May 26, 1959 E. P. NEUMANN ET AL 2,888,191

JET PUMP

Filed May 3, 1954 2 Sheets-Sheet 1

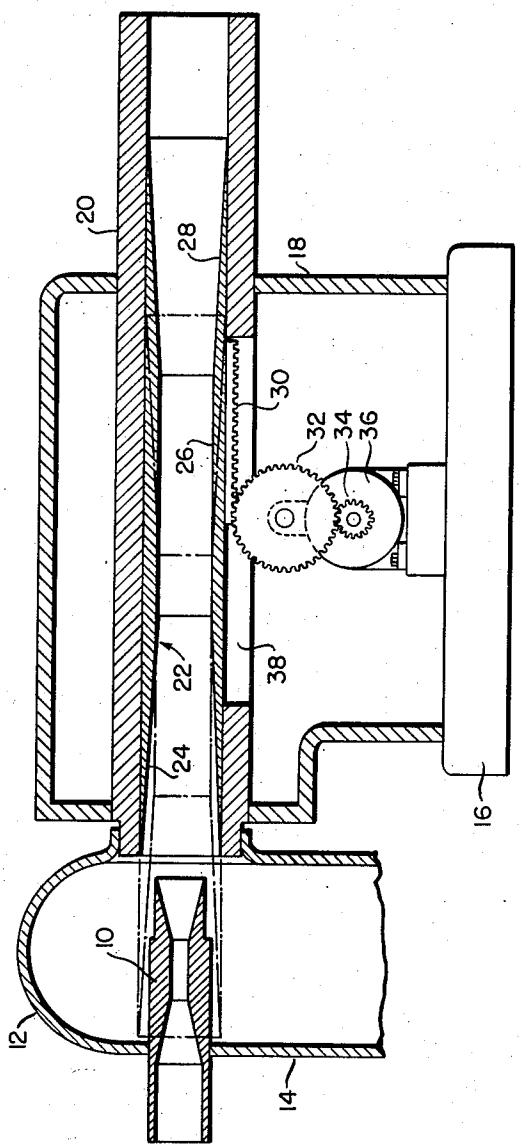


Fig. 1

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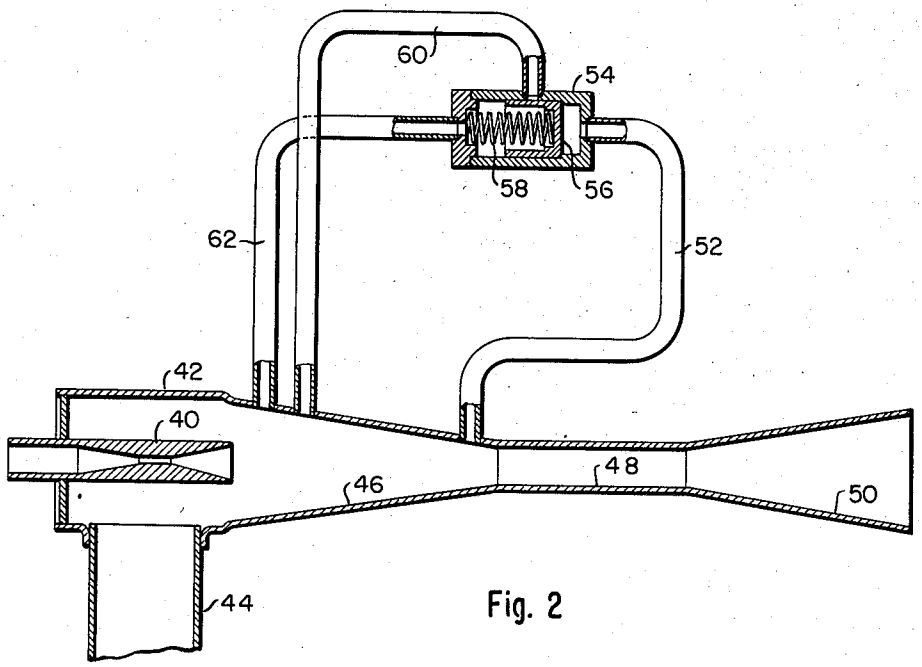


