

Sept. 29, 1925.

1,555,030

H. F. SCHMIDT

FLUID TRANSLATING DEVICE

Original Filed Sept. 14, 1914 2 Sheets-Sheet 1

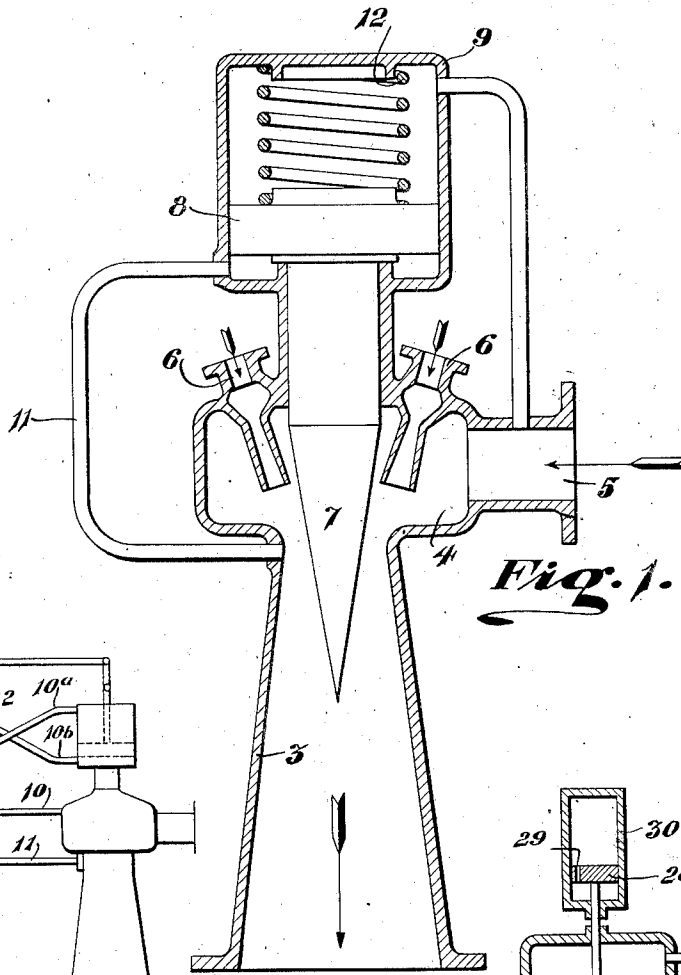


Fig. 1.

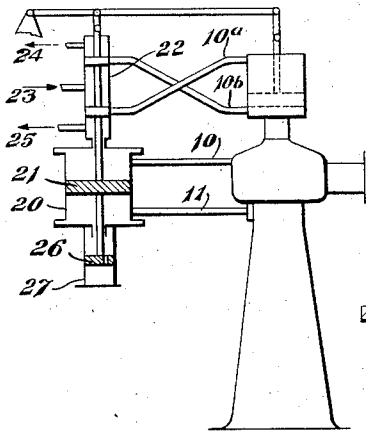


Fig. 3.

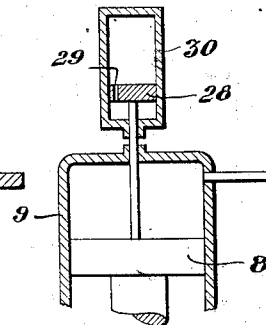


Fig. 4.

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Fig. 2.

