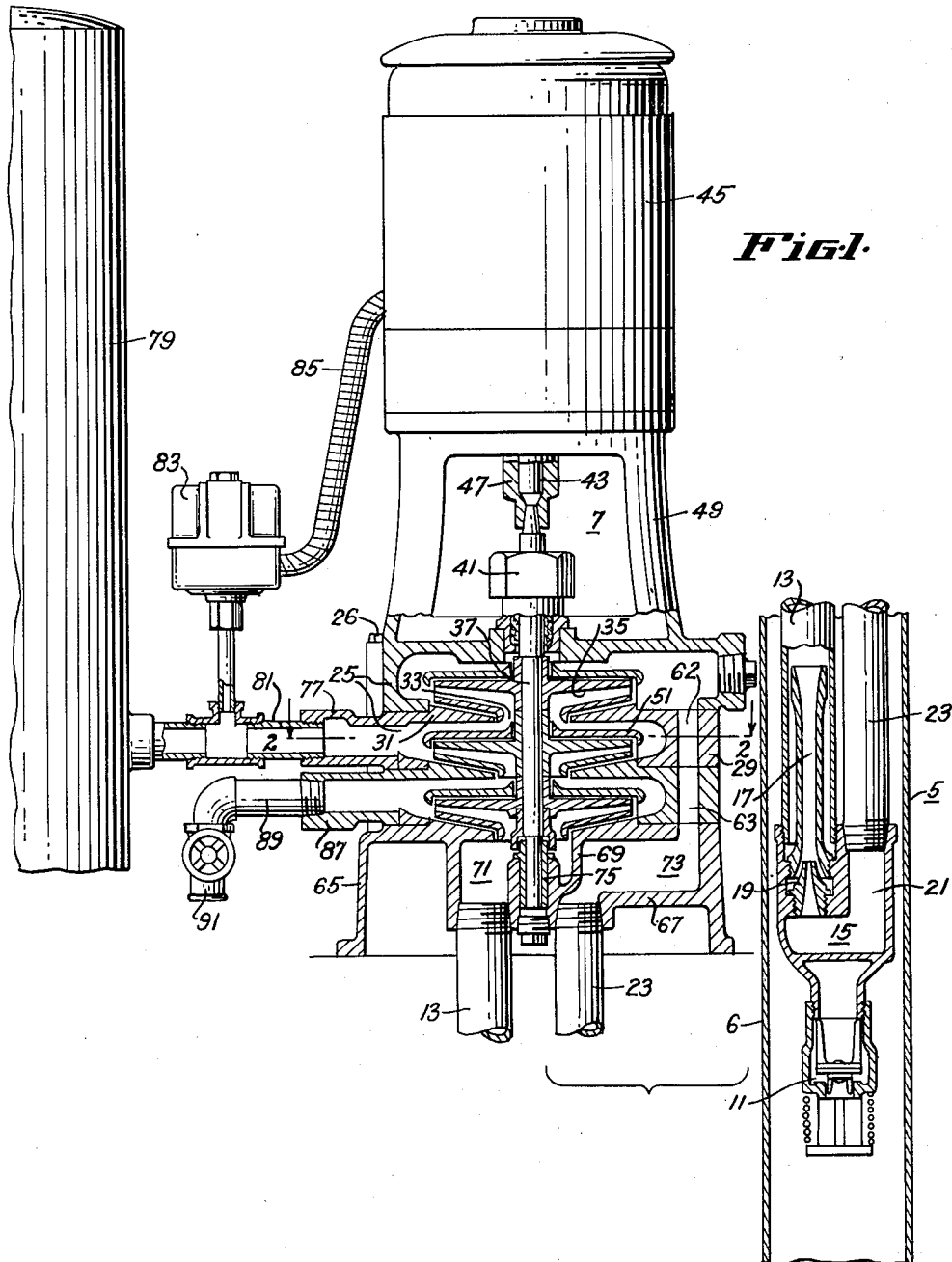


2,344,958

PUMPING SYSTEM

Filed July 15, 1941

2 Sheets-Sheet 1



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Fig. 2.

