A STUDY OF THE EFFICIENCY OF DIAPHRAGM VALVES

THESIS FOR THE DEGREE OF BACHELOR OF SCIENCE

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A Study of the Efficiency of Diaphragm Valves

A Thesis Submitted to

The Faculty of

MICHIGAN STATE COLLEGE

of

AGRICULTURE AND APPLIED SCIENCE

by

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Candidate for the Degree of

Bachelor of Science

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THESIS

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INTRODUCTION

"An Analysis of Diaphragm Valves." The process of determining these five words constituted one week of the work done on this thesis. I mean the process of choosing of a suitable subject; one in a field interesting to me, interesting and of value to the engineering world, with a range and depth attainable for me, possible with the available equipment, and approved by the Civil Engineering Department.

Research is very interesting for me in any form because of natural curiosity and a firm confidence in work done by myself. The study of hydraulics in particular, is fascinating; to endeavor to solve by theory, problems involving empirical formulae. That is, I would like to use theorems proven by logic rather than those proven by experiment. Although hydraulics in general has been studied since the time of the ancient Chinese and their water clock, the practical engineer must use equations based on observation; therefore, every new application or method requires experimentation to govern its use. The subject of this paper is limited enough to be handled with the equipment of the hydraulic laboratory of Michigan State College, and an undergraduate education.

This particular topic was suggested by Professor Leigh, and was approved by Professor Allen, both of the Civil Engineering Department of Michigan State College. I selected this one as the most suitable of the following subjects under consideration:

1. Analysis and guaging of diaphragm valves.
2. Analysis and guaging of multiport valves.
3. Continuation of a previous thesis on flow around model structures in a flume.

4. Compilation of the collective data gathered to form the now accepted formulae; a comparison and total analysis.

5. Limitations of a partial flume.

6. Redesign of the Michigan State College hydraulic laboratory.

7. River flow into Lake Michigan and beach erosion.

This list is included to be of any possible use to future thesis writers.

After settling on a topic, the limited facilities of the hydraulic laboratory became apparent, and I looked about for another possible place for the experiment. In the course of this I made a small survey to find the locations on campus with water facilities and a low elevation for a high head for the valves. A list of the eligible places I found is on the next page. However in the end none of these places had enough more head available to make it worthwhile since all the instruments were in the hydraulic lab and would have to be moved back and forth.

ENGINEERING LABORATORY DATA SHEET

DEPARTMENT OF CIVIL ENGINEERING DATE DECEMBER 1948

COURSE NUMBER C.E. 411 EXPERIMENT NUMBER OR TITLE HAND LEVEL SURVEY

IDENTIFICATION OF EQUIPMENT TESTED

(manufacturer, address, name, model, size, laboratory number, etc.)

IDENTIFICATION OF EQUIPMENT USED HAND ANEROID ALTIMETER

ALL READINGS ARE RELATIVE TO L&&(AT THE HYDRAULIC LABORATORY ?

(kinds, sizes, ranges, etc. of meters, brakes, speed indicators, etc.)

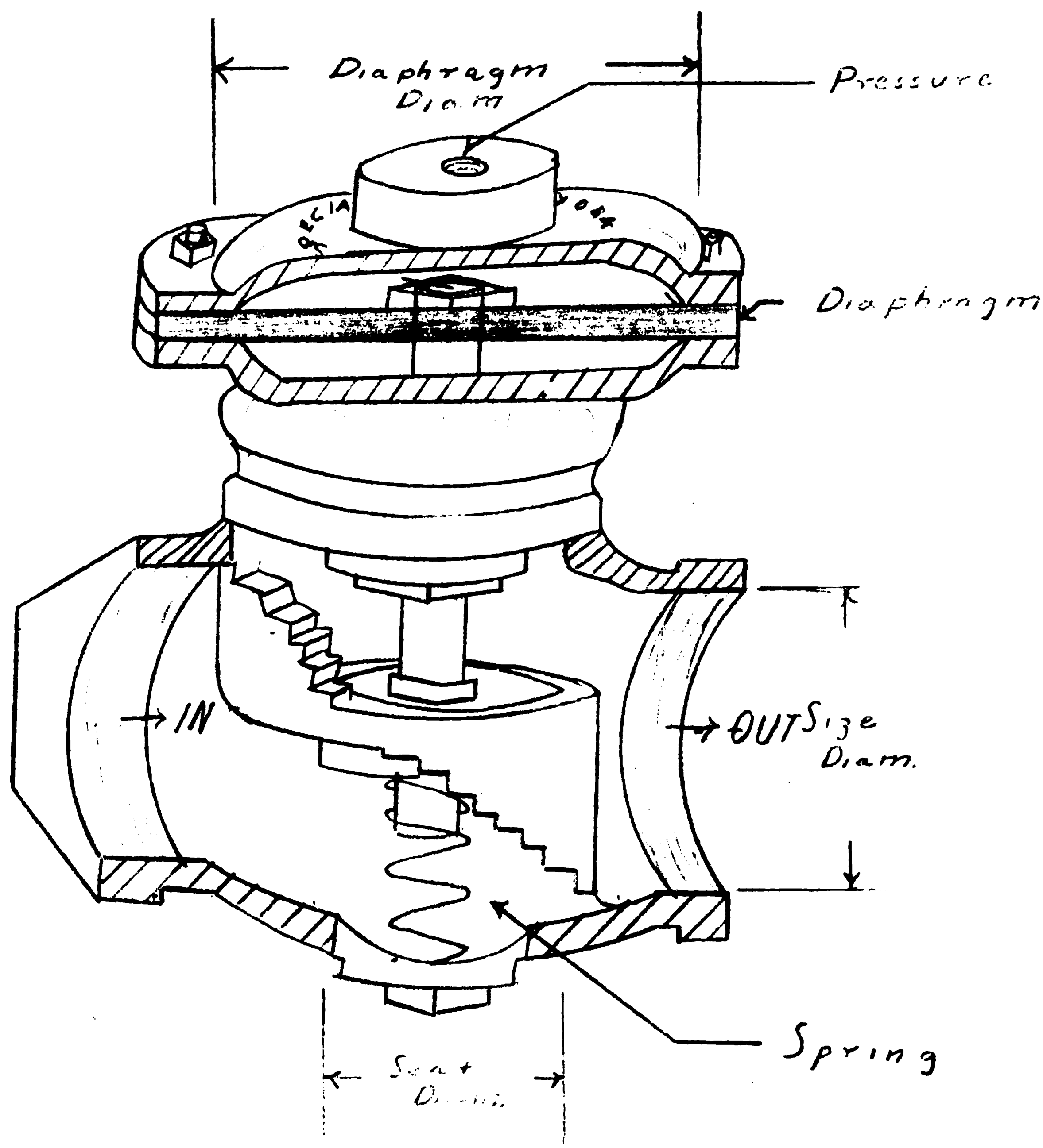
TEST DATA

Location	Reading	Drain Comment
Olds Hall:		
N.E. Corner	1,774	Closed
Mech. Engr. Flume	1,775	Good
Hydraulic Lab.	1,779	
Power Plant Basement	1,778	
Power Plant Open Air Pit	1,778	Small Drain
Power Plant Sub-basement	1,780	Hard to get at
Pit	1,773	"
Steam Tunnel	1,780	
Chem. Bldg. Basement	1,783	No Direct Drains
Pumping Plant on River	1,782	Good

Note—All abbreviations of and symbols for engineering terms and physical quantities must be in accordance with prevailing standards unless otherwise indicated by the Instructor.

MUELLER STEAM SPECIALTY VALVES

2"   2½"


Diaphragm Diam
Pressure
Diaphragm
IN
OUT
Size Diam.
Spring
Seat Diam.

EXPLANATION OF A DIAPHRAGM VALVE

A diaphragm valve, (see diagram), is motivated by hydraulic pressure on a nonporous diaphragm which is attached circumferentially to the frame of the valve. There is a piston that operates the valve and this is attached to the center of the diaphragm. Movement, therefore, of the diaphragm because of the pressure on it, opens the valve. A spring, opposing the motion of the hydraulic pressure, closes the piston and, therefore, the valve when the pressure is released.

VALVES TESTED

Herein are the results of head loss calibration trials run on the following valves:

a. 2 inch hydraulically operated diaphragm valve made by the Mueller Steam Specialty Co., Long Island, New York.

b. $2\frac{1}{2}$"hydraulically operated diaphragm valve made by the Mueller Steam Specialty Co.

c. 16 inch, Model 40 WR, made by Ross Valve Mfg. Co., Troy, N.Y.

d. 16 inch, Model 40 WR "Special", made by Ross Valve Mfg. Co.

e. 8 inch, Model 40 DAWR, Double Acting, 8 inch seat, Ross Mfg. Co.

f. 8 inch, Model 40 DAWR, Double Acting, 10 inch seat, Ross Mfg. Co.

g. 8 inch, Model 40 DAWR, Double Acting, 12 inch seat, Ross Mfg. Co.

OPERATING PROCEDURE FOR (2") VALVE

The purpose of this project was to find the head loss, or pressure loss, due to the friction in the valve. This was done at varying velocities or rates of flow of water through the valve. The essential measurements, therefore, were of flow rate and of pressure drop due to the valve. I needed a system that would provide these quantities, and this was supplied by having a continuous flew and using a stopwatch and scales to determine the weight of water collected in a certain time interval of flow through the valve. I then set up pressure guages to read the pressure of the water on each side of the valve. The difference therein was the drop due to the friction inside. The City of East Lansing supplied the valve through the courtesy of Mr. Granger; my problem was to get it installed in the laboratory which is room 4 of Olds Hall of Engineering. This was a long process for me. It involved picking the most convenient location, collecting the necessary connections, and using them in the proper manner. The location had to be such that it wouldn't interfere with the many classes, (27 hours per week), held in the room and easily accessable to the maximum pressure available. This location proved to be on an outlet that apparently hadn't been used since Archimedes. After a day of struggle, I managed to have the valve, a master gate valve, two small valves for the pressure readings, a special $\frac{1}{2}$" pipeline to put pressure on the diaphragm, a pipeline to the weighing apparatus and one to the drain installed. After installing the proper guages, testing the lines, I was ready to roll. The instruments used were sometimes changed so I have them listed with the data.

Guage For Pressure on Disc

Valve to Control Disc. Press

Application of Disc. Pressure

Weighing Tank

Source of Water Discharge

Pressure Guage For Flow in

Manometer For Out Flow Press

Setup For
2" Valve

ENGINEERING LABORATORY DATA SHEET

DEPARTMENT OF CIVIL ENGINEERING DATE DECEMBER 1948

COURSE NUMBER C. E. 411 EXPERIMENT NUMBER OR TITLE

HEAD LOSS IN DIAPHRAGM VALVES

IDENTIFICATION OF EQUIPMENT TESTED 2 inch DIAPHRAGM VALVE - HYDRAULICALLY OPERATED

by MUELLER STEAM SPECIALTY CO., LONG ISLAND, NEW YORK

(manufacturer, address, name, model, size, laboratory number, etc.)

IDENTIFICATION OF EQUIPMENT USED Mercury U Tube Differential Pressure Guage

Swiss Stop Watch 1/10 Second

(kinds, sizes, ranges, etc. of meters, brakes, speed indicators, etc.)

TEST DATA

al	Wt. (#)	Time (sec)	Lg Vel.	Vel. ('/sec)	Hd.Loss (in.Hg)	Hd.Loss (ft.Wtr.)	N
	300	23.8		9.3117	19	19.95	14.82
	"	25.4		8.6785	17.5	18.375	15.71
	"	27.7		7.9585	15.25	16.0125	16.28
	"	28.2		7.8269	15.25	16.0125	16.83
	"	29.4		7.5063	13.5	14.175	16.20
	"	30	.8660	7.345	13.0	13.65	16.28
	"	34	.8116	6.480	10.0	10.50	16.09
	"	33.9	.8129	6.500	10.0	10.50	15.99
	"	48.1	.6610	4.581	5.2	5.46	16.70
	"	50	.6441	4.407	4.6	4.83	16.00
	"	24.4	.9557	9.030	19.0	19.95	15.75
	"	24.65	.9506	8.925	18.4	19.32	15.50
	"	26.40	.9215	8.345	16.8	17.64	16.29
	"	29.10	.8792	7.572	14.6	15.33	17.20
	"	30.4	.8602	7.248	12.6	13.23	16.21
	"	34	.8116	6.480	10.2	10.71	16.41
	"	37.10	.7509	5.635	7.8	8.19	16.60
	"	53.3	.6164	4.134	4.3	4.515	17.00
	"	73.25	.4783	3.008	2.4	2.52	17.92
	"	97.7	.3532	2.255	1.4	1.47	18.60
	294	25.2	.9409	8.728	16.4	17.22	14.54
	298	24.9	.9520	8.954	17.7	18.585	14.92
	236.5	19.7	.9533	8.980	17.4	18.27	14.57
	271.8	37.75	.7314	5.388	7.0	7.35	16.29
	302	41.5	.7360	5.445	7.15	7.5075	16.29
	181	25.46	.7259	5.320	6.7	7.035	16.00
	28.65	30.4	.8483	7.052	11.9	12.425	16.17
	252	28.5	.8206	6.616	10.75	11.2875	16.58
	263	27.15	.8602	7.248	12.8	13.44	16.46
	267	115.45	.2381	1.730	1.05	1.1025	23.69

Note—All abbreviations of and symbols for engineering terms and physical quantities must be in accordance with prevailing

ENGINEERING LABORATORY DATA SHEET

DEPARTMENT OF CIVIL ENGINEERING DATE DECEMBER 1948

COURSE NUMBER C.E. 411 EXPERIMENT NUMBER OR TITLE

HEAD LOSS IN DIAPHRAGM VALVES

IDENTIFICATION OF EQUIPMENT TESTED 2 inch DIAPHRAGM VALVE - HYDRAULICALLY OPERATED

by MUELLER STEAM SPECIALTY CO., LONG ISLAND, NEW YORK

(manufacturer, address, name, model, size, laboratory number, etc.)