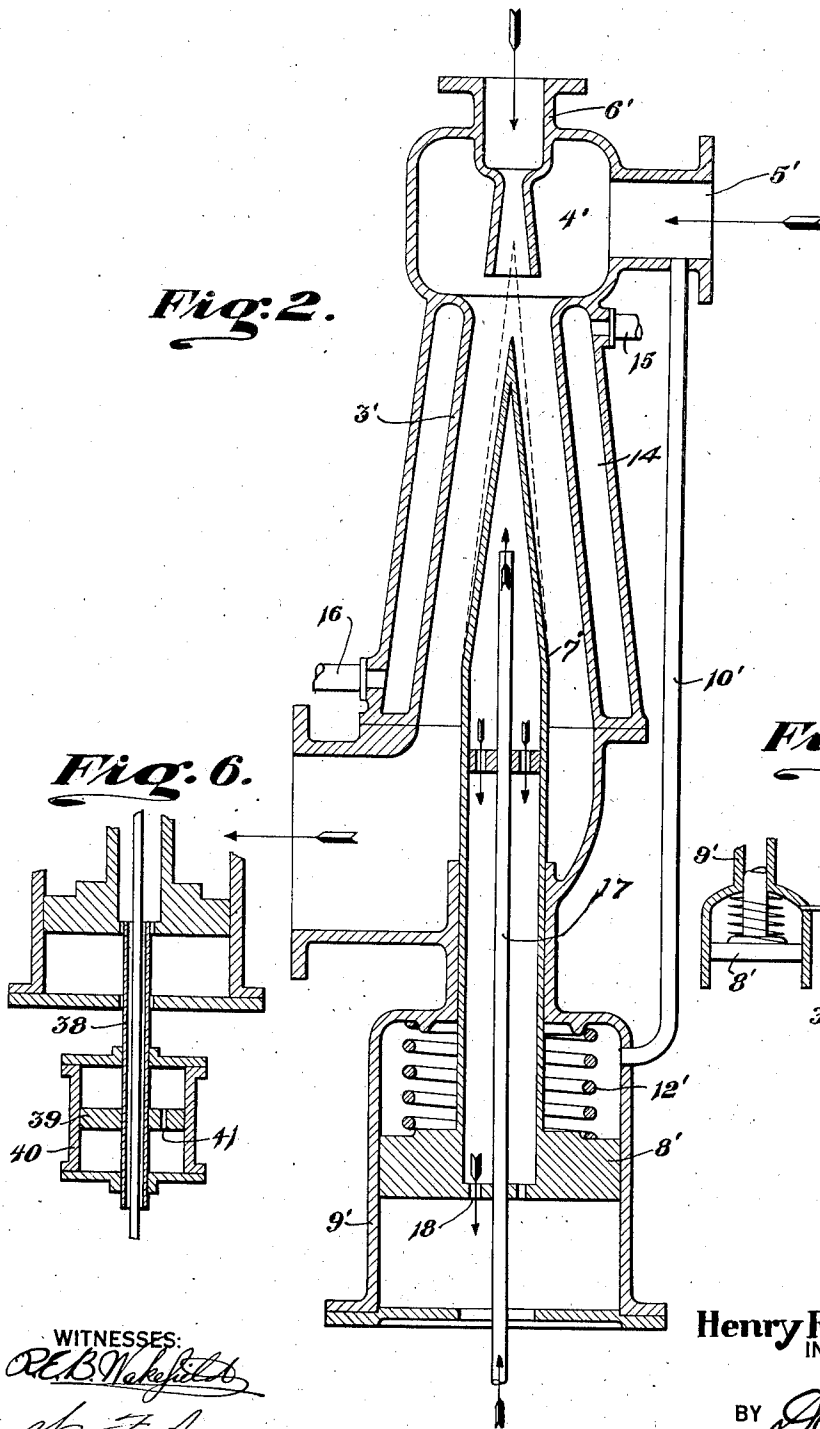


Fig. 6.

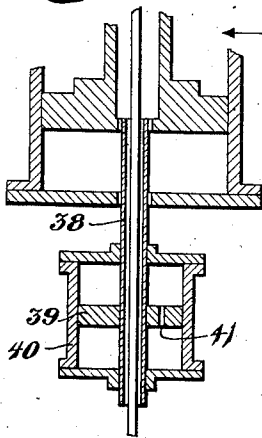
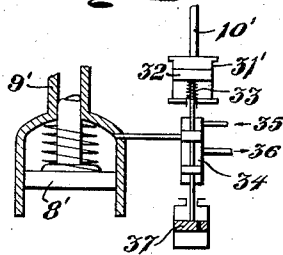


Fig. 5.



