UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

TESTS OF CREST STAGE GAGE INTAKES

By

Jack R. Carter and Charles R. Gamble

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PREFACE

This investigation was sponsored by the Floods Section (SW), Tate Dalrymple, chief, and carried out under the general supervision of R. W. Carter, chief, Research Section (SW), succeeded by M. R. Williams. The authors were assisted in running the tests by personnel of the National Bureau of Standards.

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TESTS OF CREST-STAGE GAGE INTAKES

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INTRODUCTION

Various types of crest-stage gages have been used by the Geological Survey. Most installations consist of a vertically mounted metal pipe, a wooden rod, an intake device, and a small amount of granulated cork. These gages are placed where elevations of flood crests are desired. Water rising and then falling in the gage leaves a high-water mark of granulated cork on the wooden rod. The elevation of this mark can be determined at a date subsequent to the date of the crest.

It has been found that the high-water mark left on the rod may not represent the true elevation of the flood crest in the stream at the gage site. The difference between the true elevation of the crest at the gage and the recorded elevation will be designated drawdown if the recorded elevation is less than the true elevation, or pileup if the recorded elevation is greater than the true elevation. Tests of drawdown and pileup effects have been made in the past by Survey personnel and others. (See p. 8.) These investigations have sometimes brought forth conflicting results, probably due to the varied conditions under which the gages were tested.

The purpose of this investigation was (1) to determine the pileup and drawdown characteristics of the intakes now being used by the Survey and (2) to design a better intake if existing models were found unsuitable. It was further prescribed that any new design that might result should be easily fabricated from standard pipe fittings, and should be unaffected by pileup or drawdown in excess of 0.1 foot for velocities up to about 8 feet per second.

TYPES OF GAGES TESTED

Three general types of gages now being used by the Survey were tested. The first was the Columbus type gage made of a 2-inch pipe containing a wooden indicator rod and an intake made of a 2-inch pipe cap with six 3/16-inch radially drilled holes spaced 60° apart. The indicator rod rested on a 3/4-inch round iron rod that was welded to the center of the inside of the cap and cut off flush with the top of the cap. This intake was also tested with the two downstream outside holes closed with small wooden plugs. These plugs were smoothed to fit the outside contours of the cap. Another series of tests was made using 1/4-inch holes with all holes open and then with two holes plugged as described above. This gage is shown in figure 1.

The second gage tested was the Missouri or post-type gage which was developed in the Rolla district. This gage is made of a 2-inch pipe set inside a 2½-inch pipe and held in place by a ½-inch bolt. The 2½-inch pipe can be driven into the ground or set in concrete in any desired location. The laboratory model of this gage is shown in figure 2. The short lower section (and the plug in it) which is screwed to the 2-inch pipe is not used in a field installation. It was necessary on the laboratory model in order to close off the bottom of the pipe so that the intake holes would be effective.

The third gage tested was the CP-50 gage which was developed by the College Park district. This gage uses 1¼-inch pipe and has an intake area of 0.39 square inches. A short exhibition model of this gage is shown in figure 3. As can be seen in figure 3 the pipe of the exhibition model is made of transparent lucite. However, for field installation, metal pipe is used.

Several new intake designs were tested. Those listed below were made from 2-inch pipe caps, each with a 3/4-inch round iron rod welded in the center of the inside of the cap and cut off flush with the top and with ¼-inch radially drilled holes spaced as follows:

1. Five holes upstream spaced 30° apart and one hole downstream.
2. Same as above with downstream hole plugged.
3. Three holes upstream spaced 30° apart and one hole downstream.
4. Same as above with two additional holes drilled 15° from the two outside upstream holes.
5. Two holes upstream spaced 60° apart.

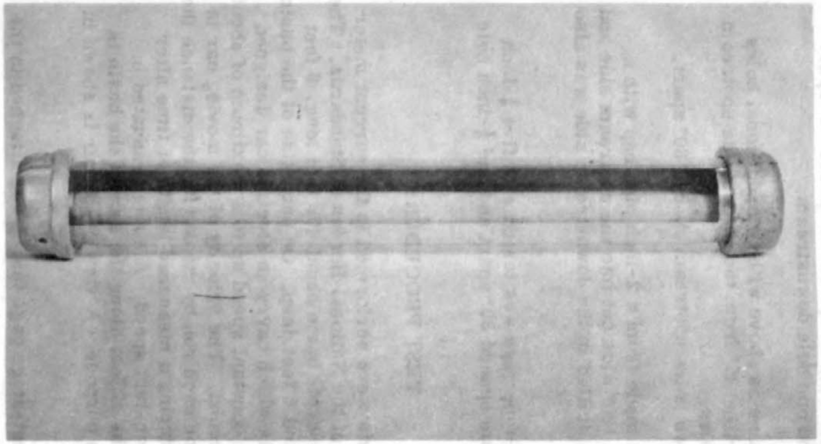
An intake made from a 2-inch pipe cap with a 1/8-inch slot 120° wide cut into the upstream side and a ¼-inch hole drilled in the downstream side was also tested.

The post-type gage was tested with five ¼-inch holes upstream spaced 30° apart and one ¼-inch hole downstream.

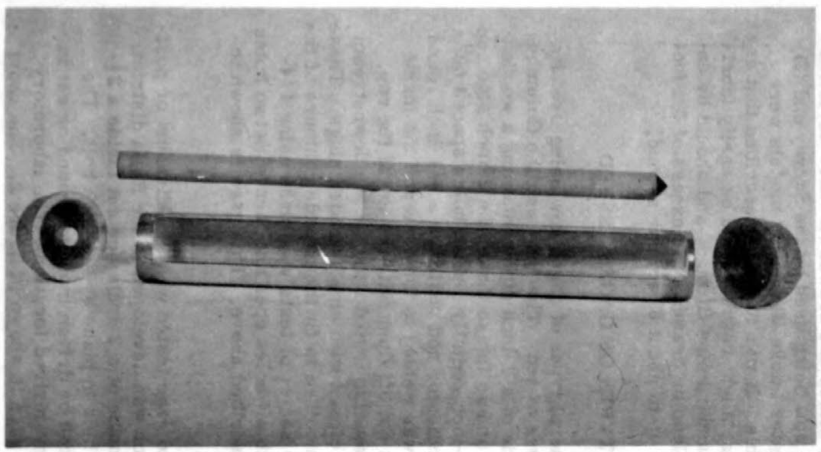
TEST PROCEDURE

These tests were performed in the current meter rating flume of the National Bureau of Standards. The flume is a concrete basin about 400 feet long, 6 feet wide, and about 8 feet deep. On each side of the basin are steel rails which carry an electric car designed to travel at a constant speed up to a maximum of about 10 feet per second. The velocity of the moving car is determined for each run by measuring the distance the car travels during a measured length of time after reaching a constant speed. A scale graduated in feet and tenths of feet along the side of the basin is used for this purpose. A view of the car is shown in figure 4.