IDENTIFICATION OF EQUIPMENT USED Mercury U Tube Differential Pressure Guage

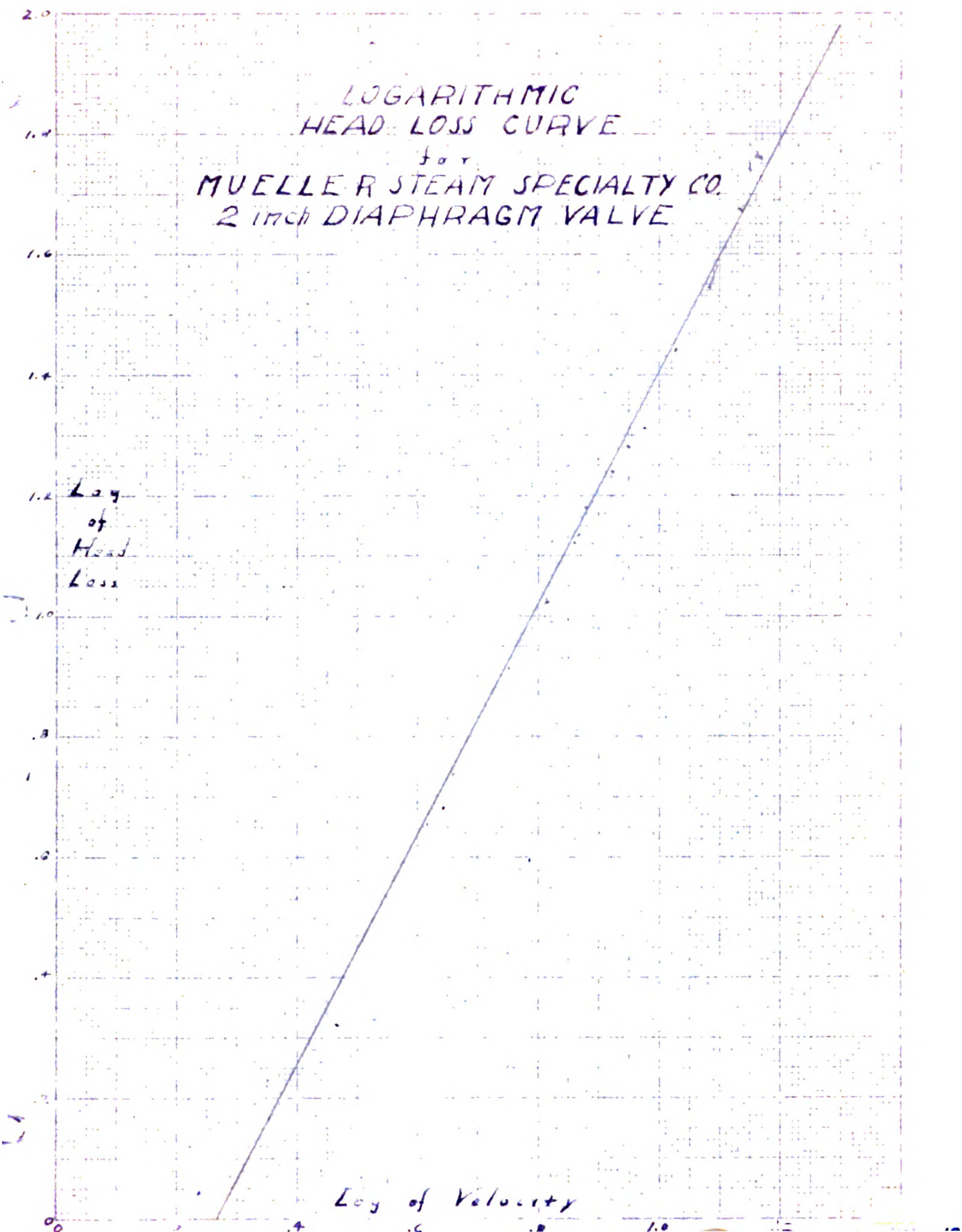
Swiss Stop Watch 1/10 Second

(kinds, sizes, ranges, etc. of meters, brakes, speed indicators, etc.)

TEST DATA

al	Wt. (#)	Time (sec)	Lg Vel	Vel. ('/sec)	Hd.Loss (ing.Hg)	Hd.Loss (ft.Wtr.)	N
1	319.5	25.6	..9703	9.339	18.3	19.2	14.16
2	366.5	28.35	-.9855	9.672	19.6	20.57	14.15
3	300	25	-.9532	8.978	18	18.9	15.09
4	"	28	.9039	8.015	14.5	15.22	15.24
5	"	30.5	.8668	7.359	11.8	12.4	14.73
6	"	35.6	.7997	6.305	9.0	9.45	15.29
7	"	38.2	.7690	5.875	7.8	8.19	15.27
8	"	44.8	.6998	5.010	5.7	5.98	15.33
9	"	57.1	..5945	3.931	3.6	3.78	15.74
0	"	77.2	.4635	2.907	2.0	2.10	15.98
1	827	74	.9223	8.362	"	15.	13.80
2	780.5	61.6	.9768	9.480	"	20.75	14.86
3	787.5	55	1.0299	10.713	"	27.7	15.53
4	755.5	46.4	1.0857	12.181	"	35.1	15.22
5	893.5	49	1.1349	13.643	"	47.3	16.35
6	842	42.5	1.1709	14.822	"	57.7	16.90
7	831	40.8	1.1829	15.237	"	65.8	18.23

Note--All abbreviat... of and symbols for engineering terms and physical quantities must be in accordance with prevailing



LOGARITHMIC
HEAD LOSS CURVE
for
MUELLER STEAM SPECIALTY CO.
2 inch DIAPHRAGM VALVE
Log of Head Loss
Log of Velocity
2.0
1.6
1.4
1.2
1.0
.8
.6
.4
0
.4
1.0

CALIBRATION PROCEDURE FOR (2") VALVE

The data for the 2 inch valve was collected and with the help of some of the classes in hydraulics enough trials were run to successfully apply the principle of least squares to get the value for head loss. I used the standard head loss formula: (A sample computation of Trial No. 1 follows each equation.)

Head Loss = N x Velocity Head $\qquad H = N \times V^2/2g$

Then in each trial, knowing the weight per time and the pressure drop from the difference in pressure on each side of the valve, the velocity was found by dividing the weight per unit time by the density of water to get cubic feet per second, (Q):

$W/T \times d = Q \qquad 300/23.8 \times 62.4 = .20299$

Now the velocity was equal to Q divided by the cross sectional area of the valve pipe:

$Q/a = V \qquad .20299/.021816 = 9.3117$

and the velocity head was the velocity squared, divided by twice the acceleration of gravity.

Vel. Hd. $= V^2/2g \qquad 1.3463 = 9.3117^2/ 64.37$

The data was collected over the course of two weeks. Some sets of readings had to be thrown out but there was still a wide range of variance in the values. I tried three systems of calculations before settling on the use of logarithams. A sliderule was too inaccurate, a calculating machine carried the result to too many places, and I needed the logarithams of the functions to plot.

When the values of N were plotted at varying velocities they formed a continuous curve instead of giving a constant value to N. I then plotted the logarithams of head loss versus those of the corresponding velocities to get a new formula. This came out a straight line with a slope of 1.92 and when extrapolated, a y intercept of -.51. The equation of this line therefore is:

$$\lg \text{Hd. loss} = 1.92 \times \lg \text{Vel.} = .51.$$

Taking the anti-log of both sides gives us:

$$\text{Hd. loss} = \text{Vel}^{1.92}/3.236$$

or:

$$\text{Hd. loss} = (\text{Vel.}^{1.92}/2g) \times 19.87$$

This is the true equation and constant for the valve, however, in the standard formula:

$$H = N \times V^2/2g$$

N may be taken as 15.5 to calculate head loss with an accuracy of plus or minus $1\frac{1}{2}$ feet in a range between 4 and 15 feet/second. The forty odd trials in this range have an arithmetical average N of 15.748. The use of the true formula gives an accuracy of plus or minus 1 foot at any velocity.

OPERATING PROCEDURE FOR ($2\frac{1}{2}$") VALVE

I encountered a few more problems in setting up the $2\frac{1}{2}$" valve, due mostly to its larger requirements for quantity of flow and larger discharge. The first thing discovered was the complete lack of any $2\frac{1}{2}$" pipe in the lab, necessitating a reducer. Even though Professor Allen would have requisitioned one, this was something the college does not carry, or have to supply its members, I soon discovered. A new one would be too much a strain on my budget and of small value to anyone afterwards. A small search was in order and, bless the happy day, one was to be found in a junk pile in back of the shops which do the repair work for the college. One of the men that works in the plumbing shop there was very kind and cut it away from the pipe it had rusted on and rethreaded it. This done, and another session of plumbing and the valve was ready to be tested. I had located this time in a corner of the lab, requiring a longer discharge pipe to reach the drainage facilities. This location demanded a tight, leakproof shutoff, for to use the remainder of the lab, water had to be held in the valve. It performed admirably in this respect for it was not capped and when the regular classes ran water not a drop leaked out through the valve.

Using the same principle of velocity measurement as in the 2" valve (finding the discharge weight per unit time) and measuring the inlet pressure and outlet pressure, the difference being the pressure drop, I ran some of the trials using pressure for the diaphragm from the section of pipe immediately preceeding the valve and then some using diaphragm pressure from a remote section. To have a check on these readings, I ran some trials on another identical valve. Also as check runs on this valve I measured velocity by using the theory of a nozzle and just letting the water run out into atmosphere. This is, of course, merely a rough check. I merely measured the drop of the water coming out of the horizontal valve and arranged a scale to make possible readings of the distance out from the valve that the water reached in this drop. Since there was only one foot of smooth pipe leading out of the valve into atmosphere, I also assumed that the pressure there was negligible and that, therefore, the pressure loss was equal to the pressure going into the valve.

Valve

Press. Application
To Diaphragm

Control Valve
For Flow

Press.
Guage
In

Mano-
meter
Guage
Out.

Discharge

Control For
Diap. Press.

Setup For
2½" Valve

ENGINEERING LABORATORY DATA SHEET

DEPARTMENT OF CIVIL ENGINEERING DATE DECEMBER 1948

COURSE NUMBER C.E. 411 EXPERIMENT NUMBER OR TITLE

HEAD LOSS IN DIAPHRAGM VALVES

IDENTIFICATION OF EQUIPMENT TESTED $2\frac{1}{2}$ inch DIAPHRAGM VALVE - HYDRAULICALLY OPERATED

by MUELLER STEAM SPECIALTY CO., LONG ISLAND, NEW YORK

(manufacturer, address, name, model, size, laboratory number, etc.)

IDENTIFICATION OF EQUIPMENT USED Mercury U Tube Differential Pressure Guage

Swiss Stop Watch 1/10 Second

(kinds, sizes, ranges, etc. of meters, brakes, speed indicators, etc.)

TEST DATA

ial .	Wt. (#)	Time (sec)	Lg Vel.	Vel. ('/sec)	Hd.Loss (in.Hg)	Hd.Loss (ft.Wtr.)	N
1	640	29.5	1.0091	10.21	18.3	19.2	11.49
2	492	23.5	.9936	9.854	19.7	20.65	13.27
3	561.5	27.0	.9907	9.788	20	21	13.68
4	554.4	29.9	.9408	8.726	14.1	14.8	12.13
5	434	22.7	.9542	8.999	14.3	15	11.56
6	474.5	26.2	.9307	8.525	12.3	12.9	11.08
7	601	34.5	..9138	8.200	11.5	12.08	11.21
8	459	27.1	.9105	7.971	11	11.54	11.33
9	398	24.1	.8906	7.773	10.3	10.8	11.15
0	389.5	24	.8830	7.638	9.8	10.28	10.99
1	517	35.3	.8384	6.823	7.6	7.98	10.48

Note—All abbreviations of and symbols for engineering terms and physical quantities must be in accordance with prevailing standards unless otherwise indicated by the Instructor.

