Dec. 15, 1925. 1,565,886

B. S. AIKMAN

PUMP AND PUMPING SYSTEM

Filed Aug. 17, 1922 8 Sheets-Sheet 1

Fig. 1

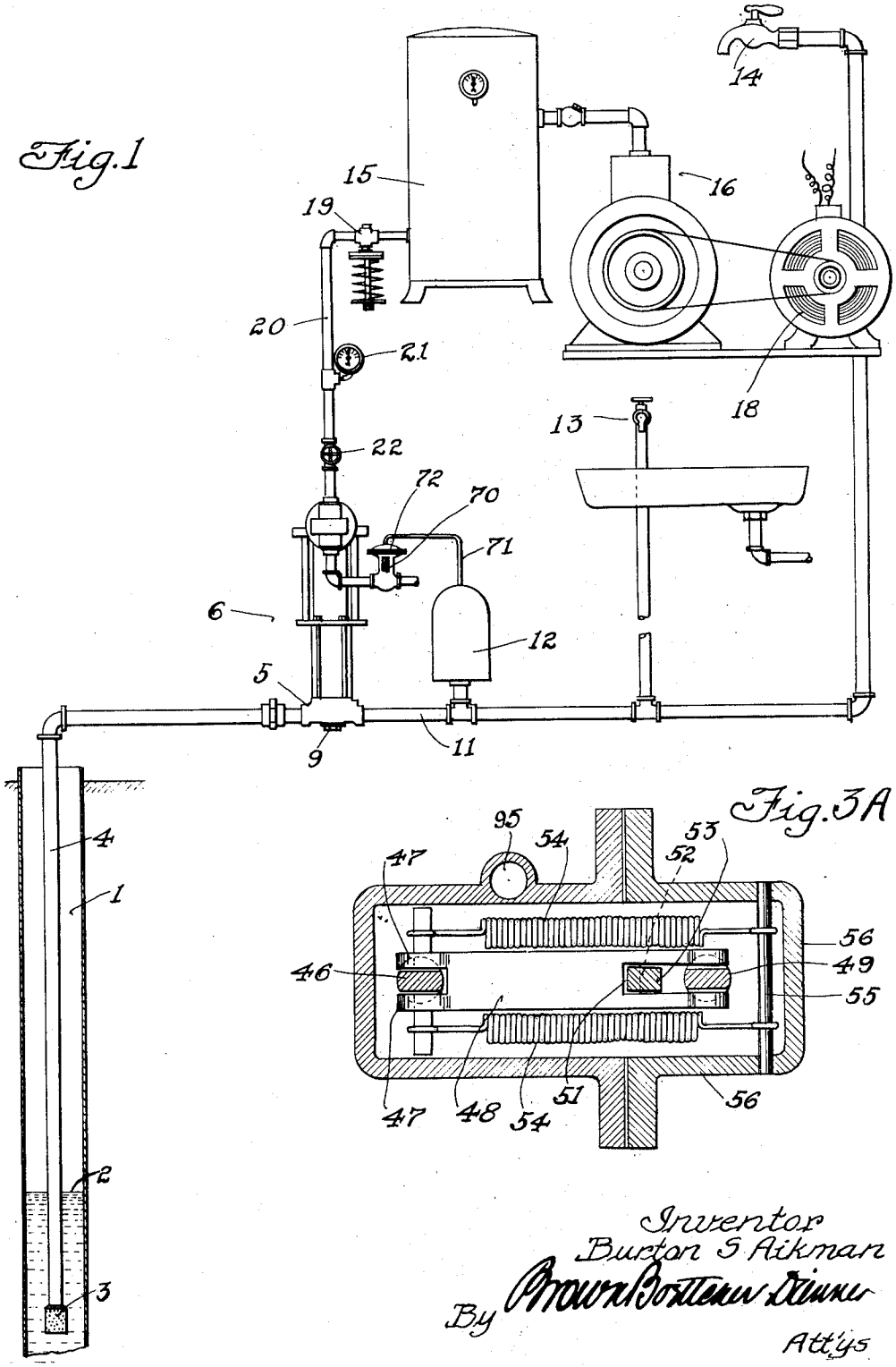


Fig. 3A

Inventor
Burton S Aikman
By Brown Boettcher Dinner
Att'ys

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B. S. AIKMAN

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Filed Aug. 17, 1922 8 Sheets-Sheet 2

