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THE RAINFALL IN 1896.

BY F. W. W. DOANE, M. CAN. SOC. C. E.,

City Engineer, Halifax, N. S.

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VI.—THE RAINFALL IN 1896. BY F. W. W. DOANE, M. CAN.
SOC. C. E., CITY ENGINEER, *Halifax, N. S.*

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The systematic and accurate registration of the rainfall is a matter of the greatest importance to the Engineer. It is absolutely necessary in order to enable him to design intelligently works for water supply, sewerage, water power, drainage of roads, bridges, culverts, &c.

He requires certain data to enable him to design dams spillways, storage reservoirs, sewers, bridges, &c., so that every possible requirement may be provided for.

The quantity of rain that falls annually in any one place varies greatly from year to year; the extreme being sometimes greater than 2 to 1. As a general rule, more rain falls in warm than in cold countries, and more in elevated regions than in low ones. Local peculiarities and conditions, however, sometimes reverse this, and also cause great difference in the amount in places quite near each other. It is sometimes difficult to account for these variations.

The earliest known records of rainfall were made in Paris in 1668. Sir Christopher Wren designed the first rain gauge in 1663. This great architect also designed the first recording gauge, but it was not constructed until 1670.

The rainfall records of some portions of the United States cover periods extending into the last century. In Canada, the average amount of rain falling in Ontario has been taken by the officials of the Magnetic Observatory at Toronto for the past 56 years. The meteorological station at Halifax was established in 1869, and observations began at Truro in 1873; a systematic registration of rainfall has been made at Yarmouth since 1879, and the record at Sydney dates back to 1893.

An examination of the records of the United States reveals some interesting and important facts, which it may be well to quote at this stage for the purpose of comparison.

The greatest annual rainfall on this continent is recorded at Greytown, the Atlantic entrance to the proposed Nicaragua Canal. It there assumes the enormous total of 240 inches (20 ft.), a figure which is only surpassed in the Western Hemisphere on the Mexican Gulf Coast in the West Indies, by Guiana and by the coast of Brazil. It is reported that from 7 to 10 per cent. of the total annual rainfall may descend in one day. The results of such a precipitation can be better imagined than described; dry river beds become torrents in a few minutes, the water coming down in a wall several feet high; marshes change to lakes, and the power so quickly developed is necessarily very dangerous to any work of man.

The most remarkable rainfall is recorded at Cuyamaca Dam in San Diego Co., California, about 40 miles east of San Diego. During a storm ending February 27, 1891, the record shows that 23.40 inches fell in 54 hours, of which 13 inches fell in 23 hours, and 7 inches in 10 hours. The elevation of the reservoir is about 4500 feet above sea level. The highest surrounding mountains are 6500 feet above sea level, and lie to the west of the reservoir between its watershed and the direction whence the storms come. The eastern boundary of the basin is on the rim of the desert at an elevation of not over 5000 ft. The topography of the country is such that a rain gauge at the dam would not be likely to indicate the maximum precipitation on the three peaks that bound the water shed on the west. The most notable thing about the above remarkable rainfall, however, is that the place where it occurred is within a few miles of one of the very driest regions in the world. The average annual rainfall at Indio, San Diego Co., a station on the Southern Pacific Railway, about 50 miles east of the Cuyamaca Dam, is given by General Greely as but 1.92 inches, and he says of this and Camp Mohave, Arizona, where the average rainfall is but 1.85 inches: "These stations, doubtless, have the smallest known

rainfall on the face of the globe. Statements have been made frequently that rain never falls in these localities, but there is no year at any station where a measurable rainfall has not been recorded, the least observed being that at Indio, 0.10 in., during the seasonal year 1884-85."

General Greely's "American Weather" gives the following instances of heavy rainfalls, which exceed the above record: Mayport, Fla., Sept. 29, 1882, 13.7 ins. in 24 hours; Newtown, Del. Co., Pa., Aug. 5, 1843, 13 in. in 3 hours; and at Brandywine, Hundred, Pa., 10 ins. in 2 hours.

