Dec. 16, 1947. H. S. BIMPSON 2,432,651

EJECTOR

Filed March 1, 1945 2 Sheets-Sheet 1

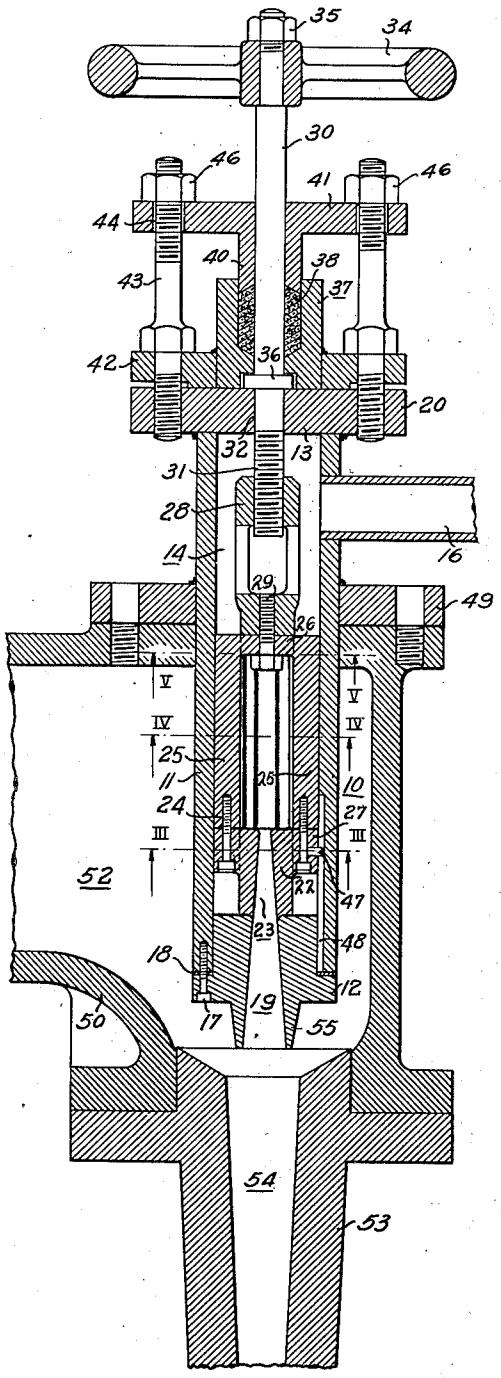


Fig. 1

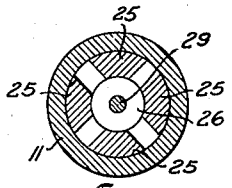


Fig. 5

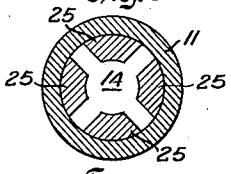


Fig. 4

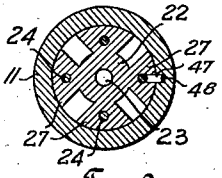


Fig. 3

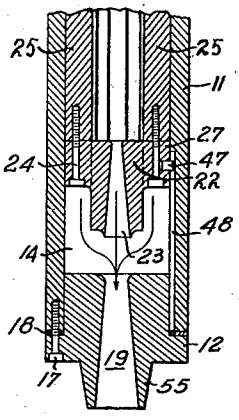


Fig. 2

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EJECTOR

Filed March 1, 1945 2 Sheets-Sheet 2

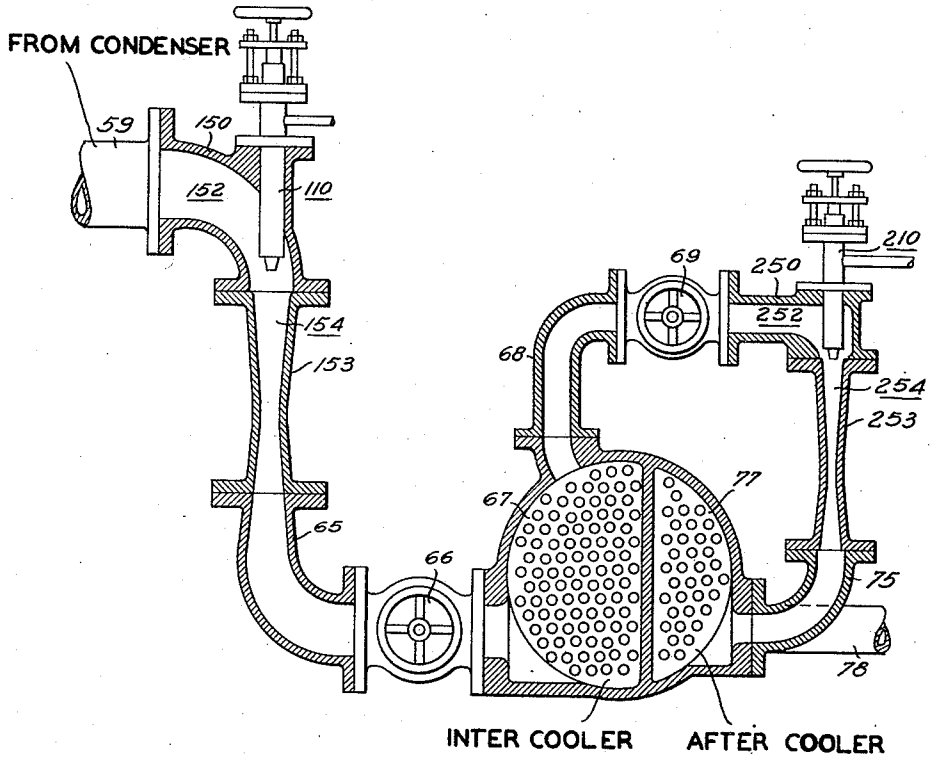


Fig. 6

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UNITED STATES PATENT OFFICE

2,432,651

EJECTOR

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7 Claims. (Cl. 299—136)

1

The present invention relates generally to improvements in jet pumps of the ejector type, and relates more particularly to improvements in the construction and operation of jet ejectors of variable capacity.

It has heretofore been proposed to evacuate air and other gaseous fluids from spaces within condensers or the like by means of jet pumps, commonly called ejectors, which utilize a propelling jet of steam or other suitable motive fluid to create a suction in the exhaust line from the space to be exhausted, thereby causing the evacuation of gases and producing a vacuum within the desired space. In addition to the mere provision of means for causing or aiding in the evacuation of gases and consequent production of a vacuum, it is extremely advantageous to provide means which may serve as a primer and operable to initially quickly evacuate the space from atmospheric pressure to a desired degree of vacuum and means for thereafter maintaining such established pressure within the space approximately constant.

To accomplish the advantageous results hereinabove set forth, it has heretofore been common practice to provide, in addition to the regular ejector or ejectors utilized for normal operation and necessary only to maintain the established vacuum, an auxiliary ejector or primer of large capacity operable to initially hurriedly evacuate the space. When a separate primer of this type is used, the primer is operated only for a relatively short period of time during the initial evacuation of the gases and until the desired vacuum has been established within the space. Thereafter, the primer is rendered inoperative by closing off the supply of motive fluid thereto; and while the established pressure in the space is maintained approximately constant by the regular low capacity ejector, no function whatsoever is performed by the primer which stands idle during such normal operation. In prior systems of this type, each ejector is designed, in accordance with known principles, to serve its required function, the so-called regular or low capacity ejector being especially designed for low capacity, high vacuum operation and the primer or auxiliary ejector being designed for high capacity, low vacuum operation. It is therefore apparent that, although the desired advantageous results may be accomplished by provision of such separate priming apparatus, the cost, weight and size of the resultant assemblage is necessarily increased by reason of the primer and the additional piping, fittings and controls essential to the operation thereof.