Each crest-stage gage tested was attached to the

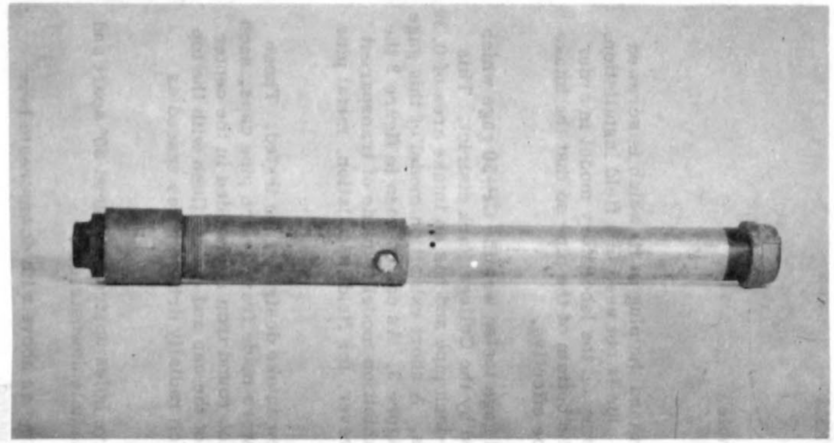


A. Assembled view

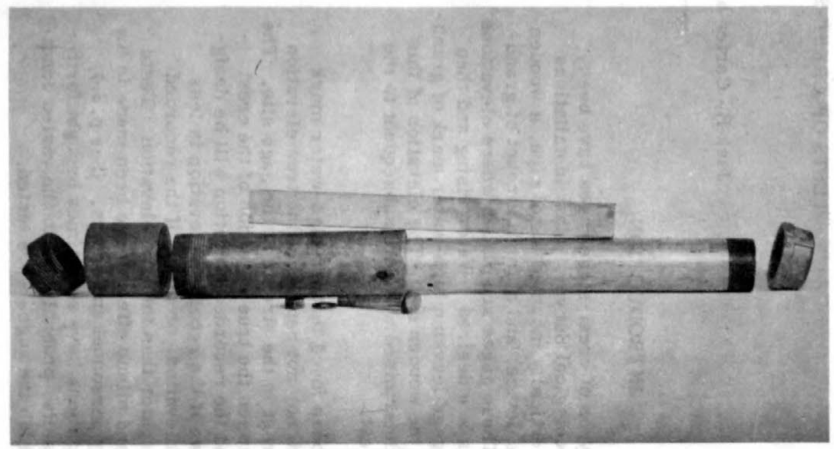


B. Disassembled view

Figure 1. --Two views of cutaway model of Columbus type crest-stage gage.

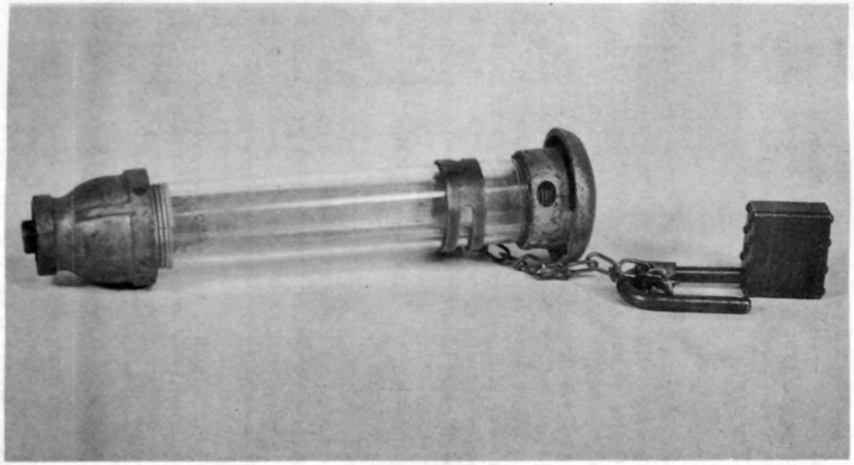


A. Assembled view

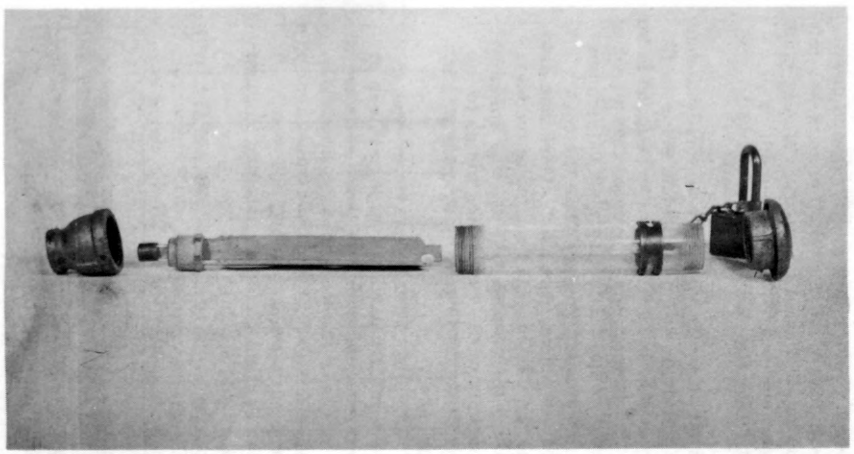


B. Disassembled view

Figure 2. --Two views of laboratory model of Missouri or post-type crest-stage gage.



A. Assembled view



B. Disassembled view

Figure 3. --Two views of CP-50 gage.