ENGINEERING LABORATORY DATA SHEET

DEPARTMENT OF CIVIL ENGINEERING DATE DECEMBER 1948

COURSE NUMBER C. E. 411 EXPERIMENT NUMBER OR TITLE

HEAD LOSS IN DIAPHRAGM VALVES (VARYING PRESSURE ON DIAPHRAGM)

IDENTIFICATION OF EQUIPMENT TESTED 2½ inch DIAPHRAGM VALVE - HYDRAULICALLY OPERATED

by MUELLER STEAM SPECIALTY CO., LONG ISLAND, NEW YORK

(manufacturer, address, name, model, size, laboratory number, etc.)

IDENTIFICATION OF EQUIPMENT USED Mercury U Tube Differential Pressure Guage

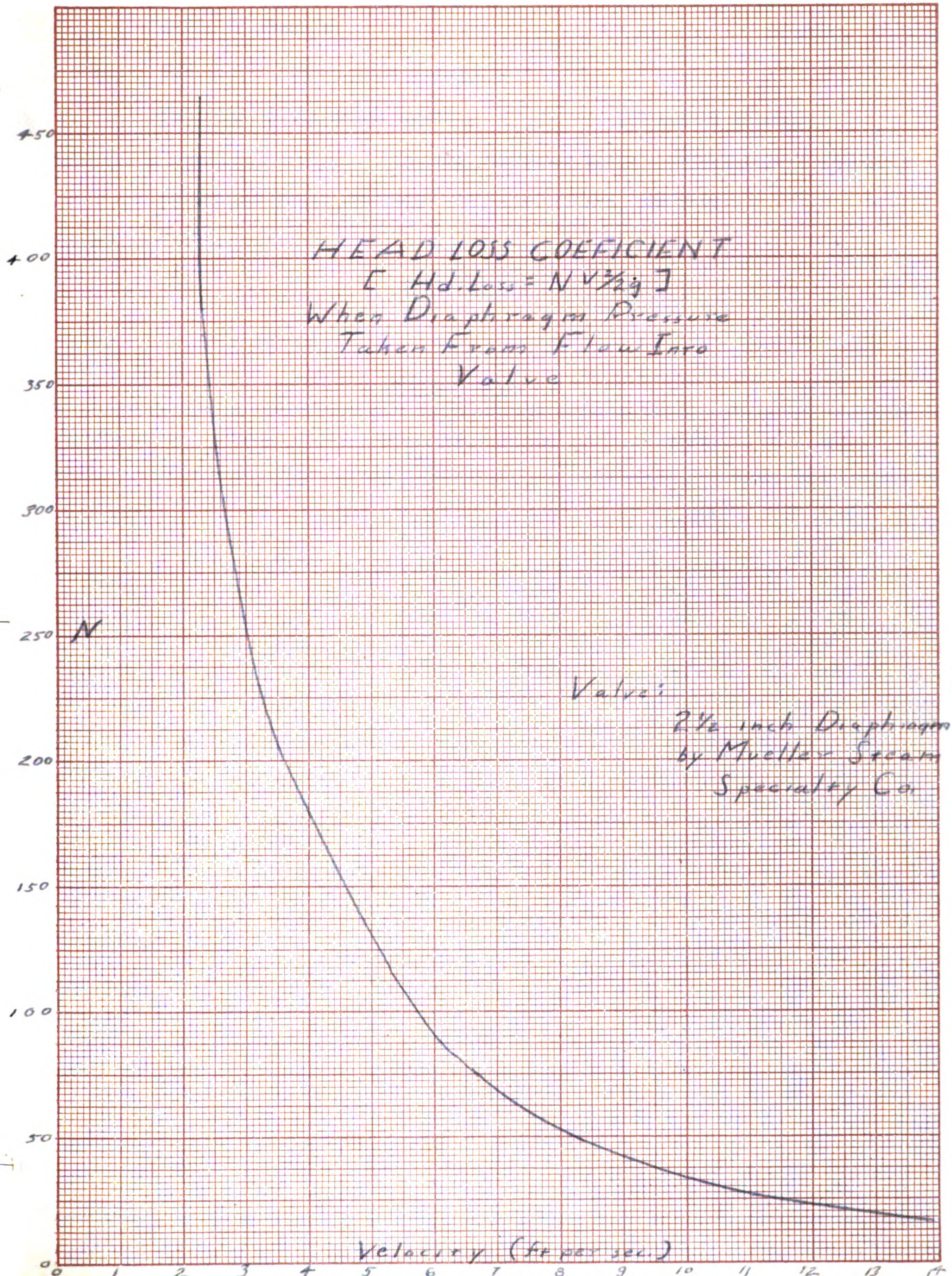
Swiss Stop Watch 1/10 Second

(kinds, sizes, ranges, etc. of meters, brakes, speed indicators, etc.)

TEST DATA

ial .	Wt. (#)	Time (sec)	Q (ft^3/sec)	Vel. ('/sec)	$V^2/2g$	Hd. in (ft.Wr)	Hd.out (inHg)	Hd.out (ft.Wr)	HdLoss (ft.Wr)	N
1	199	41.8	.0762	2.235	.0777	31	.2	.21	31	399
2	215.5	32.6	.1057	3.105	.1498	37	.35	.37	37	247
3	231.5	28.5	.1299	3.815	.226	44	1	1.05	43	190.3
4	225	27.8	.1296	4.52	.317	43	1	1.05	42	132.5
5	256.5	20.6	.1992	5.85	.5315	54	2.8	2.94	51	95.2
6	267.5	21.2	.2016	5.92	.545	54	2.9	3.05	51	93.6
7	246	15.8	.249	7.32	.833	58.5	4.4	4.7	53.8	64.6
8	294	19.3	.2438	7.16	.796	58	4.7	4.9	53	66.6
9	297.5	19	.2505	7.35	.841	58	4.7	4.9	53	63.0
0	241.5	12.2	.3165	9.29	1.342	59	8.4	8.8	50	37.25
1	301	14.4	.335	9.82	1.499	61	9.3	9.8	51	34.00
2	283.5	13.1	.346	10.16	1.603	61	9.8	10.0	51	31.82
3	236	11.6	.3255	9.55	1.417	60	9	9.45	51	36.0
4	281	12.7	.351	10.32	1.654	61	10.6	11	50	30.10
5	312.5	13.5	.373	10.93	1.860	62	11.7	12.3	50	26.88
6	264	11.3	.374	10.98	1.871	62	12.4	13	49	26.18

Note—All abbreviations of and symbols for engineering terms and physical quantities must be in accordance with prevailing standards unless otherwise indicated by the Instructor.



HEAD LOSS COEFFICIENT
[Hd. Loss = N V²/2g]
When Diaphragm Pressure
Taken From Flow Into
Valve
Valve:
2½ inch Diaphragm
by Mueller Steam
Specialty Co.
N
Velocity (ft per sec.)
450
400
350
300
250
200
150
100
50
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14

ENGINEERING LABORATORY DATA SHEET

DEPARTMENT OF CIVIL ENGINEERING DATE DECEMBER 19 48

COURSE NUMBER C.E. 411 EXPERIMENT NUMBER OR TITLE

HEAD LOSS IN DIAPHRAGM VALVES (BY NOZZLE METHOD)

IDENTIFICATION OF EQUIPMENT TESTED $2\frac{1}{2}$ inch DIAPHRAGM VALVE - HYDRAULICALLY OPERATED

by MUELLER STEAM SPECIALTY CO., LONG ISLAND, NEW YORK

(manufacturer, address, name, model, size, laboratory number, etc.)

IDENTIFICATION OF EQUIPMENT USED Standard Pressure Guage

Philadelphia Level Rod

(kinds, sizes, ranges, etc. of meters, brakes, speed indicators, etc.)

TEST DATA

ial .	Pressure (ft.Wtr.)	Drop (ft.)	Dist.out (ft.)	Vel. ('/sec)	$V^2/2g$	N
	3	1.85	3.2	9.42	1.379	2.17
	4	"	3.3	9.7	1.463	2.73
	5	"	3.7	10.9	1.85	2.7
	4	3.89	4.4	8.95	1.245	3.2
	9	"	5.8	11.8	2.16	4.15
	10	"	6.2	12.6	2.47	4.05
	11	"	6.2	12.6	2.47	4.45
	13	"	6.3	12.8	2.55	5.1

Note—All abbreviations of and symbols for engineering terms and physical quantities must be in accordance with prevailing standards unless otherwise indicated by the Instructor.

CALIBRATION PROCEDURE FOR ($2\frac{1}{2}$") VALVE

The application of

$$H = N \times V^2/2g$$

or

$$N = H/V^2/2g$$

yeildedthe valves shown on the data sheet for the two identical $2\frac{1}{2}$ inch valve, the arithmetical mean of which is 10.33. This was obtained using a steady diaphragm pressure from a remote point. When taking the pressure to operate the valve from the same place, I measured the inlet pressure (ie. immediately preceeding the valve in the flow through the valve). The value of N was very different, since a small velocity produced a relatively smaller pressure than a high velocity, the valve wasn't as far open and had a greater constriction and, therefore, a higher head loss and resulting "N". These are plotted and form a logarithmic curve with very high values for a small velocity.

The trials run as a check by measuring the velocity by nozzle methods gave a consistently lower value for N. The method was only different in regards to method of determining velocity and the assumption that the outlet pressure was zero because there was only one foot of pipe leading to atmosphere where pressure must be zero.

The velocity was determined by the theory that the water discharging from the valve took a certain time to fall the measured drop due to the acceleration of gravity and the velocity was the distance out it had traveled in this time divided by the said amount of time.

Thus since:

$d = \frac{1}{2} g T^2$ $\qquad$ Drop $= \frac{1}{2}$ 32.17 x (Time)^2

or

$T = \sqrt{2 d/g}$ $\qquad$ $T = \sqrt{2 \times 1.85/32.17} = .339$

then

Vel. $= d/T$ $\qquad$ Vel. $= 3.2/.339 = 9.42$

The values of N were determined in the standard way of

$N = \text{Hd. Loss}/V^2/2g$ $\qquad$ $N = 3/1.379 = 2.17$

These values increased with an increase of pressure but I think this is due to the cause that this method of determining velocity reaches a limit around 11.5 feet per second. This is because of the increasing effect of suppression and in spite of increasing velocity the water cannot be projected any farther than a certain limit. The approximate N therefore is 2.7 which is only $\frac{1}{4}$ of the value determined by the weight per time method. After careful consideration Idecided that the error was in the nozzle method since it didn't take into consideration any of the factors of turbulence or laminar flow which it depended on to be nonexistent. . For example if we consider the average velocity in the pipe to be $\frac{1}{2}$ of that determined by the above method,(which is plausible due to the variance in velocity over a cross section of the pipe), The resulting N would be 10.8.

CALIBRATION OF ROSS VALVES

I wrote letters of inquiry to eight manufacturers of diaphragm valves but none of them had any information concerning head loss in their valves. I was able, however, from data included in the Ross Valve Manufacturing Catalog, which users of their valves had sent to them, to find a few approximate valve values. They gave the gallons per day inlet and outlet pressures pertaining to valves in use. The conversion from gallons per day to cubic feet per second is only a matter of constants and from thence to feet per second by the cross sectional area of the valve. The N resulted from substition into

$$N = H/V^2/2g$$

This gave a value of 16.45 to the standard and 10.73 to the special Model 40 WR 16 inch valves.

Also in the catalog they gave the head loss for their eight inch 40 DAWR with different seat diameters of eight, ten and tweleve inches at varying velocities. With head loss and velocity given, the N was obtained from simple substitution into the standard formula.