It has likewise been heretofore proposed to provide ejectors of variable capacity, in which the size of the jet of motive fluid may be adjusted to facilitate starting as well as to vary the capacity

2

of the ejector within a limited range to correct the performance thereof in accordance with the requirements or demands in a particular system. In such prior variable capacity ejectors, the capacity may be adjusted so that a slight variance in the amount of vacuum within a space may be obtained as operating conditions require. The volume of steam or other motive fluid discharged from this type of ejector is ordinarily regulated by means of a plug or needle which may be moved axially within the steam chamber of the ejector in a direction away from or toward the discharge end of the nozzle centrally of its orifice, thereby acting as a valve to regulate the amount of discharge of the motive fluid through the nozzle. However, such variable capacity prior art ejectors not only are designed for operation within a relatively limited range of adjustment for normal capacity operation, but also have the objection that the movable plug or needle constitutes a restriction in the throat of the discharge orifice which not only interferes with and disturbs the normal flow of the issuing motive fluid but also creates an increased frictional resistance to such flow due to the additional surface area necessarily traversed by the fluid in its passage through the orifice, thereby decreasing the efficiency of the unit. Furthermore, adjustment of the needle or plug in such a device must be made in accordance with calibrations on the adjusting mechanism, and this is definitely not a positive means of adjustment because of inaccuracies which may occur as the several parts of the device are subjected to wear.

It is therefore an object of the present invention to provide an improved ejector which obviates the objectionable features of prior devices.

Another object of the present invention is to provide an improved ejector adapted for normal low capacity operation at a relatively high vacuum and which may be readily converted by simple adjustment to a high capacity priming ejector for operation at a low vacuum.

Another object of the invention is to provide an improved ejector of variable capacity wherein automatically positive adjustments from priming capacity to normal capacity and from normal capacity to priming capacity may be readily effected.

Another object of my invention is to provide an improved ejector for gaseous fluids which is of unitary assemblage and wherein the capacity may be readily adjusted for either high priming capacity or low normal capacity by means of separable nozzle members movable relative to each other to vary the length and effective diameter of the discharge passage without interfering with the efficiency of the ejector.

Another object of the present invention is to provide an improved ejector having a plurality of nozzle members formed with aligned openings, at

least one of the members being axially movable to vary the capacity of the ejector.

Another object of the invention is to provide an ejector with an improved nozzle having a discharge passage formed therein and means for varying the area of the discharge passage without internally obstructing the passage.

Still another object of the present invention is to provide an improved ejector having means forming a supply chamber, a priming nozzle having a discharge opening or passage formed therein communicating with the chamber, means within the chamber forming a nozzle member having an opening or passage of smaller capacity than the first mentioned opening, and means for moving the nozzle member toward and away from the priming nozzle.

A further object of this invention is to provide an improved ejector having a nozzle formed with an outwardly diverging discharge passage and means for varying the diameter of the restricted end of the discharge passage.

An additional object of the invention is to provide an improved jet ejector for evacuating gas filled spaces which is simple and compact in construction, and which may be easily manipulated to effectively and efficiently operate either at normal capacity or as a high capacity primer.

Additional objects and advantages of the present invention will be apparent from the following detailed description.

A clear conception of one embodiment of the present improvement and of the mode of constructing and of utilizing devices built in accordance with my invention may be had by referring to the drawing accompanying and forming a part of this specification, wherein like reference characters designate the same or similar parts in the various views.

Fig. 1 is a central vertical section through an ejector embodying the features of my present improvement and showing the device in a position of adjustment for normal capacity;

Fig. 2 is a fragmentary sectional view showing the device in a position of adjustment for increased priming capacity;

Fig. 3 is a horizontal section taken along the line III—III of Fig. 1;

Fig. 4 is a horizontal section taken along the line IV—IV of Fig. 1;

Fig. 5 is a horizontal section taken along the line V—V of Fig. 1; and

Fig. 6 is a diagrammatic sectional view through a system embodying the present invention.

Referring to the drawings and more particularly to Figs. 1 to 5, inclusive, my improved device comprises in general, a steam chest or housing 10 having a cylindrical side wall 11 carrying a fixed nozzle member 12 at one end thereof and provided with an end wall 13 at its opposite end, thereby forming a chamber 14 adapted to receive a supply of steam or other suitable motive fluid such as air under pressure from a suitable source through a supply pipe 16. The nozzle member 12 may be fixedly secured to the wall 11 in any suitable manner, as by means of bolts 17, with a gasket 18 for sealing the joint. A central outwardly diverging opening 19 is provided in the nozzle member 12 to form the discharge passage thereof, and this passage 19 is of sufficient diameter and of such design as to permit the nozzle member 12 to effectively function as a high capacity priming nozzle at low vacuum. The end wall 13 is secured to the cylindrical wall 12 by welding or the like and is

preferably of greater diameter than the cylinder to provide an annular flange 20.

