W. B. EDDISON.

METHOD OF AND APPARATUS FOR UNLOADING PUMPS.

APPLICATION FILED MAR. 11, 1918.

1,350,095.

Patented Aug. 17, 1920.

2 SHEETS—SHEET 1.

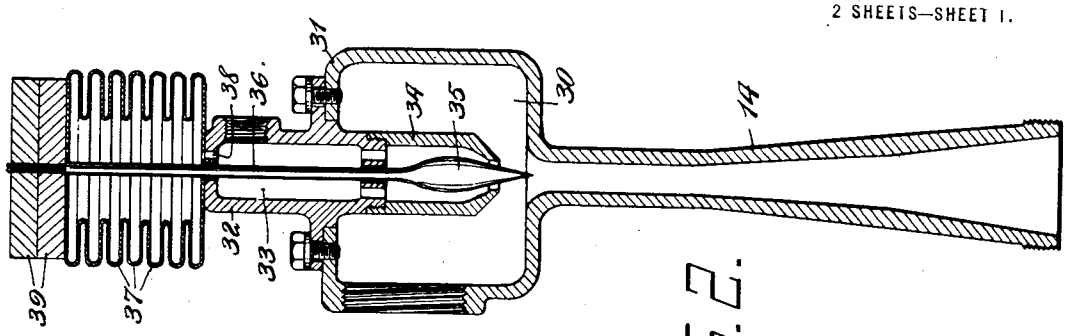


Fig. 2.