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FLUID-TRANSLATING DEVICE.

Original application filed September 14, 1914, Serial No. 861,629. Divided and this application filed December 30, 1921, Serial No. 525,932. Renewed February 27, 1924.

To all whom it may concern:

Be it known that I, HENRY F. SCHMIDT, a citizen of the United States, and a resident of Swarthmore, in the county of Delaware and State of Pennsylvania, have invented a new and useful Improvement in Fluid-Translating Devices, of which the following is a specification, this application being a division of my application, Serial No. 861,629, filed Sept. 14, 1914.

This invention relates to fluid translating devices and particularly to devices for maintaining a high vacuum in condensers or similar apparatus.

An object of the invention is to produce a fluid translating device of the kinetic type in which means are employed for maintaining the operation of the device substantially constant for practically all varying conditions.

A further object is to produce a fluid translating device employing the kinetic or velocity energy of the motive fluid delivered to it in transferring fluid from a region of lower to a region of higher pressure, which automatically adjusts itself to variations in the quantity of fluid conveyed, thus preventing fluctuations of pressure in either the region of lower or higher pressure.

These and other objects, which will be made apparent to those skilled in the art throughout the description of the invention, are attained by apparatus embodying the features herein described and illustrated in the drawings accompanying and forming a part of this application.

In the drawings:

Fig. 1 is a more or less diagrammatic sectional view of a fluid translating device or ejector embodying my invention.

Fig. 2 is a sectional view which embodies a modification of my invention.

Fig. 3 is a diagrammatic sectional view of a relay mechanism which may be employed in carrying out my invention.

Fig. 4 is a diagrammatic sectional view of a dash pot which may be employed in connection with the apparatus illustrated in Fig. 1.

Fig. 5 is a diagrammatic sectional view of a relay mechanism which may be employed in connection with the apparatus illustrated in Fig. 2.

Fig. 6 is a diagrammatic sectional view of a dash pot which may be employed in connection with the apparatus illustrated in Fig. 2.

In fluid translating devices such, for example, as ejectors, which employ a stream or jet of fluid as the propelling medium for exhausting fluid from a receptacle, or for transferring fluid from a region of lower to a region of higher pressure, it is necessary to construct the fluid conducting passage, through which the propelling medium and the medium entrained move in accordance with the following equation:

$$\frac{AV}{v'} = W,$$

in which A equals the cross sectional area of the tube at any point; V the velocity of the combined media passing that point; v' the specific volume of the combined media; and W a constant which is equal to the weight of the media passing the point, in a unit of time.

It will be apparent, therefore, that if the fluid translating device or ejector is designed to attain a high degree of compression under one set of operating conditions, it will not be suitable for starting or for operating under varying conditions. In order, therefore, to render the ejector effective for all varying conditions, it is necessary to vary the dimension of the fluid conducting or delivering passage in accordance with variations in the conditions, or to effect a change, which is the equivalent of changing the dimensions of the passage to meet the varying conditions.

In the present application I have illustrated ejectors in which means are employed for varying the effective area of the throat of the fluid delivering passage or diffuser in response to variations in the volume of fluid passing from the region of lower pressure through the diffuser to the outlet, or to the region of higher pressure. It is well known that the pressures existing throughout the diffuser vary in response to variations in the amount of fluid traversing the diffuser, and it is also well known that in order to prevent upsetting when the ejector is operating under light load, or at less than its designed capacity, it is necessary that the

pressure, at each point along the diffuser, remain substantially constant. I therefore provide means which corresponds in its operation to variations in diffuser pressure and which operates to vary the effective throat or the effective area of the diffuser.