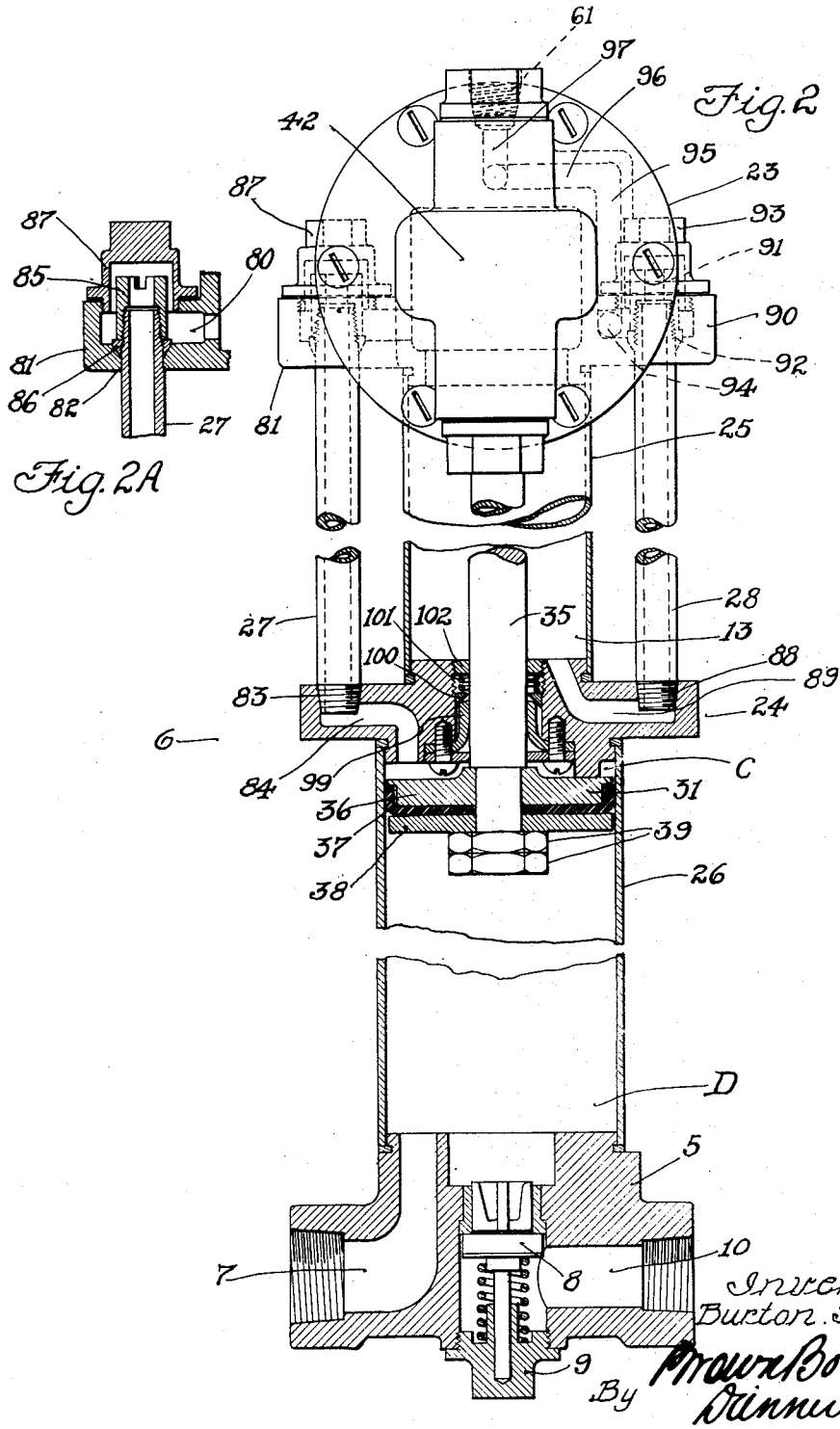


Fig. 2

Fig. 2A

Inventor
Burton S. Aikman

By Brown Bottelson & Dinnin Attys

Dec. 15, 1925. 1,565,886

B. S. AIKMAN

PUMP AND PUMPING SYSTEM

Filed Aug. 17, 1922 8 Sheets-Sheet 3

Fig. 3

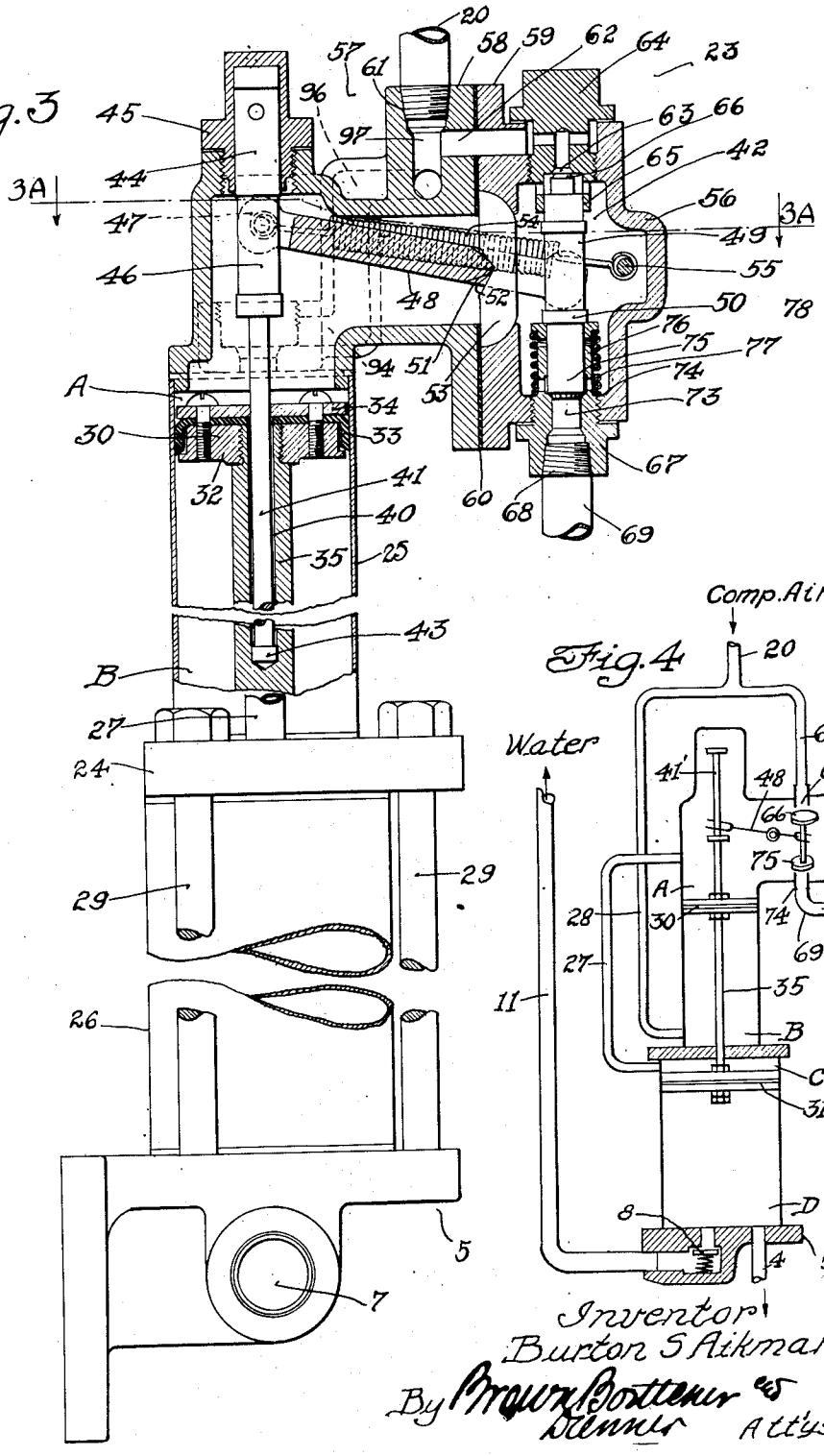


Fig. 4

Inventor
Burton S Aikman
By Brown Boettcher Dunner Atty's

Dec. 15, 1925. 1,565,886

B. S. AIKMAN

PUMP AND PUMPING SYSTEM

Filed Aug. 17, 1922 8 Sheets-Sheet 4

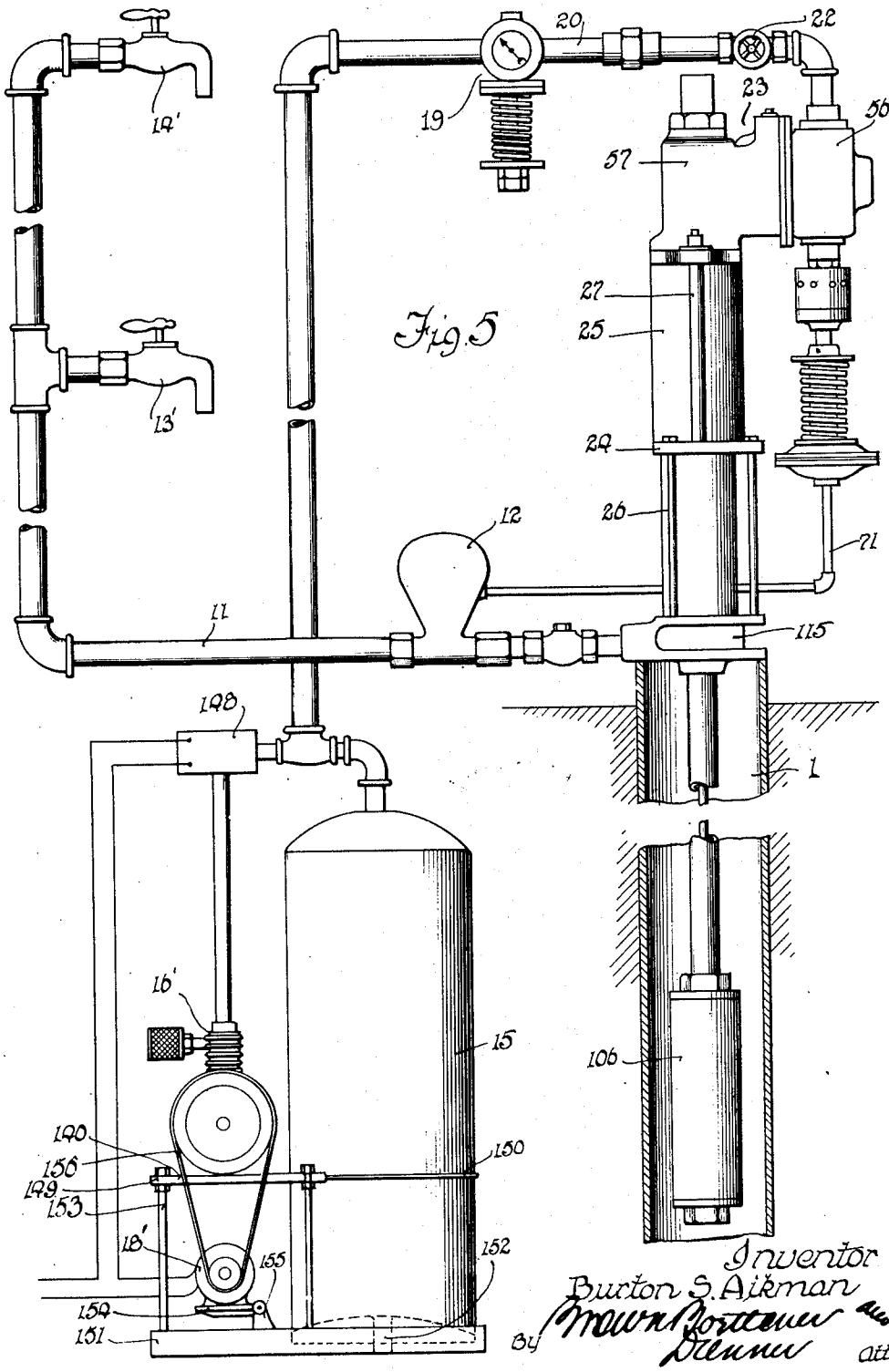


Fig. 5

Inventor
Burton S. Aikman
By Brown Boettcher and Dennis Attys

Dec. 15, 1925. 1,565,886

B. S. AIKMAN

PUMP AND PUMPING SYSTEM

Filed Aug. 17, 1922 8 Sheets-Sheet 5

Fig. 6

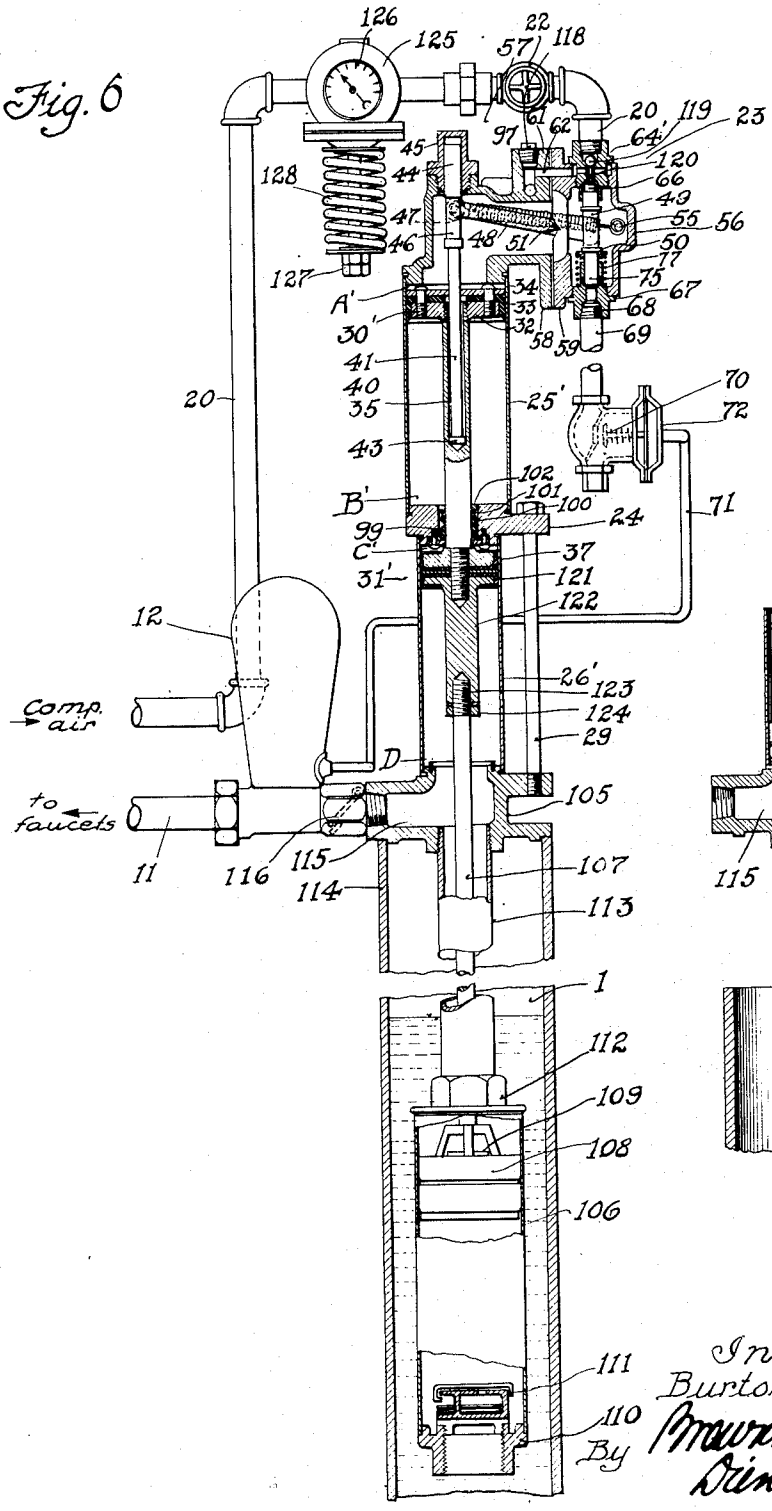
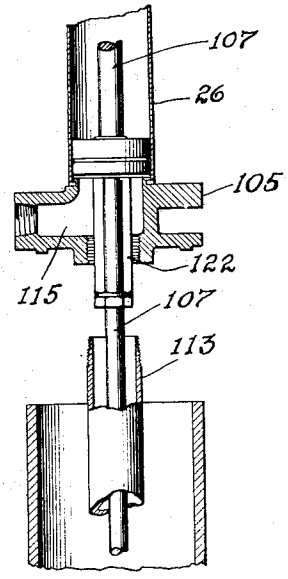