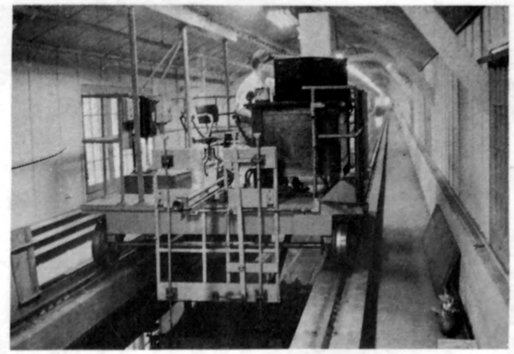


Figure 4. --Car on which the gages were attached for testing

horizontal member shown in the foreground in figure 4. This member is hinged in the middle so that it can swing down and hang vertically (it was then locked in this position) after the gage is attached. The gages were mounted so that the intake was 2 feet below the water surface.

The instrumentation for measuring the amount of pileup or drawdown for the first series of tests was developed by E. C. Moore, chief of the Electronics Section of the Administrative Division, USGS. A device consisting of two conducting plates attached to opposite faces of the indicator rod served as the depth sensing element inside the gage pipe. The electrical conductance between these two plates, which is a function of the amount of submergence and hence the depth of water in the pipe, was measured continuously during a test run and electronically recorded.

The recording equipment was necessarily hooked up with the electrical system used to drive the car. It was necessary for the car operator to vary the amount of power delivered to the car motor in order to maintain a fairly constant speed. Each time this was done the recording device was momentarily thrown out of balance and a sharp peak was produced on the chart. These peaks did not indicate any change in water level and average of the lowest points made by the recorder after the car attained a constant speed was taken as the amount of drawdown.

An independent check of the drawdown indicated by the recorder was made by dropping a small amount of granulated cork into the gage after the car reached a constant speed. Before the car was slowed down the rod was withdrawn. A clear line of cork was left on the rod and the drawdown measured. A very close agreement was found between the two methods of measurement. (See fig. 9.)

The recorder was used for tests on the Columbus type gage. An attempt was made to use it for tests on the post-type gage but the results were found to be inconsistent. An investigation revealed that a coat of oil had collected on the conducting plates which prevented uniform wetting. To save time the cork method, described above, was used. Cork was also used in testing the CP-50 gage because of inconsistent results using the recorder. This was possibly due to the proximity of the conducting plates to the wall of the pipe (the CP-50 gage is $1\frac{1}{4}$-inch pipe instead of 2-inch pipe).

The instrumentation used to measure pileup or drawdown for the second series of tests was developed by Harold O. Wires of the Research Section (SW) Water Resources Division. The instrument, called a surface follower, utilized a touching and wetting technique. The sensing element contained two concentric cylinders and a center rod which served as three open terminals. If the center rod and the first concentric cylinder were in contact with the water, the element remained stationary. If the water surface dropped and opened the water path between the center pole and the first cylinder, the drive motor let out cable; and if the water surface raised and all three terminals were in contact with the water, the drive motor took in cable.

The recording unit was a Stevens A-35 water-stage recorder. A change of 0.1 foot in water level in the pipe was represented by a 1-inch change of pen position on the chart. The clock on the recorder was replaced with a 4.5 rpm d-c motor. The time scale was approximately 3.6 inches of chart per minute.

An independent check of the drawdown was made by using the cork method, described earlier, and comparing results with those obtained from the recorder. A very close agreement was found. (See fig. 12.)

Each new intake was tested at two or three different velocities. If the amount of pileup or drawdown recorded indicated that the intake was not suitable, it was discarded. The most promising intake then was thoroughly tested.

Additional tests were run on the CP-50 gage by the cork method. The amount of protrusion of the small cap on the indicator rod below the bottom cap was varied and the corresponding measurement of drawdown noted.

RESULTS

A short section of 2-inch pipe with the first type of intake tested (2-inch cap with six 3/16-inch holes) was plunged into the water to determine the time necessary to fill the pipe. It was found that the pipe filled in a few seconds. No appreciable lag was detected in running any of the tests. It was also found that the position of the indicator rod with respect to the direction of flow did not affect the amount of drawdown.

Figures 5-16 give the results, in summary form, of the various gages tested. The sketch above each graph illustrates the type of intake and above each sketch is a plan view of the cross section at the intake holes. The arrows indicate the direction of flow of the water.

The results of tests made on the intake consisting of a 2-inch pipe cap with six 3/16-inch holes are given in figure 5. Tests at velocities higher than 6 feet per second were not obtained because the drawdown was greater than that which could be measured with instruments used. The test results of the same intake shown on figure 5 except that the two outside downstream holes were plugged are given in figures 6 and 7. This latter intake was tested under the four different conditions of flood indicated. The results of tests using the same type of intake as shown in figures 5-7 except that the holes were enlarged to $\frac{1}{4}$-inch are shown in figures 8 and 9.

The results of tests made on the post-type gage are given in figure 10. Later tests on this gage indicated that the space between the 2-inch pipe and the $2\frac{1}{2}$-inch pipe was one of the factors influencing the amount of drawdown. It was found necessary to seal this space to obtain consistent results. Since this was not done for the tests shown in figure 10 and since the space between the two pipes is never exactly the same, these results are good for only one setup tested.

Figure 11 shows the results of tests made on the CP-50 gage with the cap on the end of the rod protruding 3/8 inch. Curve B of figure 11 shows the drawdown present when the top of the gage was tilted

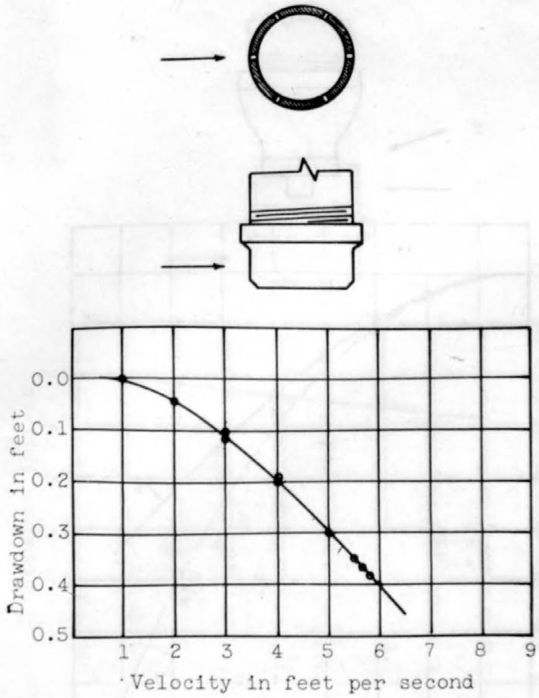


Figure 5.--Results of tests on Columbus type gage with six 3/16-inch holes spaced 60° apart.