Referring to Fig. 1, the apparatus there illustrated as an embodiment of my invention includes a diffuser 3, which is provided with a divergent wall and which communicates with a chamber 4 having an inlet port or passage 5. The passage 5 is adapted to communicate with a condenser or a receptacle from which fluid or medium is to be withdrawn. The chamber 4 is also provided with one or more fluid delivery nozzles 6 of any suitable design, but preferably converging-diverging nozzles which are adapted to receive high pressure fluid, for example, steam, and after expanding it to the pressure existing in the chamber 4, to discharge it through the diffuser 3. The nozzles, if more than one is employed, are so arranged that in discharging through the chamber 4 and into the diffuser 3, they entrain the fluid or medium in the chamber 4 and with it form a single stream which enters the throat of the diffuser and traverses the diffuser.

Since, in order to provide an effective ejector, it is necessary that the product of the area of the conducting passage and the velocity of the medium divided by the specific volume of the medium shall equal a constant, which is the weight of medium passing through the ejector in a unit of time, since it also is desirable to maintain a constant pressure in the chamber 4, the specific volume of the medium will therefore be maintained constant; and since the nozzle or nozzles 6 discharge from a constant initial to a constant final pressure, i. e., the pressure in the chamber 4, it is evident that, in order to maintain a condition of stable equilibrium in the diffuser, the area of the diffuser must be varied in direct proportion to the variations in the weight of the medium passing through it.

If the area of the throat of the diffuser is not varied, as above set forth, it is evident that, since the weight of the medium is varying while specific volume of the medium of the chamber 4 remains constant, the velocity of the medium passing through the throat must vary, that is, decrease if the weight of medium passing decreases, and increase if the weight of medium passing increases. In order to compress or discharge medium from the chamber 4 through the outlet of the diffuser 3, a definite amount of work per unit weight of medium must be performed, and this work of compression or translation must be provided by the kinetic energy of the medium at the entrance of the diffuser. Consequently if the velocity of the medium

at the entrance decreases so that the kinetic energy of the medium is less than the work necessary to move the medium from the lower to the higher pressure, it is apparent that the medium will not be discharged from the outlet of the diffuser. Under such conditions the velocity of the medium in the diffuser will immediately drop to zero, and not only no work of compression will be accomplished, but fluid will flow from the region of higher pressure or the outlet end of the diffuser into the region of lower pressure, or the chamber 4. This result is technically known as upsetting, to which reference has been previously made.

The present embodiment of my invention includes a conical plug 7, which extends axially of the diffuser 3 and is movable longitudinally by a piston 8, in such a manner as to increase or decrease the effective area of the throat of the diffuser and thereby maintain a constant velocity of the medium through the throat so as to maintain a condition of equilibrium for all rates of fluid or medium delivery.

The piston 8 is mounted in a cylinder 9, to one end of which, as for example above the piston, the pressure existing in the chamber 4 is transmitted through a pipe or passage 10, and to the other end of which, or below the piston, the pressure existing at some point along the diffuser, is transmitted through a pipe or passage 11. I also provide some means, such for example, as a light coiled spring 12, for yieldingly resisting movement of the piston in response to a preponderance of pressure introduced through the pipe 11.

The spring serves the purpose of insuring a definite position of the piston 8, and consequently of the plug 7, for each increment of pressure variation in the diffuser 3 at the point of communication with the pipe 11. With this arrangement, the plug 7 will move to different positions in response to variations in the relative pressures in the chamber 4 and the point of communication of the pipe 11 with the diffuser, and will therefore proportion the effective throat of the diffuser, in accordance with variations in the amount of fluid traversing the diffuser.

It will, of course, be understood that the pressure in the diffuser 3 will always be higher than the pressure in the inlet chamber 4 when the ejector is in operation. However, the pressure ratio, or in other words, the differential pressure acting on the piston 8, will vary as the density of the medium in the chamber 4 varies. When starting up the pressure in the diffuser will preponderate over the pressure in the inlet chamber to a much greater extent than when a partial vacuum is established in the chamber 4, consequently when the quantity of medium to be removed is large the plunger 7 is raised,

and when the quantity to be removed is small the plunger 7 is lowered.