An annular ring forming a nozzle member 22, provided with a central opening 23 therethrough, is mounted within the chamber 14 for axial movement with respect to the discharge passage 19 of the fixed nozzle member 12 as will hereinafter be more fully described. The opening 23 formed in the movable nozzle member 22 is aligned with the passage 19 and is likewise divergent but of more restricted cross section throughout the length thereof, the larger end of the opening or passage 23 being cooperable with the restricted end of the passage 19 to form a continuous divergent passage when in the position shown in Fig. 1 wherein the movable nozzle member 22 is seated against the inlet side of the fixed nozzle member 12, thereby providing a single combined nozzle.

The ring or movable nozzle member 22 is formed with an annular series of ribs 27 spaced from each other and secured, by means of bolts 24 or the like, to a corresponding series of spaced apart guide rods or arms 25 carried by a cross-head 26 and guided along the inner cylindrical wall of the chamber 14. The cross-head 26 is nonrotatably attached to a head piece 28 by means of a bolt 29 or other suitable means, and the head piece 28 is bored and tapped to receive the threaded end 31 of a spindle or shaft 30. The spindle 30 is journaled for rotation in a central bore 32 provided in the end wall 13 and extends beyond the wall 13 to receive a manipulating handle 34 secured to the free end thereof by means of nut 35.

To seal the improved device against leakage, I provide a collar or flange 36 on the spindle 30 adjacent the bore 32 in the wall 13. Surrounding the collar 36 and spindle 30 is a stuffing box 37 carrying a replaceable packing 38 retained within the stuffing box 37 by an adjustable gland 40 having an annular flange 41. The stuffing box 37 is likewise provided with an annular flange 42 firmly bolted to and seated on the flange 20 by means of stud bolts 43. The free ends of the stud bolts 43 extend through spaced bolt receiving holes 44 provided in the flange 41 and receive the threaded nuts 46 which force the gland 40 against the packing 38 when tightened.

To prevent rotation of the ring or nozzle member 22, arms 25, cross-head 26 and head piece 28 within the chamber 14 when the spindle 30 is rotated by means of the handle 34, a pin 47 is provided in one of the ribs 27 of the member 22, and a longitudinal groove or slot 48 is formed in the inner cylindrical wall of the chamber 14 for guiding the pin 47.

The steam chest or housing 10 is provided with an annular flange 49 adapted to be secured to a suction head 50 which may be in the form of an elbow, as shown, or other suitable arrangement forming a suction chamber, generally designated as 52, in the exhaust line communicating with the space to be evacuated. The passage 19 is directed toward a diffuser 53 attached to the suction head 50 and having the usual converging discharge passage 54 formed therein. The portion of the nozzle member 12 immediately adjacent the mouth of the passage 19 is preferably tapered at 55 as shown in Figs. 1 and 2 to provide an increased amount of space between the nozzle and the suction head at this point.

In operation, after the improved ejector has been properly assembled and mounted, steam or other motive fluid is supplied from a suitable source to the housing 10 through the supply pipe 16. Assuming that the space to be evacuated of

air or other gases is at atmospheric pressure, as is usually the case, and it is desired to hurriedly evacuate the space to establish a certain vacuum therein, the ejector is adjusted in the following manner. The nozzle member 22, having the opening 23 formed therein, is pulled away from the fixed nozzle member 12 and passage 19 thereof, as shown in Fig. 2, such adjustment being effected through the guide rods 25, cross-head 26, and head piece 28 by rotating the spindle 30 through its handle 34. When in such position of adjustment, the steam supplied to the chamber 14 fills the chamber and passes through the spaces, clearly shown in Figs. 3 to 5, formed between the rods 25 and the ribs 27, around the nozzle member 22 as well as through the opening or passage 23, discharging through the passage 19 of the fixed nozzle member as indicated by the arrows in Fig. 2. It is apparent that the nozzle is open to its fullest extent when in such position of adjustment, thereby permitting an increasing amount of steam to be discharged around the retracted nozzle member 22 and through the larger passage 19 and consequently increasing the suction within the chamber 52 and hastening withdrawal of gases from the desired space, such gases being drawn or sucked into the steam jet discharging from the passage 19. Therefore, when the nozzle member 22 is retracted or separated from the fixed nozzle member 12 as hereinabove described, the effect is to convert the device into a primer for high capacity operation at low vacuum with an increased steam flow through the member 12 which serves, in such instances, as a priming nozzle.