The values are:	N
16 inch, Model 40 WR	16.45
16 inch, Model 40 WR "Special"	10.73
8 inch, Model 40 DAWR, Double Acting, 8 inch seat	5.21
8 inch, Model 40 DAWR, Double Acting, 10 inch seat	1.90
8 inch, Model 40 DAWR, Double Acting, 12 inch seat	.77

PRESSURE REDUCING AND REGULATING VALVE
HYDRAULIC CONTROL

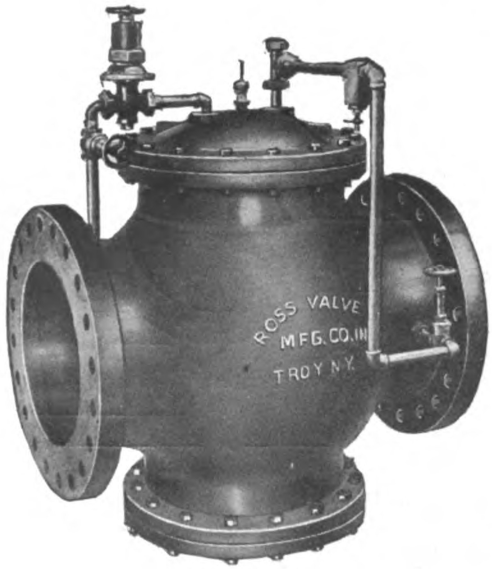


Fig. No. 1
Model 40WR—Single Pilot

Construction:
Cast Iron—Bronze Mounted

	Maximum Inlet Pressure 180 lbs.	250 lbs.
4 inch	$150.00	$160.00
6 inch	200.00	215.00
8 inch	275.00	290.00
10 inch	350.00	365.00
12 inch	425.00	435.00
14 inch	750.00	770.00
16 inch	895.00	915.00
18 inch	1050.00	1065.00
20 inch	1160.00	1180.00
24 inch	1375.00	1395.00
30 inch	2325.00	2350.00

Cast Steel Bodies—Add 20% to 250 lb. assembly.

All Bronze up to 12 inch on request.

Pressure Range Outlet—
10 lbs. to 60 lbs.
20 lbs. to 150 lbs.
125 lbs. to 250 lbs.

Model 40WR will maintain constant desired discharge pressure regardless of change in rate of flow and variation of pressure upstream of the valve. As a pressure reducing valve operates to:

1. Control and regulate pressures in gravity and pumping systems.
2. Regulate the flow between reservoirs and zones of different pressures.
3. Regulate fire flows between zones of different pressures into buildings, etc.
4. Regulate pressures in filter wash lines and aerator nozzles.

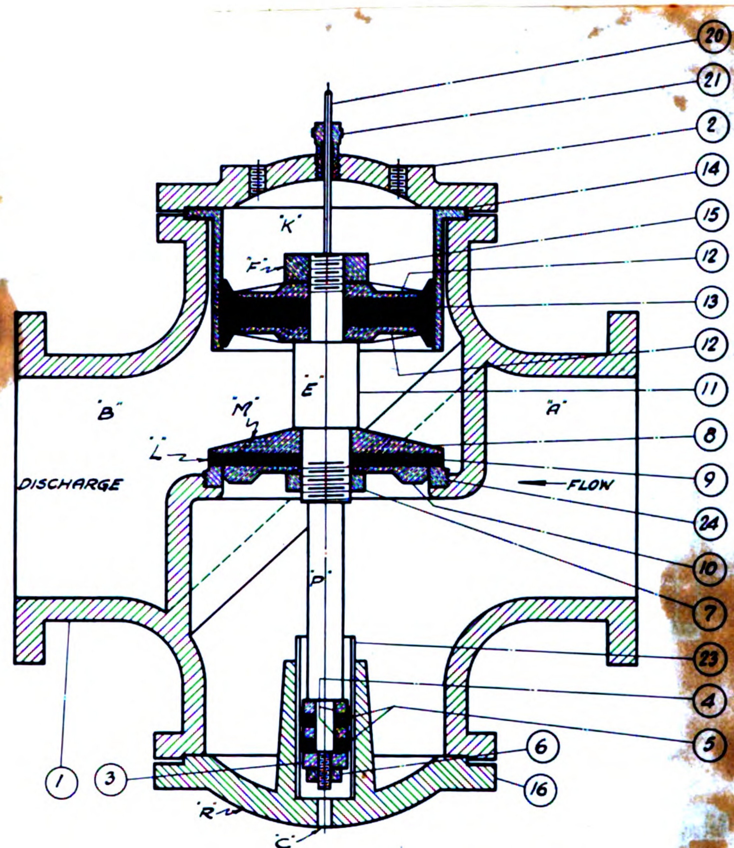
NOTE—Where high rates of flow produce eddies at the discharge of valve, pilot can be supplied with separate pressure communication for piping to a point downstream of the valve.

Valve Operates Without Waste of Water to Atmosphere, and Will Not Induce Surge.

bly in that it is furnished with indicator scale and a dual set of pilots.

In addition to being able to maintain service while repacking either pilot, the convenience of a 3-way cock allows changing instantly fixed control from one pilot to another of different pressures; advantageous where a system having a high night rate because of willful waste is operated with a day and night pressure.

All Ross Valves Repaired in Line; Internal Packing Replaced Through Top of Valves.



(20) Indicator Rod
(21) Indicator Stuffing Box
(2) Top Cap
(14) Main Bushing
(15) Top Nut
(12) Plate (2)
(13) Main Cup Leather (2)

(12) Plate (2)
(11) Stem
(8) Seat Disc
(9) Seat Leather
(24) Seat Ring
(10) Seat Leather Support
(7) Nut

(23) Cap Cylinder
(4) Bottom Cup Follower (2)
(5) Bottom Piston Cup Leather (2)
(1) Valve Shell
(3) Bottom Stem Guide Nut
(6) Bottom Stem Lock Nut
(16) Bottom Cap

ENGINEERING LABORATORY DATA SHEET

DEPARTMENT OF **CIVIL ENGINEERING** DATE **DECEMBER** 19 48

COURSE NUMBER **C.E. 411** EXPERIMENT NUMBER OR TITLE

HEAD LOSS IN DIAPHRAGM VALVES

IDENTIFICATION OF EQUIPMENT TESTED **VALVES BY ROSS VALVE MANUFACTURING CO.**

(manufacturer, address, name, model, size, laboratory number, etc.)

IDENTIFICATION OF EQUIPMENT USED

(kinds, sizes, ranges, etc. of meters, brakes, speed indicators, etc.)

TEST DATA

del	Size (in.Diam)	Q (gal/day)	Vel. ('/sec)	Seat Diam. (in.)	Hd.Loss (ft.Wtr)	N		N (Avg.)
WR	16	23,000,000	23.25		138.6	16.45		
WR Spec.	16	26,000,000	26.28		173.3	10.73		
DAWR	8		10.0	8	8	5.15		5.21
"	"		1.0	"	.082	5.27		
"	"		10.0	10	2.9	1.86		1.90
"	"		1.0	"	.03	1.93		
"	"		10.0	12	1.2	.77		

Note—All abbreviations of and symbols for engineering terms and physical quantities must be in accordance with prevailing standards unless otherwise indicated by the instructor.

REQUIRED PRESSURE ON DIAPHRAGM

By taking each valve out of the system and merely applying hydraulic pressure to the diaphragm and measuring the action of the valve, I was able to determine the required pressure to open the valve. It required 15#/sq. inch to open the 2" valve all the way and 10#/sq. inch to open the $2\frac{1}{2}$ inch valve but the total forces thus opposing the spring were 225# and 237# due to the respective diaphragm diameters of 4.375 inches and $5\frac{1}{2}$ inches. These valves probably have the same strength spring in each.

The motion of the valve was $\frac{1}{2}$" for 8# of pressure in the $2\frac{1}{2}$ inch valve which would be 380# per inch of motion.

C O M M E N T S

The head loss in these valves has a small inverse variation with the size of the valve as the N for the two similar Mueller valves was less for the $2\frac{1}{2}$" than for the 2" of the same general pattern. The N varied more noticeably with a change in the seat diameter, as we observed in the 8" Ross valves which were of the same size but varied in seat diameter. The larger the seat diameter, the small the value of N by a greater proportion than that of change in N with change in size of valve.

FUNCTIONS OF A HYDRAULIC VALVE

Hydraulically operated valves, in general, have certain inherent functions that they are better suited to perform due to their design; that is, the fact that they are operated and may be regulated by fluid pressure. It may be opened and closed by remote control or by the pressure in any part of the system. The former asset is utilized for duties such as procuring more water in a particular district for fire fighting and in directing flow in inaccessible locations. The latter asset is used to maintain any particular maximum or minimum pressure wherever desired automatically, and in controlling the amount of water in a reservoir or tank, and as pressure reducers. Hydraulic valves also operate quickly whenever speed is desired. These are, of course, only sample uses among the many jobs done. They also require no manual labor.

The diaphragm type hydraulic valve, in particular, has been explained is sometimes used as a valve directly and sometimes as a pilot valve to operate larger valves. The inherent advantage of the diaphragm valve is the relatively larger area of the diaphragm over which the hydraulic is distributed. This supplies a larger force with a smaller pressure and may be designed with a larger area on either the top or the bottom of the diaphragm, thus giving a differential of force for any given pressure.

The succeeding pages illustrate some of the various uses of hydraulic valves.

STOP CHECK DOUBLE ACTING ALTITUDE VALVES

Working Pressures	150 lbs.	250 lbs.	300 lbs.	400 lbs.
Body and Bonnet Material	Cast Iron	Cast Iron	Semi-Steel	Cast Steel
Globe Pattern, Series Fig. No.	35-D	35-U	35-V	35-W

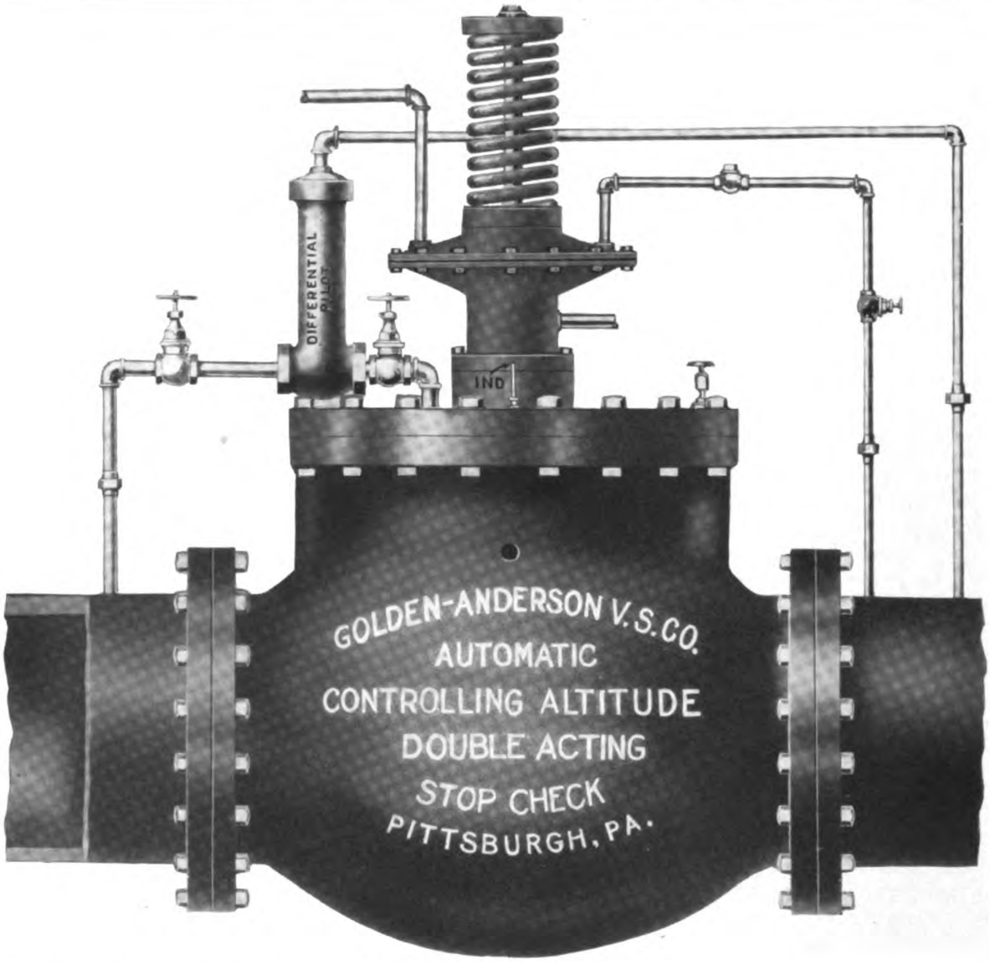


Fig. 35-D, Globe Pattern

OPERATING SEQUENCE

With a single line used both for supply and discharge this valve accomplishes three functions; 1. Maintains a constant water level within 3" to 12" variation to prevent tank overflow. 2. Automatically permits, under normal conditions, storage water distribution back through the valve for service consumption whenever upstream head drops below static tank head. 3. Instantly closes to conserve storage supply by preventing flow back through valve in case of sudden drop of inlet head below static tank head should the line break. The weighted shot pilot valve is adjustable for any differential pressure for emergency closing of valve under a line-break condition.

CONSTRUCTION

The valves are furnished special heavy cast iron, semi-steel and cast steel, with full non-corrosive trim of bronze, Gavalloy or stainless steel, depending on the working pressure and water service conditions. Renewable cups and seat washer prevent any metal to metal contacts resulting in minimum servicing costs and repairs.