Fig. 2

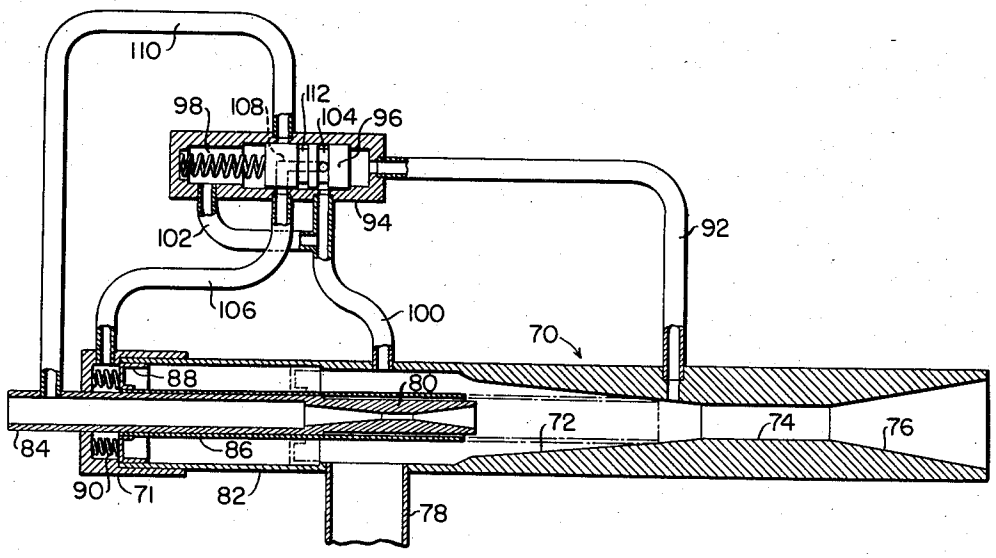


Fig. 3

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United States Patent Office 2,888,191 Patented May 26, 1959

2,888,191

JET PUMP

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Application May 3, 1954, Serial No. 427,048

2 Claims. (Cl. 230—111)

This invention relates to jet pumps and in particular to means for transferring through an ejector the standing shock waves created by the initial flow of a motive fluid into the ejector body.

Of all the difficulties encountered in the operation of jet pumps, one of the most troublesome is the impact of the motive fluid in the inlet mouth of the ejector. The shock waves created by the initial impact of the motive fluid cause an appreciable drop in efficiency, delay in the normal functioning of the pump and damage to the pumping apparatus. Moreover, eddy currents are created in the mouth of the ejector by the impact, which gives rise to a great deal of turbulence and prohibit smooth performance of the pump for a considerable time after the initial standing shock wave has passed through the ejector throat.

One important object of this invention, therefore, is to decrease the resistance to the initial surge of motive fluid in the mouth of an ejector.

Another important object of this invention is to establish normally efficient flow conditions in the ejector a predetermined interval of time after the pump has been started.

Still another object of this invention is to reduce the turbulence in the ejector and thereby increase the life of the pumping apparatus.

In the accomplishment of these and other objects I provide as one important feature of this invention means responsive to the pressure at the inlet of the ejector for effectively transmitting the shock through the throat of the ejector.

Another feature of this invention is the provision of a pressure relief valve in fluid communication with the mouth of the ejector to reduce the pressure therein created by the initial surge of motive fluid.

Another feature of the invention particularly adapted to perform the above objects is the provision of an ejector coaxially disposed with respect to the injector nozzle, the two being relatively movable.

As another feature of this invention I provide a movable sleeve surrounding the injector, which may be moved into the ejector mouth, and which restricts the size of the diverging cone of motive fluid issuing from the injector nozzle.

These and other objects and features of the invention will be more readily understood and appreciated from the following detailed description of preferred embodiments thereof selected for purposes of illustration and shown in the accompanying drawing, in which:

Fig. 1 is a view in section of a jet pump constructed in accordance with this invention,

Fig. 2 is a view in section of another jet pump constructed in accordance with this invention, and

Fig. 3 is a view in section of still another jet pump constructed in accordance with this invention.

Proceeding now to a detailed description of the embodiment of this invention shown in Fig. 1, the jet pump illustrated is organized about an injector nozzle **10** and

a tube **20** respectively mounted within a hood **12** and casing **18**. The tube **20** is longitudinally spaced from and coaxial with the nozzle **10** and contains a movable inner sleeve **22** which serves as an ejector body. The ejector body **22** is defined by a mixing chamber or mouth **24** converging away from the injector nozzle **10** and smoothly merging into a restricted orifice or throat **26** in the ejector midsection leading to a delivery tube **28** having a gradually increasing inner diameter beyond the throat.

