling the entrance of liquid upwardly into said eduction tube, an air inlet above said liquid inlet, a valve in said air inlet, said air valve being normally closed by air pressure in said pressure tube, and responsive to a predetermined differential between the relatively less pressure in said eduction tube and the relatively greater pressure in said pressure tube to open and allow the entrance of air beneath said liquid, said liquid valve being adjustable to close after said air valve is opened, and means acting when the fluid pressure in said tube is relieved to close said air inlet valve and open said liquid inlet valve.

3. In a device of the character described, a pressure tube for wells, an eduction tube spaced inside thereof, a seal between said tubes adjacent the lower end thereof, an adjustable valve controlling the entrance of liquid upwardly into said eduction tube, an air inlet above said liquid inlet, a valve in said air inlet, said air or valve being normally closed by air pressure in said pressure tube, and responsive to a predetermined differential between the relatively less pressure in said eduction tube and the relatively greater pressure in said pressure tube to open and allow the entrance of air beneath said liquid, said liquid inlet valve being adjustable to close at a pressure higher than the differential pressure required to open said air or gas inlet valve.

4. In a device of the character described, a pressure tube for wells, an eduction tube spaced inside thereof, a seal between said tubes adjacent the lower end thereof, a valve controlling the entrance of liquid upwardly into said eduction tube, an air inlet above said liquid inlet, and a valve controlling said air inlet, said air or gas valve having upper and lower seats, a spring tending to hold said valve in its lower seat, but responsive to the pressure of air in said pressure tube to allow said valve to close upon said upper seat, said valve being opened by a predetermined dif-

ferential of pressures in said eduction tube as compared with the pressure outside said inlet, said liquid inlet valve being adjustable to close after said air or gas inlet has opened.

5. In a device of the character described, a pressure tube for wells, an eduction tube spaced inside thereof, a seal between said tubes adjacent the lower ends thereof, a valve controlling the entrance of liquid upwardly into said eduction tube, and adapted to close in response to a predetermined fluid pressure above the same, an air inlet above said liquid inlet, and a valve in said air inlet, seats spaced from the upper and lower ends of said air valve, said valve being responsive to fluid pressure outside said inlet to move to an inner seat, means tending to move said valve from its inner seat to its outer seat, said valve being adapted to be balanced between internal and external pressures to open and allow air to enter below said liquid when a predetermined differential is reached between internal and external pressures relative to said tube, and then to close at a predetermined out of balance relation between said pressures, the pressure of said air in said tubing acting to assist in closing said liquid control valve so that said liquid valve will close when said air vave has opened.

6. An air inlet device for eduction tubes in wells including; a check valve adjacent the lower end thereof a housing in said tube above said check valve, an inlet from outside said tube to the lower end of said housing, upper and lower valve seats, a guided valve between said seats, means normally exerting a downward pressure on said valve, said valve being adapted to be held in its upper seat by air pressure and to be moved to open position in response to a predetermined liquid head above said inlet within said tube.

7. A method of flowing wells having an eduction tube therein, comprising admitting a predetermined head of liquid into said tube, operating through a preponderance of pressure outside said tube to open an inlet to said tube for air under pressure and thus moving said head of liquid upwardly, then shutting off the passage of fluid downwardly from said tube, and closing said air inlet when said head of liquid is wholly or partially discharged.

8. A method of flowing wells having an eduction tube therein, comprising admitting a head of liquid into said tube, operating through a difference of pressure inside and outside said tube to open an inlet to said tube for air under pressure and thus moving said head of liquid upwardly, closing the entrance of liquid to said tube, shutting off the passage of fluid downwardly from said tube, and closing said air inlet when said head of liquid is partially discharged.

9. A method of flowing wells having an eduction tube therein, comprising admitting a predetermined head of liquid into said tube, operating through a preponderance of pressure outside said tube to open an inlet to said tube for air under pressure and thus moving said head of liquid upwardly, shutting off the passage of fluid downwardly from said tube, discharging said load at the surface and closing said air inlet.

10. An air inlet device for eduction tubes in wells including; a housing in said tube above the lower end thereof, an inlet from outside said tube to the lower end of said housing, upper and lower valve seats, a valve between said seats, a valve stem, a spring on said stem normally forcing said valve stem toward said lower seat, said valve being movable a limited distance from its seat without moving said stem and to then raise said stem to force said valve to its upper seat by air pressure outside said inlet, and adapted to be balanced between said seats by outer air pressure and the inner pressure exerted by said spring and the liquid head in said tube and a guide for said valve.

ALEXANDER BOYNTON.