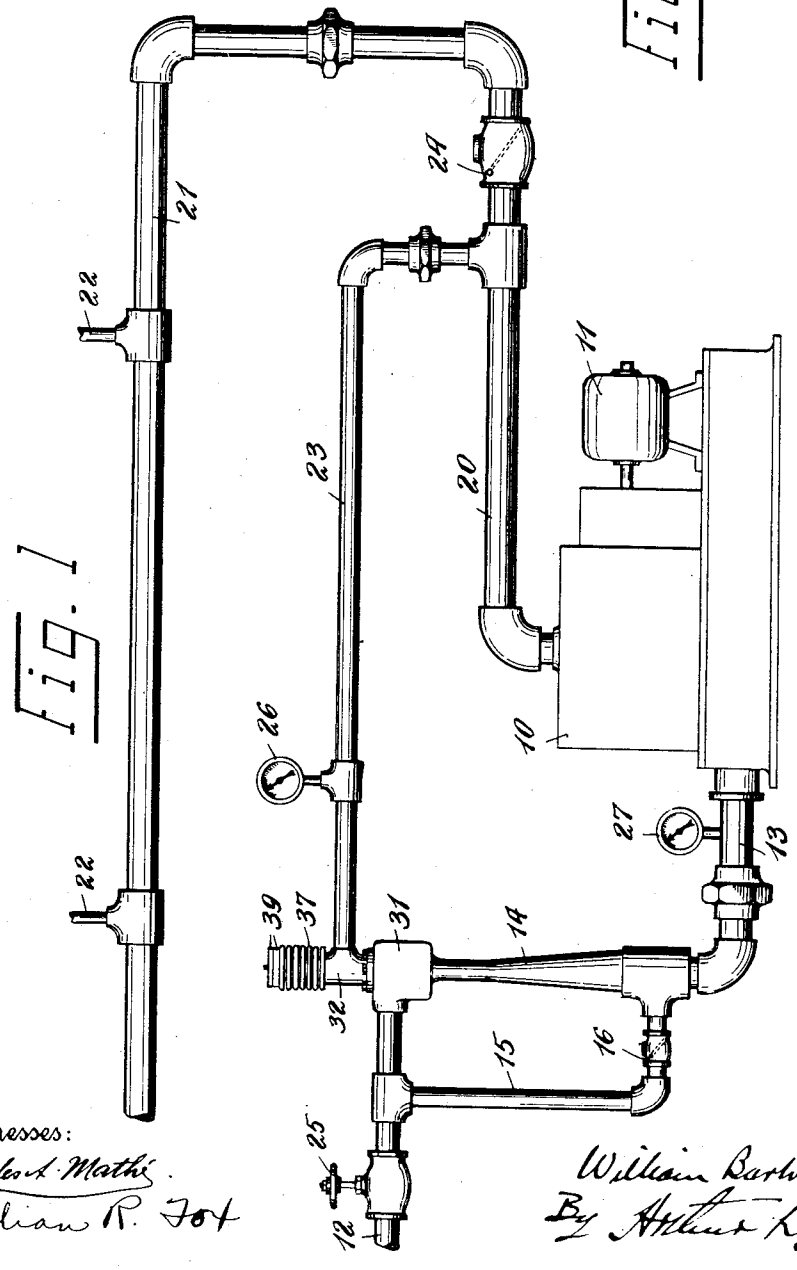


Fig. 1

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2 SHEETS—SHEET 2.

Fig. 3.

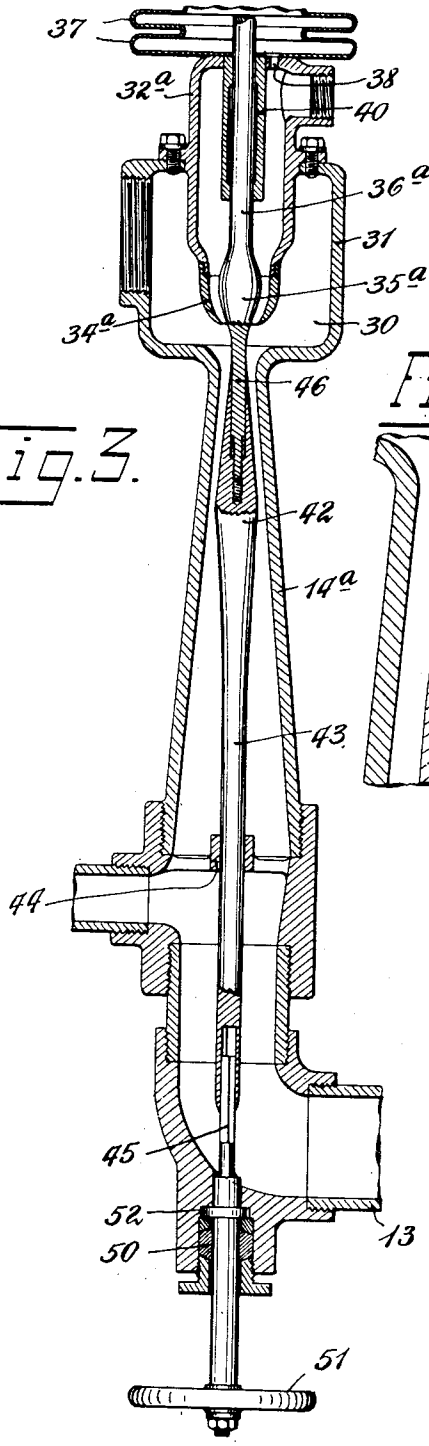


Fig. 5.

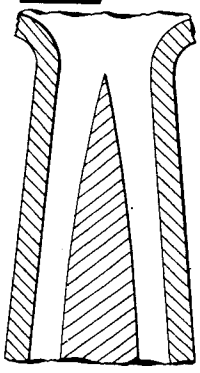
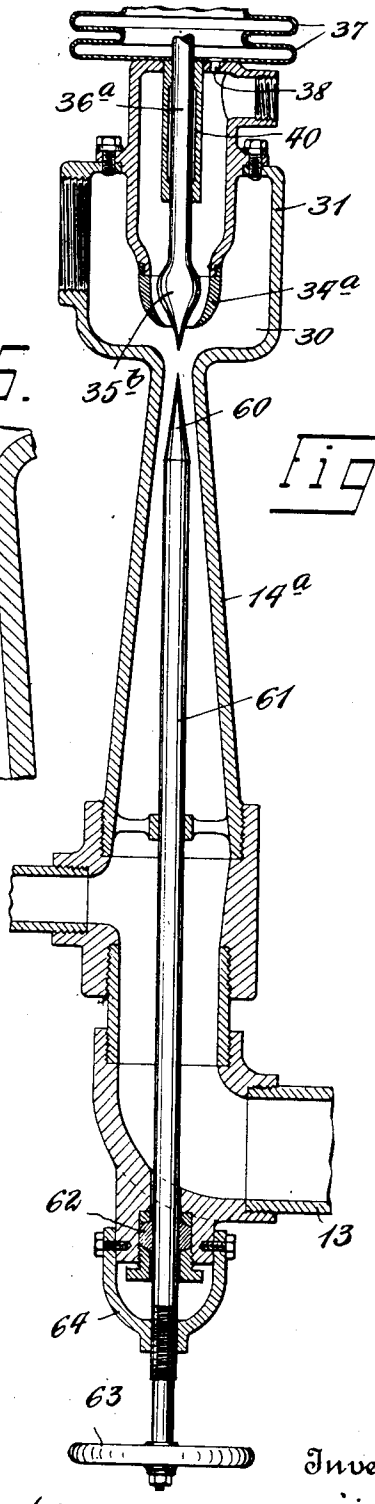


