# Note on Some Experiments With a New Form of Pressure Regulator.

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General.—The writer here records some experiments which were made under his direction in the Engineering Laboratory of Purdue University on a new apparatus by Mr. Will Hull, of the class of 1901, who developed the details of the apparatus from the suggestion of Mr. J. T. Wilkin, engineer for the Connersville Blower Company, Connersville, Ind.

The apparatus (Fig. 1) consists essentially of an expanding nozzle and a flat circular disc, against which the jet from the nozzle is directed, the disc being enclosed in a suitable chamber. The action is similar to that of the well-known ball nozzle, and the disc replaces the ball. In case of the ball nozzle the back pressure forcing the ball against the jet is the pressure of the atmosphere. In the apparatus here described the disc is enclosed in a chamber, and the back pressure is the pressure of the water in the chamber. This pressure is greater than that in the rapidly moving sheet of water on the up-stream face of the disc, so that the disc moves toward the nozzle until equilibrium is established. The disc thus automatically throttles the up-stream.

When this apparatus is inserted in a pipe line the pressure on the down-stream face of the disc is preserved fairly constant (within the limits of the experiments and for certain range of pressure in case of the apparatus used), while the up-stream pressure varies within wide limits. The principle of the apparatus will have an application whenever it is desired to deliver water at a constant pressure to a machine from a source of supply subject to fluctuations of pressure. Whether a design of disc and nozzle could be reached which would regulate the pressure in case of air or steam is not determined.

The experiments were initiated with the desire to obtain information which would serve as a basis for proportioning this apparatus to serve various conditions of pressure and delivery. The experiments were interrupted before that point was reached. The results obtained and the example are generally interesting and it seems worth while to record them.

Mr. Hull used various combinations of disc and nozzle until he found the proper combination which would regulate the pressure used in case of the apparatus available.

SECTIONAL VIEW.

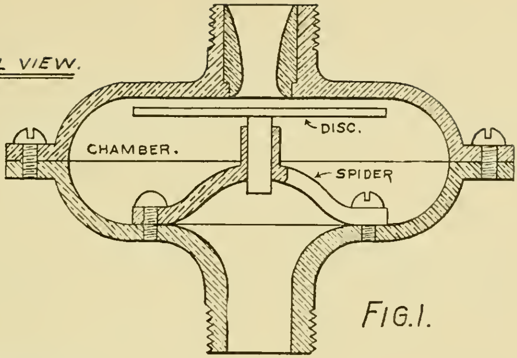
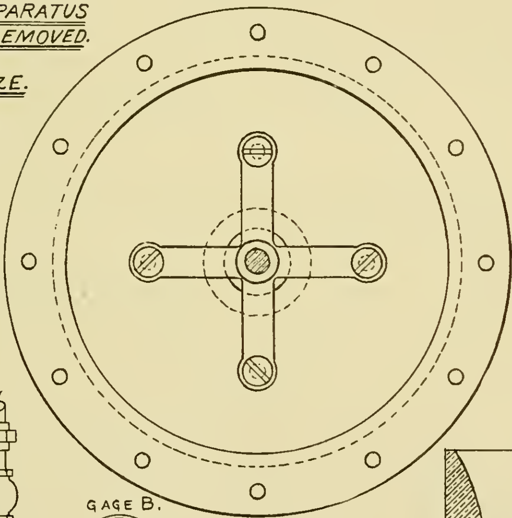



FIG. 1.

PLAN OF APPARATUS WITH TOP REMOVED.

$\frac{2}{3}$ FULL SIZE.

BRASS.



NOZZLE.

$\frac{4}{3}$ ACTUAL SIZE.