CUSHIONING

All water surges and shock are definitely eliminated by the inherent and correct mechanically designed air and water cushioning arrangement as the valve moves into opening and closing positions. The needle valve control permits of governing the speed of valve operation to suit any upstream pressure conditions. With V-shaped port or saw-tooth liner-seat design velocity flow is arrested through the valve as it begins to seat and prevents serious pressure rise or valve banging.

ARRANGEMENT

While the normal installation position of the valve is vertical in the pipe line, it may be installed in any position and give satisfactory service. Generally the valve is arranged with Base Pilot Type integral with valve lid, but the diaphragm pilot assembly may be separately mounted and piped; or, the diaphragm pilot assembly may be arranged with the Globe Pilot Type in lieu of the Base Pilot Type illustrated.

COMBINATION ALTITUDE VALVES

Working Pressures	150 lbs.	250 lbs.	300 lbs.	400 lbs.
Body and Bonnet Material	Cast Iron	Cast Iron	Semi-Steel	Cast Steel
Globe Pattern, Series Fig. No.	36-D	36-U	36-V	36-W

OPERATING SEQUENCE

Automatically controls a uniform water level in tanks, standpipes, reservoir, etc., within a variation of 3'' to 12'' to prevent any overflow; also, to close automatically against an increased upstream pressure above normal service, as in case of fire pressure, to isolate flow to tank. Valve may be piped in a single supply-discharge line to work "both ways" as well as arranged with "stop check" type piston assembly for one way flow service to prevent tank storage return back through valve.

CONSTRUCTION

The valves are designed with renewable cups and seat washer to prevent metal to metal contacts which results in minimum servicing attention, and economic part replacements. The valve bodies and bonnets are furnished special heavy cast iron, semi-steel and cast steel, with full non-corrosive trim of bronze, Gavalloy or stainless steel, as may be required to suit the working pressures and water service conditions.

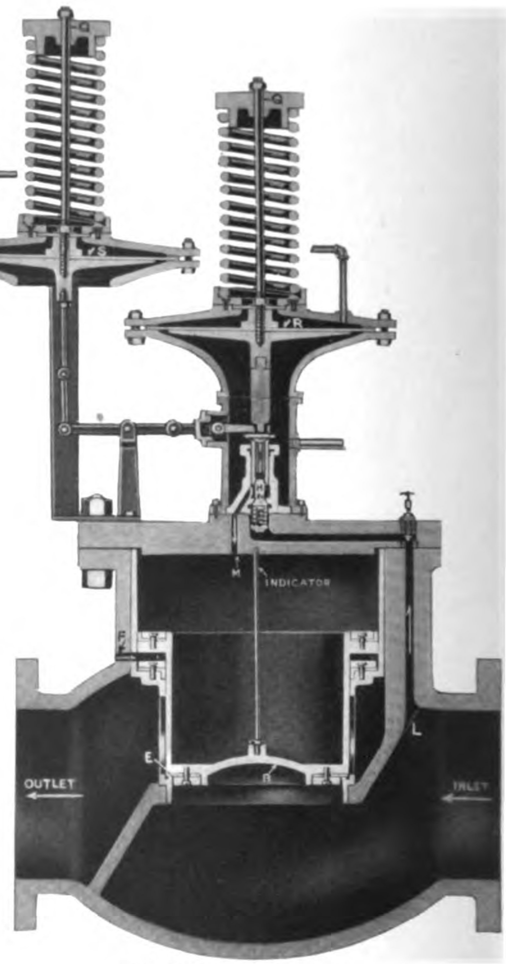


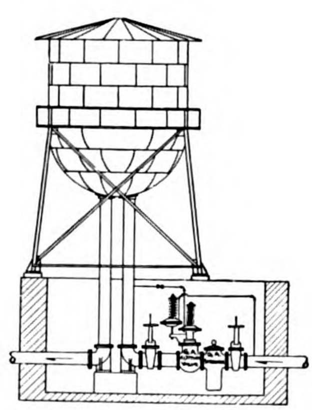
Fig. 36-D, Globe Pattern

CUSHIONING

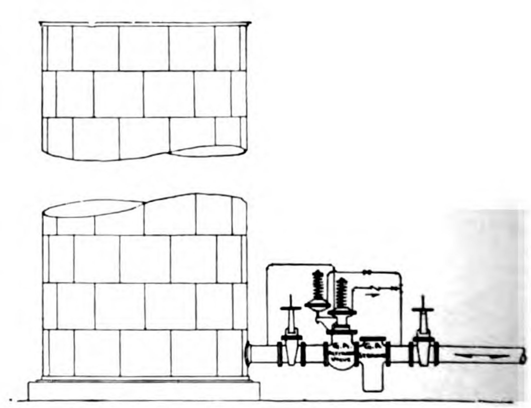
In view of surge conditions and water hammer problems existing in most water mains and to eliminate this evil, our valves are particularly designed with inherent correct mechanical air and water cushioning provisions which definitely minimize shock or jar as valve moves into opening or closing positions. With needle valve control it is possible to instantly regulate the speed of valve operation to suit any existing pressure condition. Combined with V-shaped port or saw-tooth liner-seat design any velocity flow is arrested through the valve as it begins to close and seat to avoid any disastrous pressure rise or valve closing shock.

ARRANGEMENT

Valves are usually furnished with Base Pilot Type and diaphragm chamber integral with valve lid, but same may be arranged for separate mounting, or in place of Base Pilot Type as illustrated, a Globe Pilot Type is available for piping to main valve. Generally the main valve is installed vertical in the pipe line but it may be installed in any other position and still render unfailing and efficient operation.



Piping Arrangement with Separate Tank Discharge.



Piping Arrangement where Single Line is Used both for Supply and Discharge.

Parts List Page 54 — Dimension Data Page 55

SINGLE ACTING DIFFERENTIAL ALTITUDE VALVES

Working Pressures	150 lbs.	250 lbs.	300 lbs.	400 lbs.
Body and Bonnet Material	Cast Iron	Cast Iron	Semi-Steel	Cast Steel
Globe Pattern, Series Fig. No.	32-E	32-EU	32-EV	32-EW

OPERATING SEQUENCE

This valve is designed for installation in the influent line to tank, standpipe or reservoir where a separate discharge line or by-pass arrangement is provided for removing storage water, to maintain a constant water level within a variation of 3'' to 12'', and especially, to remain closed against upstream pressure until tank water level is dissipated to a certain depth before valve opens to replenish storage supply. This operation assures proper storage water circulation and eliminates any stagnation in the storage supply, and is quite desirable in conjunction with water treatment storage tanks adapting water wheel pumps for chemical mixture. The "Differential" Globe Pilot Control is adjustable to only permit altitude valve opening at any desired minimum tank depth.

CONSTRUCTION

The valves are furnished special heavy cast iron, semi-steel and cast steel, with full non-corrosive trim of bronze, Gavalloy or stainless steel, depending on the working pressure and water service conditions. Renewable cups and seat washer prevent any metal to metal contacts resulting in minimum repairs and servicing costs.

CUSHIONING

The inherent air and water cushioning definitely eliminates any water surges or shock when the valve moves into opening or closing position, and with needle valve control the operating speed of the valve is readily governed to suit any upstream pressure conditions. The V-shaped port or saw-tooth design of liner-seat positively arrests the upstream flow through the valve while closing to prevent serious pressure rise or valve banging.

ARRANGEMENT

As shown the valves are usually furnished with diaphragm pilot control integral with valve lid, but same may be separately mounted and piped, as well as furnished with pilot in the Globe Type instead of the Base Type illustrated. Valve may be installed in pipe line in any position and function reliably, although it is generally placed vertically as indicated.

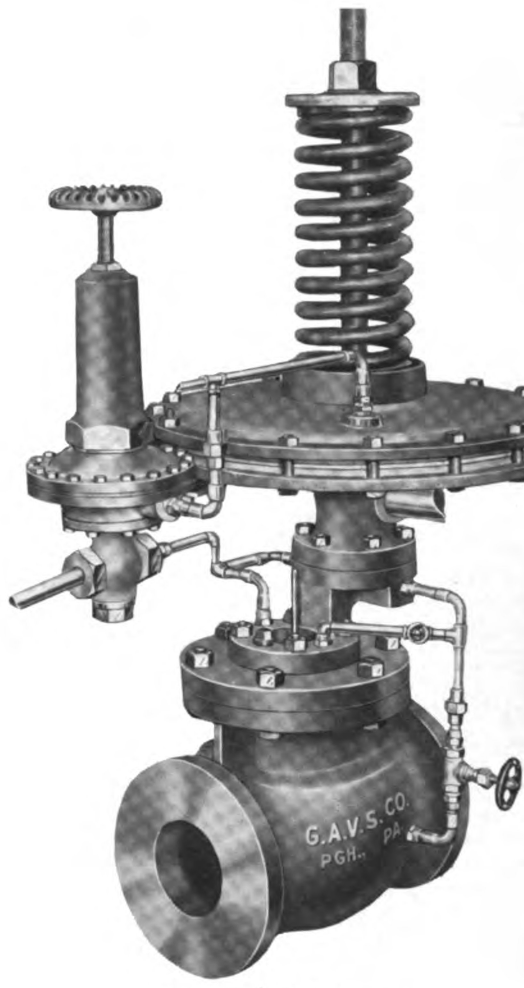
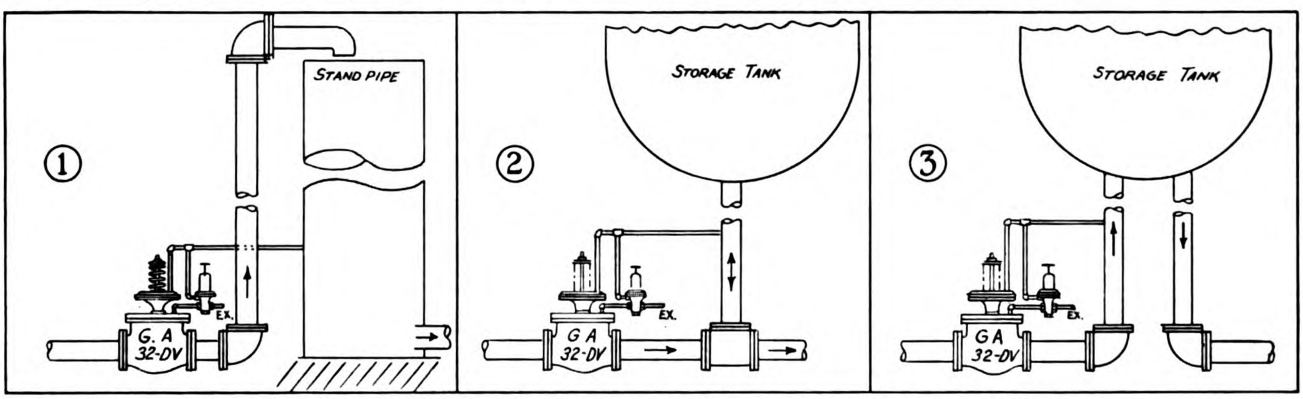


Fig. 32-E, Globe Pattern



Piping Suggestions for Differential Altitude Valve for Maintaining Any Desired Water Level and to Only Admit Upstream Flow at Any Minimum Tank Storage Level.

DOUBLE ACTING STANDARD ALTITUDE VALVES

Working Pressures	150 lbs.	250 lbs.	300 lbs.	400 lbs.
Body and Bonnet Material	Cast Iron	Cast Iron	Semi-Steel	Cast Steel
Globe Pattern, Series Fig. No	33-D	33-U	33-V	33-W

OPERATING SEQUENCE

Where a single line is used both for supply and discharge the valve assures unfailing water level control with 3" to 12" variation, and also permits storage water return back through the valve for distribution the instant upstream head drops slightly below static tank head. There is no hunting action in the valve as it either opens full or immediately closes tight, with only a slight momentary water exhaust from above piston each time valve opens.

CONSTRUCTION

The valves are furnished special heavy cast iron, semi-steel and cast steel, with full non-corrosive trim of bronze, Gavalloy or stainless steel, depending on the working pressure and water service conditions. Renewable cups and seat washer prevent any metal to metal contacts resulting in minimum servicing costs and repairs.

CUSHIONING

All water surges and shock are definitely eliminated by the inherent and correct mechanically designed air and water cushioning arrangement as the valve moves into opening and closing positions. The needle valve control permits of governing the speed of valve operation to suit any upstream pressure conditions. With V-shaped port or saw-tooth liner-seat design velocity flow is arrested through the valve as it begins to seat and prevents serious pressure rise or valve banging.

ARRANGEMENT

While the normal installation position of the valve is vertical in the pipe line, it may be installed in any position and give satisfactory service. Generally the valve is arranged with Base Pilot Type integral with valve lid, but the diaphragm pilot assembly may be separately mounted and piped; or, the diaphragm pilot assembly may be arranged with the Globe Pilot Type in lieu of the Base Pilot Type illustrated.

