Nov. 27, 1928. 1,692,916

A. A. WOODRUFF

EJECTOR

Filed Jan. 4, 1927

Fig. 1.

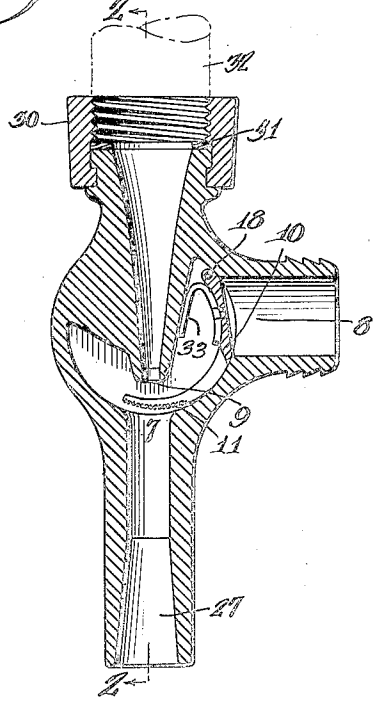


Fig. 2.

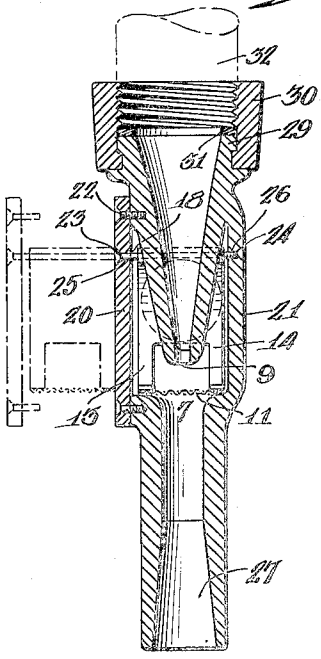


Fig. 3.

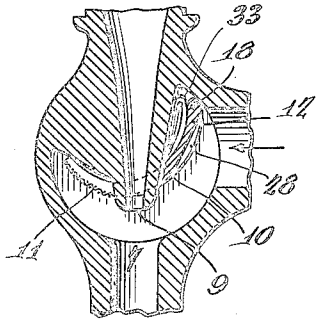
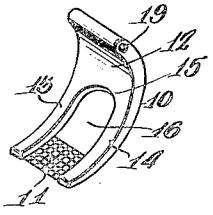


Fig. 4.



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by

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Witness:

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UNITED STATES PATENT OFFICE.

ASA ALLEN WOODRUFF, OF PHILADELPHIA, PENNSYLVANIA.

EJECTOR.

Application filed January 4, 1927. Serial No. 158,858.

My invention relates to the improved starting and subsequent improved operation of fluid actuated ejectors designed to raise the same or different kind of fluid from a lower to a higher level. As water is one of the most common of the different fluids I have for convenience hereafter in this application used the word "water" in the sense of any fluid.

The discharge passage outlet of any water actuated ejector must of necessity be larger than the actuating jet, because otherwise there would be no space for the additional volumne of water constituting the induced flow designed to be lifted by and through the device. The larger this discharge passage is in relation to the size of the actuating jet (up to a certain limit) the greater will be the volume of the induced flow of water lifted and discharged per unit of time and per unit of volume of jet. All of the energy available for increasing the velocity of the induced flow comes from the high velocity jet. This energy is transmitted from the sides of the jet by friction or contact with the surrounding inner layer or surface of the induced flow. As this action takes place concentrically with the jet and in a zone of constantly increasing diameter in the direction of flow, the center axis of the discharge passage should preferably coincide with the axis of the jet. If the jet be circular in cross-section (and this is usually the case), the discharge passage should also preferably be circular in cross-section so that this cross-section will conform to the zone of action and the flow will be evenly distributed.

This discharge passage, moreover, should preferably be designed so as to offer the least possible resistance to the flow of water through it. The passage therefore should preferably be as short as possible and its sides should preferably be smooth with parallel or slightly diverging lines. It follows from this that the sides of the discharge passage should preferably be free from any permanent obstructions, elbows, tortuous curves, irregularities, converging lines or other restrictions and the passage itself should preferably be free from any shape protruding into or across the line of discharge flow.