Nevada Co., California, reports the rainfall for the month from Dec. 23, 1861, to Jan. 23, 1862, 45 ins. Providence, R. I., records a rainfall Aug. 6, 1878, 4.49 ins. in 1 hour, 3.5 ins. of which fell in 36 minutes. At New York, the heaviest fall is Aug. 19, 1893, $1\frac{1}{2}$ ins. in 20 minutes; for 12 hours Aug. 23, 1893, 3.81 ins.; 24 hours Sept. 23-4, 1882, 6.17 ins.; month Sept., 1882, 14.51 ins.

The average annual rainfall at Halifax from 1869 to 1895 was 55.862 inches. It varies from 45.808 ins. in 1894 to 66.294 inches in 1888. A rainfall of 39.51 inches is reported for 1860, but as the Meteorological Observatory had not been established at that time, it is doubtful if the record is reliable. There is no doubt, however, that the rainfall for that year was far below the average. The scarcity of water, meagre supply from the lakes, and consequent inconvenience to householders lead to the purchase of the water works from the company in the following year, 1861.

Reference to the records shows that the years of smallest rainfall are immediately followed or preceded by years of greatest rainfall. Thus in 1888 the rainfall reached the maximum 66.294 inches. In the following year it dropped to 48.659, within 2.851 inches of the minimum. In 1894, as already noted, the season was very dry. The rainfall was the smallest recorded since the establishment of the Observatory at Halifax. The sources of our water supply dried up so that there was danger of a water famine. Similar conditions were noted throughout the New

England States. In the following year the records show a total of 62.152 inches, while in 1896 Mr. Allison, Dom. Government Meterological agent at Halifax, reports 69.862 inches, 3.568 ins. greater than that of any previous year. Rain or snow fell on 183 days. The greatest monthly rainfall on record previous to 1896 was 10.34 in February, 1870. In 1888 the heaviest monthly fall was 7.764, which is recorded in December. In 1896, 8.729 ins. fell in July, and 8.786 inches in March, while in September and October, the record shows 12.092 inches and 15.039 inches, respectively. Rain fell on 16 days in September, and on 20 days in October. The fall on the 7th, 10th, 13th and 18th of September, was 1.232 ins., 3.912 ins., 3.146 ins., and 1.510 inches, a total for the four days of 9.8 ins., or more than $\frac{3}{4}$ of the whole precipitation for the month. In October, 4.394 ins. fell on the 19th, 29 per cent. of the rainfall for the month, and 6 per cent. of the total for the year. The first month, January, gave the modest total of 1.72 inches, while for January, 1895, 10.131 inches is recorded.

There were four heavy storms during the year. Early in the morning of July 31st, rain began to fall, and during 3.8 hours the gauge showed 3.506 inches, or at the rate of .92 inches per hour. The rate of fall was the heaviest on record, although the quantity was exceeded in subsequent storms of greater duration.

On Sept. 10th, rain fell during 7.5 hours, the quantity registered being 3.912 ins., or at the rate of .52 ins. per hour, 0.186 inches fell on the 11th during 4.1 hours, 0.13 ins. on the 12th during 2 hours, and on the 13th, 3.146 ins. fell during 9.5 hours, or at the rate of .33 ins. per hour. The total fall for the four days was 7.374 inches. On October 19th the maximum quantity was recorded, the precipitation being 4.394 inches during 14.3 hours, or at the rate of .30 inches per hour.

The September rains referred to above raised Long Lake about 32 inches, the highest level reached being 10.5 inches above the waste weir. In October, the ground was saturated with

water, and the rain falling on the 19th flowed off rapidly. Long Lake was raised 20 inches by the heavy storm of the 19th in about 24 hours. The water level was 25 inches above the spill-way of the dam, while at Lower Chain Lake it overflowed the screen chambers and ran over the floor of the old gate house. Drains and culverts were destroyed, roads washed out and bridges carried away. Jubilee Road was excavated by the rush of water for a length of 100 yards, the road metal being carried away for a width of half the roadway and a depth of 6 ft. Heavy stones were deposited at the foot of the hill, while the lighter material went to sea. The main trunk sewer on the common was not only full to overflowing, but a torrent of water followed its course on the surface, sweeping through the gardens and down South Park Street, until it found an outlet at South Street.

The Meteorological Agent at Truro reports about 30 hours rain on the 18th and 19th October, the greatest on record with regard to duration. At Yarmouth and Sydney the rain fall was light.