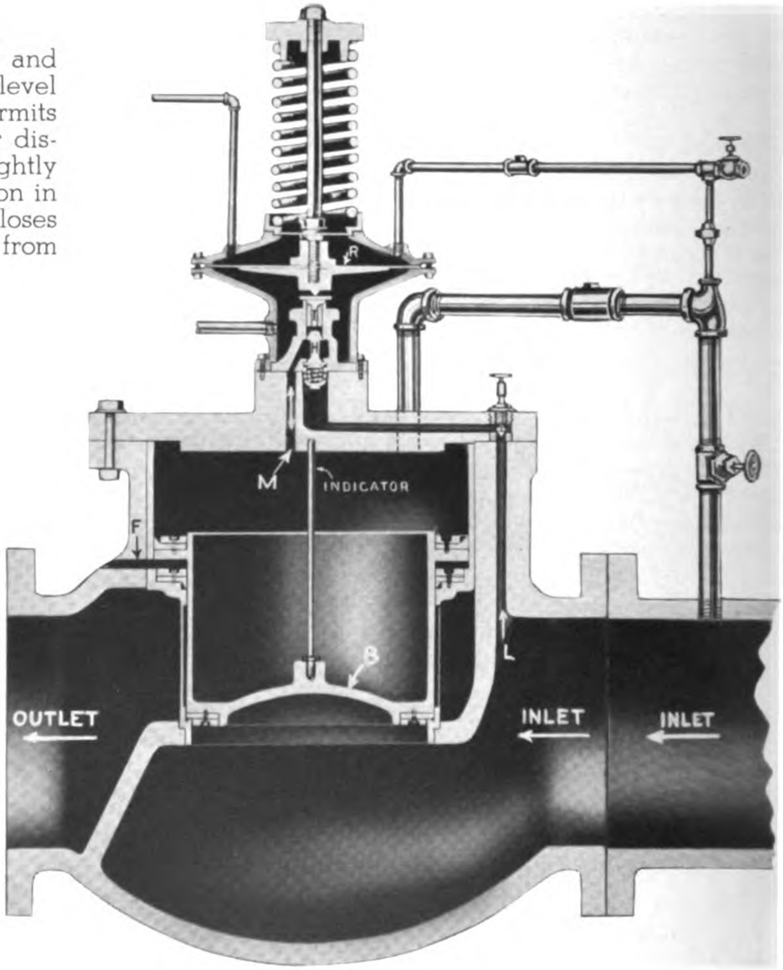
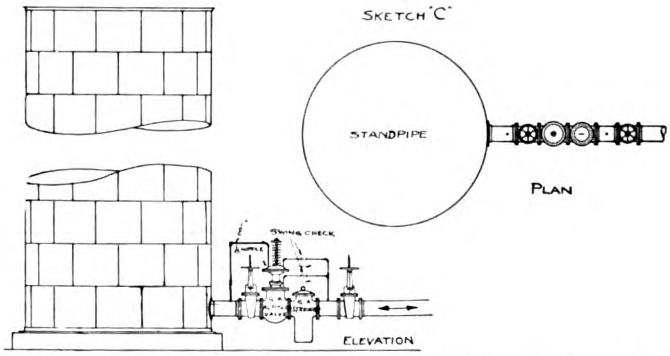


Fig. 33-D, Globe Pattern



Piping Arrangement Where Single Line is Used Both for Supply and Discharge to Control Storage Water Level and Permit Consumption Distribution.

Parts List Page 54 -- Dimension Data Page 55

ELECTRIC DOUBLE ACTING ALTITUDE VALVES

Working Pressures	150 lbs.	250 lbs.	300 lbs.	400 lbs.
Body and Bonnet Material	Cast Iron	Cast Iron	Semi-Steel	Cast Steel
Globe Pattern, Series Fig. No.	39-D	39-U	39-V	39-W

OPERATING SEQUENCE

Where a single line is used for both supply and discharge, the valve functions to normally maintain a constant water level within 3'' to 12'' variation; also, to permit tank distribution back through the valve the moment influent head drops below static tank head; or, arranged with differential control valve (page 43) to delay tank dumpage until line pressure lowers to any predetermined pressure. With solenoid control assembly for either AC or DC circuit the valve may be closed at any time from remote stations.

CONSTRUCTION

The valves are designed with renewable cups and seat washer to prevent metal to metal contacts which results in minimum servicing attention, and economic part replacements. The valve bodies and bonnets are furnished special heavy cast iron, semi-steel and cast steel, with full non-corrosive trim of bronze, Gavalloy or stainless steel, as may be required to suit the working pressures and water service conditions.

CUSHIONING

In view of surge conditions and water hammer problems existing in most water mains and to eliminate this evil, our valves are particularly designed with inherent correct mechanical air and water cushioning provisions which definitely minimize shock or jar as valve moves into opening or closing positions. With needle valve control it is possible to instantly regulate the speed of valve operation to suit any existing pressure condition. Combined with V-shaped port or saw-tooth liner-seat design any velocity flow is arrested through the valve as it begins to close and seat to avoid any disastrous pressure rise or valve closing shock.

ARRANGEMENT

Valves are usually furnished with Base Pilot Type and diaphragm chamber integral with valve lid, but same may be arranged for separate mounting, or in place of Base Pilot Type as illustrated, a Globe Pilot Type is available for piping to main valve. Generally the main valve is installed vertical in the pipe line but it may be installed in any other position and still render unfailing and efficient operation.

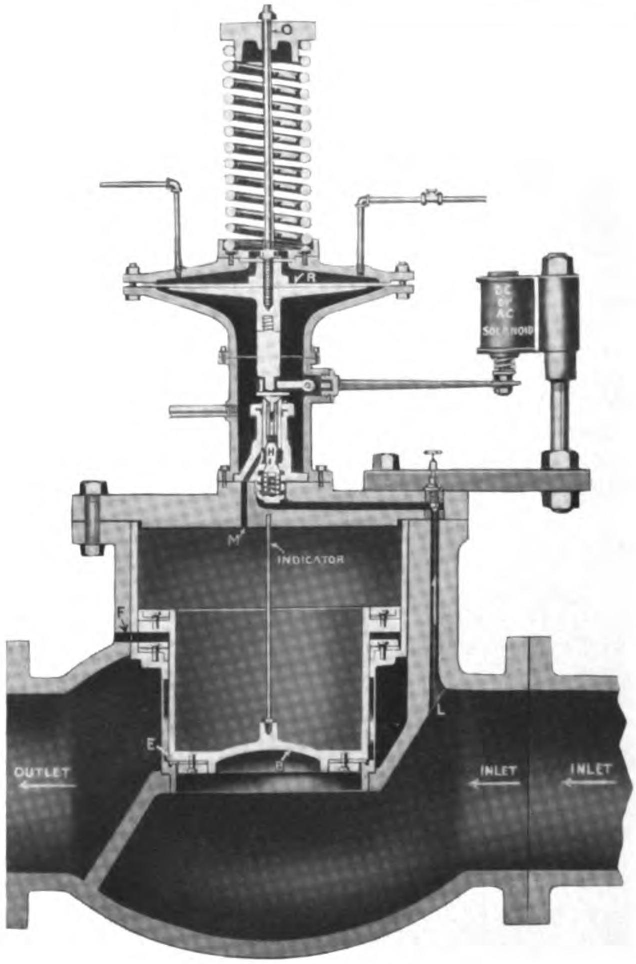
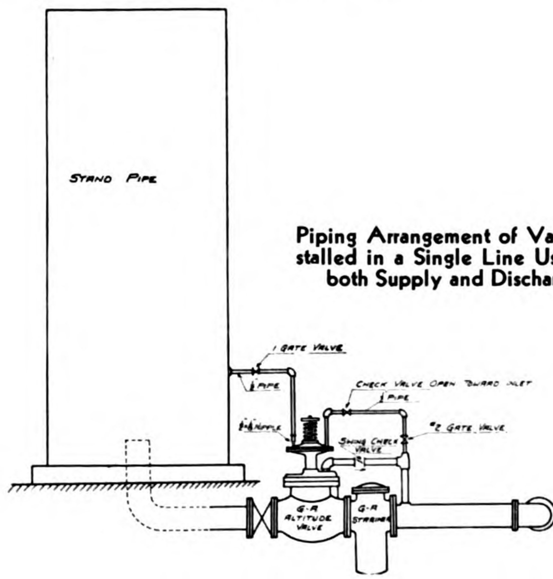


Fig. 39-D, Globe Pattern



Piping Arrangement of Valve Installed in a Single Line Used for both Supply and Discharge.

STOP STARTER SINGLE ACTING ALTITUDE VALVES

Working Pressures	150 lbs.	250 lbs.	300 lbs.	400 lbs.
Body and Bonnet Material	Cast Iron	Cast Iron	Semi-Steel	Cast Steel
Globe Pattern, Series Fig. No.	40-D	40-U	40-V	40-W

OPERATING SEQUENCE

Installed in influent line to tanks, standpipes or reservoirs having a separate discharge or by-pass for service distribution, the valve maintains a uniform water level within 3" to 12" variation and by means of "stop-starter" switch stops pump. On lowering of tank water level the "stop-starter" switch automatically starts pump and as pump pressure equals static tank head on outlet of valve, the valve opens to permit flow into tank. Valve may be arranged with "Differential" Globe Pilot Control for delayed starting of pump on minimum tank water level; also, arranged with solenoid control assembly for either AC or DC circuit to close valve any time from remote stations.

CONSTRUCTION

The valves are furnished special heavy cast iron, semi-steel and cast steel, with full non-corrosive trim of bronze, Gavalloy or stainless steel, depending on the working pressure and water service conditions. Renewable cups and seat washer prevent any metal to metal contacts resulting in minimum repairs and servicing costs.

CUSHIONING

The inherent air and water cushioning definitely eliminates any water surges or shock when the valve moves into opening or closing position, and with needle valve control the operating speed of the valve is readily governed to suit any upstream pressure conditions. The V-shaped port or saw-tooth design of liner-seat positively arrests the upstream flow through the valve while closing to prevent serious pressure rise or valve banging.

ARRANGEMENT

As shown the valves are usually furnished with diaphragm pilot control integral with valve lid, but same may be separately mounted and piped, as well as furnished with pilot in the Globe Type instead of the Base Type illustrated. Valve may be installed in pipe line in any position and function reliably, although it is generally placed vertically as indicated.

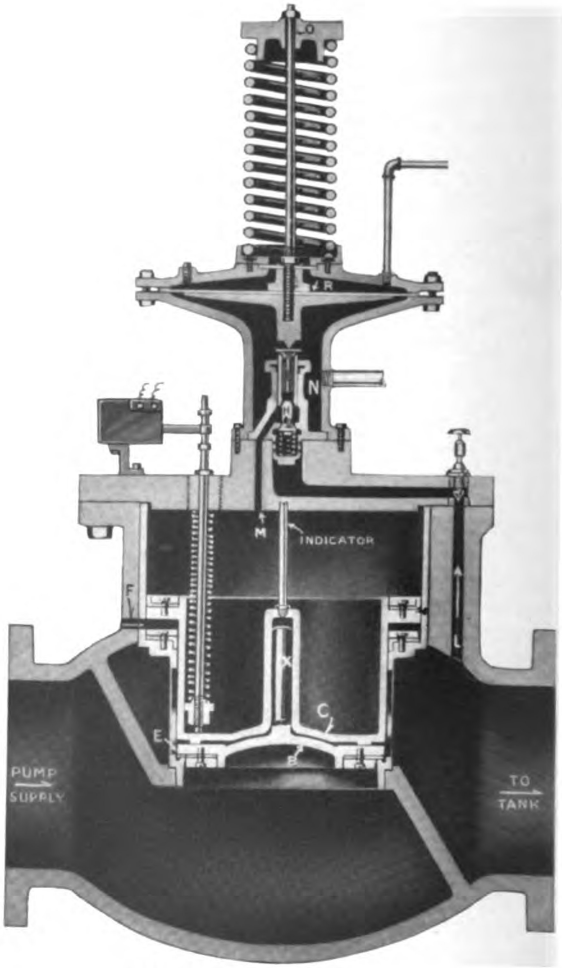
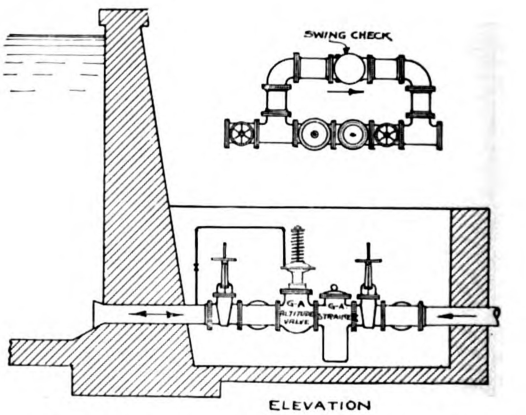


Fig. 40-D, Globe Pattern

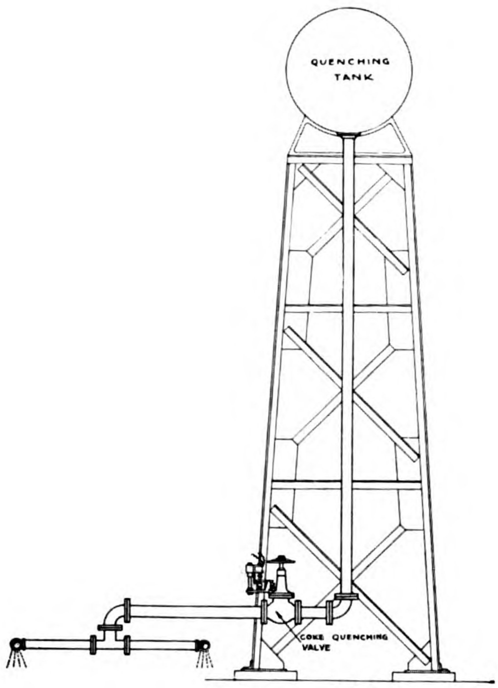


Indicated Valve Piping where a By-pass or Separate Line is Used for Storage Water Distribution.