It will be understood that the apparatus of Fig. 1 is merely illustrative, and that under ordinary working conditions, the difference in pressure existing in the cylinder 9 above and below the piston 8 may not be sufficient to overcome friction and the inertia of the parts and to insure the proper operation of the plug 7. It may therefore be desirable to connect the pipes 10 and 11 to the operating cylinder of a light and sensitive relay, which will control the delivery of operating medium to the cylinder 9 in response to variations in the pressure differences between the chamber 4 and the diffuser. It will also be apparent that under ordinary conditions it will be desirable to employ some means, such for example as a dash pot, for preventing the slight fluctuations in pressure within the diffuser 3 from affecting the operation of the plug 7; and that the dash pot may be operatively connected to either the relay or to the piston 8.

In Fig. 3 I have shown a relay mechanism which may be employed in controlling the piston 8 and hence the plug 7. As illustrated, this mechanism comprises a cylinder 20 in which a piston 21 operates in response to variations in pressure in the two pipes 10 and 11 which connect the ejector inlet 5 and the diffuser 3 with opposite ends of the cylinder 20. A pilot valve 22 is shown as adapted to be operated by the piston 21 and controls the delivery of a relatively high pressure actuating fluid to and from the cylinder 9 through the pipes 10^a and 10^b. Actuating fluid, preferably oil, may be supplied to the pilot valve by means of a pipe 23, and is carried off by means of exhaust pipes 24 and 25. I have also shown a piston 26 connected to the piston 21 for preventing slight fluctuations in pressure from affecting the operation of the piston 21. The piston 26 loosely fits in a closed cylinder 27, or may be provided with a restricted hole or passageway so as to allow a limited flow of fluid past the piston so that it may move only under the influence of a force of reasonable duration.

In Fig. 4, I have shown a dash pot as connected directly to the plug-controlling piston 8 in order to prevent movements in response to minor and discontinuous fluctuations in the pressures. As shown, the dash pot consists of a piston 28 having a restricted opening or by-pass 29 and adapted to slide in a cylinder 30. The cylinder 30 may be filled with oil or any other fluid.

In Fig. 2 I have shown an embodiment of my invention in which a single nozzle 6', for delivering impelling fluid through the chamber 4' is employed. The chamber 4' is also provided with a port 5', which is adapted to communicate with a receptacle

to be evacuated and means are employed for automatically varying the effective area of the throat or of the entire diffuser tube.

The means illustrated consists of a conical plug 7', which extends axially of the diffuser and is located in front of and in alignment with, the nozzle 6'. The plug 7' is provided with automatic means for moving it in response to variations in the pressure existing in the chamber 4'. The means illustrated consists of a piston 8', which is located in a cylinder 9' and which is rigidly secured to the plug 7'. The chamber 4' communicating with one end of the cylinder 9' through a passage 10', while the other end of the cylinder is open to the atmosphere. Under such conditions the piston 8' will move in response to variations between atmosphere pressure, as exerted on one side and chamber 4' pressure, as exerted on the other side. A spring 12', having the functions of the spring 12 of Fig. 1, is also employed for opposing the motion of the piston occasioned by a preponderance of the atmospheric pressure over that of the chamber 4'. In this apparatus, just as in the apparatus illustrated in Fig. 1, it may be desirable to employ a dash pot in connection with the piston 8', and it may also be desirable to operate the plug 7' through the agency of a relay valve which itself operates in response to variations in pressure within the chamber 4'.

In Fig. 5, I have shown a relay mechanism which may be employed for magnifying the force exerted by the pressure of the fluid in the ejector inlet 5'. As shown, the pipe 10' is connected to one end of a cylinder 31, in which a piston 32 operates. A spring 33 in the other end of the cylinder 31 is adapted to oppose the force of the fluid pressure. The piston 32 actuates a pilot valve 34, which controls the delivery of relatively high pressure actuating fluid to and from the plug controlling cylinder 9'. As illustrated, high pressure fluid, such as oil, may be delivered to the pilot valve 34, by means of a pipe 35, and a pipe 36 is adapted to carry away the fluid exhausted from the cylinder 9'. I have also shown a dash pot connected to the pilot valve 34 for preventing a response to discontinuous and minor pressure fluctuations.