When the desired vacuum has been established within the space, as may be determined in a well known manner by the use of pressure gauges or the like, the movable nozzle member 22 may be readily seated against the fixed nozzle member 12 within the chamber 14, as shown in Fig. 1, by turning the spindle 30 through its handle 34 in a direction such as will move the member 22 and its guide attachments toward the nozzle member 12. When so adjusted, the passages formed around the member 22 are closed to the orifice 19, and the only passage open to such orifice is by way of the more restricted opening 23 formed in the member 22. As will be noted from referring to Fig. 1, this adjustment to normal operating capacity gives the effect of providing a single nozz'e wherein the separable nozzle members are combined to form a continuous diverging discharge passage having its restricted end of a diameter as to admit only a sufficient volume of steam for discharge therethrough as is required to maintain the established vacuum within the desired space, thereby providing an ejector adapted for normal low capacity operation at a high vacuum.

By way of example of one possible application of my improved device, I have diagrammatically illustrated the ejector as applied to a condenser system in Fig. 6 of the drawings. Referring to this figure, the pipe 59 leading from a condenser (not shown) is provided with an elbow 150 forming the suction chamber 152 for a first stage ejector 110 of my improved design hereinabove described. The elbow 150 is, in turn, secured to a pipe 153, forming the diffuser and having a converging passage 154 therein. The diffuser 153 leads to an intercooler 67 by way of pipe 65 and past a valve 66. Pipe 68 leads from the intercooler 67 past a valve 69 to an elbow 250 which may similarly form the suction chamber 252 for

a second stage ejector 210, likewise of the type hereinabove fully described. The elbow 250 is also secured to a diffuser 253 formed with a converging passage 254; and from the diffuser 253, a pipe 75 leads to an aftercooler 77 exhausting through a pipe 78. The valves 66, 69 are provided for closing the line for purposes of cleaning or repairing parts in the system when necessary, and the steam chests of the ejectors 110 and 210 are, of course, connected to a suitable source of steam supply (not shown).

When the system is started up, steam is supplied to the steam chests of the ejectors through the respective steam supply pipes as hereinabove described, and the nozzles are adjusted to a wide open priming position for high capacity operation. The steam discharged from the first stage nozzle creates a suction in the chamber 152, drawing gases from the condenser by way of pipe 59 and discharging such gases, together with the high velocity steam jet, into the diffuser passage 154 and through the pipe 65 to the intercooler 67. Since the capacity of the first stage ejector 110 is obviously most efficiently utilized when the conduit into which the steam and gases are discharged is maintained at relatively low pressure, it is ordinarily desirable but not always necessary to provide a second stage ejector 210 in systems such as herein illustrated to aid withdrawal of the gases from the intercooler, thereby preventing establishment of a back pressure in the line from the intercooler to the first stage suction chamber. The second stage ejector may be of the same construction as the first stage ejector or may be of ordinary construction, as conditions require, and is effective to hasten withdrawal of the gases from the intercooler 67 through the pipe 68 to the suction chamber 252 and on through the passage 254 and pipe 75 to the aftercooler 77, from which the gases are exhausted by way of pipe 78.

With the ejectors operating as primers at high capacity, it is only a matter of minutes before the space within the condenser is evacuated from atmospheric pressure to the desired vacuum. Thereafter, when the desired pressure has been established within the condenser, as determined from pressure gauges installed and operated in a well known manner, the ejectors are adjusted, as fully described hereinabove, by turning the handles to effect a combination of the separable nozzle members into a single nozzle of increased length and decreased capacity for normal operation. At such normal low capacity operation of the ejectors, only a sufficient amount of steam is discharged to create a suction sufficient to withdraw gases from the condenser at such a rate as to maintain the established pressure.