Fig. 4.



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UNITED STATES PATENT OFFICE.

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METHOD OF AND APPARATUS FOR UNLOADING PUMPS.

1,350,095. Specification of Letters Patent. Patented Aug. 17, 1920.

Application filed March 11, 1918. Serial No. 221,652.

To all whom it may concern:

Be it known that I, WILLIAM BARTON EDDISON, a citizen of the United States, residing at Irvington, in the county of Westchester and State of New York, have invented certain new and useful Improvements in Methods of and Apparatus for Unloading Pumps, fully described and represented in the following specification and the accompanying drawings, forming a part of the same.

This invention relates to a method of and apparatus for unloading pumps; and it comprises a method wherein energy of unused fluid discharged by the pump is utilized for increasing the pressure under which the fluid enters the intake of the pump, thereby reducing the work to be performed by the pump when less than the full capacity of the pump is being used; and it also comprises an organization of apparatus elements for unloading a pump in accordance with said method.

The use of positive pressure pumps driven at constant speed for supplying gases or liquids at a desired pressure greater than the supply pressure has heretofore had the disadvantage that the same power is required to drive the pump whether its full capacity or only a part of its capacity of discharged fluid is being used. This results from the fact that the pump or compressor at all times delivers the fluid to its full capacity, any unused portion of the compressed fluid being by-passed back to the intake of the pump, or in the case of air, being released into the atmosphere. The object of the present invention is to overcome this disadvantage and provide a method and apparatus whereby when less than the full capacity of the pump is being used less power will be required to drive the pump. To this end, I utilize the energy of the unused fluid from the pump or compressor for increasing the pressure under which fluid is supplied to the intake of the pump by changing pressure or potential energy of the unused fluid into velocity energy with reduction of pressure, combining the required amount of additional fluid to be pumped with such unused fluid at a point of relatively high velocity and low pressure, changing velocity energy of the resultant stream of fluid back to pressure energy, and delivering the same to the pump inlet at the resultant pressure, which will be higher than the normal intake pressure of the pump, or supply pressure of the fluid to be pumped. As the increase of pressure to be imparted to the fluid by the pump is thereby lessened, the load on the pump and the power required to drive the same are diminished. The amount of increase in the intake pressure above the normal and the corresponding decrease in the work to be performed by the pump will depend upon the amount of the fluid discharged by the pump which is unused.

A full understanding of the invention can best be given by a detail description of an approved form of apparatus embodying the apparatus features of the invention and suitable for carrying out the method, and such a description will now be given in connection with the accompanying drawings; in which

Figure 1 is a side elevation of such an apparatus embodying certain features of the invention;

Fig. 2 is a sectional view on a larger scale of a part of the apparatus shown in Fig. 1;

Figs. 3 and 4 are views similar to Fig. 2, but showing modified forms of apparatus embodying additional features of the invention;

Fig. 5 is a fragmentary sectional view on a still larger scale showing a modification of part of the device shown in Fig. 4.