In Fig. 6, I have shown a dash pot which may be employed for steadying the plug controlling piston 8'. As illustrated, a hollow stem 38, enclosing the stationary cooling fluid inlet pipe is attached at one end to the piston 8' and at the other end to a piston 39. The piston 39 is adapted to slide in a closed cylinder 40 and is provided with a restricted passageway or by-pass 41 for allowing the passage of fluid from one side of the piston 39 to the other

under the influence of a reasonable continuous and powerful force.

In the apparatus illustrated in Fig. 2, I have provided means for delivering a cooling medium to the diffuser 3', which consists of a water jacket 14 surrounding the divergent wall of the diffuser, and means for introducing cooling water into the interior of the plug 7'. The water jacket 14 preferably receives cooling water through a pipe or passage 15 and discharges it through a passage 16. Cooling water is preferably delivered to the apex of the conical plug 7' through a pipe 17, which extends axially of the plug and enters the plug at its cylinder end. The water discharged from the plug issues through ports 18 and may be discharged from the cylinder 9' in any suitable manner.

The object of introducing cooling medium to the diffuser is to condense the impelling fluid or steam while it is in motion or as it traverses the diffuser. By so doing, the volume per unit of weight of the propelling fluid is materially reduced, and therefore the work which it must do to discharge itself against the outlet pressure is reduced, thereby rendering a greater amount of energy available for expelling the medium from the chamber 4'. A propelling medium with a lower initial velocity, or containing less kinetic energy per unit of weight at the nozzle outlet, is therefore capable of discharging a larger volume or weight of medium from the chamber 4' to the outlet of the diffuser than if it were not condensed or cooled.

Although it is not possible to condense all the motive fluid or steam used as the propelling medium while it is in motion, if this were possible, it will be readily seen that the resulting water of condensation would be moving with the velocity of steam discharged from the outlet of the nozzle 6'. The pressure against which this moving jet of water could discharge itself would be many thousand times the pressure against which steam moving at the same velocity could discharge itself.

In the apparatus of Fig. 2 the plug 7' is not only adapted to vary the effective area of the ejector 3', but it may also be so proportioned that it will enter the discharge end of the nozzle 6' and therefore cut down the delivery of steam by that nozzle to the ejector. It will be apparent that as the absolute pressure of the chamber 4' decreases, the plug 7' will move further into the diffuser, since a smaller volume of fluid is being discharged through the diffuser, and that at a determined pressure within the chamber 4', the amount of fluid entrained in the chamber 4' will be so reduced that the volume of steam issuing from the nozzle 6' may also be reduced. At this pressure the apex of the

plug 7' will enter the nozzle 6' and will start to reduce the discharge of steam from the nozzle.

Attention is directed to my copending application serially numbered 861,630, filed September 14, 1914, and entitled "Fluid translating device", in which I have illustrated and claimed an ejecting apparatus consisting of a diffuser communicating with the source of medium to be expelled, a nozzle for delivering expelling or motive fluid into and through the diffuser, and means responsive to variations in the pressures encountered within the ejector or the amount of medium to be ejected for varying the effective area of the nozzle. The apparatus illustrated is a two stage ejector in which the first stage includes the motive fluid delivery nozzle and the diffuser above described, and the second stage includes a diffuser and an annular nozzle or annular series of nozzles for delivering expelling or motive fluid into and through the second diffuser. The second diffuser communicates with and receives fluid and medium expelled from the first mentioned diffuser.