The only limit to the preferable shortness of the discharge passage is that it must be long enough to enable it and the discharged flow satisfactorily to perform the "sealing" function so essential to the operation of any ejector. The maintenance of a moving column of water or its equivalent out of the discharge passage of sufficient volume effectively to fill or "seal" the passage, is essential in order to prevent outside air from forcing its way back through the discharge passage and into the suction chamber around the mouth of the jet-forming nozzle. The air (or water) in this suction chamber is being constantly drawn out or exhausted by entrainment with the surface or sides of the high velocity jet. This drawing-out or exhaustion process results in a constantly lowered pressure in the suction chamber with tendency toward vacuum. The lifting of other water into this chamber through another opening therein depends entirely upon the maintenance of this partial vacuum within the suction chamber. If there be no "seal" in the discharge passage or if that "seal" be broken, the partial vacuum in the chamber will instantly be relieved by outside air rushing in through the discharge passage and no induced flow will result.

At the commencement of operation of any lifting ejector, the only water which is present in the suction chamber is the water of the jet itself, and with the discharge passage constructed so as to contain all of the preferable features above mentioned and nothing more, the jet would pass directly through the discharge passage without touching the sides. Under these conditions no "seal" would result as there would be ample space in the discharge passage between the outside surface of the jet and the inside surface of the passage to permit the free flow of air back into the suction chamber to take the place of the air entrained and carried out by the jet, consequently no difference of pressure would result, no inducing flow would take place and the ejector would not commence to function.

The first main purpose of my invention is to provide means whereby the high velocity jet stream of small cross-section is instantly expanded as it enters the discharge passage of large cross-section into an emulsion of water and air sufficiently large in cross-section effectively to fill and seal the discharge passage.

At the moment when the function of my jet-stream-expanding device (hereinafter for convenience called "expanding device") is complete and when its presence in the jet stream is no longer necessary and moreover is objectionable because of the resistance which it offers, I utilize the induced flow of

water automatically to move the expanding device out of the path of the jet, thus effecting the second main purpose of my invention. Almost simultaneously with this movement, the induced flow of water will completely surround the jet stream and thereafter I utilize the volumes of water so combined to keep the discharge passage full, and thereby to maintain throughout the remaining period of operation a highly effective seal from outside air. The high velocity jet, thus freed from the resistance initially introduced by the expanding device, is now enabled to act throughout its full length upon the surrounding and more slowly moving induced flow of water, thus continually drawing the induced flow out through the discharge passage to the greatest advantage.

At the end of any water-lifting operation by an ejector or if, during the operation, an interruption should occur in the induced flow to the extent that the suction chamber again becomes filled with air at atmospheric pressure, a new "priming" or starting operation must take place or the ejector will not function. The third main purpose of my invention is to combine my expanding device with an ejector in such a manner that upon the happening of either such event, my expanding device will instantly and automatically resume its initial position for the performance of its stream-expanding function. Thus it will be seen that my expanding device is always automatically present when needed and automatically out of the way when not needed.

Further purposes will appear in the specification and in the claims.

My invention relates to the methods involved and also to the apparatus by which the methods may be carried out.

I have elected to illustrate one form of my invention only, selecting a form which has proved to be simple, practical, efficient and reliable and which at the same time well illustrates the principles of my invention.

Figure 1 is a longitudinal section of an ordinary fluid actuated ejector showing my expanding device and a preferred method of its attachment.

Figure 2 is a longitudinal section of the same ejector shown in Figure 1 taken upon line 2—2.

Figure 3 is a fragmentary longitudinal section corresponding with a part of Figure 1, but with the expanding device in a changed position.

Figure 4 is a perspective view of my expanding device.

In the drawings similar numerals indicate like parts.

In Figures 1 and 2 I show an ejector comprising a nozzle 5, the jet from which passes through a suction chamber 6 and into a discharge passage 7 of much larger cross-section than the jet. The suction chamber is in communication laterally of the jet with water to be lifted through a suction inlet 8 adapted for attaching thereto any hose or pipe extending into said water. The nozzle terminates at 9, sufficiently above the entrance to the discharge passage to furnish room for entrainment of air and water and for the expanding device.

Referring to Figure 4 my stream-expanding device 10 consists of an expanding element 11 affixed by the arms 13 and 14 of a fitting 15 to a member 12, here generically called a "vane" and preferably imperforate. Opening 16 spaces the arms. The device is pivoted suitably as by a pin 18 passing through a hole 19 in the upper part of the vane and resting at its ends in walls 20 and 21 of the ejector casing. The expanding device is adapted to swing about the pin in planes in line with the direction of flow induced into the suction chamber through the inlet 8.

For convenient insertion of the expanding device one side 20 of the ejector is removable and is attached to the body of the ejector—with any gasketing desired—by suitable devices 22.