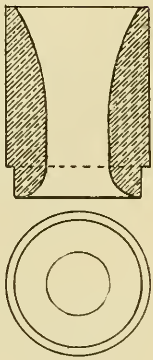


FIG 2

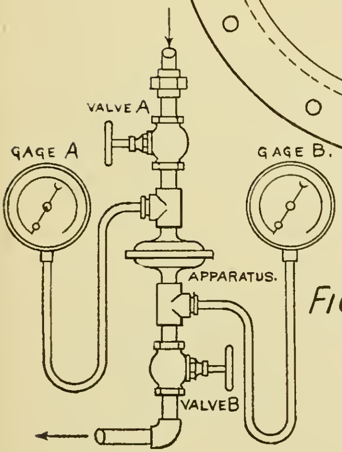
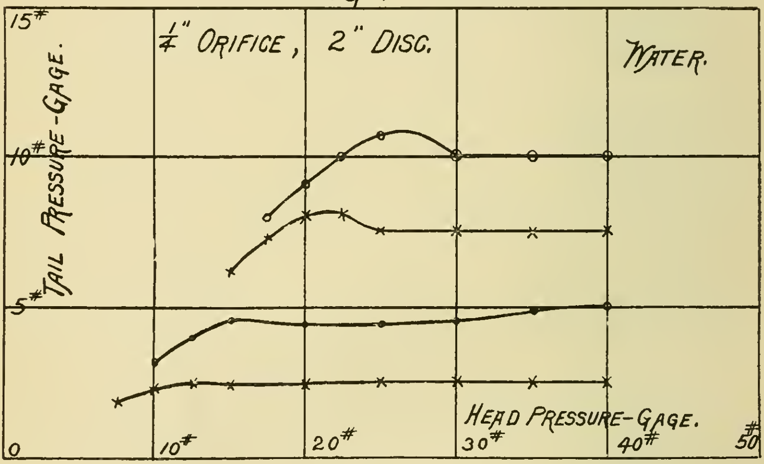



FIG 3

In brief, he found that a nozzle of form specified in Fig. 2 (called a ¼ inch nozzle), in combination with a 2 inch flat disc, would regulate the pressure in a ½ inch pipe to the following extent:

The pressure on the down-stream section of the pipe was preserved constant at 2½ pounds by the action of the disc while the pressure of the up-stream section varied between 10 to 40 pounds per square inch by gauge (as shown on Fig. 4).

FIG 4




## APPARATUS.

Fig. 1 shows the construction of the apparatus with nozzle, disc, chamber and spider for supporting the disc. The fitting of the apparatus for experimental work is shown in Fig. 3. The two gauges for measuring the pressures were placed as close as possible to the chamber containing the disc. The fittings were made with great care. The valves shown were for controlling the pressures used in experimentation.

## METHOD OF EXPERIMENT.

The apparatus was attached to the standpipe of the hydraulic laboratory, the pressure in which was controlled by a steam pump. Starting with a given standpipe pressure, say 40 pounds, the water was allowed to flow through the apparatus, being throttled by the lower valve to indicate a down-stream pressure of, say 2½ pounds per square inch on the lower gauge. This down-stream pressure was allowed to remain fixed during the test, the lower valve not being disturbed. The up-stream pressure was varied by the use of the upper valve, throttling the up-stream section. In this way up-stream pressures of from 40 pounds per square inch down by 5 five pounds per square inch steps to the lower limit were effected. The apparatus discharged into a weighing tank and the discharge was weighed. The temperature of the water was taken every minute because this temperature varied greatly throughout the tests, due to the fact that the standpipe tank was connected to the condenser of a Corliss engine. (With respect to the effect of the temperature on the results, it may be said that when the temperature of the discharge rose above the 100° F., the tail pressure gauge showed a very unsteady pressure, the needle vibrating with a range of as much as one-half pound. The disc was no doubt at this time subject to vibrations, which, when the temperature of the water rose to 110° F., were of such frequency as to cause a musical note. Under the latter condition the needle was too sluggish to respond and remained at a fixed position. The movement is probably connected with alternate periods of vaporization and condensation of the water on the upper side of the disc.)

Results.—The following combinations of nozzle and disc were used: One-eighth-inch nozzle, 1-inch disc; ⅛-inch nozzle, 1½-inch disc; ⅛-inch nozzle, 2-inch disc; 3-16-inch nozzle, 1-inch disc; 3-16-inch nozzle, 1½-inch disc; 3-16-inch nozzle, 2-inch disc; ¼-inch nozzle, 1-inch disc; ¼-inch nozzle, 1½-inch disc; ¼-inch nozzle, 2-inch disc.