In my copending application entitled "Fluid translating device", Serial No. 861,631, filed September 14, 1914, I have disclosed and claimed an ejector in which the main nozzle is surrounded by accelerating nozzles. The flow of motive fluid to the accelerating nozzles is controlled by means responsive to variations in pressure conditions within the ejector, and the position of the main nozzle is similarly controlled. The controlling means described and illustrated is similar to the means, illustrated in Fig. 2 of my application, Serial No. 861,633, hereafter referred to, for controlling the position of the main nozzle. The delivery of motive fluid to the accelerating nozzles of this application, No. 861,631, is controlled by ports formed in a movable tubular extension of the movable main delivery nozzle.

In my copending application serially numbered 861,633, filed September 14, 1914 and entitled "Fluid translating device", I have illustrated, described and claimed a single stage ejecting device communicating with a source of medium to be expelled, and a nozzle for delivering expelling or motive fluid through the diffuser. The nozzle is capable of movement toward and away from the inlet end of the diffuser and this movement is controlled by pressure variations within the ejecting device. Means are also disclosed and claimed for varying the effective throat of the movable nozzle in response to variations in the pressure encountered within the apparatus.

In my copending application, Serial No. 861,634, filed September 14, 1914 and entitled "Fluid translating device", I have illustrated, described and claimed an eject-

ing device provided with a passage from which medium is to be ejected communicating with a diffuser through which the medium from the passage is expelled. A fluid delivery nozzle delivers expelling fluid through a diffuser and a means responsive to variations in the amount of medium entering the passage is provided for controlling direct communication between the diffuser and the passage. I have further illustrated and claimed a two-stage ejector in which both stages are provided with inlet members capable of being placed in communication with a source of medium to be expelled. The first stage is shown in open communication with the source of medium to be expelled, whereas the second stage is provided with ports located substantially at the throat of its converging-diverging diffuser and communicating with the source of medium to be expelled through a passage which in effect forms a by-pass around the first stage. This passage is provided with a valve which operates in response to variations in pressure at the throat of the second stage diffuser and therefore controls the delivery of medium to be expelled to the ports of the second stage diffuser.

In my copending application, Serial No 861,635, filed September 14, 1914 and entitled "Fluid translating device", I have disclosed and claimed a multi-stage ejector in which the diffuser of the final ejector of the series is movable for the purpose of varying the delivery of motive fluid through the nozzles of the second stage or the expansion ratio of those nozzles. In addition to the above, the application discloses and claims a diffuser for the final stage which is movable in response to variations in pressure within the ejector for the purpose of delivering fluid from the source of medium to be expelled around the initial stage or stages directly to the final diffuser.

In my copending application serially numbered 374,371, filed April 16, 1920, and entitled "Fluid translating device", I have illustrated, described and claimed a single stage ejecting device in which a nozzle head, comprising a central nozzle and an annular series of nozzles surrounding and below the central nozzle, is capable of movement toward and away from the inlet of the diffuser, this movement being controlled by pressure variations within the ejecting device. The nozzle head is also provided with ports for fluid to be translated cooperative with the central diffusing nozzle.

In my copending application entitled "Fluid translating device", filed September 14, 1914, and serially numbered 861,629, I have illustrated and claimed an ejecting device comprising a diffuser provided with a jacket thereabout through which a cooling medium is adapted to be circulated, a nozzle

for delivering expelling or motive fluid through the diffuser, and means movable in response to variations in the amount of medium to be expelled for varying the effective area of the diffuser, said means, as illustrated, being a hollow movable plug or cone-shaped member through which a cooling medium is adapted to be circulated and which is moved to different positions in relation to the diffuser for the purpose of varying both the effective area of the diffuser and the delivery of expelling fluid through the nozzle. The hollow plug is shown as actuated by a piston which moves in response to variations in pressure conditions within the diffuser. The claims in the above described application are limited to features involving cooling of the fluids during their passage through the ejector.

It will be apparent that my invention may be employed in connection with ejectors employing a liquid, a condensable or non-condensable fluid as the propelling medium, and that it may be employed in connection with ejectors adapted to convey or eject a liquid or non-condensable fluid. For these reasons I have employed the term fluid in its broadest sense throughout the entire application, since I do not wish to limit the invention to apparatus employing either compressible or non-compressible fluids as the impelling or the impelled medium.