It should be noted that although I have shown one of the improved ejectors utilized in each of two stages in the system illustrated in Fig. 6, any desired number of such ejectors may be utilized in any number of stages, the location and number as well as the size and capacity of the ejectors being dependent upon the size of the condenser, the degree of vacuum it is desired to establish therein and other attendant conditions. Obviously the steam supplied to the ejectors through the supply pipe may be readily controlled in the usual manner by means of suitable shut off valves.

From the foregoing detailed description, it is apparent that the present invention provides an improved jet pump of the ejector type which is simple in construction and operation, which may be readily manufactured at relatively low cost,

which may be conveniently applied and utilized for evacuating gaseous fluids from any desired space, which, although compact, is strong and durable, which may be quickly dismantled for inspection, and wherein the parts may be readily replaced at nominal cost when necessary. The improved nozzle structure provides an ejector of variable capac'ty which may be used either as a high capacity primer for initially hurriedly establishing a desired pressure as well as for normal low capacity operation to maintain the established pressure, thereby eliminating the need for separate bulky and expensive priming apparatus. Obviously, the adjustments of the nozzle for either priming operation or normal operation are automatically rendered positive by reason of the fixed diameter of the discharge passage of each nozzle member. Likewise, the adjustment of the nozzle from a high capacity to a low capacity is effected without internally obstructing the discharge passage, thereby eliminating structure which interferes with the normal flow through the discharge passage and causes additional frictional resistance to such flow. If desired, the unit may be rendered completely automatic by providing mechanical means for manipulating the operating handle responsive to pressure changes in the system. It should be noted that although the ejector has been designed herein as primarily utilizing steam as the motive fluid, I do not wish to limit my invention to such use since any suitable motive fluid may be utilized. Since the high velocity flow of motive fluid through the passages **19, 23** causes the greatest amount of wear adjacent these points, the nozzle members **12, 22,** in which these passages are respectively formed, are preferably detachably secured to their supporting structures as shown, thereby enabling replacement of these parts as required independently of the remaining structure. In designing the separable nozzle members, known expansion principles are utilized to determine the angle and length of divergence of the discharge passages for most efficient operation with the particular motive fluid to be used.

It should be understood that it is not desired to limit the present invention to the exact details of construction and mode of operation or the particular application herein shown and described, since various modifications within the scope of the claims may occur to persons skilled in the art.

It is claimed and desired to secure by Letters Patent:

1. In an ejector having a supply chamber formed therein, a nozzle comprising, a fixed nozzle member having a discharge passage communicating with said chamber, a ring within said chamber having an opening therethrough of lesser diameter than the discharge passage of said fixed nozzle member, an annular series of spaced apart ribs on said ring, said ribs cooperating with a wall of said chamber to retain said ring in spaced relationship with respect to said chamber wall and the opening in said ring in alignment with the discharge passage of said fixed nozzle member, guide means within said chamber coacting with said ribs to guide said ring within said chamber, and means cooperable with said guide means for moving said ring axially of said fixed nozzle member to establish communication between the discharge passage of said fixed nozzle member and said chamber either through the opening of said ring or through said opening and around said ring between said ribs.

2. In an ejector having a supply chamber formed therein, a nozzle comprising, a fixed nozzle member having a discharge passage communicating with said chamber, a ring within said chamber having an opening therethrough of lesser diameter than the discharge passage of said fixed nozzle member, an annular series of spaced apart ribs on said ring, said ribs cooperating with a wall of said chamber to retain said ring in spaced relationship with respect to said chamber wall and the opening in said ring in alignment with the discharge passage of said fixed nozzle member, guide means comprising an annular series of spaced apart rods guided along a wall of said chamber, each of said guide rods being attached at one end thereof to one of said ribs and being joined at the opposite end to form a head, and means cooperable with said head for moving said guide rods and said ring axially of the discharge passage of said fixed nozzle member to establish communication between the discharge passage of said fixed nozzle member and said chamber either through the opening of said ring or through said opening and around said ring through the spaces formed between said guide rods and said ribs.