Of these, the ¼-inch nozzle gave successful results; the ¼-inch nozzle, with the 2-inch disc, gave the best results. These are shown in Fig. 4. In working the head pressure down toward the tail pressure the former would approach a critical point at which the difference of pressure became so slight that the regulating effect ceased and both head and tail gauges suddenly moved to the same reading. The disc at this period, no doubt, dropped away from the jet. That is a certain difference of pressures is needed to enable the apparatus to work. This difference of pressure became greater as the tail pressure was increased, as is shown in Fig. 4.

In experiments with the other orifices mentioned the lines shown in Fig. 4 became straight lines inclined to the horizontal. The hump in Fig. 4 was characterized by an unsteady head pressure.

One disc was bevelled so as to give a constant area of passageway to the expanding ring of water, that is, it was dished with the deepest part next to the nozzle. This disc preserved a constant difference of pressure between the head and tail pressures.

Some experiments were carried on with air as the fluid passing through the pipes. With the nozzle and discs used there appeared to be no governing effect, in case of these air pressures.

In general it may be said that the shape of the nozzle has most to do with the action observed. A number of nozzles of different form were used; those most nearly like that shown on Fig. 2 gave the best governing effect.

The size of the disc affects the results obtained with any given nozzle. Two-inch disc gave better results than 1-inch or the 1½-inch disc.

The action desired could be obtained with water at a temperature of 75° F. as well as at the higher temperatures.

A very pretty cylindrical sheet of water could be obtained by removing the lower part of the casing. The disc acted like the well-known ball-nozzle. Under these conditions, with a head pressure of 40 pounds and a nozzle velocity (as figured from the discharge) of 14.6 feet per second, it was found necessary to exert a force of 9 pounds to pull the disc from the jet.

WATER.

| ¼-Inch Orifice. | | | | 2-Inch Disc. | | | |
|---|---|---|---|---|---|---|---|
| Gage Pressure. | | Discharge Per Min. Cubic Ft. | Temperature of Water. | Gage Pressure. | | Discharge Per Min. Cubic Ft. | Temperature of Water. |
| Head. | Tail. | | | Head. | Tail. | | |
| 40 lbs. | 2.5 lbs. | 0.301 | 105° F. | 40 lbs. | 7.5 lbs. | 0.334 | 88° F. |
| 35 “ | 2.5 “ | 0.304 | 105 “ | 35 “ | 7.4 “ | 0.337 | 92 “ |
| 30 “ | 2.5 “ | 0.304 | 108 “ | 30 “ | 7.5 “ | 0.342 | 93 “ |
| 25 “ | 2.5 “ | 0.304 | 109 “ | 25 “ | 7.5 “ | 0.342 | 93 “ |
| 20 “ | 2.4 “ | 0.300 | 112 “ | 22.5 “ | 8.2 “ | 0.342 | 95 “ |
| 15 “ | 2.4 “ | 0.300 | 112 “ | 20 “ | 8.0 “ | 0.350 | 96 “ |
| 12.5 “ | 2.5 “ | 0.304 | 111 “ | 17.5 “ | 7.25 “ | 0.323 | 95 “ |
| 10 “ | 2.3 “ | 0.282 | 106 “ | 15 “ | 6.2 “ | 0.314 | 94 “ |
| 7.5 “ | 1.9 “ | 0.267 | 112 “ | | | | |
| 40 lbs. | 5 lbs. | 0.330 | 95° F. | 40 lbs. | 10 lbs. | 0.377 | 82° F. |
| 35 “ | 4.8 “ | 0.322 | 100 “ | 35 “ | 10 “ | 0.385 | 81 “ |
| 30 “ | 4.5 “ | 0.315 | 99 “ | 30 “ | 10.2 “ | 0.388 | 80 “ |
| 25 “ | 4.4 “ | 0.306 | 97 “ | 25 “ | 10.7 “ | 0.388 | 78 “ |
| 20 “ | 4.4 “ | 0.306 | 100 “ | 22.5 “ | 10 “ | 0.385 | 78 “ |
| 17.5 “ | 4.5 “ | 0.315 | 105 “ | 20 “ | 9 “ | 0.361 | 78 “ |
| 15 “ | 4.5 “ | 0.315 | 104 “ | 17.5 “ | 8 “ | 0.336 | 78 “ |
| 12.5 “ | 4.0 “ | 0.302 | 105 “ | | | | |
| 10 “ | 3.2 “ | 0.270 | 108 “ | | | | |