Fig. 6A



Inventor
Burton S Aikman
By Mauro Bottemer & Dinnen Attys

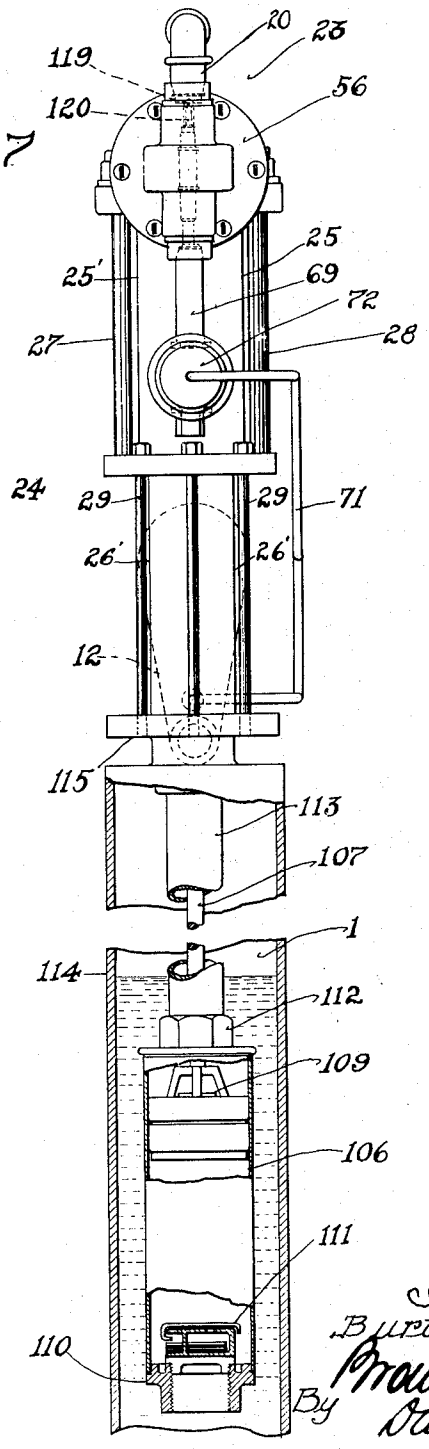
Dec. 15, 1925. 1,565,886

B. S. AIKMAN

PUMP AND PUMPING SYSTEM

Filed Aug. 17, 1922 8 Sheets-Sheet 6

Fig. 7



Inventor
Burton S. Aikman
By Brown Bottelen & Dinnies Attys

Dec. 15, 1925. 1,565,886

B. S. AIKMAN

PUMP AND PUMPING SYSTEM

Filed Aug. 17, 1922 8 Sheets-Sheet 7

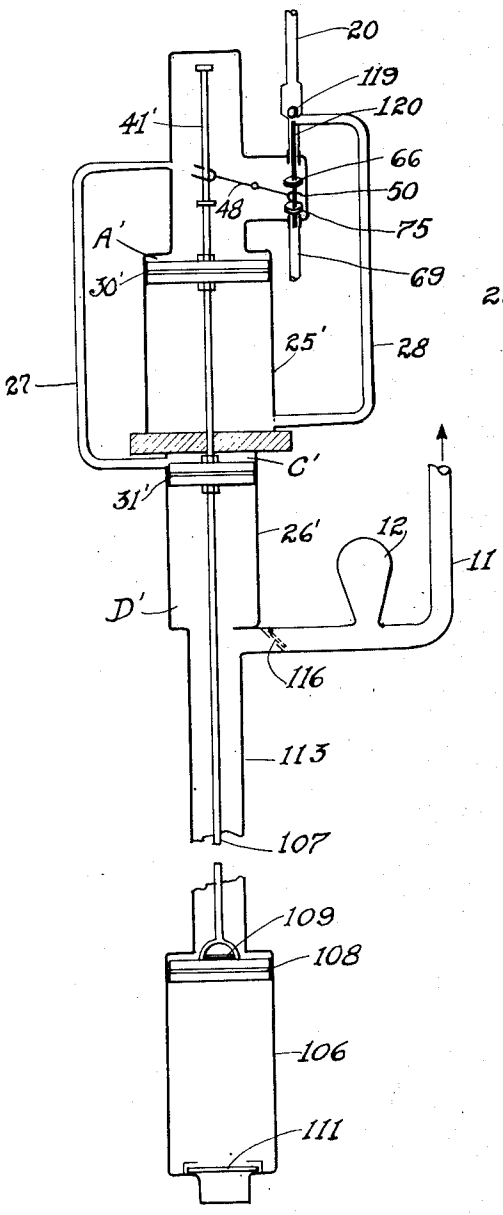


Fig. 8

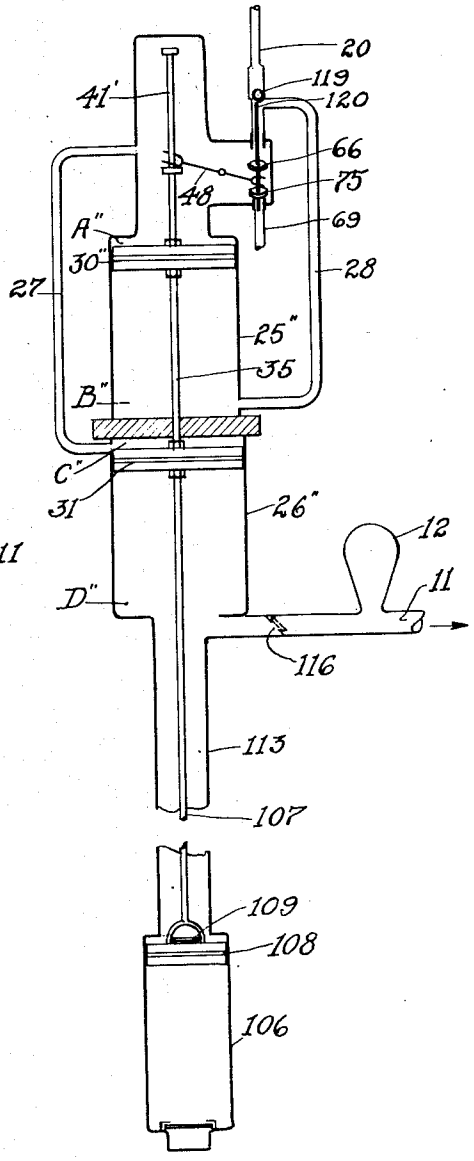


Fig. 9

Inventor
Burton S. Aikman
By Brown Boettcher Mc Dinner Att'ys

Dec. 15, 1925. 1,565,886

B. S. AIKMAN

PUMP AND PUMPING SYSTEM

Filed Aug. 17, 1922 8 Sheets-Sheet 8

Fig. 10

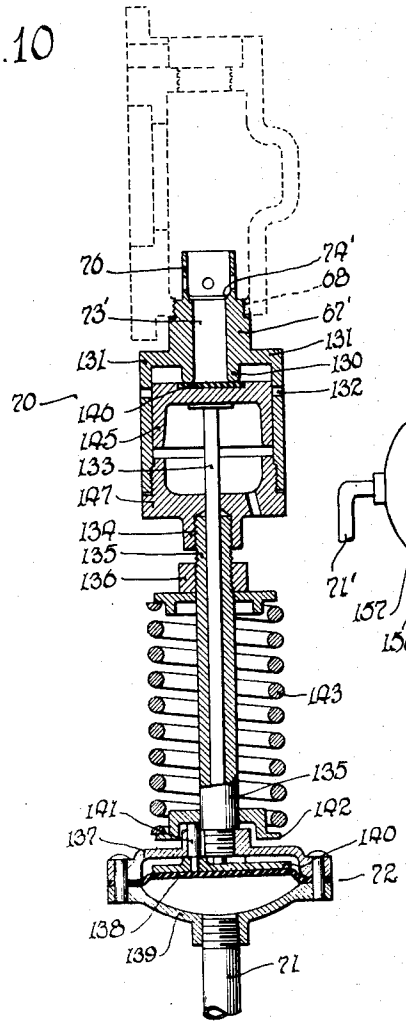
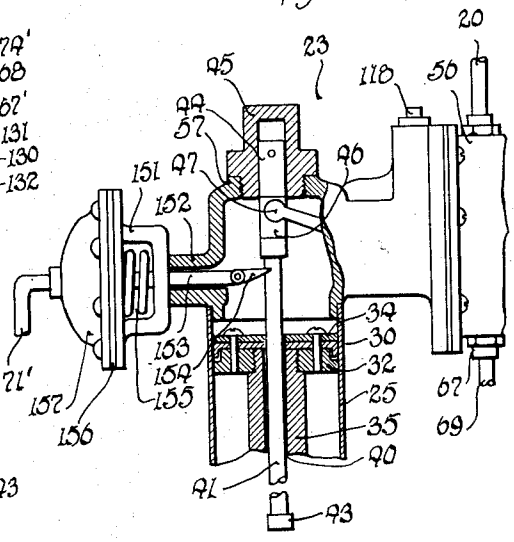


Fig. 11



Inventor
Burton S. Aikman
By Brown Boettcher & Dennen
Att'ys

Patented Dec. 15, 1925. 1,565,886

UNITED STATES PATENT OFFICE.

BURTON S. AIKMAN, OF MILWAUKEE, WISCONSIN, ASSIGNOR TO NATIONAL BRAKE AND ELECTRIC CO., OF MILWAUKEE, WISCONSIN, A CORPORATION OF WISCONSIN.

PUMP AND PUMPING SYSTEM.

Application filed August 17, 1922. Serial No. 582,421.

To all whom it may concern:

Be it known that I, BURTON S. AIKMAN, a citizen of the United States, residing at Milwaukee, in the county of Milwaukee and State of Wisconsin, have invented a certain new and useful Improvement in Pumps and Pumping Systems, of which the following is a full, clear, concise, and exact description, reference being had to the accompanying drawings, forming a part of this specification.

In my work in connection with the development of pumps for systems which have aptly been called "Fresh water systems," I have brought the matter of pumping by air displacement to a high degree of efficiency and reliability.

However, the pneumatic displacement pump, desirable as it is for certain uses, has definite physical limitations. First it will not operate as a suction pump. Next, where the lift exceeds from 100 to 150′ efficiency of the system as a whole drops to a point where the cost of operation and maintenance is excessive. This is due to two fundamental causes. First, with a given tank capacity, as for instance, a 50 gallon air tank, and a certain maximum permissible pressure—say 150 pounds per square inch, the available amount of air for a low lift is invariably greater than for a high lift. Thus assume a 100′ lift operating at 65 pounds air pressure and compare it with a 30′ lift operating at 22 pounds air pressure. The above tank will have only 85 pounds of air available for the greater lift, whereas it has 123 pounds available for the lesser lift.

The same tank thus presents much greater storage capacity for the lower pressure than it does for the greater pressure; or, vice versa, a smaller tank will carry a greater delivery of water in the case of the lower lift.

This matter of tank capacity is, however, a minor matter as compared with efficiency. The overall efficiency of the plant depends primarily upon two factors. First, the efficiency of the air compressing mechanism, and second the efficiency of the water raising device or method.

Air compressors of the present commercial type are more efficient at low pressures than at high pressures. Thus for a range of pressure from 20 pounds per square inch to 150 pounds per square inch, the efficiency of the average commercial compressor in smaller sizes may drop from around 90% down to around 50% or even less. In the case of the higher pneumatic lift, the compressor works only on the upper end of the range, that is, in the present instance, only from 65 pounds to 150 pounds, whereas, in the case of the lower lift, the compressor might work on a range of from 22 pounds to 150 pounds. When efficiency is to be considered ahead of tank capacity the maximum pressure of the above tank is lowered. Thus the range may be for example from 22 to 107 pounds. This would give the same water delivery, but at a higher efficiency. Consequently, the overall efficiency of the latter system is considerably greater.

In a displacement system the air is applied directly to the water. Hence, the air pressure must be always great enough to balance the column of liquid plus a suitable delivery head to overcome friction and to maintain flow. Hence the range of usefulness as to height of lift is limited by the pressure required and the efficiency of the system is controlled very greatly by the lift encountered. The pneumatic displacement pump must always lift from the pumping cylinder, not from the actual water level in the well. This is not true of the pump forming the subject matter of the present invention.

In a pneumatic displacement system, the air is exhausted at a pressure corresponding to the lift plus friction load and delivery head. This means that air which is exhausted at a pressure of say 65 pounds per square inch represents a very large loss of mechanical energy. Thus the work which the compressor did in raising the air from

atmospheric pressure to the pressure of the exhaust, that is, 65 pounds is dead loss.