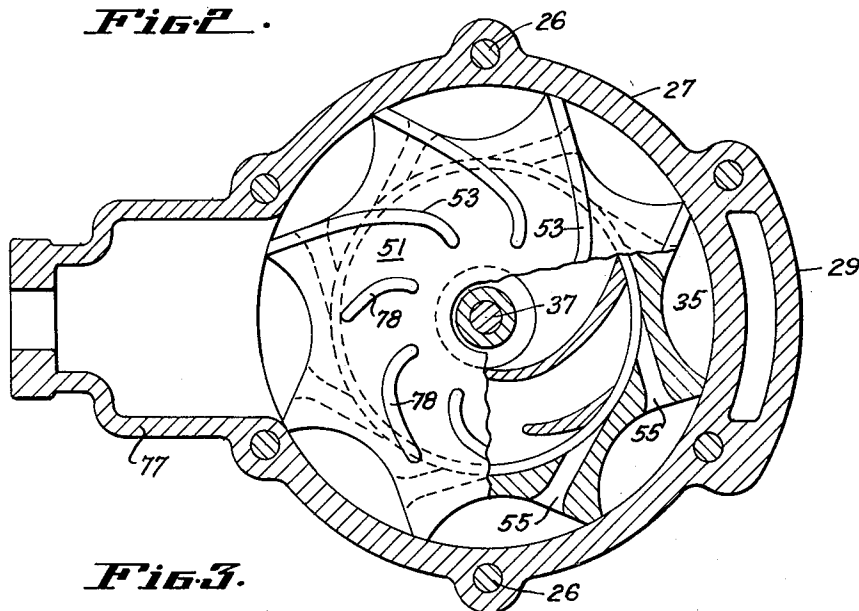
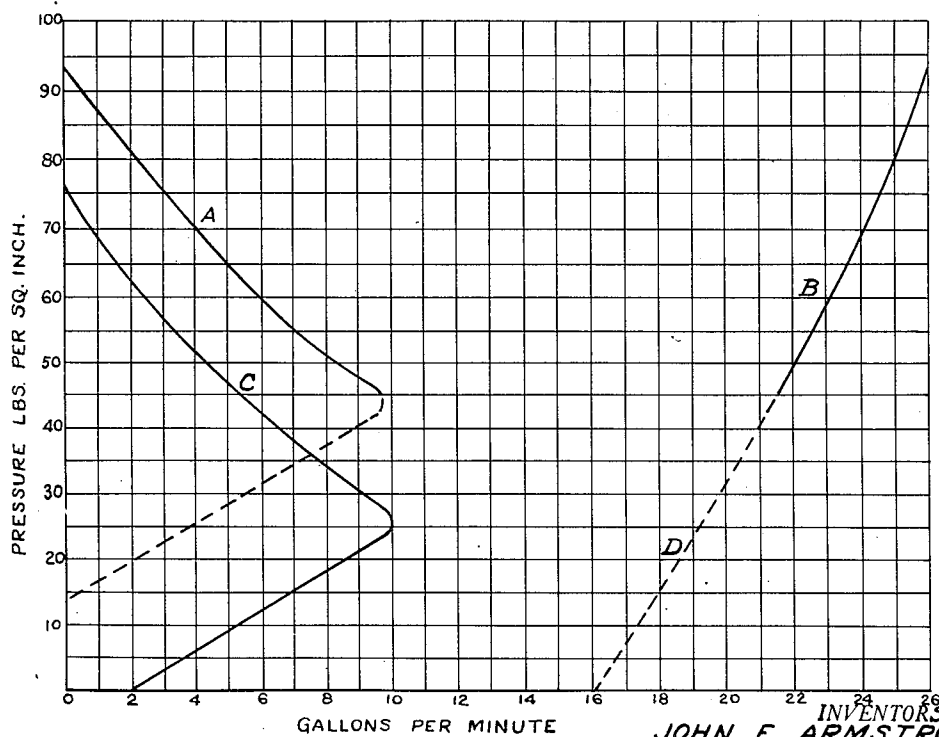


Fig. 3.



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PUMPING SYSTEM

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Application July 15, 1941, Serial No. 402,468

9 Claims. (CL 103—5)

Our invention relates to pumping systems, and more particularly to a system utilizing a pump of the injector type.

This application is a continuation in part of our application for Pump and pump system, Serial No. 396,018, filed May 31, 1941.