It will also be apparent that while I have illustrated but two modifications of my invention, various changes, modifications, substitutions, omissions and additions may be made without departing from the spirit and scope of the invention as set forth by the appended claims.

What I claim is:

1. In combination in an apparatus of the character described, a diffuser, a chamber communicating therewith, means for delivering a jet of motive fluid through the diffuser for translating medium contained in the chamber through the diffuser, and movable means within the diffuser responsive to variations in the amount of medium to be translated for varying the effective area of the throat of the diffuser.

2. In combination in an apparatus of the character described, a diffuser, a chamber communicating with the diffuser, means for delivering a jet of motive fluid through the diffuser for translating medium contained in the chamber through the diffuser, and movable means within the diffuser responsive to variations in the amount of medium to be translated from the chamber for varying the effective area of a portion of the diffuser.

3. In combination in an apparatus of the character described, a diffuser, a chamber communicating therewith, means for delivering a jet of motive fluid through the diffuser for translating medium from the

chamber through the diffuser, and a member movable in response to variations in the amount of medium to be translated, for varying the effective area of a portion of the diffuser.

4. In combination in an apparatus of the character described, a chamber from which fluid medium is to be exhausted, a diffuser communicating therewith, a nozzle for delivering motive fluid into and through the chamber, and means located within the diffuser for varying the effective area of the diffuser to compensate for variations in the amount of medium to be removed from said chamber.

5. In combination in an apparatus of the character described, a chamber from which fluid is to be removed, a diffuser communicating with said chamber, a nozzle for delivering motive fluid into and through said chamber and diffuser, and means located within the diffuser for varying the effective area of the diffuser and the nozzle.

6. In combination in an apparatus of the character described, a diffuser, a chamber communicating therewith, means for delivering a jet of motive fluid through the diffuser for translating medium from the chamber through the diffuser, and a member movable in response to variations in the amount of medium to be translated, for varying the effective area of the diffuser and of the motive fluid delivery means.

7. An ejector comprising an inlet chamber, a converging-diverging tube communicating therewith, means for delivering motive fluid at high velocity to said tube, a member located within the tube and formed to present a minimum resistance to flow for varying the effective area of the converging-diverging tube, and means responsive to variations in the operating pressure ratio of the ejector for controlling said member.

8. An ejector comprising an inlet chamber, a converging-diverging tube communicating therewith, means for delivering motive fluid at high velocity to said tube, a

member formed to present a minimum resistance to flow for varying the effective area of the tube, means responsive to variations in the operating pressure ratio of the ejector for controlling said member, and means for preventing said means from responding to minor discontinuous variations in the pressure ratio.

9. In combination in an apparatus of the character described, a diffuser having means for varying the effective flow area of a portion of the diffuser.

10. In combination in an apparatus of the character described, a diffuser having means for effecting a coordination of the effective flow area of a portion of the diffuser and the amount of fluid flowing there-through.

11. The process of ejecting a fluid which consists in passing a motive fluid together with fluid entrained therein through a diffuser, and in maintaining a normal ratio of compression in the diffuser under varying amounts of the fluid passing there-through.

12. The process of ejecting a fluid which consists in passing a motive fluid together with fluid entrained therein through a diffuser, and in automatically stabilizing the flow of fluid through said diffuser.

13. The process of ejecting a fluid which consists in passing a motive fluid together with fluid entrained therein through a diffuser, and in automatically stabilizing the compression of fluid in the diffuser under varying conditions of fluid flow there-through.

14. The process of ejecting a fluid which consists in compressing a fluid in a diffuser, and in automatically stabilizing the compression under varying amounts of fluid undergoing compression in the diffuser.

In testimony whereof, I have hereunto subscribed my name this 29th day of December, 1921.

HENRY F. SCHMIDT.