September 10th-13th, Sydney reports no rain; Yarmouth and Truro comparatively light rains. July 31st, moderate rainfall at Sydney, Truro and Yarmouth.

Comparing the Halifax records by months we find:—

July, 1896, 8.729 ins.—next—July, 1884, 8.294 ins.

Sept., 1896, 12.092 “ “ Sept. 1876, 6.094 “

Oct., 1896, 15.039 “ “ Oct., 1875, 9.98 “

Mr. E. H. Keating, City Engineer, says in making his report on a design for the Halifax sewer system:—

“The heaviest rainfall in a short time, of which I have any information, occurred on the 19th June, 1872, when 0.183 of an inch fell in half an hour.”

He also reports a rainfall of 4.406 inches in 18 hours on the 10th October, 1875.

Our sewer system was designed to discharge a rainfall of 0.38 ins. per hour, together with the house sewage when running

two-thirds full. The designer made a liberal estimate in determining the capacity required, and yet during the past year it was plainly demonstrated that the capacity of the sewers was not sufficient to carry off the rainfall, and great trouble, damage and inconvenience has been caused in consequence. There is not the slightest doubt that the greater part, if not the whole, of this trouble would have been obviated if records of self-recording rain gauges had been available. While the greatest rainfall on record in 1876 was .183 inches in half an hour, we had in 1896 a storm lasting 7.5 hours, with an average rate of fall of .52 inches per hour, and another lasting 3.8 hours, with an average fall of .92 inches per hour. The maximum rate must have been greatly in excess of even the latter figure, but as the storm came on the dark hours of the morning, and the rain was not measured by self-registering instruments, we can only guess at the maximum rate per hour.

The design of sewers depends principally on two classes of storms. These are short storms of great rates of precipitation, and long storms of ordinary rates of precipitation. It is not sufficient to know the rainfall per hour. The severity of a storm often reaches a maximum during from 10 to 20 minutes only, and this maximum should be determined, if possible. It is also most important that the local conditions of the surface should be known. If the ground is saturated before the storm the rainfall will run off more rapidly.

A chief purpose to be subserved by a rainfall record is not merely how often does the maximum rainfall occur at each point, for that is an event which only occurs once or twice in a century. The great desideratum is: How often do the heaviest rainfalls of various rates occur, and for how long a maximum and average time does such a rainfall continue? The records from which such laws are deduced must necessarily be somewhat voluminous, and yet by proper study, aided by records of a number of years, a very close approximation to the real probabilities could be obtained and drawn graphically on charts, which would be of the greatest aid to hydraulic and city engineers; and even without

this, the bare records would give to a man who might be designing works at special points, material for digging out for himself some approach to a law where now all is guess work, and often very bad guess work.

It is to be regretted that the Meteorological Stations in this Province are not supplied with the most modern self-recording instruments. With an ordinary rain gauge it is not possible to determine the rate per hour of the fall of rain during a storm, without noting the time with a watch; and as it is very inconvenient, if not impracticable in the majority of cases to do this, it is very rarely done, and when it is, an average rate is all that is generally ascertained, although it may have been raining faster or slower at intervals during the time noted. By the use of a reliable self-recording rain gauge the different rates at which rain has fallen during a storm can be readily determined.

DEPTH OF RAINFALL AND MELTED SNOW, AND DURATION OF EACH STORM,
FOR THE YEAR 1896.