Injector pumps, as conventionally designed, comprise a pump unit of one or more impeller stages, and an injector assembly including a venturi and a nozzle connected in the suction line to the pump unit. The last impeller stage discharges usually to the pressure tank of a pressure system, an overhead tank, or sometimes at open discharge, while a portion of the discharge is diverted to the nozzle of the injector assembly. The number of stages is determined by the pressure requirements of the injector assembly, and this in turn is a function of the depth of water level in the well.

In installing a pressure system, including a pump of the injector type, the maximum permissible output of the pump must be carefully correlated to the pressure and volume requirements of the injector assembly, to preclude stalling of the pump under conditions when heavy demands are made upon it. Accordingly, it has always been necessary to insert in the discharge connection, a control valve, and, as a final step in the installation of such a system, the control valve had to be adjusted until the pressure and volume of liquid to the injector assembly approached that point where the pressure and volume were insufficient to sustain operation of the pump system. The control valve was then left in its adjusted position, and was not to be tampered with by the customer or consumer.

Inasmuch as such adjustment necessarily restricts the maximum output of the pump unit to a value below its actual physical capacity to deliver, the desire to realize as great an output as possible under the circumstances, renders this adjustment a rather critical one, and it is further complicated by the fact that consideration must also be given to the probable seasonal changes apt to occur in the water level of the well throughout the year, and at times when heavy demands are made upon the system. If these facts are not gauged properly, one is apt to find that during a dry spell or as a result of any other condition which might result in a lowering of the water level in the well, the system will fail to supply water, and a further adjustment of the control valve will be required to restore the system to a condition of operativeness. Such further adjustment will necessarily have to be in

a direction imposing a greater restriction on the output of the pump system.

Among the objects of our invention is to provide a novel and improved pumping system including an injector type pump,

(1) In which the aforementioned adjustments have been eliminated,

(2) Which requires no control valve,

(3) In which the injector assembly has been effectively isolated from the discharge of the pump unit,

(4) In which the pressure at discharge shall approximate that desired in a pressure system, without upsetting the conditions necessary to assure continued operativeness of the injector assembly,

(5) In which the pump unit need not be restricted as to maximum discharge to preclude stalling of the pump system, and

(6) Which not only requires no adjustments upon installation, but is capable of considerable increase in output capacity over the conventional system and at pressures within ranges desired, regardless of the depth of water level in the well.

Additional objects of our invention will be brought out in the following description of the same taken in conjunction with the accompanying drawings wherein—

Figure 1 is a conventionalized sectional view of a pressure system embodying our invention, said view being split and displaced to conserve space and permit of an enlarged showing.

Figure 2 is a sectional view taken along the line 2—2 of Figure 1 and partly broken away to expose underlying structure.

Figure 3 is a graph illustrating characteristics of the improved system of our invention.

Broadly speaking, our invention involves a modification of conventional type pump systems of the injector type, whereby we are enabled to sufficiently isolate the injector assembly from the discharge of the pump unit as to always maintain the system in a condition of operativeness, irrespective of demands upon the system, or predictable changes in water level of the well. This we accomplish by creating a multiple stage pump unit of the required number of stages to provide effective operation of the injector assembly at the lowest level to which the water in the well may at any time fall, and then supplying the consumer's requirements from an intermediate stage, which theoretically might even include the initial stage of the pump unit. With the intermediate stage designed to permit of a sufficient flow to the subsequent stage under conditions of maxi-

imum discharge from the intermediate stage, we have found that the injector assembly will not be influenced in its operation to the extent of rendering it incapable of functioning to maintain pump operation at any time when operation is desired, even under maximum discharge conditions.

Such isolation of the injector assembly from the discharge under the conditions noted, dispenses with the necessity for a control valve in the discharge connection, and what is more significant, eliminates entirely, the rather delicate and troublesome adjustments of such valve in setting up a system for operation.

Referring to the drawings for a more detailed description of our invention, we have illustrated the same as applied to a pump system of the type forming the subject of the patent to Jacuzzi, No. 2,150,799, of March 14, 1939, as incorporated in a pressure system, although it is not necessarily limited to the particular structure of the patent referred to.

In describing our invention, the term "pump unit" is employed to designate the multiple impeller stage assembly, "pump system" to include the "pump unit" and associated "injector assembly," while the expression "pressure system" is utilized to designate the "pump system" with pressure tank and associated distribution system.