Referring to the drawings, and first to Figs. 1 and 2, 10 represents a positive pressure pump, such, for example, as an ordinary figure **8** pump or a Nash hydro-turbine, the pump being shown as driven by an electric motor 11 by which the pump will be driven at an approximately constant speed. Interposed between the supply pipe 12 and the pump intake pipe 13, is the Venturi tube 14 of a Venturi inspirator, and a connecting pipe 15 is also provided forming a by-pass about the Venturi tube, this by-pass being provided with a check valve 16. The discharge pipe 20 of the pump leads in the apparatus shown to a high pressure supply main 21 provided with a plurality of branches 22 through which the fluid under the desired pressure may be taken for use. A return pipe, or by-pass, 23 leads from the discharge pipe 20 back to the Venturi inspirator to supply unused fluid to the jet nozzle of the inspirator. A check valve 24 is provided beyond the connection of the pipe 23 to prevent return flow of fluid from

the high pressure supply main, and a shut off valve 25 is provided in the supply pipe 12. Pressure gages 26 and 27 serve to show the discharge pressure and the pump intake pressure respectively.

Referring now to the Venturi inspirator shown in section in Fig. 2, the entrance cone of the Venturi tube 14 opens into a chamber 30 formed by a casing 31 having an opening in one wall to receive the end of the supply pipe 12. A second casing 32 to which the return pipe 23 is connected and which provides a chamber 33 to receive the unused fluid from the pipe 23 is set into an opening in the upper wall of the casing 31, being secured as shown by a flange bolted to the casing 31. The lower end of the casing 32 carries within the chamber 30 a nozzle 34 removably secured to the casing 32 and set to discharge a jet into the entrance cone and throat of the Venturi tube to serve as a driving jet. The nozzle orifice is controlled by a conical valve 35 carried by a valve rod 36 guided in the upper and lower walls of the casing 32 to move longitudinally of the axis of the nozzle and of the Venturi tube, the lower wall of the casing 32 being formed with openings to permit free passage of fluid to the nozzle.

The valve 35 is controlled according to the pressure on the discharge side of the pump to remain closed when such pressure does not exceed a predetermined pressure and to be opened when the pressure exceeds the predetermined pressure. For so controlling the valve, any suitable pressure controlled actuating means controlled according to the pressure on the discharge side of the pump may be used. For small size apparatus, direct acting pressure controlled means is found satisfactory, and such a means is shown in Fig. 2 of the drawings, such means comprising an expansible and contractible pressure chamber formed by a metal bellows 37 which is secured to the top of the casing 32 and to the top of which the valve rod 36 is connected and the interior of which is in communication with the interior of the casing 32 through an opening 38, means such as the weights 39 being provided for exerting pressure tending to collapse the bellows against the fluid pressure on the inside thereof and thereby move the valve downward to closing position. As shown, the reduced end of the valve rod extends through the upper wall of the bellows and is threaded to extend into threaded openings in the weights 39, which will be of suitable size and number according to the pressure to be maintained. As the chamber 33 is at all times in open communication with the discharge pipe 20 through the pipe 23, the pressure in the chamber 33 will always be the same as the pressure within the pipe 20 except for such slight drop as may result from the interposition of the pipe 23; and the nozzle valve will thus be controlled according to the pressure on the discharge side of the pump and will operate to control the flow of fluid through the by-pass 23 to prevent increase in pressure on the discharge side of the pump above the pressure at which the valve opens. By varying the weight on the bellows 37, the pressure at which the valve opens may be varied as desired.

The apparatus as so far described operates as follows: The valve 25 in the supply pipe 12 being open to supply fluid to be pumped, and the pump being driven at a constant speed, so long as the pressure on the discharge side of the pump does not exceed the desired or predetermined pressure, the relief valve controlling the return pipe 23, that is, the nozzle valve 35 in the construction shown, will remain closed and the fluid will be drawn by the pump through the Venturi tube and through the by-pass 15. On account of the restricted throat of the Venturi tube, a sufficient volume of fluid could not be drawn by the pump through said tube without the pressure at the pump intake being reduced substantially below the normal supply pressure. Such reduction of pressure at the pump intake is avoided, however, by the by-pass 15, the check valve in which opens and permits free passage of the fluid when the inspirator is not operating to increase the pressure in the intake pipe 13 above the normal supply pressure. The above is the operation when the pump is operating at full load, that is, when fluid discharged by the pump is being used up to the full capacity of the pump at the desired pressure.