Day of Month.	JANUARY.		FEBRUARY.		MARCH.		APRIL.		MAY.		JUNE.	
	Amt.	Hours.	Amt.	Hours.	Amt.	Hours.	Amt.	Hours.	Amt.	Hours.	Amt.	Hours.
1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0.180	1.5
2	.....	.....	0.440	20.	0.089	7.2	.....	.....	.....	.....	0.020	.....
3	0.065	1.75	*T.	.....	0.094	3.5	0.889	5.6	.....	.....	.....	.....
4	.....	.....	.....	.....	0.510	6.7	0.015	1.	.....	.....	.....	.....
5	.....	.....	.....	.....	0.186	4.	0.323	6.5	0.106	2.0	.....	.....
6	.....	.....	T.	.....	.....	.....	0.012	0.5	0.050	2.0	0.020	0.5
7	.....	.....	1.310	14.	0.030	1.6	.....	.....	.....	.....	.....	.....
8	.....	.....	.....	.....	0.596	7.	.....	.....	.....	.....	.....	.....
9	.....	.....	0.010	1.	.....	.....	.....	.....	T	.....	0.770	10.1
10	0.660	10.5	0.342	6.5	.....	.....	.....	.....	T.	.....	0.970	11.3
11	0.030	2.5	0.480	3.	0.030	1.1	.....	.....	.....	.....	0.990	2.3
12	.....	.....	0.100	1.	1.619	15.	.....	.....	0.130	0.5	0.444	8.5
13	0.040	1.5	0.020	1.7	.....	.....	.....	.....	.....	.....	.....	.....
14	0.140	4.66	0.522	7.75	.....	.....	0.009	1.0	.....	.....	T.	.....
15	T.	.....	.....	.....	.....	.....	0.034	2.0	.....	.....	0.841	14.5
16	0.020	10.	0.260	6.5	0.040	2.	T.	.....	.....	.....	0.086	3.
17	.....	.....	.....	.....	1.655	13.5	0.040	2.5	.....	.....	.....	.....
18	.....	.....	0.010	1.	.....	.....	0.015	2.0	0.250	1.0	0.010	0.5
19	.....	.....	0.220	5.2	0.020	0.8	0.020	0.8	0.068	3.0	.....	.....
20	.....	.....	0.410	8.3	1.498	9.4	0.010	1.0	0.210	3.5	0.050	1.5
21	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
22	0.050	7.5	.....	.....	.....	.....	.....	.....	0.305	5.8	0.060	1.7
23	.....	.....	.....	.....	.....	.....	.....	.....	0.186	0.5	.....	.....
24	.....	.....	0.075	2.	.....	.....	.....	.....	.....	.....	.....	.....
25	0.390	10.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
26	0.270	12.5	.....	.....	0.192	1.7	.....	.....	.....	.....	0.230	4.0
27	0.045	1.75	.....	.....	1.450	8.5	.....	.....	0.247	3.0	0.200	3.7
28	0.010	.....	.....	.....	.....	.....	.....	.....	0.014	.....	.....	.....
29	.....	.....	.....	.....	.....	.....	0.046	.....	0.540	2.7	0.700	8.3
30	.....	.....	.....	.....	0.274	8.2	.....	.....	0.426	6.0	.....	.....
31	.....	.....	.....	.....	0.503	7.3	.....	.....	.....	.....	.....	.....
	1.720	.....	4.199	.....	8.786	.....	1.413	.....	2.532	.....	4.671	.....

* Trace.

DEPTH OF RAINFALL AND MELTED SNOW, AND DURATION OF EACH STORM,
FOR THE YEAR 1896.