The pump system may be conveniently divided into two portions, that portion 5 located in the well casing 6 below ground level, and the pump unit 7 located above ground. The portion below ground and located in the well casing is conventional structure and is not a part of the present invention, except in so far as it comprises an element of a new combination when considered in connection with the pump unit 7 above ground and the associated distribution system.

Such apparatus below ground, comprises a foot valve 11 disposed below the liquid level in the well, and forming the lower terminal of the suction line 13 which leads upward to the pump unit 7. Connected into the suction line, is the injector unit assembly 15 comprising a venturi 17 and a nozzle 19. As is conventional, the venturi is disposed to receive water from both the well and the discharge end of the nozzle 19, the nozzle being provided with a separate input passage 21 connecting to the pressure line 23, which in turn extends upwardly for connection to the pump unit 7.

The pump unit which, in a conventional system, may straddle the upper end of the well casing 6, or as in some installations, may be located off to one side, comprises in the present instance, a plurality of impeller stages 25 stacked one upon the other for operation in series, and secured together by a plurality of casing bolts 26.

Each stage comprises a generally cylindrical casing section 27 (Figure 2) provided with an offset 29, and having an end wall 31 with a central opening 33. Housed within each casing section is an impeller unit 35 of the centrifugal type. All such impeller units are affixed to a common impeller shaft 37, extending longitudinally through the casing formed by the casing sections 27, and are accordingly adapted to rotate upon rotation of such shaft. This shaft extends through a suitable packing gland 41 in the end wall of the last stage, and is connected for rotation to the shaft 43 of a driving motor 45, through a suitable coupling 47, the driving motor being mounted on a bracket 49 formed integral with the upper casing section.

To provide for smooth stream-lined flow of water through the various stages in series, intermediate guide elements, or spiders 51, as they are sometimes termed, are provided, one for each stage. Each of said spiders is of star-shaped contour (Figure 2), having a plurality of ribs 53 across the upper surface, extending from the points of the star toward the center. The ribs are curved to define passages offering minimum resistance to flow of liquid from the outer edge inwardly toward the input end of the impeller of the next stage. These passages, each receive the output of a preceding impeller via a Venturi opening 55 in each alternate peripheral wall of the spider, whereby the velocity of the impeller discharge is converted to pressure.

Each guide element is press fitted or otherwise secured within its associated casing section and has an internal diameter permitting free rotation of the impeller therein. By reason of the presence of a plurality of guide channels distributed uniformly about the guide element or spider, it is well adapted to receive the discharge from an associated impeller during continuous rotation thereof, and guide such discharge with a minimum of loss, to the input of the impeller associated with the following stage in the series. This applies to all guide elements, except the guide element of the last stage, which is designed to receive the output of its associated impeller and direct the same into a by-pass channel 62, to be described, for use in operating the injector assembly.

Each of the casing sections 27, except the section of the last stage, is cast with an independent passage 63 longitudinally through the offset 29 of the casing section, which, upon assembling of all the sections of the pump unit, cooperate with the last stage, to provide the by-pass channel 62 previously referred to.

The entire assembly of stages is supported upon a base section 65 which is secured thereto by the casing bolts 26 and is adapted to straddle the well casing 6. This base section is cast with a horizontal transverse wall 67 and a partition 69 dividing the base section into two chambers 71 and 73. One of these chambers, 71, opens into the input side of the impeller of the first stage, and the transverse wall 67 is provided with a threaded opening for receiving the upper end of the suction line 13. The other chamber, 73, connects with the by-pass 62 and terminates in a threaded opening in the transverse wall 67 to which the pressure line 23 is connected.

The impeller shaft 37 extends centrally through the base section 65 which carries an end bearing 75 for the shaft.

One of the intermediate stages is formed or otherwise provided with a discharge spout 77. In this stage, the spider 51 is preferably formed with shortened ribs 78 adjacent the spout, to facilitate the flow of water therethrough. The stage to be selected is preferably that one which will discharge at approximately the pressure desired in the pressure system. In the system as illustrated, the stage selected is the second stage and it is connected to the pressure tank 79 of such a system by a pipe connection 81. Unlike conventional systems, this pipe connection is devoid of any control valve. The customary pressure switch 83 is tapped into this connection, whereby it is made responsive to the pressure existing in the pump unit and tank at all times, and in turn is connected, by means of suitable

cable 85, in the conventional manner to the pump motor to control its operation.