The present form of pump to which my invention relates and which was first disclosed in my co-pending application Ser. No. 488,551, filed July 30, 1921, is in a class of mechanism entirely different from a pneumatic displacement pump, but it is designed to furnish fresh water directly from the well under faucet control and to use compressed air as an operating medium.

I believe that I am the first to provide an air operated piston displacement pump completely and satisfactorily under faucet control for the purpose of furnishing fresh water on demand under the conditions which are to be met on the farm, suburban home, etc.

I am aware that it is old to have a faucet controlled water system using a pneumatic displacement pump, but as I shall point out, the present system is a new system producing results not before obtainable by known systems.

I here refer to the fact that with my present system I can take water from wells which could not be touched by prior systems. I can operate purely on suction lift or I can raise water from depths and to heights which are prohibitory to known pneumatically actuated systems operating under faucet control.

I can employ apparatus which previously had to be scrapped. I can operate the system so as to use the air expansively. I can maintain the system under pressure upon high lift with only a low air pressure on the valve. I can operate the system satisfactorily and at a reasonable efficiency even if the water containing part of the pump leaks seriously. I can operate the system under faucet control even though the pump is defective. All this is in sharp contrast to prior systems which must be maintained in substantially perfect condition, or be shut down altogether.

I am also aware that pumping systems having direct driven pumps have been employed to furnish fresh water under faucet control. But in such systems the motor must be automatically started and stopped each time that the faucet is opened and closed for fresh water delivery. This is impractical where a gas engine is the source of power. Furthermore, in such systems there must be a mechanical connection between the driving motor and the pump. This is undesirable for several reasons, chief of which is the necessity for placing the operating pump and motor together and generally at the head of the well.

The preferred form of pump comprises a liquid cylinder and piston which may be part of a mechanically operated pump extensively used and well known for a long time. With this I employ two other cylinders; one of which is an air cylinder having air pressure available on both sides of its cooperating piston, and the other cylinder is a combined air and water cylinder. The piston of the latter being exposed on one side to the action of compressed air and on the other side operates upon the water to be moved. This pump, from a mechanical standpoint, comprises what may be termed a working head and in conjunction therewith a drop pipe and cylinder with a conventional sucker rod forming the mechanical operating connection between the head and the water cylinder at the end of the drop pipe. Where the pump oper tes within suction limits the drop pipe and its cylinder may be supplanted by a suction pipe and check valve.

The working head includes the two cylinders and the valve mechanism cooperating therewith. The pistons of the two cylinders are direct connected and the diameters of the pistons may be proportioned to secure a number of different arrangements of great advantage. For instance, the pistons may be proportioned to the respective lifts. Live air may be used for each lift, or the air may be used in stages, for a compound working. The total lift of the water may be divided into a primary lift from the water in the well to the head of the well, and a secondary lift from the head of the well to the point of consumption and a partial expansion of the air may raise the water through the primary lift, and another expansion may discharge it through the secondary lift. In fact, almost any condition may be very nicely met by relative proportioning of the parts of the pump.

The areas of the air pistons with respect to the water pistons may also be proportioned to secure any desired effect.

The air pistons may be operated as a simple pump and the desired compounding effect may be secured in the water pistons by an arrangement of differential areas.

As the pump is under faucet control, it is adapted to "stall" when the faucets are closed. By "stalling" I mean stopping delivery of water and stopping use of air but standing ready immediately to supply water to the discharge system upon demand. The real desideratum is to confine the use of air to the actual work of delivering water. There are, as I have found, two fundamental ways to stall the pump. First by blocking the movement of the water pistons and consequently the motor pistons by closure of the water outlet, and second by blocking the movement of the motor pistons in any one of three ways. First, by shutting off the motive fluid, second by blocking the exhaust pipe and third by mechanically blocking the motor piston or a connected mechanical part. I may employ any one of the above methods.

The simplest way of securing the desired result, although I have found it to be the least advantageous is to stop the pump by blocking the water outlet, leaving full air pressure upon the motor or head mechanism. This is comparable to the method now employed in pneumatic displacement systems. There is considerable objection to this method. The average fresh water system stands quiet but ready to serve for about 20 to 22 hours out of the 24, and is in operation only about 2 to 4 hours. If there is any leak in the air valve this standing under pressure represents a direct loss in live air which quickly wastes the supply of compressed air and tends to destroy the usefulness of the system. If in the present system there is any leakage in the water containing parts of the pump it will continue to make strokes at a speed roughly in proportion to the leak. This is highly undesirable, mainly because it wastes air and also because it excites undue apprehension of inefficiency of the pump.

The blocking of the motor mechanism, either mechanically or pneumatically, is desirable. Of these methods I have found to be the most desirable the method of stopping the operation of the pump by blocking the exhaust pipe. In carrying out this preferred method, I provide a pressure actuated snap action valve for stopping exhaust outlet when the water system has been pumped up to a predetermined pressure. This leaves the pump ready to operate instantly when the blocking valve opens. Meanwhile the pistons stand under balanced pressure in the main motor cylinder and hence no leakage occurs there. The auxiliary piston stands under reduced pressure but there is very little tendency for leakage to occur because water at substantially equal pressure lies on the opposite side of the auxiliary piston.

Shutting off the supply of compressed air is less desirable since it subjects the pump to more extreme conditions—namely, under pressure at one moment and without pressure at another. Furthermore, such a valve would normally tend to leave the pump less responsive to faucet control. Furthermore, with such a control there is a greater tendency to wastage of air than with the blocking of the exhaust pipe, as the air which is in the pump at the time that the cut-off valve operates tends to be dissipated without useful effect.

Mechanical blocking of the down stroke is not quite as desirable because of the mechanical strain imposed under deep submergences, but this method of blocking may be used with a fair degree of satisfaction.

With the blocking of the motor or head member, it is possible to regulate the reducing valve to better advantage. There is a saving of air since the pump does not need to pump the water system against the false head up to full reducing valve pressure before shutting off as is the case in hydraulic blocking.

In fact it is possible to set the reducing valve pressure and the shut-off or blocking pressure independently. This means that the blocking pressure may be adjusted to a fairly low value and the reducing valve pressure to a fairly high pressure. The result is the pump shuts off promptly when the faucets are closed and when the faucets are wide open a large delivery is not hampered by lack of air pressure through the reducing valve.

The pump of my invention may be operated at a greater rate than the rate of liquid in flow without a blow over. It merely draws in and delivers air in addition to what liquid it can get. However, I can regulate the working of the pump to correspond to the rate of liquid in flow by throttling the air supply. This is of great advantage in pumping a well having limited in flow, for instance, such as occurs in oil wells, where the rate of in flow is less than the normal capacity of the pump. The pump is throttled to the rate of in flow of oil or slightly in excess thereof. The oil is regularly withdrawn, any excess of pumping capacity resulting merely in taking in air which represents only a nominal loss.

A further advantage of the pump of my invention resides in the use of a simple valve mechanism employing only lift valves. These valves are in the preferred form of the invention only three in number and of simple construction employing no stuffing boxes or packed joints.

The pump of my invention is peculiarly free of hammering even on high rates of delivery because I employ the principle of compression upon the end of the exhaust stroke. This is secured by the use of the differential air and water pistons and the peculiar valve mechanism which I employ.

The use of the differential air and water piston is highly efficacious. This construction secures a saving in the use of air. It permits the work of secondary and primary lifts to be divided and it permits the use of lower initial air pressure.

My invention may be embodied in a great variety of forms, some of which I have illustrated in the accompanying drawings which form a part of the present specifications. Throughout the specifications and drawings the same reference characters represent the same or similarly operating parts.

In order to acquaint those skilled in the art with the manner of constructing and operating my invention I shall now describe a specific embodiment thereof.

In the drawings, Figure 1 is a diagrammatic layout of a system and pump embody-

ing the present invention. In this system the secondary lift from the head of the well to the outlets exceeds the primary lift from the water in the well to the head of the well and the latter lift is within suction limit.

Fig. 2 is a longitudinal sectional view partly in front elevation showing the construction of the pump employed in Fig. 1.

Fig. 2A is a fragmentary sectional view of a detail of construction.

Fig. 3 is a left side elevation partly in longitudinal section of the pump shown in Figs. 1 and 2.

Fig. 3A is a cross sectional view through the head member on the line 3A—3A of Fig. 3.

Fig. 4 is a diagram of connections of the pump shown in Figs. 1 to 3 inclusive.

Fig. 5 is a diagrammatic layout similar to Fig. 1 of a system and pump embodying my invention. This pump is designed for any primary lift whether within suction limits or not. It is the preferred form of the invention.

Fig. 6 is a vertical sectional view of a modified form of pump employed in a system in which the primary lift out of the well exceeds the secondary lift from the head to the outlets.

Fig. 6A is a fragmentary sectional view showing the manner of making connections between the operating head and the pump rod.

Fig. 7 is an elevational view partly in section taken at right angle to the view of Fig. 5.

Fig. 8 is a diagram of the pump shown in Figs. 5 to 8.

Fig. 9 is a diagram of a modified form of single acting pump for use in a system where the lift out of the well is relatively great.

Fig. 10 is a sectional view of the exhaust blocking valve; and

Fig. 11, indicates the manner in which mechanical blocking of the pump may be secured.

As above indicated I have illustrated two embodiments of the invention namely, the pump and system of Fig. 5 which is of universal application and a simplified pump and system shown in Fig. 1 which is limited to suction lifts. I believe I can make the invention clearer by first describing the simplified form of Fig. 1.

As previously indicated, Fig. 1 shows a system operating within suction limits in which the major part of the lift namely, the secondary lift is from the head of the well to the delivery outlets, such as faucets or the like. The well in this case is illustrated as an open well 1; with the level of the water at 2, the suction intake screen 3 being disposed a suitable distance below the level of the water. At the head of the well the suction pipe 4 is connected to the base 5 of the pump 6, the pipe 4 communicating thru the intake passageway 7. The base member 5 has a discharge passageway 10 containing a suitable check valve 8 disposed substantially centrally in the base member 5 and arranged to be readily accessible by removal of the plug 9 which closes the lower end of the bore in which the check valve 8 is seated. The discharge passageway 10 communicates with the delivery pipe 11, this pipe having connected thereto a steady flow chamber 12, and being connected to the various faucets 13, 14 in a manner well known in the art. The operation of the pump 6 is automatic, this pump being arranged to maintain the water supply system under pressure so that as soon as faucets are open the water will flow therefrom, and the pump will immediately start into operation to maintain the delivery, within limits. The pump 6 is supplied with compressed air from a tank 15 which tank is re-charged whenever necessary or desirable by means of the compressor 16. The compressor 16 may, where electric power is available, be driven by an electric motor 18. In this case the recharging of the tank 15 may be made automatic. The manner of recharging the tank is not of the essence of the present invention, but it has an important bearing upon the value of the system.

Where a gas engine forms the source of power recharging of the tank once a day or once every two days may be employed to keep the system in operation. This feature is particularly valuable in connection with the system of Fig. 5. It means that the user may upon opening a faucet draw water fresh from a very deep well without the trouble and delay of starting up heavy and cumbersome machinery.

The tank 15 operates between a maximum and a minimum pressure but a pressure reducing valve 19 is interposed between the tank 15 and the pump 6 so that substantially a constant pressure is maintained upon the pump 6 even though the pressure in the tank 15 varies between relatively wide limits. The connecting pipe 20 may contain a suitable pressure gauge 21 and throttle valve 22 and other auxiliary apparatus as may be desired. The throttle valve may be set to control the maximum rate of operation of the pump as above indicated.