3. In an ejector having a supply chamber formed therein, a nozzle comprising, a fixed nozzle member having a discharge passage communicating with said chamber, a ring within said chamber having an opening therethrough of lesser diameter than the discharge passage of said fixed nozzle member, an annular series of spaced apart ribs on said ring, said ribs cooperating with a wall of said chamber to retain said ring in spaced relationship with respect to said chamber wall and the opening in said ring in alignment with the discharge passage of said fixed nozzle member, means provided on said ring and cooperable with a wall of said chamber for preventing rotation of said ring within said chamber, guide means comprising an annular series of spaced apart rods guided along a wall of said chamber, each of said guide rods being attached at one end thereof to one of said ribs and being joined at the opposite end to form a head, and a spindle cooperable with said head and operable externally of said chamber for moving said guide rods and said ring axially of the discharge passage of said fixed nozzle member to establish communication between the discharge passage of said fixed nozzle member and said chamber either through the opening of said ring or through said opening and around said ring through the spaces formed between said guide rods and said ribs.

4. In an ejector having a supply chamber for supplying fluid under pressure greater than atmospheric pressure to a nozzle, comprising a fixed nozzle having an outwardly divergent first discharge passage directly communicating with said chamber at the smaller end of said first passage to provide a high capacity nozzle, a movable nozzle within said chamber having a corresponding divergent second discharge passage with the larger end thereof substantially the same diameter as the smaller end of said first passage, and means for selectively positioning said movable nozzle in abutting and in axially spaced relation with respect to said fixed nozzle, said movable nozzle when abutting said fixed nozzle having the large end of said second passage merging with the small end of said first passage to form a single continuous diverging discharge passage of lesser capacity than said fixed nozzle for the same fluid pressure.

5. In an ejector having a chamber for supplying fluid under pressure greater than atmospheric pressure to a nozzle, comprising a fixed nozzle for receiving fluid under pressure from said chamber, said nozzle having an outwardly divergent first discharge passage directly connected at the smaller end thereof with said chamber to provide a high capacity jet, a movable nozzle within said chamber, said movable nozzle having a corresponding outwardly divergent second discharge passage coaxial with and of the same taper as said first passage, and means for moving said movable nozzle axially to have the larger end thereof abut the smaller end of said fixed nozzle to provide a nozzle having a single uniformly progressively divergent discharge passage of relatively low capacity for the same fluid pressure.

6. In an ejector having a supply chamber for supplying fluid under pressure greater than atmospheric pressure to a nozzle, comprising a fixed nozzle having an outwardly divergent first discharge passage directly communicating with said chamber at the smaller end of said passage, a movable nozzle within said chamber, said movable nozzle having a corresponding divergent second discharge passage with the larger end thereof substantially the same diameter as the smaller end of said first discharge passage, means for selectively positioning said movable nozzle so that in one position thereof, the larger end thereof abuts the smaller end of said fixed nozzle to provide a single continuous diverging discharge passage of relatively low capacity from said chamber through said movable nozzle and through said fixed nozzle, and so that in another position thereof the larger end of said movable nozzle is removed from the smaller end of said fixed nozzle to establish direct communication between said chamber and said first discharge passage for relatively high capacity flow of fluid through said fixed nozzle for the same fluid pressure.

7. In an ejector having a chamber for supplying fluid under pressure greater than atmospheric pressure to a nozzle, comprising a fixed jet nozzle for receiving fluid under pressure from said chamber, said nozzle having a divergent discharge passage of large capacity connected at the smaller end thereof with said chamber to provide a high capacity jet, a movable nozzle disposed in upstream relation with respect to said fixed nozzle and having an outwardly divergent passage axially alined with and of less capacity than the discharge passage in said fixed nozzle, said divergent passage in said movable nozzle having a discharge end cross-sectional area substantially equal to the cross-sectional area of the inlet end of the passage in said fixed nozzle member, and means for moving said movable nozzle from a position in axially spaced relation with respect to said fixed nozzle to a position wherein said movable nozzle abuts said fixed nozzle with the passage in said movable nozzle forming an upstream converging continuation of the passage in said fixed nozzle to provide a relatively low capacity jet for the same fluid pressure.

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