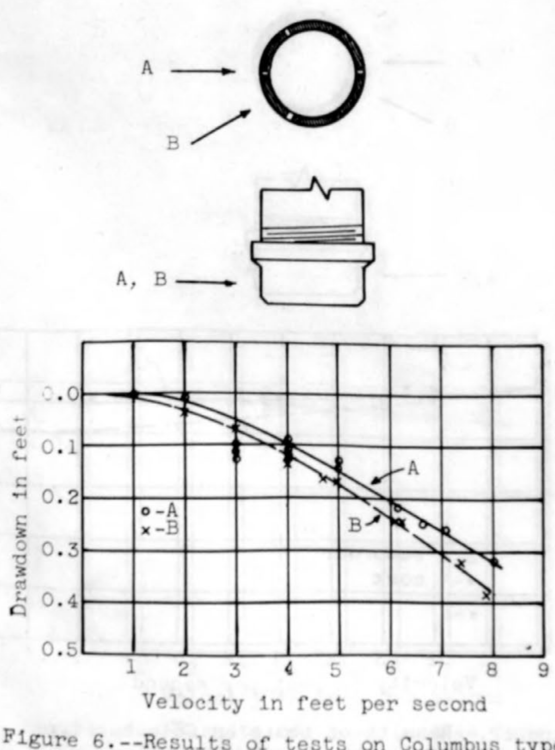


Figure 6.--Results of tests on Columbus type gage with six 3/16-inch holes spaced 60° apart with two downstream holes plugged.

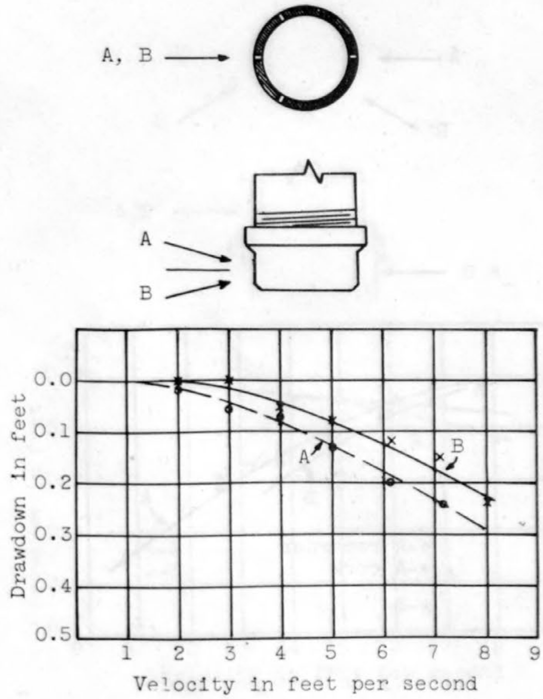


Figure 7.--Results of tests on Columbus type gage with six 3/16-inch holes spaced 60° apart with two downstream holes plugged and gage tipped 15° upstream and 15° downstream.

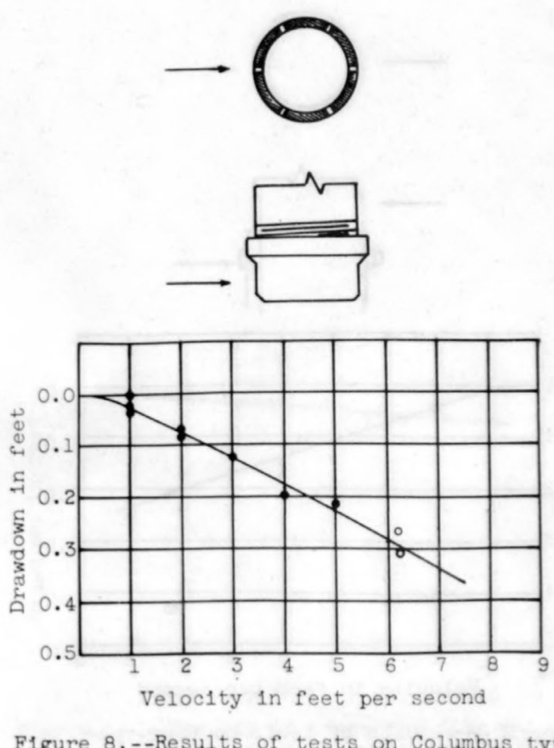


Figure 8.--Results of tests on Columbus type gage with six ¼-inch holes spaced 60° apart.

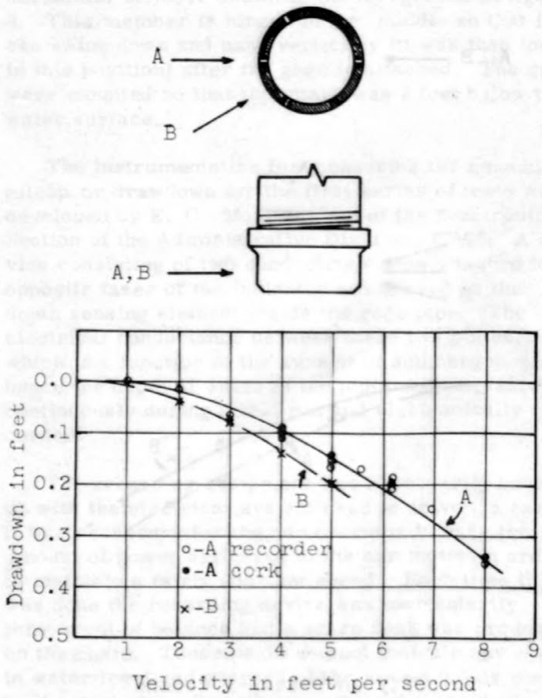


Figure 9.--Results of tests on Columbus type gage with six ¼-inch holes spaced 60° apart with two downstream holes plugged and intake turned 30° horizontally.