The injector nozzle **10** is of venturi configuration similar to the ejector but of a much smaller size. The hood **12** defined as containing the nozzle **10** has a relatively large suction tube **14** leading to an annular chamber formed about the nozzle by the hood. The annular chamber freely communicates with the mixing chamber **24** permitting fluid entrained into the annular chamber to pass into the mouth of the ejector body and mix with the motive fluid.

The structure thus far described will be recognized as conventional jet pump apparatus and is, without the additional structure later to be described, subject to the failings set forth in the introductory paragraphs of this specification. Upon the commencement of pump operation the motive fluid emerging from the nozzle strikes a relatively dead column of air in the ejector; hence the standing shock wave has difficulty passing through the converging mouth and restricted orifice. Continued emission of the motive fluid from the nozzle will fill the mouth of the ejector and destroy the low pressure area in the annular chamber necessary for the entrainment of the fluid through the suction conduit **14**. Generally, after some appreciable delay, the shock wave will pass through the throat of the ejector body and normal operation of the pump will then occur. However, on some occasions time will not cure the impaired operation and the motive fluid will back up in the nozzle overloading the pump (not shown) moving the fluid therethrough which may damage it and prevent further operation.

Proceeding now to a description of the apparatus comprising the heart of this inventive concept, it has been found that by moving the ejector body an appreciable distance toward the nozzle (to the position illustrated in dotted lines in Fig. 1), the standing shock wave accompanying the initial emission from the nozzle will, without appreciable difficulty, pass through the mixing chamber and throat of the ejector. Consequently, entrainment of fluid from the section tube **14** commences almost immediately following the initial flow of motive fluid from the nozzle. No backing up of the fluid occurs and turbulence in the ejector is greatly reduced. When the pump is observed to be functioning properly, the ejector body may be moved away from the nozzle **10** to its normal operating position illustrated in full lines in the drawing.

To move the ejector in the manner described a geared reversible motor **36** is positioned to cooperate with a rack **30** longitudinally disposed on the ejector body **22**. The motor **36** is illustrated as mounted on a base **16** which also serves as a mounting block for the casing **18**. A pinion **34** rotatably mounted on the shaft of the motor **36** engages a gear **32** which in turn registers with the teeth of the rack. To permit the mechanical connection of the rack **30** and the gear **32**, the tube **20** is provided with a longitudinal slot **38** of a length substantially greater than the rack. The slot **38** permits translational motion of the ejector body **22** and the rack **30** between fixed limits defined by the slot. When motor **36** rotates in a clockwise direction as viewed in the drawing, pinion **34** will rotate in the same direction, turning gear **32** counterclockwise. The rack **30** will be moved to the left carrying with it the ejector **22** and will cause the mixing cham-

ber 24 to telescopically fit over the nozzle 10 as shown in dotted lines. Initial operation of the motor may be timed with the first emission of motive fluid from the nozzle, while after a predetermined interval of time the rotation of the motor may be automatically reversed, returning the ejector body to the position shown in full lines in the drawing. Although no automatic means has been illustrated to perform this function, it will be obvious to a man skilled in the art that numerous means may be provided to control the motor operation. For example, a pressure responsive switch may be included in the power supply line of the motor 36, which is actuated to closed position by pressure in the mixing chamber, while a timing mechanism may automatically reverse the motor after a predetermined interval. Alternatively the motor may be replaced by a spring and holding solenoid actuated in response to an increase in pressure in the mixing chamber or to the initial emission of fluid from the injector nozzle. Irrespective of the means employed to move the ejector body, a reduction in the resistance opposing the passage of the standing shock wave through the mixing chamber and throat will result.

Proceeding now to a description of another embodiment of this invention, Fig. 2 illustrates a fully automatic means for reducing the resistance to the passage of a standing shock wave through the ejector. Both the injector nozzle and the ejector are stationary in the jet pump illustrated. A relief valve is provided to carry out the function performed by the movable ejector in the previously described embodiment.

In detail, a venturi type injector nozzle 40 is mounted in a hood 42 and forms therewith an annular chamber. Leading into the annular chamber is a suction conduit 44 provided as an inlet passage for the secondary fluid to be entrained by the motive fluid discharge by the nozzle. The hood 42 merges smoothly into a mixing chamber 46 disposed coaxially with and longitudinally displaced from the outlet of the nozzle 40. The mixing chamber 46 converges away from the hood and terminates in a relatively narrow throat or orifice 48 of constant diameter throughout its length. Integrally formed with the hood, mixing chamber and throat is a delivery tube 50 which completes the ejector body. The diameter of the delivery tube 50 gradually increases away from the throat 48 rendering a venturi configuration to the ejector.