When less than the full amount of fluid discharged by the pump is being used or taken from the main 21, the pressure in the discharge pipe 20 and main 21 will increase until the increase in pressure causes the nozzle valve 35 to be raised to open the nozzle orifice, thereby permitting fluid to flow through the by-pass or return pipe 23. The nozzle valve will be raised more or less according to the amount of the fluid discharged by the pump which is unused, that is, the amount which must be by-passed through the pipe 23 to prevent increase in pressure on the discharge side of the pump above the desired pressure, and the valve will be maintained at all times in position to permit such amount of fluid to be discharged from the nozzle as is required to keep the pressure on the discharge side of the pump down to the desired maximum, this action of the valve being that of an ordinary relief valve as commonly used with a positive pressure pump operated at a constant speed to supply fluid under a constant pressure.

By the construction shown, the unused fluid passing through the pipe 23 is discharged from the nozzle 34 into the entrance cone and throat of the Venturi tube 14 in the form of a driving or inspirating jet, pressure energy of the fluid being converted into velocity energy in passing through the nozzle orifice so that the fluid passes from the nozzle into the Venturi tube in the form of a jet of relatively high velocity and low pressure. By the action of such jet an additional amount of fluid from the supply pipe 12 sufficient to make up the amount required to supply the pump is entrained and drawn into the throat of the Venturi tube, some of the velocity energy of the fluid from the nozzle being imparted to the fluid drawn from the pipe 12. The resulting body of fluid in passing through the pressure cone of the Venturi tube has some of its velocity energy transformed into pressure energy and is delivered into the intake pipe 13 at a pressure which is greater than the normal intake pressure to a degree dependent upon the amount of unused fluid discharged through the nozzle 34 and upon the efficiency of the Venturi inspirator. The check valve 16 controlling the by-pass 15 will close when the pressure in the intake pipe 13 is above the normal intake pressure, thereby preventing backward flow of fluid from the intake pipe or from the Venturi tube through the by-pass 15. By such increase in pressure at the intake of the pump through the utilization of energy of the unused fluid returned through the pipe 23 to the Venturi inspirator, the pressure which the pump has to build up in the fluid in order to deliver it at the desired pressure is lessened and the work to be done by the pump is therefore reduced.

As the pump must always be supplied with a constant volume of fluid in a given unit of time, the unused fluid returned through the pipe 23, unless such unused fluid is the whole body of fluid discharged by the pump and the fluid is a non-compressible fluid, will be insufficient to supply the pump, and additional fluid must be supplied to the pump with the unused fluid. Such additional fluid in the amount required to supply the pump is drawn from the supply pipe 12 by the action of the Venturi inspirator and discharged with the unused fluid into the intake pipe 13. The amount of such additional or fresh fluid to be drawn from the supply pipe will vary inversely with the amount of unused fluid, and the greater the amount of unused fluid and the less the amount of fresh fluid the greater will be the increase in intake pressure above the normal intake pressure.

The discharge orifice of the nozzle 34 should be of sufficient size so that when the nozzle valve is withdrawn to the maximum open position the nozzle will pass sufficient fluid to maintain the pressure on the discharge side of the pump at the desired point when none of the discharged fluid is being used. The Venturi tube may be of ordinary form, but for the best efficiency in building up the intake pressure a tube having its throat or portion of minimum cross-section elongated for a distance equal to several times its diameter, as described in my Patent No. 1,295,086 dated February 18, 1919, is most desirably employed.

As the pump takes in the fluid at a constant volumetric rate, the volume of fluid passing through the Venturi tube in a unit of time when the by-pass 15 is closed must also be constant, except as this may be affected by increase in pressure at the pump intake; but as the velocity of flow of the fluid through the Venturi throat increases as the amount of unused fluid discharged from the nozzle 34 increases, a throat of sufficient size for the passage of the fluid when a relatively small amount of unused fluid is discharged from the nozzle will be larger than required for the passage of the same volume of fluid when a relatively large amount is discharged from the nozzle and the throat velocity is higher, and in such latter case the throat would not be filled by the fluid passing through it. As this condition of having the Venturi throat so large that it is not suitably filled by the stream of fluid passing through it reduces the efficiency of the Venturi tube in building up pressure in its discharge or pressure cone, it is desirable for securing the most efficient action of my apparatus to provide means for varying the effective size of the throat of the Venturi tube. This may be accomplished by means adjustable by hand or by means automatically adjustable. Fig. 3 illustrates a construction providing for automatic adjustment of the effective size of the Venturi throat whereby the cross-area of the throat is reduced as the effective size of the nozzle orifice is increased and vice versa.