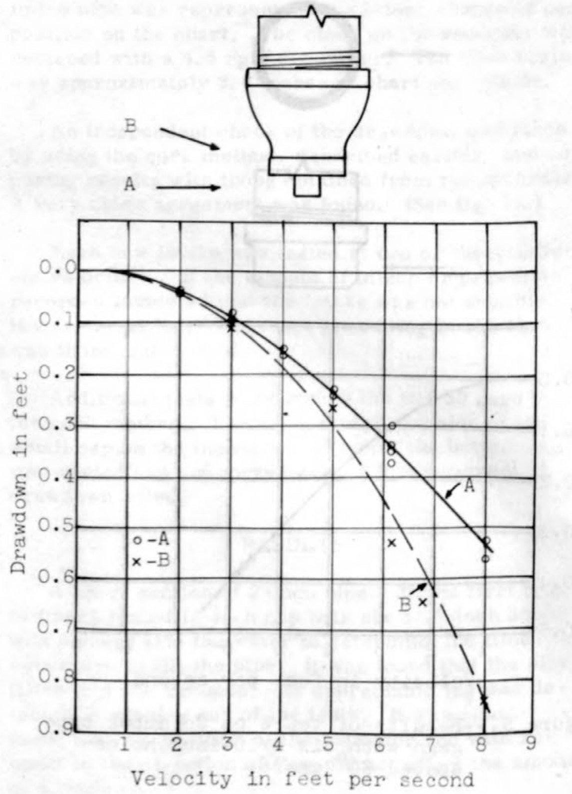


Figure 11.--Results of tests on CP-50 gage.

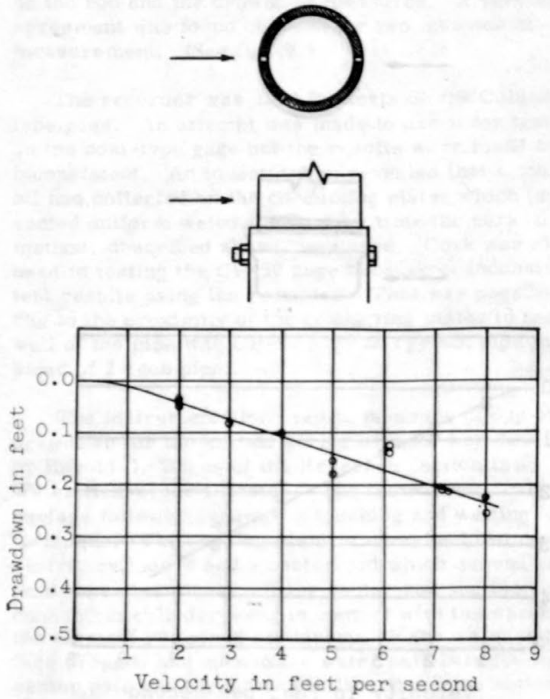


Figure 10.--Results of tests on post-type gage with three holes upstream spaced 60° apart and one hole downstream.

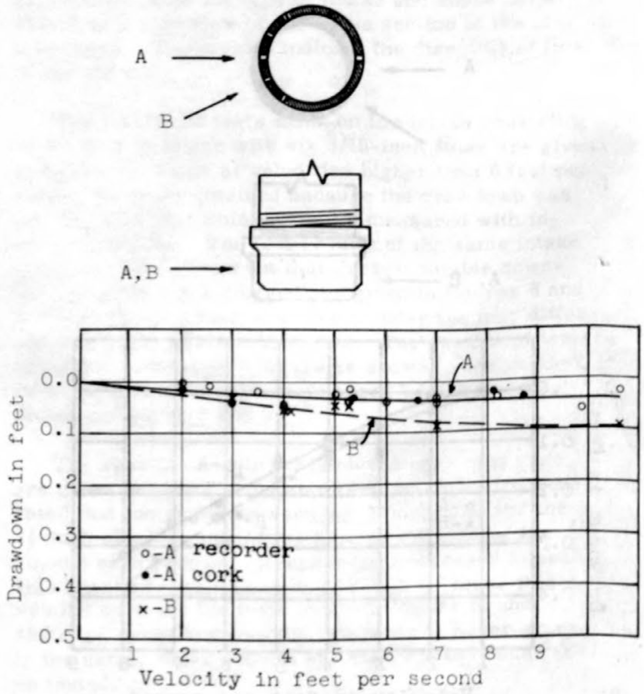


Figure 12.--Results of tests on Columbus type gage with five ¼-inch holes upstream spaced 30° apart and one ¼-inch hole downstream and intake turned 30° horizontally.

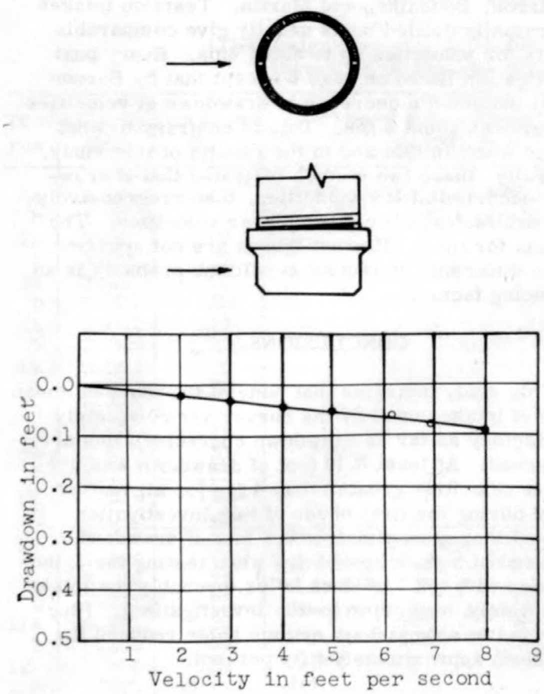


Figure 13.--Results of tests on Columbus type gage with five $\frac{1}{8}$-inch holes upstream spaced 30° apart and one $\frac{1}{4}$-inch hole downstream.

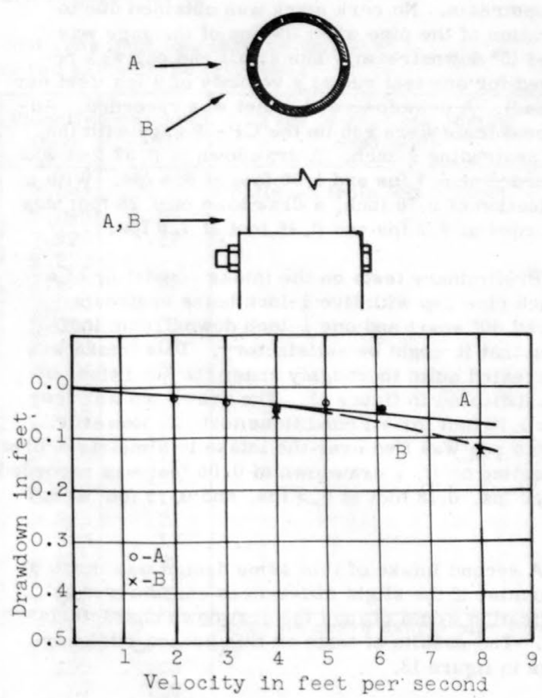


Figure 15.--Results of tests on post-type gage with five $\frac{1}{8}$-inch holes upstream spaced 30° apart and one $\frac{1}{4}$-inch hole downstream and intake turned 30° horizontally; holes are 1 inch above large pipe.