The pivot pin 18 for convenience of insertion, along with the removable side, is provided with a slotted head 23 and a threaded end 24 so that it may initially be passed through an opening 25 in the side 20 to support the expanding device while the side is being put in place and may then be secured into a threaded opening 26 in the casing wall.

The expanding device is adapted to swing inside the suction chamber between the positions shown in Figures 1 and 3, to which latter position it is pushed by the induced flow of water moving in through suction inlet 8 in the direction shown by the arrow. In order more effectively to provide for the induced flow of water in the latter position, where the vane is constructed of solid material as distinguished from sheet metal, it is grooved at 28 giving additional space for flow at the back of the vane.

The ejector is shown as swelled at 29 into loose engagement with coupling collar 30 by which it is sealed at 31 against any pipe fitting or other terminal 32 from which a source of water under pressure is introduced into the nozzle.

The expanding element is most effective when it operates to swell or expand the jet stream evenly and equally in all directions at right angles to the axis of the jet. Any foraminous plate or screen or sieve of proper proportions will perform this function and I prefer to use for this purpose a meshed or woven wire screen as I find that form of expanding element to be highly effective. Whatever the expanding element used, whether a meshed or woven wire screen or a

different and less efficient form, I prefer to make it movable and to cause its movement by a vane, lying within the path of flow of the fluid lifted. The more evenly the expanding element enlarges the jet stream and the closer it is located to the entrance of the discharge passage, the more need there will be to shift it out of the way when the induced flow of lifted fluid commences. In my best form the connection between the expanding element and vane—by arms 13 and 14—is direct and positive.

The discharge passage as shown is constructed with all the preferable features heretofore mentioned. It is very much larger in cross-section than the cross-section of the jet issuing from the ejector nozzle. Its center axis coincides with the axis of the jet. The jet issuing from the nozzle being circular in cross-section, the discharge passage is also made circular in cross-section so as to conform to the shape of the jet. It is constructed so as to offer the least possible resistance to the flow of water through it. It is very short with smooth sides. A longitudinal section shows the lines of its sides after entrance to be parallel for a short distance and thereafter at 27 to be slightly diverging. Its sides are free from any permanent obstructions, elbows, tortuous curves, irregularities, converging lines or other restrictions and the passage itself is free from any shape protruding into or across the line of discharge flow.

All of the preferred features of the discharge passage mentioned above operate to decrease the resistance which the passage will offer to the flow of water through it, especially the flow of water constituting the jet stream and the induced flow. I appreciate that there is an inter relation between the diameter of the discharge passage, the size of the nozzle, the extent of expansion of the jet and the longitudinal contour or line of section and length of the discharge passage which may be varied considerably to secure good results and I have illustrated the form shown for the purpose chiefly of complying with the statute by disclosing the best form known to me and without any thought of this form being essential to the operation of my invention.

I recognize that my expanding device will improve the performance of many different combinations of jet and discharge passages and that the improvement is likely to be greater with an inferior form of jet or discharge passage or with an inferior combination of both than with a superior form by reason of the greater opportunity for improvement.

The expanding device assumes by gravity (in the vertical position of ejector shown in the drawings) the position shown in Figure 1. In this position the vane lightly closes the suction opening 8 which offers the only path through which an induced flow of water can enter suction chamber 6. In this position of the expanding device, element 11 lies across the entrance to the discharge passage and consequently in line with any jet issuing out of ejector nozzle. This position of the expanding device may be called the "priming" position.

I recognize that the expanding device may be used to advantage in combination with an ejector which is placed in many other positions than the vertical position which I have shown and that in such other positions my expanding device can be made to assume its proper position at the proper time by the use of a spring such as that shown at 33. In my best form the ejector is operated in a vertical position so that in the performance of its priming or starting function the force of gravity alone is sufficient to maintain the device in its proper position. Here again, I have illustrated the form shown for the purpose chiefly of complying with the statute by disclosing the best form known to me and without any thought of this form being essential to the operation of my invention.

Having thus described the various parts of my expanding device and a method of attaching the same to the form of ejector selected to illustrate its operation, I will now describe its operation in cooperation and combination with such an ejector.