As shown in this figure, the casing 32^a is similar to the casing 32 in Fig. 2 and is mounted with its lower end extending into the chamber 30 and is provided with a removable nozzle 34^a, the stem 36^a of the nozzle valve 35^a being guided in a sleeve 40 extending downward from the top of the casing. The Venturi tube 14^a is of the ordinary form having a short throat, and arranged in the throat and adjacent expanding portion of the tube is a plug or valve 42 which is connected to the nozzle valve 35^a to move therewith longitudinally of the tube, so that when the nozzle valve is raised as the amount of unused fluid increases, the valve in the throat of the Venturi tube will also be raised to decrease the effective throat area,

and vice versa, the throat area being thus reduced as the velocity of the fluid passing through it increases, and increased as the flow velocity of the fluid decreases.

The throat valve 42 is formed on or carried by the end of a rod 43 which passes through a guide 44 and is guided at its lower end on a rod 45. To permit adjustment of the ratio between the size of the Venturi throat and the size of the nozzle opening, the nozzle valve and throat valve are connected by means permitting relative longitudinal movement between them. As shown, the nozzle valve is formed with a cylindrical extension 46 which extends into a cylindrical axial recess in the throat valve, and the extension 46 has a reduced end which is threaded and screwed into a threaded extension of the recess in the throat valve, so that by turning one valve relatively to the other they may be brought closer together or moved farther apart. The nozzle valve is held against turning in the construction shown by its connection to the bellows 37, and the throat valve is turned for causing relative adjustment between the valves by means of the rod 45 which has a squared or other suitably formed end extending into a correspondingly formed recess in the end of the valve rod 43 so that the valve stem will turn with the rod 45 and at the same time be free to move longitudinally relatively thereto. The rod 45 extends through an opening in the elbow forming part of the intake pipe 13 and through a stuffing box 50, and carries at its outer end a hand wheel 51 and is held against longitudinal movement by means of a collar 52.

The necessity for adjustment of the size of the Venturi throat with variation in the amount of unused fluid discharged from the injector nozzle and in the flow velocity through the throat in order to secure the most efficient building up of pressure in the fluid supplied to the pump intake is modified when the fluid pumped is a gas because of the compressibility of gases. As the pump is a constant volume machine, taking in the same volume of gas at all times whether under full, partial or no load, the weight of gas taken in by the pump increases as the pressure at which the gas is supplied to the pump intake increases. Therefore, as the amount of unused gas discharged by the pump increases and the pressure at the pump intake is raised by the recovery of energy of the unused gas, the actual amount or weight of gas passing through the Venturi tube increases; and as the gas passes through the Venturi throat at the normal or supply pressure, the volume of gas passing through the Venturi throat is also increased. While such increase in the volume of gas passing through the Venturi throat may not entirely make up for the increase in flow velocity through the throat so as to properly fill a throat of a size sufficient for operation when a lesser amount of the discharged gas is unused, it does to a considerable extent avoid the necessity of adjustment of the effective area of the throat for securing the best operating conditions under variation in the amount of gas returned from the pump. When a liquid, or non-compressible fluid, is being pumped, increase in the pressure under which the liquid is supplied to the pump intake causes no increases in volume of liquid passing through the Venturi tube, and there is no such modification of the conditions which call for change in size of the Venturi throat under variations in amount of unused fluid as there is in the case of gases, or compressible fluids. Such modification of conditions in the case of compressible fluids is especially noticeable when the pump discharge pressure is relatively high, say in the neighborhood of 10 or 15 pounds, as in such cases the change in pressure at the pump intake under variations in the quantity of fluid unused is correspondingly great. With a pump supplying gas at such relatively high pressures, the efficiency of the apparatus is quite satisfactory without any adjustment whatever of the effective area of the Venturi throat.