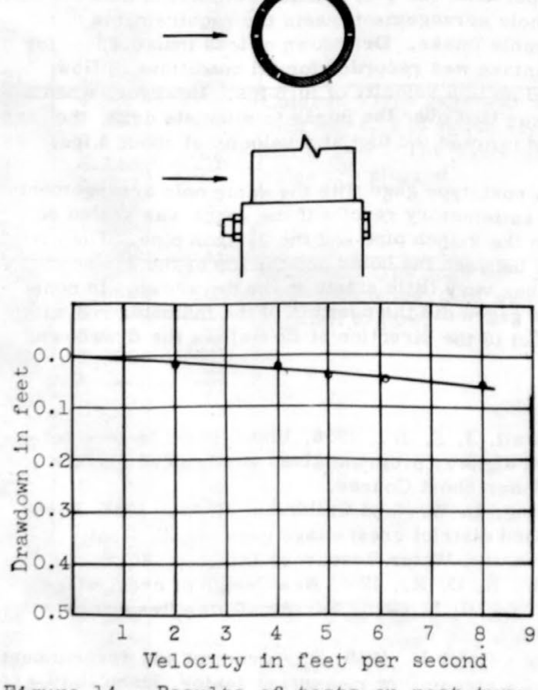


Figure 14.--Results of tests on post-type gage with five $\frac{1}{8}$-inch holes upstream spaced 30° apart and one $\frac{1}{4}$-inch hole downstream; holes are $\frac{1}{2}$ inch above large pipe.

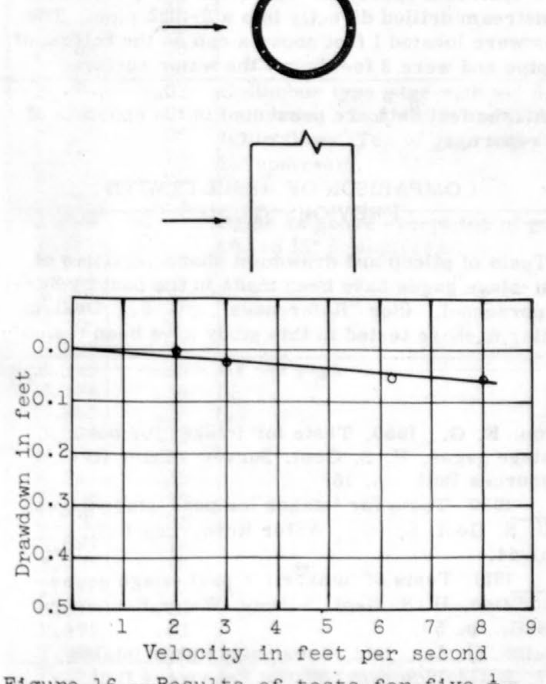


Figure 16.--Results of tests for five $\frac{1}{8}$-inch holes upstream spaced 30° apart and one $\frac{1}{4}$-inch hole downstream drilled directly into 2 inch pipe.

15° upstream. No cork mark was obtained due to vibration of the pipe when the top of the gage was titled 15° downstream. The small end cap was removed for one test run at a velocity of 8 fps (feet per second). A drawdown of 1.1 feet was recorded. Additional tests were run on the CP-50 gage with the cap protruding $\frac{1}{4}$-inch. A drawdown of 0.67 foot was recorded at 6.7 fps and 1.00 foot at 8.4 fps. With a projection of 9/16 inch, a drawdown of 0.26 foot was recorded at 6.2 fps and 0.46 foot at 7.6 fps.

Preliminary tests on the intake consisting of a 2-inch pipe cap with five $\frac{1}{4}$-inch holes upstream spaced 30° apart and one $\frac{1}{4}$-inch downstream indicated that it might be satisfactory. This intake was then tested quite thoroughly under the conditions of flow indicated in figure 12. The drawdown was less than 0.10 foot for all conditions tested. However, when a rag was tied over the intake to simulate debris collecting on it, a drawdown of 0.06 foot was recorded at 3.0 fps, 0.18 foot at 5.3 fps, and 0.25 foot at 6.7 fps.

A second intake of this same design was made to determine if the slight differences encountered in fabrication would change the drawdown characteristics. The results of tests on this second intake are given in figure 13.

Figure 14 and 15 give results of tests made on post-type gage with five $\frac{1}{4}$-inch holes upstream spaced 30° apart and one $\frac{1}{4}$-inch hole downstream. The space between the 2-inch pipe and the $2\frac{1}{2}$-inch pipe was sealed in each case. In figure 14 the intake holes are $\frac{1}{2}$ inch above the large pipe and in figure 15 they are 1 inch above it.

Figure 16 gives results of tests for five $\frac{1}{4}$-inch holes upstream spaced 30° apart and one $\frac{1}{4}$-inch hole downstream drilled directly into a 2-inch pipe. The holes were located 1 foot above a cap on the bottom of the pipe and were 2 feet below the water surface.

All the test data are presented in the appendix of this report.

COMPARISON OF RESULTS WITH PREVIOUS STUDIES

Tests of pileup and drawdown characteristics of crest-stage gages have been made in the past by Survey personnel. (See "References", p. 8.) Designs similar to those tested in this study have been tested by Barron, Bodhaine, and Martin. Tests on intakes with radially drilled holes usually give comparable results for velocities up to about 4fps. Every past investigation listed on page 8 except that by Barron in 1951 indicated a decrease in drawdown at velocities greater than about 6 fps. This is contrary to what Barron found in 1951 and to the results of this study. Generally, these two studies indicated that if drawdown occurred at low velocities, then progressively more drawdown occurred at higher velocities. The reasons for these different trends are not apparent but the difference in testing conditions probably is an influencing factor.