The pump itself which is shown more in detail in Figs. 2 and 3 comprises an upper head member 23, and intermediate connecting member or head member 24 and the lower base member 5 previously referred to. A cylinder 25 which may be in the form of a short length of brass or bronze tubing is closed by the heads 23 and 24 and a second cylinder 26 of a similar construction, but of different size has its ends closed by the head 24 and the base 5. The head 23 and the intermediate head 24 are clamped upon the ends of the cylinder 25 by the tie pipes

27 and 28, two in number. The intermediate head 24 and the base 5 are clamped against the ends of the tube or cylinder 26 by means of three tie rods 29. Suitable gaskets are interposed between the ends of the cylinders and the cooperating heads or base members. Cylinders 25 and 26 are provided with suitable cooperating pistons 30 and 31 respectively. These pistons are double acting, that is to say, they are operated upon by a fluid or fluids under more or less pressure on each side thereof, so that the cylinders 25 and 26 in effect constitute the equivalent of four single cylinders, and I have therefore indicated the upper end of the cylinder 25 by the reference character A, the lower end of the same cylinder reference by character B, the top of the cylinder 26 by reference character C and the bottom of the cylinder 26 by reference character D. The piston 30 comprises a main piston member 32 provided with a cup leather 33 and a follower plate 34. The follower plate is secured by suitable screws as shown in Fig. 3 to the main piston member 32, which main piston member is connected by a rod 35 to the double acting piston 31 of the cylinder 26. The piston 31 is constructed like the piston 30 having a main piston member 36, a cup leather 37 and a follower plate 38. The end of the piston rod 35 passes through the piston 31 and is clamped by means of the lock nut 39. At its upper end, the rod 35 is threaded in the main member 32 of the piston 30. The upper end of the piston rod 35 is bored out as shown at 40 to receive an operating rod 41 for actuating the valve mechanism indicated generally at 42. The operating rod 41 has a head 43 which fits fairly closely within the bore 40 and which is adapted to engage the follower plate 34 when the piston 30 is at the lower end of its stroke moving downwardly. The follower plate 34 closely fits about the rod 41 so that it will engage the head 43, but otherwise it has a free sliding fit. At its upper end the operating valve rod 41 has an enlarged end 44 which is guided in the cap or nut 45. This enlarged portion 44 is splayed on opposite sides as indicated at 46 to provide shoulders for engaging the rounded ends 47 of the swinging valve operating lever 48. The swinging lever 48 is forked at both ends, at the left as indicated in Fig. 3 to embrace the splayed portion 46 of the rod 41 and at its right end, as seen in Fig. 3, to embrace a similarly splayed portion 49 of a compound valve structure 50. The right hand forked end of the lever 48 provides a knife edge pivot 51 which engages a notch 52 in a stationary web member, which stationary web member forms not only a bearing but also a guide for the adjacent forked end of the lever. The left hand end of lever 48 has connected thereto a pair of snap operating springs 54, these springs being attached at their rear ends to a pin 55 mounted in the valve housing 56. The head 23 comprises the valve housing 56 and the main head portion 57 both of which are provided with co-operating clamping flanges 58, 59 adapted to receive a suitable gasket 60 between them.

The snap springs 54 which are two in number lie outside of the swinging lever 48 and are so arranged that after the swinging lever passes over center in one direction the springs will assist movement further in the same direction and vice versa. The valve actuating rod 41 secures a lost motion connection with the moving piston and piston rod structure 30, 35, 31 so that when its piston and rod structure completes an excursion in one direction the lever 48 will be tripped from one position to the other and the compound valve structure 50 will be thrown from one position to the opposite position. This last motion permits of a snap actuation of the lever 48. The lever 48 thereby is able to deliver a blow to the valve member 50 for more certainly throwing it from one position to another particularly to throw the exhaust valve 75 open against the internal pressure.

The head casting 57 has a suitable screw socket 61 for an air admission pipe 20, this socket communicating by passageway 62 with an admission port 63 formed in the plug 64 in the valve housing 56. The plug member 64 is screwed down to form a closure for the end of the bore which is formed vertically through the valve housing 56 as is apparent from Fig. 3. The plug 64 has a depending guiding flange shown at 65 for guiding the upper end (admission valve) of the compound valve member 50. This valve member has the conical admission valve 66 formed integral on its upper end. The admission port 63 when opened communicates with the interior of the valve housing and this in turn communicates with the interior of the head casting 57.

Opposite the plug 64 is arranged a similar plug 67 which has a screw socket 68 adapted to receive an exhaust pipe 69. This exhaust pipe may communicate directly with atmosphere or it may be controlled by blocking valve 70 governed by the pressure in the steady flow chamber 12 as shown in Fig. 1 depending upon the method employed for stalling the pump. A connection 71 from the steady flow chamber 12 leading to the diaphragm chamber 72 of the cut off valve 70, so that when the pressure in the water system rises to a predetermined value the valve 70 will be actuated to shut off the exhaust pipe, preventing further operation of the pumping mechanism.

The plug 67 contains a passageway 73 which terminates in a valve port having a seat 74 adapted to be controlled by the exhaust valve 75 which is formed integral with the compound valve member 50. The exhaust valve 75 is guided in an extension 76 of the plug 67, this guide 76 having suitable transverse ports adjacent the valve seat 74 as is clear from Fig. 3. A spring 77 is interposed between a shoulder on the plug 67 and a shoulder on the collar 78, which collar is secured on the valve structure 50. The spring 77 tends therefore to hold the admission valve 66 upon its valve seat 63 against the incoming pressure particularly at the stage where rod 41 begins to shift lever 48 away from the upper shoulder on the stem 49 of valve 50 and also tends to balance the pressure of the compressed air in the pump which holds the valve 75 against seat 74.

The head casting 57 is hollow, the interior of this casting communicating at all times with the cylinder A. The interior of the head casting 57 communicates thru the admission valve with the live air supply pipe 20 and thru the exhaust valve with the exhaust pipe 69. The interior of the head casting 57 also communicates at all times with the cylinder C thru the hollow pipe 27. This communication is afforded thru a passageway 80 in the lug 81 by which the head 23 is clamped to the intermediate member 24. The lower end of the pipe 27 is threaded solidly into a suitable socket 83 which socket has a port communicating with the cylinder C. The upper end of the pipe 27 passes thru a bore 82 in the lower side of the lug 81 and is engaged at its upper threaded end by a hollow nut 85 which presses upon a tapered inner packing member 86, forming a tight joint or seal between the bore 82 and the pipe 27. The upper end of the nut 85 is covered by a plug or cap member 87 which threads into the upper side of the lug 81. This detail is shown in Fig. 2A.

The pipe 28 is threaded at its lower end into a suitable threaded socket 88, which communicates by way of a passageway 89, with cylinder B; the upper end of the pipe 28 is secured to the lug 90 by a nut 91 similar to the nut 85 shown in Fig. 2A and it also engages a packing ring 92 for forming a tight joint between the hollow rod 28 and the adjacent wall of the lug 90. The nut 91 is covered by a cap 93 similar to the cap 87. The lug 90 is hollowed out to form a passageway which communicates with a vertical passageway 95 cored in the head casting 57, this vertical passageway in turn communicating with a horizontal passageway 96. The horizontal passageway 96 in turn communicates with a vertical passageway 97 which joins the air intake pipe 20 and the passageway 62 leading to the admission valve port 63. From the above it will be seen that the cylinder B is always in communication with the live air entering by way of pipe 20.

In Fig. 4 I have shown diagrammatically the connections of this pump.

The intermediate casting 24 contains a stuffing box for the rod 35 for separating the cylinders B and C. This stuffing box comprises a leather or fibre ring 99 pressed into engagement with the rod 35 by means of a tapered ring or follower 100, which is pressed against the end of the packing ring 99 by means of a spring 101 abutting against a threaded ring 102. The packing ring 99 is clamped in place by means of a suitable follower plate and screws as shown in Fig. 2.

The operation of the system is as follows: Assuming that the pump is properly connected to a source of compressed air such as the tank 15 which is maintained at a suitable pressure for supplying air through the reduction valve 19 and that the suction pipe 4 is submerged in the water of the well. The delivery pipe 11 after it is once pumped full stands under pressure so long as the faucets 13, 14 are closed.

If hydraulic stalling is depended upon then the pump will stand idle upon the downstroke trying to force water out of the cylinder D. If the exhaust is blocked the pump stands idle upon the end of the downstroke beyond the point of normal reversal. The exhaust blocking valve 70 is closed because of the pressure in the delivery pipe 11. Assume that one of the faucets is opened to relieve the pressure in the delivery pipe. The valve 70 is shifted to open position, exhaust of the pump occurs and thereupon the pistons are moved to their uppermost position moving the parts into the position shown in Figs. 2, 3 and 4.

The parts being in this position compressed air enters by way of the pipe 20, and passes to the interior of the head casting 57 thru the passageway 62, admission port 63, past the admission valve 66 which is now open into the interior of the hollow head casting 57, into the cylinder A, thru the port 80, pipe 27, passageway 84 into cylinder C. At the same time air is free to enter cylinder B thru the passageways 97, 96, 95, 94 pipe 28 and passageway 89. Thus the pressures in cylinders A and B are substantially equal and act with equal force minus piston rod area upon opposite sides of the piston 30. This piston 30 is substantially balanced and ineffective at this time. The live air in the cylinder C acts upon the top of the piston 31 and tends to drive it downwardly to expel the water from cylinder D. Depending upon the rate at which the water is permitted to escape at the faucet, the piston 31 is thereby moved downwardly, the

entire movable system moving downwardly, the rod 41 however remaining in its uppermost position until the follower plate 34 of the piston 30 engages the head 43 of the rod 41 as the piston structure completes its stroke, thereby moving the swinging lever 48 downwardly until the end 47 passes the line defined by the pivot 51 and the spring pin 55, whereupon the spring 54 throws the lever 48 violently in a counterclockwise direction, the right hand end of the lever 48 having lost motion just as it has at its left end, strikes the shoulder at the upper end of the reduced portion 49, moving the compound valve structure 50 upwardly to open the exhaust port and substantially simultaneously close the admission port.

It is to be noted that the exhaust valve tends to be held to its seat by the internal pressure, whereas the admission valve faces against pressure and tends to be moved off its seat. This tendency is partly compensated by the spring 77, the spring being suitably selected to adapt it to the different pressures required for different installations. As a result of the lost motion connection which the swinging lever 48 has, both with its actuating rod 41 and with the valve structure 50, the valve structure 50 is moved with a vigorous snap from one position to the other. When the exhaust valve 75 is unseated and the admission valve 66 is seated, air is free to escape from the cylinders A and C. It will be noted that in this particular case the cylinders A and B are of a smaller diameter than the cylinders C and D. In the present case the major part of the work of delivering the water from the well consists in the lift from the pump to the faucet. As will be explained later in connection with the preferred form herein illustrated and described, if the primary lift is greater than the secondary lift then the proportions of the cylinders are reversed.