Parts List Page 54 — Dimension Data Page 55

ELECTRIC HYDRAULIC COKE QUENCHING VALVES

Working Pressures	150 lbs.	250 lbs.	300 lbs.	400 lbs.
Body and Bonnet Material	Cast Iron	Cast Iron	Semi-Steel	Cast Steel
Angle Pattern, Series Fig. No.	171-D	171-U	171-V	171-W
Globe Pattern, Series Fig. No.	172-D	172-U	172-V	172-W



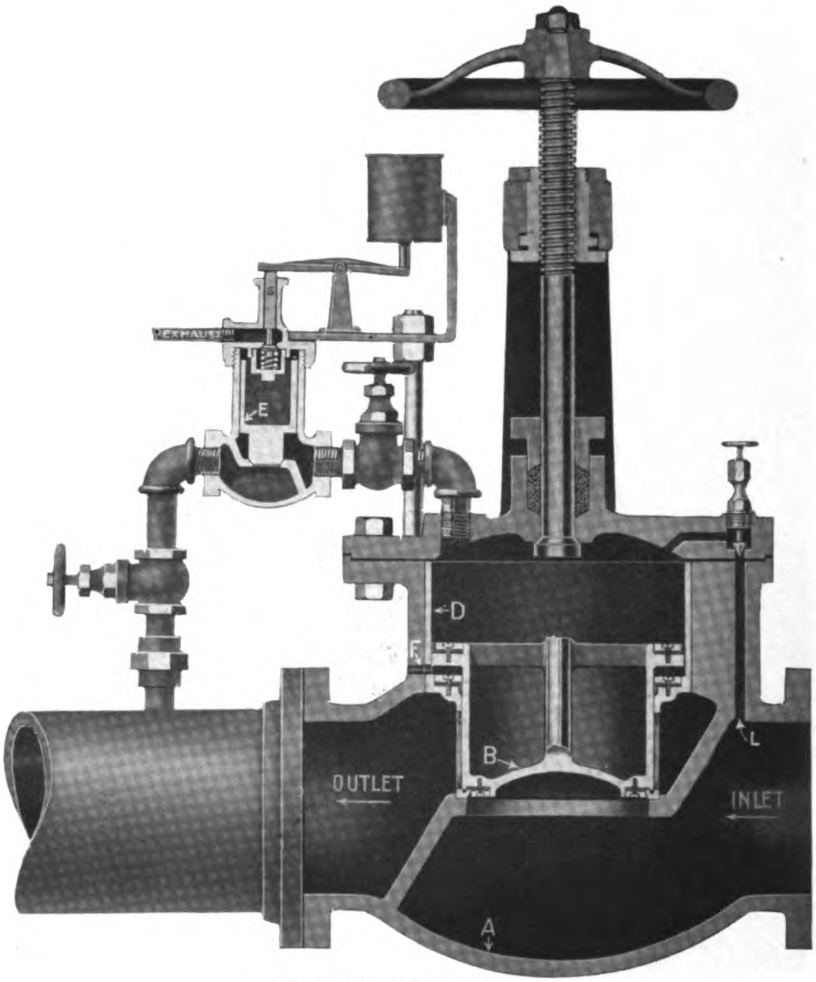


Fig. 172-D, Globe Pattern

Furnished for electric-hydraulic control for quenching operation with solenoid designed for either AC or DC circuit of any voltage. Valve opens quickly for any necessary spraying or quenching operations, and also provides for rapid closing without shock or jar due to inherent air and water cushioning and needle valve adjustment control.

Valve supplied in cast iron, semi-steel and cast steel, with non-corrosive trim of bronze, Gavalloy or stainless steel for working pressure and water service conditions. Arranged with V-shaped or saw-tooth liner-seat so that on rapid valve closure piston is arrested just before seating contact to eliminate shock or bang.

Renewable cups and seat ring, which may be inexpensively replaced, assures low maintenance costs inasmuch as there are no metal to metal contacts, consequently minimum servicing attention. These valves for years have proven their efficiency for quenching service and their complete dependability.

ALL DIMENSIONS IN INCHES

Size Valve		3	4	6	8	10	12	14	16	18	20	24	30	36
Series 15, 25, 30 and 40:														
Center to Face	Angle	6	6½	6¾	11¼	14¼	15½	16½	18	20½	20½	24	30	31½
Face to Face	Globe	12	13	18	24½	28½	31	33	36	40	40	48	60	63

Parts List Page 83—Flange Drilling Pages 92 and 93

COUNTER-BALANCED RAILROAD STANDPIPE VALVES

Working Pressures	150 lbs.	250 lbs.	300 lbs.	400 lbs.
Body and Bonnet Material	Cast Iron	Cast Iron	Semi-Steel	Cast Steel
Angle Pattern, Series Fig. No.	76-D	76-U	76-V	76-W
Globe Pattern, Series Fig. No.	77-D	77-U	77-V	77-W

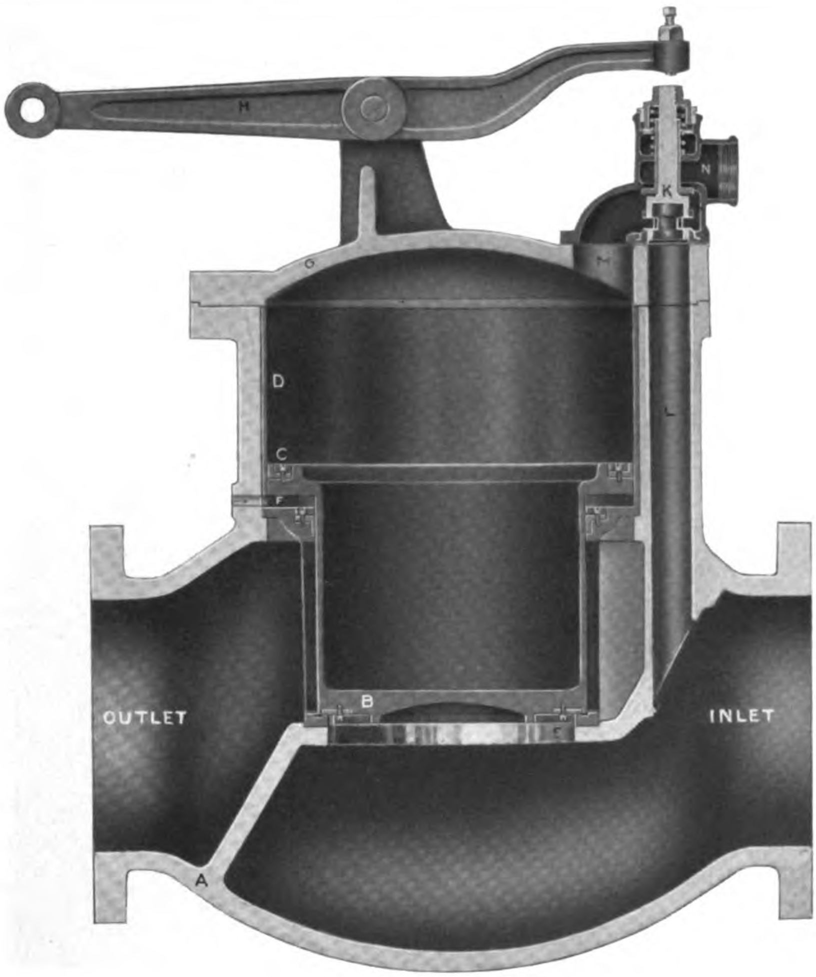


Fig. 77-D, Globe Pattern

The valve is furnished in either Angle or Globe Patterns and has proven the only truly efficient and dependable valve for use with railroad water columns or standpipes for operation on varying and high pressures. The pilot control valve is readily adjustable for any required speed of operation to suit operation needs.

It may be furnished with suitable operating lever for application with various types of water columns; and the valve, in either Angle or Globe pattern, may be placed in any position to affect proper operating lever hook-up in connection with column operating lever-rods. Valve also applicable for any type of overhead system.

Due to inherent air and water cushioning, and accessible pilot control adjustment, the valve functions at all times without any water hammer or shock. The liner-seat is provided with V-shaped ports or saw-tooth design for any necessary arresting of valve piston seating to eliminate any bang.

ALL DIMENSIONS IN INCHES

Size Valve		3	4	6	8	10	12	14	16
Series 15, 25, 30 and 40:									
Center to Face	Angle	6	6½	6¾	11¼	14¼	15½	16½	18
Face to Face	Globe	12	13	18	24½	28½	31	33	36

Parts List Page 84—Flange Drilling Pages 92 and 93

HYDRAULIC DOUBLE CUSHIONED CHECK VALVES

Working Pressures	300 lbs.	400 lbs.	600 lbs.	900 lbs.
Body and Bonnet Material	Semi-Steel	Cast Steel	Cast Steel	Cast Steel
Angle Pattern, Series Fig. No.	123-V	123-W	123-X	123-Y
Globe Pattern, Series Fig. No.	124-V	124-W	124-X	124-Y

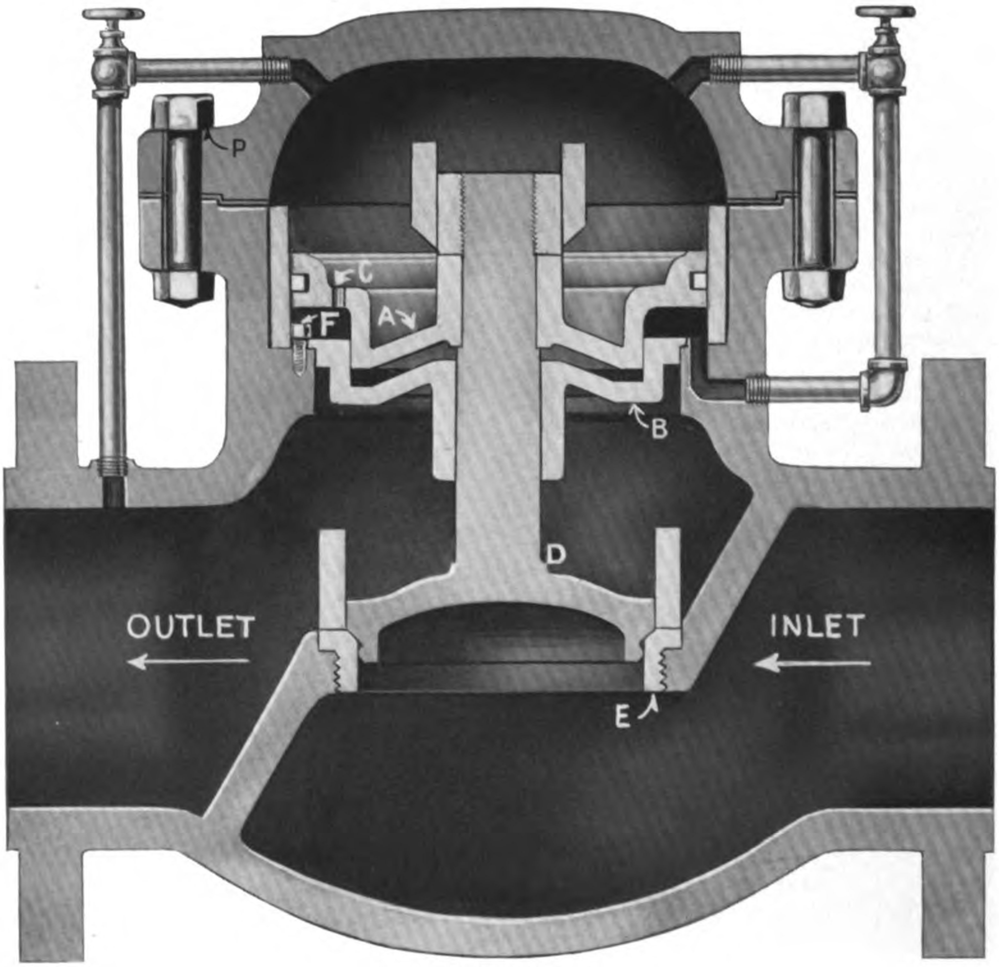


Fig. 124-V, Globe Pattern

Especially designed for high pressure boiler feed lines, and may be equipped with manual handwheel control. Inherent cushioning prevents any shock or jar in sudden valve closure, and needle valve control permits of adjustment to regulate the operating speed of valve to suit any operating conditions.