CONCLUSIONS

This study indicates that none of the more common types of intakes used by the Survey are completely satisfactory as far as drawdown characteristics are concerned. At least 0.10 foot of drawdown was present at velocities greater than 4 fps for all models tested during the first phase of this investigation. It is noted that approximately 0.4 foot of drawdown occurred at a velocity of 6 fps when testing the 2-inch pipe cap with six 3/16-inch holes (probably the intake most widely used prior to this investigation). Plugging the two downstream outside holes reduced the drawdown approximately fifty percent.

The small cap on the end of the aluminum rod in the CP-50 gage greatly reduced the drawdown for that gage. By increasing the projection of the cap from $\frac{1}{4}$ inch to 3/8 inch, the drawdown was reduced somewhat. However, very little change in drawdown occurred when the cap was projected 9/16 inch.

The results of the tests on the intake made from a 2-inch pipe cap with five $\frac{1}{4}$-inch holes upstream spaced 30° apart and one $\frac{1}{4}$-inch hole downstream indicate that this hole arrangement meets the requirements of a desirable intake. Drawdown of less than 0.1 foot for this intake was recorded for all conditions of flow tested up to a velocity of 10.5 fps. However, when a rag was tied over the intake to simulate drift, the drawdown was 0.1 foot at a velocity of about 4 fps.

A post-type gage with the same hole arrangement gave satisfactory results if the space was sealed between the 2-inch pipe and the $2\frac{1}{2}$-inch pipe. The distance between the holes and the top of the $2\frac{1}{2}$-inch pipe has very little effect on the drawdown. In none of the gages did the position of the indicator rod with respect to the direction of flow affect the drawdown.

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Table 1. --Test data on the various gages tested

[The designation of a and b for some of the test runs indicates that the car was travelling in opposite directions for the two parts of the test run.]

Test run	Velocity (fps)	Drawdown (ft)	Type of gage and testing conditions
1a	1.000	0.02	Columbus type gage with six $\frac{1}{4}$-inch holes, 2 holes parallel to flow.
b	1.000	0	
2a	1.000	.03	
b	1.000	.02	
3a	1.999	.07	
b	1.998	.08	
4a	3.010	.13	
b	3.005	.13	
5a	3.996	.20	
b	4.003	.20	
6a	5.002	--	
b	5.000	.22	
7a	6.153	.31	
b	6.157	.27	
8a	7.310	.41+	
b	7.018	.41+	
9a	5.003	.06	Columbus type gage with six $\frac{1}{4}$-inch holes, 2 of which are parallel to flow. The 2 downstream holes are plugged during run a, while the 2 upstream holes are plugged during run b (see headnote).
b	4.999	--	
10a	6.146	.12	
b	6.148	.25	
11a	6.951	.25	
b	7.102		
12	7.985	.36	
13a	1.021	0	
b	1.000	0	
14a	2.001	.02	
b	1.997	.04	
15a	3.006	.07	
b	3.011	.13	
16a	3.997	.10	
b	4.001	.20	
17	5.000	.14	
18a	2.004	.04	Same as above except pipe turned 30°.
b	1.999	.05	
19a	3.006	.08	
b	3.004	.15	
20a	3.998	.15	
b	3.996	--	
21	4.999	.20	
22	4.998	0.16	Columbus type gage with six $\frac{1}{4}$-inch holes, 2 of which are parallel to flow. The 2 downstream holes are plugged.
23	5.461	.17	
24	6.136	.21	
25	6.146	.18	
26	8.007	.36	
27	7.992	.35	
28	4.988	.18	
29	4.000	.12	
30a	1.005	0	Columbus type gage with six 3/16-inch holes, 2 of which are parallel to flow.
b	1.991	.04	
31a	3.006	.10	
b	3.008	.11	
32a	3.998	.21	
b	4.002	.20	
33a	3.999	.20	
b	3.996	.20	
34a	4.993	.30	
b	5.001	.30	
35a	6.152	--	
b	5.562	.35	
36a	5.651	.37	
b	5.858	.38	
37a	5.722	.37	
b	5.863	.38	
38	3.996	0	Columbus type gage with six 3/16-inch holes, 2 of which are parallel to flow. The 2 downstream holes are plugged during run a, while the two upstream holes are plugged during run b (see headnote).
39	3.996	.09	
40	5.001	.15	
41a	4.995	.14	
b	5.003	.30	
42a	6.156	.22	
b	6.161	.43	
43a	6.651	.26	
43b	7.083	--	Continued from left column.
44	7.089	0.27	
45	7.996	.32	
46	9.223	--	
47	7.995	.32	
48	1.000	0	
49a	2.000	.01	
b	2.003	.04	
50a	2.004	.01	
b	2.000	.05	
51a	3.018	.13	
b	3.006	.13	
52a	3.010	.12	
b	3.007	.13	
53a	3.007	.10	
b	3.994	.21	
54a	3.994	.11	
b	3.997	.21	
55	4.992	.15	
56	2.999	.06	
57	1.000	0	Same as above except pipe turned 30°.
58	2.004	0.04	
59	1.995	.04	
60	3.007	.08	
61	2.998	.08	
62	3.998	.13	
63	3.998	.13	
64	4.993	.17	
65	4.994	.17	
66	3.993	.12	
67	3.993	.12	
68	4.661	.16	
69	4.789	.15	
70	6.143	.24	
71	6.150	.24	
72	6.147	.22	
73	7.337	.32	
74	7.884	.38	
75	7.998	.38	
76	2.000	.02	Columbus type gage with six 3/16-inch holes, 2 of which are parallel to flow. Top of gage was tipped 15° upstream.
77	2.989	.06	
78	4.006	.08	
79	4.987	.14	
80	6.131	.20	
81	7.093	.24	
82	1.994	0	Same as above except top of gage tipped 15° downstream.
83	2.999	0	
84	4.002	.06	
85	4.992	.08	
86	6.150	.12	
87	7.105	.15	
88	7.993	.23	
89	6.149	.30	CP-50 gage
90	6.164	.38	
91	7.983	.56	
92	8.002	.52	
93	6.158	.34	
94	6.144	.35	
95	5.000	.22	
96	5.030	.23	
97	3.994	.15	
98	3.986	.16	
99	2.996	.09	
100	3.016	.08	
101	1.992	.03	
102	2.006	.04	
103	7.994	1.10	CP-50 gage with plug removed
104	.997	0	CP-50 gage with top of gage tipped 15° upstream.
105	1.998	.04	
106	1.999	.05	
107	2.998	.12	

Table 1.--Test data on the various gages tested-Continued

[The designation of a and b for some of the test runs indicates that the car was travelling in opposite directions for the two parts of the test run.]