Fig. 4 illustrates a form of inspirator which is similar to that shown by Fig. 3 except that the valve in the Venturi throat is not connected to the nozzle valve 35^b to move therewith for automatically adjusting the throat area, but is arranged to be manually adjustable independently of the nozzle valve. As shown in this figure, the throat valve 60 is carried by a rod 61 which extends through a stuffing box 62 on the elbow of the intake pipe 13, being provided at its outer end with a hand wheel 63 and having a threaded portion passing through a threaded opening in a yoke 64, whereby by turning the rod in one direction or the other the valve 60 may be advanced into or withdrawn from the Venturi throat. Such a manually operable means for adjusting the effective throat area is useful for adjusting the inspirator for relatively slight variations in pump capacity, which may be due to changes in driven speed of the pump or may result from variations in pumps of approximately the same capacity, and is also suitable for use in adjusting for best operation under variations in amount of unused fluid returned to the inspirator when such variations are not too frequent.

A conical valve such as shown in Figs. 3 and 4 of suitable angle set in the throat and adjacent portions of the expanding or pressure cone of a Venturi tube of the form shown in these figures, provides an elongated throat, or part of the tube of minimum cross-section, which may be of substantially con-

stant cross-area throughout its length, thus securing pressure equalizing advantages of the form of elongated throat shown in Fig. 2. In order that such elongated throat, or portion of minimum cross-section, resulting from the use of a conical plug or valve shall be exactly of constant cross-area throughout its length, the plug or valve when the diverging walls of the adjacent portion of the Venturi tube extend in straight lines should be slightly curved longitudinally, or of slightly convex form, as illustrated by Fig. 5.

What is claimed is:

1. The method of operating a positive pressure pump against substantial pressure resistance, comprising diverting unused fluid discharged by the pump in an amount which varies inversely with variations in the amount of compressed fluid utilized, and applying energy of said unused fluid to raise the pressure of intake fluid to reduce the load on the pump.

2. The method of operating a positive pressure pump against substantial pressure resistance, comprising diverting unused fluid discharged by the pump in an amount which varies inversely with variations in the amount of compressed fluid utilized, and applying pressure energy of said unused fluid to induce a flow of fresh intake fluid in inverse proportion to the amount of said unused fluid and reduce the pump load by raising the pressure at the intake.

3. A method of pumping fluids, which consists in forcing the fluid positively against resistance and diverting a part of said fluid proportional to the resistance to maintain a constant delivery pressure, and applying energy of such diverted part of the fluid to decrease the amount of energy required for forcing the fluid against such resistance.

4. The method of operating a positive pressure pump, which comprises driving the pump at a constant speed, preventing increase in pressure in the discharge from the pump by diverting unused fluid therefrom, returning such unused fluid to the pump intake, and utilizing energy of such unused fluid to increase the pressure under which fluid is supplied to the pump intake.

5. Apparatus for supplying fluid under pressure, comprising a positive pressure pump, automatically acting means for preventing increase in pressure on the discharge side of the pump by diverting unused fluid therefrom, and means for increasing the pressure of fluid supplied to the intake of the pump by energy of the unused fluid, whereby the power required to drive the pump when less than the amount of fluid discharged by the pump is being used is reduced.

6. Apparatus for supplying fluid under pressure, comprising a positive pressure pump, automatically acting means for limiting increase in pressure on the discharge side of the pump by diverting unused fluid therefrom, and means for returning such unused fluid combined with additional fluid to the intake of the pump at a pressure above the normal intake pressure, whereby the power required to drive the pump when less than the amount of fluid discharged by the pump is being used is reduced.

7. The combination with a constant pressure pump driven at a constant speed, and means controlled by the pressure on the discharge side of the pump for limiting increase in pressure on the discharge side of the pump by diverting unused fluid therefrom, of means for reducing the load on the pump when less than the full amount of fluid discharged by the pump is used, comprising means for combining with the unused fluid such additional amount of fluid as is required to supply the pump and for raising the pressure of fluid supplied to the pump intake by recovery of energy of the unused fluid.