The structure now to be described comprises the pressure relief means employed to reduce the resistance in the ejector to the passage of the standing shock wave. A conduit 52 connected to the rear of the mixing chamber 46 adjacent the throat 48 is serially connected at its other end to a conduit 60 by a cylindrical casing 54. A piston 56 within the cylinder 54 is urged by a spring 58 to a position interrupting free communication between the two conduits. The conduit 52 serves as a relief tube for the ejector by carrying off a portion of the fluid initially introduced into the mixing chamber by nozzle 40 and further acts as a pressure relief conduit for the mixing chamber. The instantaneous pressure surge adjacent the entrance of the throat accompanying the starting of pump operation will be transmitted by the conduit 52 into the cylinder 54, and the piston 56 will be moved to the left against the bias of the spring 58. The pressure surge in the mouth of the injector will then be dissipated from the mouth through conduit 52 and out into the conduit 60. The conduit 60 which communicates with the inlet side of the mixing chamber 46 will also permit the motive fluid which was carried into the conduit 52 to recirculate in the system.

A third conduit 62 is connected at one end to the cylinder 54 on the side of the piston 56 opposite to that of the conduit 54 while its other end is connected to the the mixing chamber. Any fluid that passes around the piston will be directed by the conduit 62 into the mixing chamber.

In operation, the relief mechanism functions in the following manner. The initial flow from the injector nozzle 40 will cause a build up in pressure in the rear of the mixing chamber 46. This pressure build up will, by virtue of the communicating conduit 52, move the piston 56 to the left and the pressure will subsequently be released from the mixing chamber by conduit 60. The reduction in pressure adjacent the throat 48 will permit the standing shock wave to pass through the ejector body and a low pressure area will then be created in the annular chamber within the hood 42. Entrainment of the secondary fluid will then be instituted. Simultaneously with the beginning of the pumping of the secondary fluid from tube 44, the pressure in the rear of the mixing chamber will be appreciably reduced, and the spring 58 will return the piston 56 to the right terminating communication between conduits 52 and 60. Any fluid that has passed into the cylinder 54 and around the piston will be returned to the mixing chamber by the conduit 62. The jet pump will then function in a normal manner and any of the difficulties encountered in conventional jet pumps as recited above will have been avoided.

The embodiment of this invention illustrated in Fig. 3 employs many of the principles used in each of the previously described embodiments. As is evident from a cursory inspection of the drawing, the nozzle is effectively placed in a position at the rear of the mixing chamber immediately adjacent the throat of the ejector.

In detail, the pump apparatus is organized about an elongated conduit 70 having a venturi type injector comprising mixing chamber or mouth 72, a throat 74 and a delivery tube 76 integrally formed at one end. A cap or cover 71 telescopically receives the other end of the conduit 70 closing that end. Projecting through the cap into the conduit coaxially therewith is a second conduit 84 which terminates adjacent the mouth of the mixing chamber 72. Integrally formed within the terminal portion of the conduit 84 is an injector nozzle 80 for discharging motive fluid into the mixing chamber. Radially connected to the conduit 70 adjacent the nozzle 80 is a suction line 78 which directs the fluid to be pumped into the mixing chamber.

Thus far the description of the invention illustrated in Fig. 3 has been limited to rather conventional structure. The apparatus for transferring the standing shock wave through the ejector throat will now be described. A sleeve 86 is slidably mounted on the conduit 84 and is of a length approximately equal to the portion of the conduit 84 within the conduit 70. A piston 88 is fixed on the forward end of the sleeve 86 adjacent the cover 71 and is in sliding engagement with the inner walls of the conduit 70. A pair of springs 90 fixed at their ends to the cover 71 and the piston 88 urge the sleeve to a retracted position illustrated in full lines wherein the terminal portion of the sleeve does not project beyond the end of the nozzle 80. By means later to be described the sleeve 86 may be moved to its extended position (shown in broken lines in Fig. 3) against the bias of the springs 90. In the extended position it effectively lengthens the nozzle 80 wherein it extends to a position at the rear of the mixing chamber 72 juxtaposed with the throat 74.