As soon as the air is exhausted from cylinders A and C and from the interior of the hollow casting 57, the live air which passes down through the hollow rod 28 into the cylinder B is permitted to expand to raise the piston structure to make the intake stroke. As the piston structure rises the lower end of the stem 41 engages the bottom of the bore 40 so that the rod 41 is pushed up positively engaging the rounded ends of the fork 47 on the swinging lever 48, whereupon the valve structure is moved from the exhaust position to the admission position and air enters through the passageway 62 admission port 63 into the interior of the hollow head casting 57 into cylinder A, and at the same time through the hollow rod 27 into cylinder C. The result is that piston 30 is substantially balanced by pressures in cylinders A and B, whereas the live air acts on top of the piston 31 in cylinder C, causing the piston structure to move downwardly to expel the water. As the piston 30 moves down, it pushes the air which is in the cylinder B out of said cylinder thru the hollow rod 28, this air merely moving over to the other side of the piston 30. Assume that the exhaust blocking valve is not employed and the faucets are closed while the piston is moving downwardly. The pump is thereupon stalled and the piston structure ceases to move as soon as the water discharge pressure reaches the reducing valve pressure or its equivalent. Where the exhaust blocking valve 70 is employed, the valve is closed when the pressure in the water system reaches the predetermined value at which it is set to operate. The reducing valve 19 is preferably set at a higher value than the cut off valve 70. This permits the pump to shut off promptly when the faucets are closed without being compelled to pump the water system up to reducing valve pressure.

If the faucets are closed during the time that the pump is making a suction stroke, the suction stroke will be completed and the valve 50 shifted to the admission position and the pistons will complete a discharge stroke and a shifting of the valve 50 to exhaust position, whereupon the movement of the air pistons will be stalled until the pressure in the main 11 has been brought to the lower limit of pressure required for opening the blocking valve.

The exhaust blocking valve 70 is shown in detail in Fig. 10. This valve comprises a plug member 67′ which screws into the threaded socket 68 and takes the place of the plug shown in Figs. 3 and 6. The plug 67′ has a bore 73′ which terminates in an annular valve seat 130. A depending cylinder 131 is also formed integral with the plug 67′ and it surrounds the seat 130. This cylinder has a series of exhaust ports 132 arranged radially about and a short distance below the valve seat 130. The lower end of the cylinder 130 is closed by a head 147 having a central bore for receiving a piston rod 133 and having a central boss 134 counterbored and threaded to receive the threaded stem 135. A nut 136 is threaded upon the upper end of the stem 135 and a diaphragm frame plate 137 is threaded upon the lower end. A diaphragm 138 is clamped between the frame plate 137 and the cylinder member 139. The cylinder or diaphragm chamber 139 communicates with the water system 11 through pipe 71. The diaphragm 138 has a follower plate 140 bearing three pins 141 that are guided in the frame plate 137 into engagement with the spring retainer plate 142. The controller spring 143 is confined between the spring retainer plates 142 and 144 the po-

sition of the latter and hence the tension of the spring being adjustable by means of the nut 136.

The piston rod 133 engages at its lower end the diaphragm plate 140 and at its upper end carries a piston and valve structure. This piston and valve structure comprises a piston 145 fitting closely in the cylinder 131 and controlling the exhaust outlet ports 132 and a flat lift valve 146 cooperating with the valve seat 130.

The operation of the valve 70 will be apparent from the above. Assume that the valve is closed by pressure in the diaphragm chamber 139, and that this pressure is slowly dropping. Finally a pressure will be reached when the spring 143 moves the valve 146 very slightly off seat 130. Thereupon the air pressure escaping past valve 146 acts upon the area of piston 145 moving it quickly down accelerating the opening of the valve. The air then escapes through ports 132. The pressure having been relieved on the air side of piston 145 it will, if the same pressure still prevails in chamber 139, snap shut.

Referring now to Figs. 5 to 8, I shall describe an embodiment of my invention in which the air is employed at normal pressure for the primary lift and the air is then used expansively for the secondary lift.

Where the limit of suction lift is exceeded, a pumping cylinder is lowered into the well and the water forced upwardly. The use of the forcing cylinder is not limited to any particular depth. It may be employed within the suction limits.

In Fig. 5 I have shown the preferred form of the invention. The pump is shown as taking water from a well 1 and delivering the same under faucet control to the outlets 13′—14′ which may be upon different floors of a building. It is assumed that the primary lift is in excess of the secondary lift and the present pump is shown as operating expansively. Air is supplied from tank 15 at a pressure suitable for making in this case a lift of part of the water through both stages. The tank 15 is shown as provided with a suitable compressor 16′ operated by a motor 18′ under the control of a pressure regulator 148. The motor and compressor are preferably mounted upon the tank 15 which serves as a framework. A platform 149 is bolted to the tank by means of a strap or U bolt 150 which extends around the tank. A base member 151 is connected to the bottom of the tank 15 by means of a connecting stud 152. The platform and base are connected by a pillar or rod 153. The compressor is mounted on the platform 149 and the motor is mounted upon a base 154 which base is pivoted horizontally to the base 151. The driving belt 156 passes around the pulley of the motor and over the fly wheel of the compressor. Thus the motor serves as its own belt tightener.

This compressing unit is suitable for places where electric current is available. At all events the compressor and driving motor whether electric, gasoline or the like, may be placed at any convenient point and the compressed air pipe run to the well.

As shown in Fig. 6 the pump comprises a main pumping mechanism at the head of the well and a pumping cylinder 106 lowered in the water of the well. The pumping cylinder 106 may be of any standard construction and may, in fact, be a part of a pump already in place where it is desired to change from mechanical pumping to fluid pressure pumping with the operating mechanism of my invention. The pumping mechanism at the head of the well is substantially the same as that described in connection with Figs. 1 to 4 inclusive, with the exception that instead of filling the water cylinder D′ by suction it is raised by means of the pumping rod or sucker rod 107 and piston or sucker 108, operating in the cylinder 106. The piston or sucker 108 has a central check valve 109 to permit the raising of water therethrough during the normal reciprocation of the piston 108. The lower end of the cylinder 106 comprises a foot member 110 which may have a suitable screen (not shown) and which is provided with the usual check valve 111 of any usual or preferred construction. The upper end of the cylinder 106 comprises a cylinder head 112 connected with the drop pipe 113 which drop pipe is connected by threading into the base member 105. The base member 105 rests directly upon the well casing 114 and serves thereby to support the upper part of the pumping mechanism and to suspend the lower part of the pumping mechanism just previously described. This base member 105 has a suitable discharge passageway 115 which discharges the water through a check valve 116 into the steady flow chamber 12 and the discharge pipe 11. The operating mechanism at the head of the well comprises the air cylinder 25′ and the air and water cylinder 26′, corresponding generally in function to the cylinders 25 and 26 heretofore described.

The head member 23 comprises the head casting 57 and the valve housing 56 which is substantially identical with the corresponding parts described in connection with Figs. 1 to 4 inclusive. The only exception or difference resides in the following: The socket 61 instead of receiving the air pipe 20 is closed by a plug 118 and the air pipe 20 enters a socket formed in the plug 64′. This plug 64′ also provides a valve seat for a ball lift valve 119 closing downwardly, that is in the direction of the in flowing live air. This valve 119 must be raised off its

seat before any air can be admitted thru the passageways 62, 97, 96, 95, 94, hollow rod 28 and passageway 89 into cylinder B', since the passageway 62 communicates with live air at a point below said valve 119. The admission valve 66 heretofore described, therefore, loses its function of admitting live air to the interior of the head casting 57 the motor cylinder A' and the connected motor cylinder B' since opening of the admission valve 66 is accompanied by closing of the live air admission valve 119. Opening of the live air admission valve 119 is accomplished by means of a small stem or rod 120 projecting from the end of the compound valve 50 immediately above the admission valve 66, otherwise the valve member 50 is the same as previously described.

The exhaust valve 75 and connected parts are identical with the exhaust valve and connected parts described in connection with the showing of Figs. 1 to 4 inclusive.

The moving piston structure comprising the piston rod 35 and the pistons 30' and 31' are substantially the same as heretofore described, the sole exception being in connection with piston 31' which has an additional cup leather 121 facing downwardly. Instead of employing a lock nut on the end of the rod 35, a depending stem member 122 is threaded upon the rod 35. This depending stem or coupling member has an upper head which becomes the follower plate for the cup leather 121. The stem member 122 is of hexagonal or square cross section so as to be grasped readily and it has a threaded socket at its lower end as shown at 123 for receiving the threaded end of the sucker rod or stem 107. A lock nut 124 locks the two parts in engagement.

Where the pump of the present invention is to be installed in place of a mechanical pump, the drop pipe 113, sucker rod 107 and the working barrel and plunger 106, 108 may be employed in connection with the working head mechanism above described. Where it is desired to change over from a force pump, a windmill, a power driven pumping jack or the like, to the pump of my invention, the drop pipe 113 is cut and threaded to the proper length, if it is not already prepared. The sucker rod is then cut off and threaded according to predetermined dimensions which may be furnished with suitable instructions or which may readily be secured by measurement of the pumping head. The sucker rod 107 is then drawn up above the end of the drop pipe and the piston structure is moved down so that the stem or coupling member 122 lies below the foot member 105 so that the sucker rod 107 may be readily threaded into the stem 122 and locked in place with the lock nut 124. Thereupon, the drop pipe 113 is threaded into the bottom of the base member 105, and the base member lowered into position upon the well casing. Connection is thus established between the working head and the drop pipe and its operating connections.

It will be noted that the cylinder 25' is of greater diameter than the cylinder 26' and also that the pumping barrel 106 in the well is of a greater diameter than the cylinder 26'. Since the greater part of the lift in the present case is from the well to the head of the well, the cylinder 25' is made of a greater diameter than the cylinder 26 in order that a greater working area may be obtained for lift than for discharge.

In the present case a part of the water on the up stroke is discharged out of the pump since the cylinder 26 is not large enough to receive it all. Under these conditions the check valve 116 is not necessary.

The proportioning between the cylinders 26' and 106 is independent of the proportioning between the cylinders 25' and 26', the present proportion being provided in order that water may be discharged from the pump at each upward and each downward stroke, that is to say these cylinders present differential areas. This gives a more nearly uniform flow of water from the pump, consequently the steady flow chamber 12 may be greatly reduced or even dispensed with if desired. It is generally advisable to employ a steady flow chamber of a capacity large enough to supply minor leakage losses over a considerable period of time so that the pump will not be stopped and started by a small loss of water, as might be the case if one of the fixtures had a slow leak or drip at one of the faucets.

The cylinders A' and C' are in constant communication through the hollow rod 27 and these cylinders are intermittently put into connection with exhaust and then with cylinder B'. Cylinder B' is alternately put into communication with live air through the pipe 20 and then with cylinders A' and C' when the live air admission valve 119 is seated and the intermediate admission or transfer valve 66 is opened.