Body and bonnet construction is semi-steel and cast steel with non-corrosive trim of bronze, Gavalloy or stainless steel for the pressure and service conditions. Furnished in Angle and Globe patterns 2½" sizes to 14." Angle pattern valve has bottom inlet and side discharge.

ALL DIMENSIONS IN INCHES

Size Valve	**2½**	**3**	**4**	**5**	**6**	**7**	**8**	**10**	**12**	**14**
Series 30 and 40:										
Center to Face Angle	5¾	6¼	7	7⅞	8¾	9⅝	10½	12¼	14	18
Face to Face Globe	11½	12½	14	15¾	17½	19¼	21	24½	28	36
Series 60 and 90:										
Center to Face Angle	7	8½	10	12	13	14	15½	17	18½	20
Face to Face Globe	14	17	20	24	26	28	31	34	37	40

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STANDARD DOUBLE CUSHIONED CHECK VALVES

Working Pressures	150 lbs.	250 lbs.	300 lbs.	400 lbs.
Body and Bonnet Material	Cast Iron	Cast Iron	Semi-Steel	Cast Steel
Globe Pattern, Series Fig. No.	73-D	73-U	73-V	73-W

To eliminate serious surge and water hammer on emergency shut-down of pumps this balanced check valve instantly closes before reverse flow occurs due to the proper double cushioning feature inherent in the valve, and it prevents any probability of reversing of pump and motor.

With needle valve regulation the valve may be adjusted to any required operating speed to suit requirements. The valves are furnished 3" sizes and larger flanged ends with body and bonnet cast iron, semi-steel and cast steel with non-corrosive trim of bronze, Gav-alloy or stainless steel to meet any working pressure or water service conditions.

Designed with V-shaped ports or saw-tooth liner-seat construction necessary for minimum to rapid maximum service demands, the valve in closing properly arrests the reverse flow to prevent any surging and damaging water shocks.

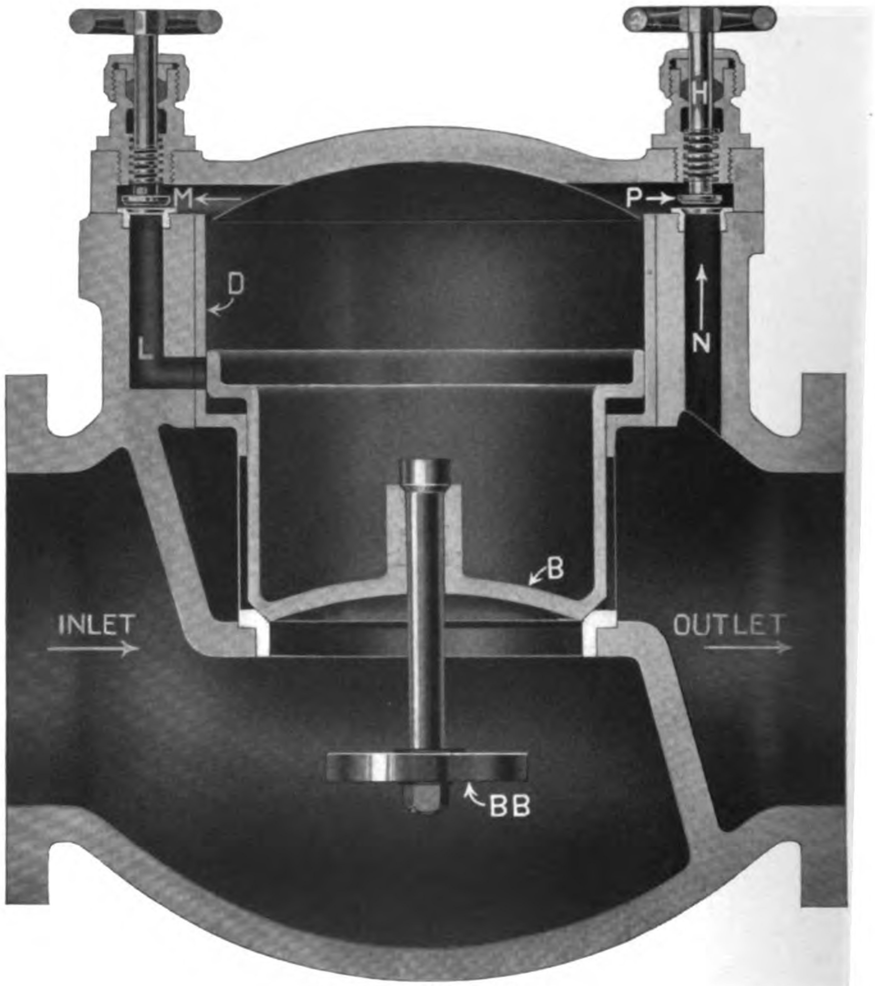
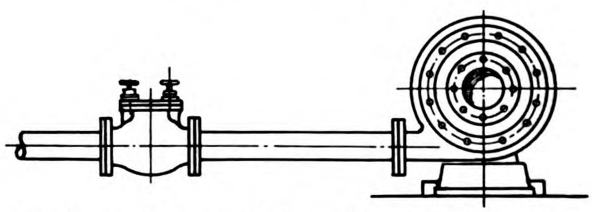


Fig. 73-D, Globe Pattern



Installation of Valve on Discharge Side of Centrifugal Pump.

ALL DIMENSIONS IN INCHES

Size Valve	**3**	**4**	**6**	**8**	**10**	**12**	**14**	**16**	**18**	**20**	**24**	**30**	**36**
Series 15, 25, 30 and 40:													
Center to Face Angle	6	6½	6¾	11¼	14¼	15½	16½	18	20½	20½	24	30	31½
Face to Face Globe	12	13	18	24½	28½	31	33	36	40	40	48	60	63

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WATER PRESSURE REDUCING AND CHECK VALVES

GLOBE PILOT TYPE*

Working Pressures	150 lbs.	250 lbs.	300 lbs.	400 lbs.
Body and Bonnet Material	Cast Iron	Cast Iron	Semi-Steel	Cast Steel
Series Fig. No.	49-D	49-U	49-V	49-W

Also available with integral Base Pilot Type.

OPERATING SEQUENCE

Downstream pressure is automatically maintained against any higher upstream head accordingly as the Reducing Pilot Valve is adjusted, but with "stop check piston" assembly in main valve it is impossible for downstream side pressure to return back through the valve. The valve is virtually two valves in one, that is, a regular water reducing valve as well as a reverse flow check valve. This valve is ideal for service on pump discharge where a definite service pressure is required to be maintained and where in case of pump shut-down from any causes the valve will prevent any back flow through the valve to tend to reverse the pump and dissipate storage water back into suction.

CONSTRUCTION AND DESIGN

The valves are furnished special heavy cast iron, semi-steel and cast steel, with bronze trim, Gavalloy or stainless steel, accordingly as to pressure and water service conditions. Cushioning by air and water prevents any shock or jar under any varying flow capacities, and the perfectly balanced pilot valve control assures any necessary positioning of valve to meet volume demands without creating a hunting action in the valve. The "stop check piston" independent of regular valve piston definitely protects against any reverse flow whenever upstream head drops below the outlet or downstream pressure.

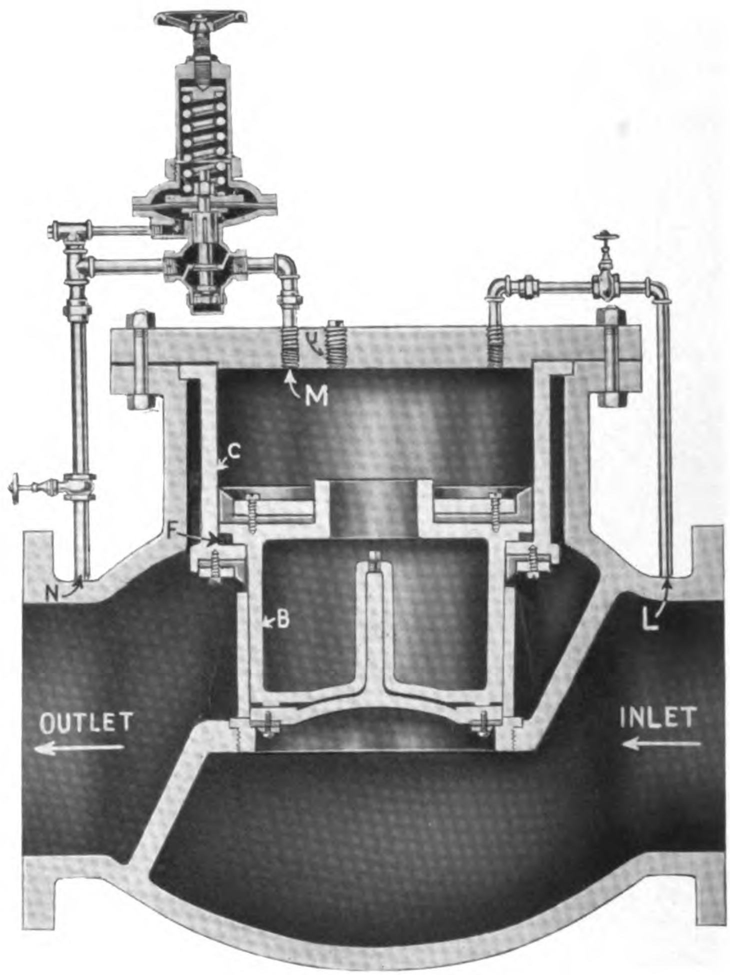

Fig. 49-D, Globe Pilot Pattern

ALL DIMENSIONS IN INCHES

Size Valve	**3**	**4**	**6**	**8**	**10**	**12**	**14**	**16**	**18**	**20**	**24**	**30**	**36**
Series 15, 25, 30 and 40: Face to Face Flanged Ends	12	13	18	24½	28½	31	33	36	40	40	48	60	63

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WATER PRESSURE REDUCING AND DOUBLE ACTING WATER LEVEL CONTROL VALVES

Working Pressures	150 lbs.	250 lbs.	300 lbs.	400 lbs.
Body and Bonnet Material	Cast Iron	Cast Iron	Semi-Steel	Cast Steel
Series Fig. No.	50-D	50-U	50-V	50-W

OPERATING SEQUENCE

This design valve performs three important functions. 1. Acting as an altitude control valve to prevent any overflow of storage tank and being full open when filling tank. 2. Dissipating tank storage back through the valve at any desired reduced pressure until tank level lowers to a minimum depth. 3. At any minimum depth of water level in tank valve then fully opens to full area to dump remaining tank storage into distribution system. This valve is particularly desired where low and high pressure zones are maintained, and where it is desired to store excess volume under minimum service demands but only dissipate storage from high pressure zone at a reduced pressure until peak load demands when the valve will dump tank storage from high pressure zone at any predetermined minimum tank depth.

CONSTRUCTION AND DESIGN

The valves are furnished special heavy cast iron, semi-steel and cast steel, with bronze trim, Gavalloy or stainless steel, to suit any pressure and water service conditions. Under throttling or full open service the valves eliminate any shock or jar in their operation due to the inherent air and water cushioning. The perfectly balanced pilot controls affect all necessary proper positioning of the valves without hunting for any partial or full opening of the valves for the required flow requirements. Suitable indicator rod shows the valve position at all times.

Fig. 50-D, Base Pilot Pattern

ALL DIMENSIONS IN INCHES

Size Valve	3	4	6	8	10	12	14	16	18	20	24	30	36
Series 15, 25, 30 and 40: Face to Face Flanged Ends	12	13	18	24½	28½	31	33	36	40	40	48	60	63

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AUTOMATIC VALVES—TWO OR MORE OPERATIONS
HYDRAULIC CONTROL

Showing Aerator Operation through
Combined Altitude and Aerator Control Valve

Valve operates entirely automatic, maintaining preadjusted heighth of spray and when aerator basin is at point of overflow the valve closes.

Maximum depth of water in basin may be changed or the valve made to open and close between maximum and minimum fixed limits.

Cut shows filling of basin with a battery of nozzles automatically shutting down while another battery continues with fixed heighth to fill reservoir.

APPRECIATION

I would like to take this occasion to express my appreciation for the invaluable aid generously given to me by:

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Mr. Granger

R. L. Rinehart