Day of Month.	JULY.		AUGUST.		SEPTEMBER.		OCTOBER.		NOVEMBER.		DECEMBER.	
	Amt.	Hours.	Amt.	Hours.	Amt.	Hours.	Amt.	Hours.	Amt.	Hours.	Amt.	Hours.
1	.....	.....	.....	.....	.....	.....	2 352	10 4	0.005	0.4	0.020	0.5
2	.....	.....	0.354	5.0	.....	.....	0.764	9.5	0.170	6.6	.....	.....
3	.....	.....	0.378	5.0	.....	.....	0.552	8.7	0.032	1.0	.....	.....
4	T.	.....	.....	.....	0.112	3 8	0 010	1.5	.....	.....	T.	.....
5	0.938	11.0	.....	.....	.....	.....	.....	.....	.....	.....	0 362	5.3
6	.....	.....	.....	.....	.....	.....	0 685	11.2	0 824	10.1	.....	.....
7	0.664	6.0	0.102	8.0	1.232	12.5	0.312	24.	T.	.....	.....	.....
8	0.306	3.0	0.010	1.0	0.030	1.0	0.230	6.5	.....	.....	.....	.....
9	.....	.....	.....	.....	.....	.....	.....	.....	0.853	6.5	1.524	13.3
10	.....	.....	0 010	.....	3.912	7.5	.....	.....	0.036	0 3	0.020	0.8
11	.....	.....	.....	.....	0.186	4.1	.....	.....	0.033	2.0	T.	.....
12	.....	.....	T.	.....	0.130	2.0	.....	.....	0 682	5.5	.....	.....
13	.....	.....	T.	.....	3.146	9.5	0.756	10 0	T.	.....	0.020	1.0
14	0.170	3.3	T.	.....	.....	.....	1.597	12.2	0.207	7.3	.....	.....
15	0.062	1.2	.....	.....	.....	.....	0.125	12 0	T.	.....	.....	.....
16	0.220	5.0	0.250	5.5	.....	.....	0.622	6 1	0 071	3.0	0 450	9 7
17	T.	.....	0.082	3.0	0.302	4.0	.....	.....	.....	.....	0.150	2.5
18	.....	.....	.....	.....	1.510	4.5	0 823	10.4	.....	.....	.....	.....
19	.....	.....	0.034	1.7	0.546	4.5	4 394	14.3	0.020	1.5	0.692	8.0
20	.....	.....	0.060	0.9	0.507	.....	.....	.....	.....	.....	.....	.....
21	0.670	11.0	.....	.....	T.	.....	.....	.....	0.010	0 1	.....	.....
22	.....	.....	.....	.....	0 041	1.5	0.372	5.2	0.732	7.5	.....	.....
23	1.041	12.8	.....	.....	0.405	5 8	.....	.....	.....	.....	.....	.....
24	.....	.....	1.372	8.4	.....	.....	0.562	6.0	0.178	9.4	.....	.....
25	0.568	8.0	.....	.....	.....	.....	1.007	8.0	.....	.....	.....	.....
26	.....	.....	.....	.....	.....	.....	.....	.....	0.130	13 0	0.010	3.2
27	.....	.....	0.333	5.4	.....	.....	0.010	0.4	0.121	6.3	.....	.....
28	0.584	7.0	0.052	3.8	0.033	0.2	.....	.....	.....	.....	.....	.....
29	.....	.....	.....	.....	.....	.....	0.109	3.0	0 202	6 3	.....	.....
30	.....	.....	.....	.....	T.	.....	0.227	18.2	0.090	5 0	.....	.....
31	3.506	3.8	T.	.....	.....	.....	0 130	4.1	.....	.....	T.	.....
	8.729	.....	3.037	.....	12.092	.....	15.039	.....	4.396	.....	3.248	.....

TOTAL PRECIPITATION AT HALIFAX, N. S.
Compiled from Returns furnished by the Meteorological Agent of the Dominion Government.

MONTH.	1869.	1870	1871.	1872.	1873.	1874	1875.	1876.	1877.	1878.	1879.	1880.	1881	1882.
January	4.53	7.11	3.73	3.88	7.83	5.42	3.94	3.576	4.200	7.534	4.400	7.738	3.607	6.840
February	4.38	10.34	5.88	4.49	1.61	5.31	5.83	6.401	1.809	2.697	3.001	5.122	5.329	5.949
March	7.95	3.02	6.16	5.37	4.09	3.98	2.13	6.329	8.666	10.274	6.044	3.365	6.556	7.068
April	2.57	3.91	4.88	2.85	2.86	4.55	3.38	3.208	3.801	3.452	3.481	4.797	3.498	4.824
May	5.57	3.19	2.59	4.44	2.34	4.77	3.98	5.662	4.024	5.769	4.687	4.088	2.460	4.677
June	3.92	1.69	2.96	4.23	2.96	7.92	4.07	3.376	3.841	4.477	1.191	1.343	5.301	5.507
July	2.92	3.21	3.38	2.88	3.90	2.29	5.61	3.914	4.468	1.483	3.843	3.086	3.177	5.071
August	2.58	2.20	3.69	6.82	4.45	3.37	3.55	1.909	3.539	3.127	4.827	3.920	3.062	3.925
September	1.57	3.33	4.81	1.41	4.48	5.04	2.06	6.094	3.164	.800	2.600	5.702	3.105	5.914
October	7.30	6.85	4.49	4.88	8.63	2.46	9.98	4.076	6.857	5.060	4.760	4.590	4.206	7.403
November	5.47	6.28	4.18	6.65	7.98	3.58	5.54	7.397	8.678	6.909	4.837	4.710	4.420	1.392
December	5.77	6.06	4.39	6.16	4.31	5.49	1.61	3.164	4.493	5.120	4.029	4.291	7.034	3.452
Totals	54.53	57.19	51.14	54.06	55.44	54.18	51.48	55.106	57.540	56.702	47.700	52.752	51.755	62.022

TOTAL PRECIPITATION AT HALIFAX, N. S.—(Continued).