Test run	Velocity (fps)	Drawdown (ft)	Type of gage and testing conditions
108	3.998	0.16	CP-50 gage with top of gage tipped 15° upstream -Continued.
109	4.996	.26	
110	6.128	.53	
111	6.736	.64	
112	7.996	.85	
113	4.997	.16	Missouri or post-type gage.
114	5.003	.18	
115	6.172	.13	
116	6.160	.15	
117	7.123	.21	
118	7.267	.22	
119	8.016	.26	
120	7.996	.23	
121	3.995	.10	
122	2.991	.08	
123	1.997	.04	
124	2.001	.03	
125	2.997	.08	
126a	4.95	.03	Columbus type gage with five $\frac{1}{4}$-inch holes upstream and one $\frac{1}{4}$-inch hole downstream for run a, and one $\frac{1}{4}$-inch upstream and five $\frac{1}{4}$-inch holes downstream for run b (see headnote).
b	5.02	.30	
127a	5.34	.04	
b	5.28	.34	
128a	5.93	.04	
b	8.68	--	
129	7.41	.04	
130	9.89	.06	
131	5.07	*.09	Columbus type gage with three $\frac{1}{4}$-inch holes upstream and one $\frac{1}{4}$-inch downstream.
132	6.47	*.15	
133	8.14	*.28	
134a	5.38	*.18	Columbus type gage with 1/8-inch slot 120° wide upstream and $\frac{1}{4}$-inch hole downstream.
b	5.40	.38	
135	8.70	*.51	
136	1.99	0	Columbus type gage with five $\frac{1}{4}$-inch holes upstream spaced 30° apart and one $\frac{1}{4}$-inch hole downstream.
137	2.52	.01	
138	3.55	.02	
139	5.37	.02	
140	6.91	.04	
141	6.14	--	
142	7.06	.03	
143	8.19	.03	
144	10.6	.03	
145	3.97	.03	Same as above except upstream and downstream holes 30° to line of flow.
146	2.95	.02	
147	4.17	.04	
148	5.34	.04	
149	6.93	.07	
150	5.04	.04	
151	10.3	.09	
152	6.49	*.09	Columbus type gage with five $\frac{1}{4}$-inch holes upstream 30° apart and $\frac{1}{4}$-inch hole downstream; downstream hole plugged.
153	8.35	*.17	
154	4.02	*.03	
155	3.52	*.02	Columbus type gage with three $\frac{1}{4}$-inch holes upstream 30° apart; two $\frac{1}{4}$-inch holes 15° downstream from the 2 outside holes and one $\frac{1}{4}$-inch hole downstream.
156	5.38	*.04	
157	6.71	*.08	
158	8.60	*.14	
159	6.68	.04	Columbus type gage with five $\frac{1}{4}$-inch holes upstream and one $\frac{1}{4}$-inch hole downstream. Test made using cork instead of instruments to measure drawdown.
160	8.12	.02	
161	8.82	.03	
162	5.40	.03	
163	5.39	.03	
164	3.98	.04	
165	4.06	.04	
166	3.00	.03	
167	2.03	.01	
168	5.37	*0.10	Columbus type gage with two $\frac{1}{4}$-inch holes upstream spaced 30° apart.
169	3.04	*.02	
170	6.59	*.19	
171	8.05	*.29	
172	3.01	0	Columbus type gage with five $\frac{1}{4}$-inch holes upstream and one $\frac{1}{4}$-inch hole downstream with top of gage tipped 15° upstream.
173	2.99	0	
174	4.00	.03	
175	5.36	0	
176	2.96	.01	Same as above except top of gage tipped 15° downstream.
177	4.03	0	
178	5.36	*.01	
179a	8.75	.51	CP-50 gage with 3/8-inch projection.
b	6.56	.33	
180a	6.21	.26	CP-50 gage with 9/16-inch projection.
b	7.59	.42	
181a	8.41	1.00	CP-50 gage with $\frac{1}{4}$-inch projection.
b	6.73	.67	
182	3.00	.06	Columbus type gage with five $\frac{1}{4}$-inch holes upstream and one $\frac{1}{4}$-inch hole downstream with a rag tied over the intake.
183	5.34	.18	
184	6.72	.25	
185	4.0	.09	Missouri or post-type gage with five $\frac{1}{4}$-inch holes upstream spaced 30° apart and one $\frac{1}{4}$-inch hole downstream.
186	5.0	.07	
187	6.2	.16	
188	8.0	.17	
189	6.2	.19	
190	8.0	.22	
191	5.0	.09	
192	3.0	.08	
193	2.0	.02	Columbus type gage with five $\frac{1}{4}$-inch holes upstream spaced 30° apart and one $\frac{1}{4}$-inch hole downstream. Intake is 3 feet below water surface.
194	3.0	.03	
195	4.0	.04	
196	5.0	.05	
197	6.2	.06	
198	6.9	.08	
199	8.0	.09	
200	2	.02	Missouri or post-type gage with five $\frac{1}{4}$-inch holes upstream spaced 30° apart and one $\frac{1}{4}$-inch hole downstream. Space between large and small pipe is sealed. Holes are 1 inch above end of large pipe.
201	3	.03	
202	4	.04	
203	5	.03	
204	6.1	.05	
205	8	.08	
206	4	.05	Same as above except holes are turned 30° from line of flow.
207	8	.12	
208	6.1	.05	
209	4	.02	Missouri or post-type gage with five $\frac{1}{4}$-inch holes upstream spaced 30° apart and one $\frac{1}{4}$-inch hole downstream. Space between large and small pipe is sealed. Holes are $\frac{1}{2}$-inch above end of large pipe.
210	5	.04	
211	6.1	.05	
212	8	.06	
213	2	.02	
214	2.0	0	Columbus type gage with intake holes in pipe rather than in pipe cap. Five $\frac{1}{4}$-inch holes upstream spaced 30° apart and one $\frac{1}{4}$-inch hole downstream. Holes are 1 foot above pipe cap and 2 feet below water surface.
215	4.0	.03	
216	6.2	.05	
217	8.0	.06	
218	3.0	.02	

* Pileup

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