The apparatus now to be described is employed as actuating means for the sleeve. A high pressure conduit 110 connected at one end to the conduit 84 is radially connected at its other end to a hollow cylinder 94 which has a piston valve 96 movable axially therein. A conduit 106 radially connected at one end to the cylinder 94 opposite to the connection of high pressure conduit 110, communicates at its other end with the conduit 70 immediately to the left of the piston 88. A biasing spring 98 within the cylinder 94 urges the piston valve 96 to a position interrupting the flow of fluid from the high pressure conduit 110 to the conduit 106. An annular recess 112 on the surface of the piston is adapted to

permit communication of conduit **110** with conduit **106** when the piston is moved to the left against the bias of the spring **98**. A relief conduit **100** connected to the cylinder and to the conduit **70** adjacent the end of the nozzle **80** communicates with the conduit **106** by means of a port **112** and a second annular recess **104** when the piston **96** assumes its biased position under the influence of the spring **98**. A fourth conduit **92** joined at one end to the mixing chamber **72** adjacent the throat **74** is connected at its other end to the cylinder **94**.

It will be seen that the initial emission of the motive fluid from the nozzle **80** will create a high pressure area at the rear of the mixing chamber. The pressure surge will be transmitted to the cylinder by conduit **92** and piston **96** will be moved to the left placing the recess **112** in a position to connect the conduits **110** and **106**. A portion of the high pressure motive fluid in the conduit **84** will pass through the conduit **110**, the annular recess **112**, and the conduit **106** into the conduit **70** to the left of the piston **88**. The pressure build up at that location will move to the right the piston **88** and with it the sleeve **86**. The sleeve will assume its extended position as suggested by the dot-and-dash lines in the drawing.

Extended sleeve **86** will restrict the size of the diverging cone of motive fluid issuing from the nozzle **80** and the fluid will be guided through the throat **74**. The passage of the motive fluid through the orifice **74** will cause a pressure drop in the mixing chamber and the standing shock wave will pass through the ejector throat. Moreover, the secondary fluid will be drawn into the mixing chamber **72** from the suction tube **78**. The reduced pressure in the chamber will further result in a reduction of the pressure against the piston **96**, and the spring **98** will return it to its biased position discontinuing registration of recess **112** with conduits **110** and **106**. The high pressure conduit **110** no longer being in fluid communication with the conduit **106**, the springs **90** will return the sleeve to the retracted position shown in full lines. The fluid to the left of the piston **88** will be forced out of the conduit **70** through the conduit **106**, and the port **108**, the slot **104** and the conduit **100** will carry the fluid into the conduit **70**. A conduit **102** merging into conduit **100** is adapted to drain away any accumulated fluid in the cylinder.

It is seen that each of the embodiments illustrated effectively reduces the pressure build up at the mouth of the ejector thereby reducing the resistance to the standing shock wave. As a result the disadvantages of jet pumps discussed in the introductory paragraphs of the specification are either appreciably reduced or entirely eliminated.

Obviously numerous minor variations of the illustrated embodiments of this invention will occur to one skilled

in the art to which this invention pertains. Therefore, it is our intention that this invention be limited only by the appended claims and not by the specifically described embodiments.

What we claim as new and desire to secure by Letters Patent of the United States is:

1. A jet pump comprising in combination a pump body which includes a chamber, a converging mouth and a restricted throat, a suction tube connected to supply fluid to the chamber, an injector nozzle located in the chamber rearwardly of and coaxially with the throat, a pressure tube connected to supply motive fluid through said nozzle and projectively toward said throat, conduit means connected to said chamber adjacent the reduced end of said mouth adjacent said throat and to a rearward portion of said chamber adjacent said injector nozzle, a normally closed biased valve operatively positioned in said conduit means, said valve being operative to open in response to a predetermined abnormal pressure in said mouth generated by the operation of said nozzle to direct fluid to said rearward portion of said chamber and thereby reduce said pressure, and means normally maintaining said valve in closed position.

2. A jet pump comprising in combination a pump body which includes a chamber having a converging mouth and a restricted throat, a sleeve axially slidable in the pump body, a suction tube connected to supply fluid to the chamber, an injector nozzle whose external diameter is smaller than the maximum internal diameter of said mouth and positioned axially within said sleeve, said nozzle having a flaring orifice whose maximum diameter is smaller than the diameter of said throat, said nozzle being located in the chamber coaxially with and rearwardly of the throat, a pressure tube connected to supply motive fluid through said nozzle and projectively toward said throat, means normally urging said sleeve rearwardly whereby said nozzle orifice extends forwardly of the sleeve end, conduit means operatively connected to said converging mouth portion of said chamber, and plunger means operatively engaged with said sleeve and in operative communication with said conduit means for urging said sleeve forwardly towards said throat upon abnormal pressure conditions existing in said converging mouth portion and said conduit means.

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