MONTH.	1883.	1884.	1885.	1886.	1887.	1888.	1889.	1890.	1891.	1892.	1893.	1894.	1895.	1896.
January	6.930	4.406	6.388	8.67	7.656	5.442	4.391	3.963	8.383	6.321	4.781	7.122	10.131	1.720
February	3.860	6.161	5.090	3.84	6.735	6.284	6.181	4.645	8.740	2.605	5.979	3.571	4.605	4.199
March	4.941	7.034	3.889	4.03	4.629	4.310	2.046	9.889	2.685	5.986	2.303	3.623	5.931	8.786
April	3.703	7.213	3.520	0.82	6.386	3.675	7.403	2.958	4.010	2.653	4.209	5.648	3.956	1.413
May	8.613	3.629	3.282	8.82	2.126	2.877	3.871	3.970	4.195	5.459	5.054	1.769	4.089	2.532
June	3.322	3.773	2.749	2.71	2.121	4.939	3.755	3.440	4.131	3.638	1.753	3.803	1.827	4.671
July	3.542	8.294	5.817	6.53	2.045	5.001	2.668	2.141	4.003	2.710	4.757	1.059	3.924	8.729
August	5.342	2.771	3.001	4.53	8.351	7.000	2.633	7.042	3.385	6.809	5.954	3.993	5.502	3.037
September	3.864	1.788	2.497	4.46	3.308	5.331	1.399	4.534	3.052	1.744	4.391	1.010	2.491	12.092
October	5.841	3.093	6.280	2.13	3.058	6.855	4.179	6.603	9.621	3.492	5.640	3.863	5.627	15.039
November	5.478	5.992	5.423	5.28	6.718	6.772	7.145	3.716	2.388	9.240	3.760	5.785	8.223	4.396
December	6.678	9.124	8.693	5.47	4.120	7.764	2.988	7.202	4.076	3.053	10.167	4.562	5.846	3.248
Totals	58.112	63.278	56.629	57.29	57.253	66.294	48.659	60.103	58.669	53.690	58.748	45.808	62.152	69.862

PRECIPITATION AT TRURO IN 1896.

MONTH.	Rainfall	Melted Snow-	TOTAL.
January	0 07	2.3	2.37 inches.
February	0.12	1.5	1.62 "
March	4 11	1.0	5 11 "
April	0.60	0 5	1.10 "
May	1.45	.....	1.45 "
June	3.44	.....	3.44 "
July	6 19	.....	6.19 "
August	2.24	.....	2 24 "
September	5 01	.....	5.01 "
October	11 47	.....	11.47 "
November	2.58	0 62	3.20 "
December	1.49	0.65	2.14 "
Totals	38.77	6 57	45.34 inches.
July 31	0.44	.....
Sept. 10-11	0 33	.....
" 13	0.35	.....
Oct. 1-3	4 65	.....
" 18-19	4 02	.....
Average rainfall for October, for 23 years.....	4 51	.....
Average precipitation for 17 years.	43.85	.....

PRECIPITATION AT YARMOUTH.

July 19-25, 1896.....	2.02
" 30-31, "	0 58
Aug. 23-24, "	2.45
Sept. 6-7, "	0 91
" 13-14, "	0.48
Oct. 1-2, "	0.12
" 18-19, "	0 04
" 23-24, "	1.97

Heaviest recorded rain, 4.16 inches, August 5th, 1885, in 8 hours.

Greatest precipitation in a month, 10.7 inches, October, 1888.

Total in 1888, 71.57 inches, 22.5 above the average.

PRECIPITATION AT SYDNEY.

July 31, 1896	0 60
Sept. 10, "	0 00
" 13, "	0.00
Oct. 1, "	1.76
" 19, "	0.54

Heaviest rain on record, 2.04 inches, August 17th, 1893.