Assuming the parts to be in the condition shown in Figs. 5 to 8 the pump will have completed an upward stroke of the pistons 30', 31' and 108. During this upward movement, the valve 119 was unseated, the valve 66 was seated and the valve 75 was unseated. Under these conditions, live air was admitted to the cylinder B' under the piston 30', while cylinder C' and A' were connected to exhaust. As the piston 108 moves upwardly, the water which was forced up thru the drop pipe 113 could not all find room in the cylinder D' since the latter is of smaller diameter than the cylinder 106, with the result that some of the water was forced out thru the check valve 116 into the delivery system. Towards the end of the upward

movement, the swinging reversing valve lever 48 was moved over center, with the result that the spring 54 threw this lever and the connected valve structure 50, into the position shown in Fig. 5. In this position, the valve 119 which controls the admission of live air now stands closed, the transfer valve 66 is open and the exhaust valve 75 is closed. As a result, cylinders B′ and A′ are in communication thru the hollow rod 28 and connected passageways down thru the admission port 63 to the interior of the head casting 57. At the same time, the cylinder A′ is in communication with the cylinder C′, thru the hollow rod 27. The result is that the air in cylinders B′ and A′ is now permitted to expand into the cylinder C′ without the admission of further live air to make the discharge stroke. In this form of pump, hydraulic stalling, due to closing of the faucets, may be caused upon either the upward or the downward stroke, that is to say, with the compound valve structure 50 in either raised or lowered position. As the air expands out of the cylinders A′ and B′ into the cylinder C′, it drives the pistons 30′, 31′ and 108 downward. The check valve 111 of the pumping barrel 106 prevents the escape of water with the result that the piston 108 moves down through the water, its check valve 109 permitting this to occur, and water is forced out of the cylinder B′ into the delivery system.

As soon as the pistons approach the end of the downward stroke, the head 43 of the stem 41 engages the follower plate 34 of piston 30′, pulling down the adjacent end of the valve shifting lever, the compound valve structure 50 being shifted from admission to exhaust position with the subsequent raising of the live air admission valve 119 to admit live air to cylinder B′ below the piston 30′, while cylinder C′ and A′ are permitted to exhaust. The result is that the live air acting upon the lower surface of the piston 30′ raises the moving system including the sucker rod and sucker 108. This movement may require a relatively great effort, first because of the lift of water and second, because of the weight of the sucker rod and connected parts. As soon therefore as the moving piston system has been raised to the uppermost position, live air is shut off by downward motion of the valve member 50 closing the live air admission valve 119, opening the transfer valve 66 and closing the exhaust valve 75, with the result that the air has been charged into the cylinder B′ and is now free to expand into the cylinders A′ and C′ to make the discharge stroke for expelling the water from the cylinder D′. This use of otherwise waste energy effects a considerable saving in the operation of the pump. The valves are so timed that there is no hammering. This is secured by the trapping of air in cylinder B below the air piston 30′ so that the downward motion is quietly checked and reversed. This trapping permits of compression or cushioning of the reversal as is done in steam engines. The result is a surprisingly smoothly operating and efficient pump construction.

There is nothing which is difficult to construct or maintain in the present pump, or that would be difficult for the average owner to keep in repair. The valves are simple mechanical lift valves, the pistons employ cup leathers with which every pump owner is familiar and the operation is a straight mechanical operation. There is very little opportunity for leakage because of the peculiar relation of the pistons to each other and to the water. For instance, in the pump shown in Figs. 1 to 4 inclusive, assume that the pump stands under pressure as indicated in Fig. 4. The pressures upon the both sides of piston 30 are equal; there is no tendency for air to blow around and escape. At the same time, the stuffing box between cylinders B and C is not subject to any stress since the pressures in cylinders A, B and C are substantially all the same. Any leakage of air which would tend to occur past the piston 31 from the cylinder C into cylinder D would have to displace the water of the delivery system, and since this is under substantially equal pressure with the air the tendency for air leaks to occur is wholly negligible. In the pump shown in Figs. 1 to 4 the return stroke is always made at full speed, that is to say, the pump never stands under pressure during the suction stroke, consequently no appreciable amount of air could be lost even if the piston 30 should leak. After the cup leathers and the packing 99 are once wet they need no further lubrication and will remain tight for a long time. The valve structure 50 is of a character which does not require much lubrication, since the valves are of the lift type and the rocking of the valve shifting lever 48 is upon a knife edge pivot rather than upon a trunnion or shaft, consequently successful operation is not predicated upon continuous and careful lubrication. This, furthermore, tends to prevent the admixture of any oil with the water which forms an objectionable feature. The same advantages accrue to the pump shown in Figs. 5 to 10 inclusive. This pump may stall hydraulically on the upward stroke, when live air pressure is admitted to the cylinder B′ and the cylinders D′ and A′ are exhausted. However, the use of the blocking valve 70 prevents any leakage of air, even if the pistons 30′ and 31′ should become leaky, because with the rise of pneumatic stalling the pressures equalize. It will be noted that the cup leather 33 of the piston 30 in Fig. 3, and similarly the cup leather 33 in the piston

30′ in Fig. 5 face downwardly, so that there is a tendency for the air pressure thereupon to make the piston tight under pressure. In the same manner, the packing ring 99, as shown in Fig. 2, is so arranged that the pressure of compressed air in cylinder B tends to make the joint tight. This prevails also in the packing ring 99 shown in Fig. 5.

In Fig. 9 I have illustrated a pump similar to that shown in Figs. 5 to 8, in which the sucker cylinder 106 is of a capacity not in excess of and perhaps less than the capacity of the cylinder 26″ so that upon the up stroke of the pump no water is discharged from the pump all of the water being discharged into the cylinder D″. As a result, the only work that needs to be done on this stroke is to raise the weight of the sucker rod and the water, the downward stroke expelling the water from the cylinder D″ into the delivery system 11. As previously indicated, this permits of a higher lift for a given air pressure but it gives an intermittent discharge which must be equalized by a larger steady flow chamber 12. Otherwise, the pump diagrammatically illustrated in Fig. 9 is the same as shown in Figs. 6 to 8. In this form of pump the check valve 116 is necessary to prevent backflow from the pipe 11 upon the upstroke.

If the secondary lift is high, or if a high delivery pressure is desirable at all times, the valve construction of the pump shown in Figs. 1 to 4 may be employed, that is, live air may be admitted for each stroke of the pump as distinguished from making the downward stroke with an expansive working of air. This is a matter of selection within the range of my invention.

As shown in Figs. 5 and 6, I have provided a combined reducing valve and pressure gauge 125 since the reducing valve is generally adjusted according to the pressure gauge, I have provided the pressure gauge 126 integral with the reducing valve construction, so that when the adjusting nut 127 is turned to adjust the tension of the spring 128 the operator may have before him an indication of the effect which the adjustment produces. The pressure gauge 126 is set into the body of the reducing valve and communicates with the low pressure side of the reducing valve so that it shows the pressure which is maintained by said reducing valve

In Fig. 11 I have indicated more or less diagrammatically one manner in which mechanical blocking of the pump may be accomplished.

In this construction the head casting 57 has an integral bracket and frame member 151 connected therewith through a hollow boss 152. This hollow boss has a bore closely fitted about a plunger or stem 153 which bears at its inner end a claw or forked detent member 154. This claw or detent member is hinged to the stem 153 so that it may yield in the upward direction but is rigid in the downward direction. The stem passes through a stuffing gland at the outer end of the bore and is connected to a diaphragm 156, which is pressed outwardly by a spring 155 to resist the pressure in the diaphragm chamber 157. The diaphragm chamber 157 is connected to the water delivery system through a pipe 71′. The operation of the pump will be apparent from the above description. When the faucets are closed the pressure in the water system at once rises. This acts upon the diaphragm to push stem 153 to the right so that detent 154 comes in the way of the shoulder at the upper end of the stem 41. Upward movement of the piston 30 and stem 41 are not prevented but the detent 154 holds the stem 41 against complete movement. Engagement of head 43 with follower plate 34 prevents further movement of the pistons. Hence the pistons and valve actuating stem are stopped with the moving parts in almost complete downward position. This means that the valves stand in the position shown in Figs. 4, 8 and 9. Obviously a snap action may be employed for throwing the detent 154 into and out of the path of the stem 41.

Other features of utility and novelty will be apparent from the foregoing description and drawings.

I employ the term "double acting" with respect to a piston as meaning that useful applications of fluid pressure are employed upon both sides of the same.

I do not intend to be limited to the details nor embodiments shown and described except as set out in the appended claims.

I claim:

1. A faucet controlled fresh water supply system comprising a pump having a double acting motor cylinder and piston at the head of the well, and a single acting pumping cylinder and piston submerged in the water of the well, said motor cylinder having a reversible valve member comprising a poppet admission valve and a poppet exhaust valve for controlling said double acting motor piston, said valve member comprising a stem mounted parallel to the axis of the piston and means operated by said motor piston for imparting a snap action to the throw of said valve member.

2. A faucet controlled fresh water supply system comprising a pump having a double acting motor cylinder and a single acting pumping cylinder, said motor cylinder having a piston and a reversible valve member comprising a stem bearing opposed poppet valves at its ends, said valve constituting an admission and an exhaust valve and an operating connection between the motor piston and said valve member.

3. A faucet controlled fresh water supply

system, comprising a pump having a double acting motor cylinder and piston at the head of the well and a pumping cylinder submerged in the water of the well, said motor cylinder having a piston and having a reversible valve mechanism comprising an admission lift valve seating with pressure, a transfer lift valve seating against pressure for equalizing the pressure upon opposite sides of said piston, and an exhaust lift valve seating with pressure, said mechanism comprising a shifting stem bearing said transfer valve and said exhaust valve.

4. A faucet controlled fresh water supply system comprising a working head having three air cylinders, A, B and C and a water cylinder D, pistons for said cylinders and three lift valves namely, a live air admission valve, a transfer valve and an exhaust valve and a connection for the transfer valve for transferring air from one motor cylinder to the other two motor cylinders.

5. A faucet controlled fresh water supply system comprising a working head having three cylinders, A, B and C and a water cylinder D, pistons for said cylinders and three lift valves namely, a live air admission valve for admitting live air to cylinder B, a transfer valve for equalizing air pressure in cylinders A, B and C and an exhaust valve for exhausting cylinders A and C, a common stem for all of said pistons and means operated by said common stem for shifting said valves simultaneously.

6. A fresh water pump having compressed air actuated motor cylinders A, B and C and water cylinder D, pistons for said cylinders said pistons having a common stem, a valve member having opposed faces, valve ports having facing seats and means actuated by said common stem for shifting said valve members for engagement with said facing valve seats, said means comprising a mechanical snap action device.

7. In a fresh water pump, a water cylinder and three compressed air actuated motor cylinders, pistons for said cylinders a common stem for the pistons, a source of compressed air and connections to the air cylinders and a single inter-connected admission and exhaust valve actuated thru the movement of the common piston rod.

8. A pump comprising an operating head at the head of the well, a pumping cylinder in the water in the well and a drop pipe connecting the working head and the pumping cylinder, the pump being adapted to be connected to a normally closed delivery system, and means supplying compressed air to the operating head to maintain the delivery system under pressure, said operating head having lift valves controlling the movement of the compressed air into and out of the pump, a common valve stem for said lift valves disposed vertically in the head and a mechanically actuated snap action for shifting said valves.

9. In a pneumatic pump, a vertical air cylinder having an air piston, a water pump cylinder having a water piston, a sucker rod connected to said pump piston connected to said piston, a valve mechanism for admitting air to and exhausting the same from said air cylinder, snap means actuated by the piston for shifting the valve mechanism, said valve mechanism causing the trapping of air below the air piston towards the end of the down stroke, and simultaneously exhausting the air above the air piston to prevent hammering of the water piston.