A flow of water under pressure is introduced through the coupling into the ejector nozzle and issues from the mouth of the nozzle in a high velocity jet stream. This jet stream continues at high velocity until it reaches the expanding element of expanding device 10. During this part of its flow the jet will entrain by friction along its sides a quantity of air from the suction chamber. Upon passing through the expanding element 11 of the expanding device 10 in the position shown in Figures 1 and 2, this high velocity jet with the air entrained by it will be expanded into an emulsion of water and air of lower velocity and of correspondingly larger cross-sectional area, sufficient effectively to fill and seal the discharge passage from any ingress of outside air. The continued outward flow of this emulsion of water and air through the discharge passage reduces the air pressure in the space and as long as the jet continues to issue out of the nozzle this process will continue until, in a very few seconds, a large part of the air originally contained in the suction chamber will be exhausted and air will flow into the chamber through the suction opening past the sides and edges of vane 12 which is not designed or constructed to effect an air tight closure of suction opening. This process will almost instantaneously effect a very low pressure in any hose or enclosed connection between the suction

opening and the water intended to be lifted, with the result that the water will rise in said connection until it reaches the suction opening and the outside face of the vane. The force of water thus induced against vane 12 will thereupon push the vane away from the suction opening with a swinging movement at right angles to the line of pivot pin. This movement of the vane will at the same time cause the other parts of the expanding device to move similarly with the same swinging motion to the position of those parts shown in Figure 3. Thus the expanding element will be moved out of the path of the jet stream, and the space between the arms 13 and 14 will accommodate the mouth of the ejector nozzle. Almost simultaneously with this movement of the vane and other parts of the expanding device, the induced flow of lifted water will enter through the suction opening 8 into the suction chamber, passing between the outside face of the vane and the inside of chambered casing. The groove in the vane aids this flow by furnishing an additional cross sectional area at this point. This induced flow will thereupon completely surround the high velocity jet stream as it enters the discharge passage, now freed and clear of the expanding element. The combined volumes of jet stream and induced flow will now completely fill the discharge passage and thereupon effectively perform the sealing function previously performed by the emulsion of water and air created by the expanding device. The entire energy of the jet stream now acts violently upon the surrounding flow of water induced and by contact and friction with its sides transmit the greater portion of that energy to the induced flow causing the originally low velocity of the induced flow to be greatly increased with the result that the induced flow is rapidly discharged to the greatest advantage. The more rapidly this discharge is effected the more rapidly will water be lifted and sucked into this chamber through the suction opening.

As long as there is any water remaining to be lifted the above process will continue and will finally result in complete lifting and exhaustion of that water. As soon as that occurs, outside air will follow the induced water through the opening 8 into the suction chamber, whereupon the vane, released from the pressure of the induced flow, will instantly fall back or resume its original position (shown in Figure 1) carrying with it the expanding element, which once more cooperates with the jet stream to form an emulsion seal in the discharge passage and, thereafter, until the jet is cut off by closure of the supply of water under pressure, air will be continually drawn into the suction chamber through the suction opening.

It will be evident that my automatically shiftable stream expanding device will be of benefit with any form of nozzle, varying in effectiveness with the particular type of expanding element which is used, and that its effectiveness will be greatest with an expanding element which evenly and quickly expands or enlarges the jet stream cross-section, reaching its greatest effectiveness as an automatic device with a foraminous expanding element having a considerable number of openings or holes, however formed.

In view of my invention and disclosure, variations and modifications to meet individual whim or particular need will doubtless become evident to others skilled in the art, to obtain part or all of the benefits of my invention without copying the structures shown, and I, therefore, claim all such in so far as they fall within the reasonable spirit and scope of my invention.

Having thus described my invention, what I claim as new and desire to secure by Letters Patent is:

1. An ejector having a suction chamber, a jet nozzle discharging into said chamber, a discharge passage from said chamber, a suction inlet connected to said chamber and operatively arranged in respect to said nozzle, and a movable primer element arranged in the chamber and adapted in normal position to overlie the nozzle and in abnormal position to clear the nozzle, and said primer element disposed opposite the suction inlet in position to be moved by the fluid discharge from said inlet into abnormal position.

2. An ejector having a suction chamber, a jet nozzle, and a suction inlet to said chamber, said ejector provided with a pivotal primer element including a vane portion operatively arranged in respect to the suction inlet and an expanding portion and an opening, said expanding portion normally confronting the nozzle and said opening adapted to be shifted into position for confronting the nozzle by the action of the fluid discharge from the suction inlet on the vane portion.

3. An ejector having a suction chamber, a jet nozzle, and a suction inlet to said chamber, said ejector provided with means normally confronting the nozzle to expand the fluid discharge therefrom and adapted to be automatically moved by the fluid discharge from the inlet clear of the nozzle to permit unimpeded discharge therefrom.

ASA ALLEN WOODRUFF.