When installing a pressure system of the character described, and after all connections have been made, the system is ready for operation under any of the conditions normally apt to exist in such installation. None of the aforementioned adjustments has to be made, and this not only facilitates the actual installation, but assures continued operativeness of the system and freedom from failure, from such causes as have already been mentioned.

The operation of our improved pressure system and the advantages derived therefrom are explainable by reference to the graph of Figure 3, wherein we have depicted curves representative of a three stage pump unit, with the pressure tank connected to the second stage, and the injector assembly fed from the terminal or last stage, all as illustrated in the drawings.

The curve A represents the discharge curve of a conventional pump system where the discharge is taken from the terminal stage that supplies the injector assembly. The stable operating range of the pump system occurs along the solid line portion of the curve, while the dotted line portion represents an unstable or transient condition of the pump system, and indicates the changes in discharge pressure occurring in that brief period of operation through which the pump system goes in the process of stalling.

The curve B represents the characteristics of the supply to the injector assembly in a conventional pump system of the type described. The solid line portion corresponds to that of the discharge curve A and represents stable operation, while the dotted line portion represents the pressure changes occurring during the same brief period involved in the process of stalling. This process of stalling is stimulated, when the discharge pressure of curve A is permitted to fall below the critical value represented by the end of the stable operation portion of said curve, and is apparently the result of a cumulative mutual effect between the pump unit and the injector assembly.

Inasmuch as both the discharge pressure and the supply pressure in the conventional system, are developed in the same stage, namely the terminal or last stage, the pressure existing at any instant in the supply to the injector assembly will be the same as that of the discharge, and, therefore, upon the dropping of the discharge pressure below the critical value, the resulting transient condition set up, will cause the supply pressure to slide to a value below that essential toward maintenance of operation of the pump system, and the system will stall. This explains why in a conventional system, a control valve is a necessary element and why the adjustment of such a valve is a delicate and critical matter.

With further reference to the graph, the curve C represents the discharge curve of the second stage of the pump system under consideration. The pressures existing simultaneously at the discharge and in the supply to the injector assembly are no longer the same as in the conventional system, but the value of the supply pressure to the injector assembly, is maintained at a substantially higher value than that at the discharge. When this difference is such as to satisfy the requirements of the injector assembly under conditions existing at the lowest level to which the water in the well may at any time drop, the operativeness

of the pump system will be maintained in spite of any lowering of the discharge pressure. The discharge characteristic of the pump system, therefore, has no critical value of pressure, and the system is stable at all pressures which may be developed at the discharge. Thus, the effect is to extend the stable operation portion of the supply curve B along the dotted line portion to some point of lower pressure such as at point D, which value is still sufficient to maintain the system in operative condition. Below this value, the pressure will be precluded from dropping by reason of the fact that the pressure of the discharge will have reached its minimum value at that time.

Our invention does not forbid the simultaneous use of other intermediate stages of the pump unit, for obtaining open discharge, for example, at pressures developed in such stages during operation. As illustrative of this, we have shown the first stage of the pump unit of Figure 1 as being provided with a spout 87 and a connection 89 terminating in a spigot 91 for open discharge. When such is the case, the effect on the water level in the well will be taken into consideration in determining the differential in pressure to be maintained between the supply to the injector assembly and either of the discharge stages.

As stressed in our co-pending application, previously identified, we have found a considerable increase in output over the conventional system can be realized from the first stage of a pump unit as illustrated, and at practically zero pressure. These characteristics admirably adapt the system for irrigation purposes.

Similarly, a greater output, though to a somewhat lesser extent, may be realized by taking the water from the second stage, for example. At this stage, the pressure at discharge will be of a value between that of the first stage discharge and that developed in the terminal stage. Inasmuch as the pressure in the terminal stage is often far in excess of that really desired in a pressure system, our invention, in addition to the advantages of eliminating troublesome adjustments of the system, offers the added advantages of permitting the consumer considerable leeway in selecting the pressure he desires in his pressure system, with operation at such pressure accompanied by an increase in the output of the pump system over what one could realize under conventional practice.

From the above description of our invention, it will be appreciated that, in a pressure system, the presence of a control valve and the necessity for properly adjusting the same in the installation of such system, is completely avoided and that all the objects of our invention will be fulfilled. While we have described one embodiment of our invention in detail, the same may be susceptible to variations and changes without departing from the spirit thereof, and we, accordingly, do not desire to be limited in our protection to such details, except as may be necessitated by the appended claims.