10. A vertical air actuated pump comprising a motor cylinder at the head of the well and a pumping cylinder in the well, pistons for said cylinders connected with an actuating rod, valve mechanism for the motor cylinder comprising a reversible valve and valve passageways controlled by said valve for permitting air pressure to equalize on both sides of the air piston upon the downward stroke and to admit live air under the air piston for the up stroke.

11. The method of operating a deep well direct acting pump, having a double acting motor cylinder at the head of the well, and a water cylinder in the water in the well, which comprises equalizing the pressure at opposite ends of the motor cylinder for the down stroke, disconnecting the ends of the motor cylinder from each other as the motor piston nears the end of the down stroke, trapping air in the lower end of the motor cylinder, admitting live air to said lower end of the cylinder, and exhausting the air from the upper end to make the up stroke.

12. The method of raising water from a well to a point of use in two lifts or stages, namely a primary lift or stage from the source of supply to the head of the well, and a secondary lift or stage from the head of the well to the point of use with a fluid operated piston displacement pump which comprises applying the motor fluid to a lifting piston, the area of which is proportional to the lift and the pressure of the motive fluid to make the primary lift, then applying the air thus employed for the primary lift to a discharging piston, the area of which is proportional to the secondary lift and inversely proportional to the pressure of air so applied, and permitting said air to expand to make the secondary lift.

13. The combination of three air cylinders, means for admitting live air into one of the cylinders for making a stroke and means for admitting air from said one cylinder into the other cylinders to make the next stroke.

14. A compound fresh water pump having

three cylinders axially in line, pistons for said cylinders and a common axial piston rod, said cylinders comprising a double acting motor cylinder, a pump cylinder, and a cylinder, one end of which is a part of the pump and the other end of which is a part of the motor.

15. A compound fresh water pump having three cylinders axially in line, pistons for said cylinders and a common axial piston rod, said cylinders comprising a double acting motor cylinder, a pump cylinder, and a cylinder, one end of which is a part of the pump and the other end of which is a part of the motor, and valve mechanism for said motor pistons, said valve mechanism being actuated through a lost motion connection with said common piston rod.

16. In a faucet controlled water supply system, a pump having an air cylinder and piston, said air cylinder having an exhaust outlet, a water cylinder and piston, said pistons being connected together, a delivery system having normally closed, manually controllable outlets, a source of compressed air available at all times to operate the pump and means for blocking the exhaust outlet from the air cylinder when said delivery outlets are closed.

17. In a faucet controlled water supply system, a pump having a compressed air inlet and exhaust outlet, a control valve therefor, a source of compressed air for the pump, a delivery system having normally closed, manually controllable outlets, and means independent of said control valve for blocking the exhaust outlet from the pump when said delivery outlets are closed.

18. In a faucet controlled water supply system, a tank for storing compressed air at a relatively high pressure, a reducing valve, a pneumatically operated pump, a normally closed delivery system, means for stopping the operation of the pump, said means comprising a pressure responsive element connected to the delivery system and operable at a pressure lower than the pressure at which the reducing valve is set.

19. In a faucet controlled water supply system, a tank for storing compressed air at a relatively high pressure, a reducing valve, a pneumatically operated pump, a normally closed delivery system, means for stopping the operation of the pump, said means comprising a pressure responsive element connected to the delivery system and operable at a pressure lower than the pressure at which the reducing valve is set, said means further comprising a valve for blocking the exhaust outlet of the pump.

20. In combination, a pair of cylinders having an intermediate head member, a piston rod passing through said intermediate head member, a pair of pistons on said rod one for each cylinder, compressed air connections for three ends of said cylinders, a water connection for the fourth end, and a mechanically actuated reversible valve for said air cylinder ends operated by said piston rod.

21. In a fresh water system the combination of a pair of cylinders having a common intermediate head member, a piston rod passing through said intermediate head member, a pair of pistons, one for each cylinder two ends of one cylinder and one end of the other cylinder having compressed air connections, a mechanically actuated valve for controlling the application of compressed air to said 3-cylinder ends, and a loose coupling between said valve and said piston rod.

22. In combination, a pair of cylinders separated by a common wall, a pair of pistons, one for each cylinder, a head member for the upper end of one cylinder two ends of one cylinder and one end of the other cylinder having compressed air connections, a valve actuating rod, a reversible air valve, adapted to be actuated by said rod for controlling the application of compressed air to said 3-cylinder ends, said rod having a lost motion connection with said pistons.

23. In a faucet controlled water supply system, a pneumatically operated pump having an air admission and exhaust valve mechanism including an exhaust port governed by said valve mechanism, a delivery system connected to the pump having normally closed, manually controllable outlets, a source of compressed air available at all times to operate the pump and being controlled by said valve mechanism and means independent of said valve mechanism for blocking the exhaust outlet from said pump when said delivery outlets are closed.

24. In a pump of the class described, a pair of cylinders, a foot member for the upper cylinder, said foot member having a portion adapted to rest upon a suitable support at the head of the well such as a well casing, an axial opening through said foot member having a lateral passageway communicating with said axial opening, a drop pipe, the lower end of said opening being threaded to receive said drop pipe, the lower cylinder being connected to the bottom of said drop pipe, a piston for the upper cylinder, said piston having a stem extending down and being threaded for receiving the end of a sucker rod, a sucker rod extending through said drop pipe to the lower cylinder, the stem of the piston being adapted to enter the drop pipe upon the lower end of the stroke thereof, a head for the upper cylinder and means comprising a plurality of rods connecting said head to said foot member.

25. In combination a cylinder, a head casting having a flange for closing the end of the cylinder, a guiding cap axially in line with said f nge for guiding a stem member, a hollow lug communicating with the interior of said head member, said lug extending laterally from the flange, a second hollow lug, said lug having a live air passageway communicating with said second hollow lug and an admission passageway having a port communicating on one side with a live air passageway and on the other with the interior of the head casting, an admission valve for said port and means for actuating said valve, said means projecting into the hollow head casting and an exhaust valve mechanically connected to the admission valve and shiftable therewith.

26. A hollow head member having a flange adapted to close the upper end of a cylinder, a cylinder cooperating with the flange, a piston in the cylinder, said head member having a pair of laterally extending lugs, an intermediate member for closing the bottom of the cylinder, a packing gland in said intermediate member, said intermediate member having means for closing the upper end of a second cylinder, a second cylinder cooperating with said intermediate member, and a foot member for closing the lower end of the second cylinder, a series of bolts for securing the intermediate member and the foot member together upon the said cylinder, a pair of hollow rods connecting the lugs of the head member to the intermediate member, said hollow rods communicating at their lower ends thru passageways in the intermediate member with the adjacent ends of the first cylinder and of the second cylinder, the hollow rods at their upper ends communicating thru the hollow lugs one with the interior of the head casting and the other with a source of compressed air.

27. In combination, a first cylinder having a single acting piston cooperating therewith, a second cylinder having a double acting piston cooperating therewith, said pistons being connected, a compressed air control valve comprising an admission valve, connections between said cylinders comprising a permanently open connection between the tops of both cylinders and comprising a connection between the top of the first cylinder and the bottom of the first cylinder, said latter connection being governed by said admission valve, and a live air admission valve adapted to establish communication between the bottom of the first cylinder and a source of compressed air.

28. In combination, a first cylinder having a double acting piston cooperating therewith, a second cylinder having a double acting piston cooperating therewith, said pistons being connected, a compressed air control valve actuated by said pistons, said control valve comprising an admission valve and an exhaust valve, a permanently open connection between corresponding ends of both cylinders, a connection between opposite ends of said first cylinder controlled by said admission valve, said exhaust valve communicating with said first connection.

29. In combination, a first cylinder having a double acting piston cooperating therewith, a second cylinder having a double acting piston cooperating therewith, said pistons being connected, a compressed air control valve actuated by said pistons, said control valve comprising an admission valve and an exhaust valve, a permanently open connection between opposite ends of said first cylinder controlled by said admission valve, said exhaust valve communicating with said first connection, and a live air admission valve actuated when said exhaust valve is opened to admit live air to the said opposite end of the said cylinder.

30. In a system of the class described, a pump for raising water from the well to delivery outlets, such as faucets, the lift from the well to the head of the well being greater than the lift from the head of the well to the faucets, a pair of double acting cylinders, one cylinder having both ends devoted to compressed air and the other cylinder having one end devoted to compressed air and the other end to water, means for admitting live air against one of the pistons for raising water from the well and means for employing the expansion of said air to raise water from the head of the well to said faucets.

31. In a system of the class described, a pump having a pump cylinder in the well, a drop pipe and sucker rod extending to the head of the well, a pair of cylinders at the head of the well, pistons for said cylinders, means for admitting live air below one of said pistons to raise the sucker rod, and means for permitting the air so admitted to expand and act upon another piston to lower the piston rod and expel water from the pump.

32. In a system of the class described, a pump having a two-stage lift from the well to the point of use, said pump comprising a cylinder and piston in the well to raise water from the well to the head of the well, and a connected cylinder and piston at the head of the well for discharging the water to a point of delivery, a fluid operated motor for the pump comprising a lifting piston, the area of which, taking into account the pressure of the live air, is proportioned substantially to the first lift, and a discharging piston, the area of which, taking into account its applied pressure, is substantially proportional to the discharge lift, and valve means

permitting the air from under the first piston to expand against the said second piston for making the discharge lift.

33. A water pump comprising a cylinder in the water in the well, a check valve inlet for said cylinder, a piston having a check valve therethrough for drawing water into the cylinder through the first check valve, a cylinder at the head of the well, a piston therein connected to said first piston, a pipe connecting said cylinders and enclosing said connection, a water discharge connection connected to said pipe, and means for applying air pressure on the top side of the piston in the cylinder at the head of the well.

34. A water pump comprising a cylinder in the well and a cylinder above the well, a piston for each cylinder, a drop pipe connecting said cylinder, an outlet from said pipe, a connecting rod between the pistons, a water inlet for the lower cylinder, and means for applying air pressure to the top of the piston in the upper cylinder.

35. In combination, an upper head member, an intermediate member and a foot member, cylinders between and closed by said members, longitudinal rods compressing said members against the ends of the cylinders, said cylinders being superposed axially in alignment with respect to each other, a piston in the upper cylinder, a piston in the lower cylinder, a piston rod connecting said pistons and passing through a packed joint in the intermediate member, a drop pipe inserted axially into the bottom of the foot member, a discharge pipe communicating with the lower cylinder and with said drop pipe, a pumping cylinder connected to the lower end of the drop pipe and extending into the well, a separable rod connected to the lower piston, a pump piston in the pump cylinder connected to the bottom of said rod and valve means for admitting and exhausting air to and from the top of both of said upper pistons and the bottom of the uppermost piston.

36. In combination, a head member, an intermediate member and a foot member, cylinders between said members, a drop pipe and pump cylinder extending from the foot member into the well, pistons in each of said cylinders, a common stem connecting all of said pistons, said stem having a tight fit with the intermediate member, and an air control valve mechanism for admitting and exhausting air to and from the bottom and top of the uppermost piston and from the top of the second piston.

In witness whereof, I hereunto subscribe my name this 14th day of August, 1922.

BURTON S. AIKMAN.