8. The combination with a pump, of means controlled by the pressure on the discharge side of the pump for limiting increase in pressure on the discharge side of the pump by diverting unused fluid therefrom, means for transforming pressure energy of such unused fluid into velocity energy with reduction of pressure, means for supplying additional fluid to be pumped to the stream of unused fluid at a point of high velocity and low pressure, and means for changing velocity energy of the resultant stream of fluid into pressure energy and for delivering the same to the pump intake.

9. The combination with a pump, of a Venturi inspirator for supplying fluid to the intake of the pump, means controlled by the pressure on the discharge side of the pump for limiting increase in pressure on the discharge side of the pump by diverting unused fluid therefrom, and means for supplying to said inspirator such unused fluid to serve as the driving fluid in the inspirator.

10. The combination with a pump, of a Venturi tube interposed in the fluid supply line leading to the pump inlet, a by-pass around said Venturi tube provided with a check valve, a by-pass leading from the discharge side of the pump to a nozzle set to discharge into the throat of the Venturi tube, and a valve controlled according to the pressure on the discharge side of the pump for controlling the flow of fluid through said last mentioned by-pass.

11. The combination with a pump, of a Venturi tube interposed in the fluid supply line leading to the pump inlet, a by-pass leading from the discharge side of the pump to a nozzle set to discharge into the throat of the Venturi tube, and means controlled

according to the pressure on the discharge side of the pump for controlling the flow of fluid through said by-pass by varying the effective size of the discharge orifice of said nozzle.

12. The combination with a pump, of a Venturi tube interposed in the fluid supply line leading to the pump inlet, a by-pass leading from the discharge side of the pump to a nozzle set to discharge into the throat of the Venturi tube, means controlled according to the pressure on the discharge side of the pump for controlling the flow of fluid through said by-pass by varying the effective size of the discharge orifice of said nozzle, and means for varying the effective area of the throat of the Venturi tube.

13. The combination with a pump, of a Venturi tube interposed in the fluid supply line leading to the pump inlet, a by-pass leading from the discharge side of the pump to a nozzle set to discharge into the throat of the Venturi tube, means controlled according to the pressure on the discharge side of the pump for controlling the flow of fluid through said by-pass by varying the effective size of the discharge orifice of said nozzle, and means for varying the effective area of the throat of the Venturi tube inversely as the effective size of the nozzle orifice is varied.

14. The combination with a pump, of a Venturi tube interposed in the fluid supply line leading to the pump inlet, a by-pass leading from the discharge side of the pump to a nozzle set to discharge into the throat of the Venturi tube, a conical valve set small end outward in the nozzle orifice, means controlled according to the pressure on the discharge side of the pump for moving said valve to vary the effective size of the nozzle orifice, a valve movable to vary the effective area of the throat of the Venturi tube connected to the valve in the nozzle orifice to move therewith to decrease the effective cross-area of the Venturi throat as the effective size of the nozzle orifice is increased and to increase the area of the Venturi throat as the size of the nozzle orifice is decreased.

15. The combination with a pump, of a Venturi tube interposed in the fluid supply line leading to the pump inlet, a by-pass leading from the discharge side of the pump to a nozzle set to discharge into the throat of the Venturi tube, means controlled according to pressure on the discharge side of the pump for varying the effective size of the nozzle orifice and thereby controlling the flow of fluid through said by-pass to limit the increase in pressure on the discharge side of the pump, a conical valve formed and positioned within the Venturi tube to provide an elongated throat portion of minimum cross-section, and means for adjusting the position of said valve longitudinally of the tube to vary the cross-area of such portion of minimum cross-section.

16. The combination with a pump, of means for supplying fluid to the intake of the pump, including an inspirator comprising a Venturi tube and a nozzle set to discharge into the throat of the Venturi tube, means for conveying unused fluid from the discharge side of the pump to said nozzle, and means controlled by the pressure of the fluid on the discharge side of the pump for varying inversely the effective size of the nozzle orifice and the effective cross-area of the throat of the Venturi tube.

In testimony whereof I have hereunto set my hand in the presence of two subscribing witnesses.

WILLIAM BARTON EDDISON.

Witnesses:
ADELE M. ERB,
FREDERIC W. ERB.