We claim:

1. A pump system comprising a pump unit having a plurality of stages arranged in series; a suction line connected to the input of the initial stage of said series; an injector assembly in said suction line and including a Venturi and a nozzle; a pressure line connecting said nozzle to one of said stages beyond said initial stage; and a valve-free discharge passage from one of said stages preceding the stage to which said injector nozzle is connected.

2. A pressure system comprising a pump unit having a plurality of stages arranged in series; a suction line connected to the input of the initial stage of said series; an injector assembly in said suction line and including a Venturi and a nozzle; a pressure line connecting said nozzle to one of said stages beyond said initial stage; a pressure tank; and a valve-free discharge passage to said pressure tank from one of said stages preceding the stage to which said injector nozzle is connected.

3. A pressure system comprising a pump unit having a plurality of stages arranged in series; a suction line connected to the input of the initial stage of said series; an injector assembly in said suction line and including a venturi and a nozzle; a pressure line connecting said nozzle to one of said stages beyond said initial stage; a pressure tank; a valve-free discharge passage to said pressure tank from one of said stages preceding the stage to which said injector nozzle is connected, and a discharge passage from another of said stages preceding that stage to which said pressure tank is connected.

4. A pressure system for a well, comprising a pump unit having a plurality of stages arranged in series; a suction line connected to the input of the initial stage of said series; an injector assembly in said suction line and including a venturi and a nozzle; a pressure line connecting said nozzle to the last stage of said series; a pressure tank; and a discharge connection to said tank from a preceding stage having a discharge pressure lower than that of said last stage by an amount equal at least to the minimum pressure necessary to maintain operativeness of such system when installed in said well.

5. A pump system for a well, comprising a pump unit having a plurality of stages in series, from which discharge at any one of a number of pressures may be taken; a suction line connected to the input of said pump unit; an injector assembly in said suction line and including a venturi and a nozzle; a pressure line connecting said nozzle to said pump unit at a point of high discharge pressure; a pressure chamber; and a discharge connection to said pressure chamber from said pump unit at a pressure value lower than that to said nozzle by an amount sufficient to maintain said injector assembly operative at the lowest normal level of water in said well.

6. A pump system for a well, comprising a pump unit having a plurality of stages in series, from which discharge at any one of a number of pressures may be taken; a suction line connected to an early stage of said pump unit; an injector assembly in said suction line and including a ven-

turi and a nozzle; a pressure line connecting said nozzle to a stage of said pump unit of relatively high discharge pressure; a pressure chamber; and a discharge connection to said pressure chamber from a different stage of said pump unit of a pressure value lower than that to said nozzle by an amount sufficient to maintain said injector assembly operative at the lowest normal level of water in said well.

7. A pump system for a well, comprising a pump unit having a plurality of pressure levels at which a discharge may be obtained; a suction line connected to the input of said pump unit; an injector assembly in said suction line and including a venturi and nozzle; a discharge connection from one pressure level of said pump unit, said discharge connection being free of any control valve thereby permitting full capacity discharge therethrough; and a pressure line connecting said nozzle to a pressure level in said pump unit higher in value than that at full capacity discharge through said discharge connection by an amount sufficient to maintain said injector assembly operative in the production of such full capacity discharge.

8. A pump system for a well, comprising a pump unit having a plurality of pressure levels at which a discharge may be obtained; a suction line connected to the input of said pump unit; an injector assembly in said suction line and including a venturi and nozzle; a pressure chamber; a discharge connection from one pressure level of said pump unit to said pressure chamber, said discharge connection being free of any control valve thereby permitting full capacity discharge therethrough; and a pressure line connecting said nozzle to a pressure level in said pump unit higher in value than that at full capacity discharge through said discharge connection by an amount sufficient to maintain said injector assembly operative in the production of such full capacity discharge.

9. In a pump system including a pump unit having a plurality of stages arranged in series, and an element for receiving the discharge of said pump unit; a suction line connected to the input of the initial stage of said series; an injector assembly in said suction line and including a venturi and a nozzle; a pressure line connecting said nozzle to one of said stages beyond said initial stage; and a valve-free discharge passage from one of said stages preceding the stage to which said injector nozzle is connected, and leading to such element of the system.

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