DEPARTMENT OF THE INTERIOR,

CENSUS OFFICE.

FRANCIS A. WALKER, Superintendent,
Appointed April 1, 1870; resigned November 3, 1881.

CHAS. W. SEATON, Superintendent,
Appointed November 4, 1881. Office of Superintendent abolished March 3, 1885.

STATISTICS OF POWER AND MACHINERY EMPLOYED IN MANUFACTURES.

PROF. W. P. TROWBRIDGE,

CHIEF SPECIAL AGENT.

REPORTS

ON THE

WATER-POWER OF THE UNITED STATES.

PART I.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1885.

LETTER OF TRANSMITTAL.

DEPARTMENT OF THE INTERIOR,
OFFICE OF THE SECRETARY,
Washington, D. C., December 29, 1885.

Hon. L. Q. C. LAMAR,
Secretary of the Interior.

SIR: I have the honor to transmit herewith the sixteenth and seventeenth volumes of the quarto series comprising the final report on the Tenth Census, namely, that devoted to the water-power of the United States, prepared under the direction of Professor W. P. Trowbridge, of the School of Mines, Columbia College, New York, N. Y., chief special agent.

The report comprises the following-named monographs:

PART I.

Streams of eastern New England	Swain.
Region tributary to Long Island sound	Porter.
Hudson River basin and Lake George outlet	Porter.
Region tributary to lake Ontario and the New York state canals	Porter.
Drainage basins of lakes Huron and Erie, and water-power of Niagara falls and river	Greenleaf.
Middle Atlantic water-shed	Swain.
Southern Atlantic water-shed	Swain.
Eastern Gulf slope	Porter.

PART II.

The Northwest	Greenleaf.
Mississippi river and some of its tributaries	Greenleaf.
Mississippi river on the west, below Dubuque	Porter.
Ohio River basin and Ohio state canals	Porter.
Water-supply of certain cities and towns	Elliot.

The general review and summary which is so strongly commended and approved by Professor Trowbridge was prepared by George F. Swain, Assistant Professor of Civil Engineering in the Massachusetts Institute of Technology, at Boston, Massachusetts.

Very respectfully, your obedient servant,

JAMES H. WARDLE,
Chief of Census Division.

INTRODUCTION

TO THE

REPORTS ON THE WATER-POWER OF THE UNITED STATES.

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GENERAL LETTER OF TRANSMITTAL.

SCHOOL OF MINES, COLUMBIA COLLEGE,
New York, N. Y., October 12, 1882.

Hon. CHAS. W. SEATON,
Superintendent of Census, Washington, D. C.

SIR: I have the honor to transmit herewith the reports of Messrs. George F. Swain, James L. Greenleaf, and Dwight Porter on the water-power of the United States.

As special agent of the Tenth Census in charge of the collection of statistics of power and machinery, I arranged, at the request of General Francis A. Walker, and under his general direction, the plan of investigations of which the results are embodied in these reports. I have already transmitted the reports of the other special agents selected by me for the collection of statistical information on the other branches of the work under my charge, and the results which I now forward complete the series of investigations intended to cover, so far as practicable, the subject of power and machinery.

The general scheme of inquiries in relation to water-power was arranged in consultation with General Walker before the special agents who were to take the field had been selected. It embraced the examination of the different great water-sheds of the country as they are naturally defined by mountain systems and intermediate slopes and valleys. The investigations were to be conducted by personal explorations and reconnaissances in the field, with the aid of all available maps and other sources of information that could be procured. It was foreseen at once that great care must be taken not to make the examinations so general that the results would have no specific value, nor so much in detail as to preclude the possibility, with the limited force at my disposal, of embracing the entire country east of the Rocky mountains.

For the work thus planned I selected, with General Walker's approval, Mr. George F. Swain, civil engineer, a graduate of the Massachusetts Institute of Technology; Mr. James L. Greenleaf, civil engineer, a graduate of the School of Mines, Columbia College, New York, N. Y.; and Mr. Dwight Porter, a graduate of the Sheffield Scientific School of Yale College, New Haven, Connecticut. These gentlemen remained in the field continually until their investigations were concluded, receiving advice and directions by mail as their work progressed.

I need only refer you to their reports for evidence of the large amount of work which they accomplished.

But these reports do not, and can not, exhibit any evidence of the fatigue and exposures undergone by these gentlemen in their efforts to accomplish within the time allotted the work which was assigned to them.

As contributions to the hydrology of the country, the reports will, I am sure, be found to be of a character not heretofore attempted, and to contain general and specific information of the highest public value and interest.

The whole cost of the work consisted of the very moderate salaries of the three special agents named above, and their necessary traveling expenses.

I have the honor to be, very respectfully, your obedient servant,

W. P. TROWBRIDGE,
Chief Special Agent, Tenth Census.

GENERAL INTRODUCTION.

By PROF. GEORGE F. SWAIN.

According to the returns of the Tenth Census, there were in use for manufacturing in the United States, in 1880, 55,404 water-wheels, using a total power of 1,225,379 horse-power, this being 35.93 per cent. of the total power used in the country for manufacturing purposes.

Although statistics of other countries are not at hand, it is probably safe to say that in no other country in the world is an equal amount of water-power utilized, and that, not only in regard to the aggregate power employed, but in regard also to the number and importance of its large improved powers, this country stands pre-eminent. And yet a very hasty glance will suffice to convince us that even this enormous total is but a very small fraction of the total theoretical power generated by our streams and rivers in their passage from their sources to the sea. A rough approximation to this total theoretical power may be made by dividing the country into sections having a general uniformity in the climatic, topographic, and other conditions affecting water-power, and assuming in each an average elevation above the sea, from which a certain proportion of the rainfall descends to the sea-level. A calculation of this kind, based upon the best data obtainable, furnishes the astonishing result that the total theoretical power of our streams, taken as the average through the year, reaches the enormous figure of over two hundred million horse-power. Such is the energy developed by our rivers, streams, and brooks, of which we are using but little over one-half of one per cent. Could it all be utilized, the power afforded would probably be more than sufficient to turn all the machinery of the globe.

But although the above estimate has some theoretical interest, it is evidently of no value as an indication of the amount of power technically available. The latter will be but a small fraction of the former, for it will be necessary to discard at once the power generated in the lower or navigable portions of our rivers, and in many other parts of their courses where their slope is small, as well as a large amount near their head-waters, where, on account of variable flow, excessive slope, or topographical configuration, the development of power is impracticable. Some idea of how large a proportion of the total power is thus unavailable may perhaps be gathered from the fact that the theoretical power generated by the Mississippi river alone, from Cairo to the gulf of Mexico (within which distance no development of power is possible), is not less than thirteen million horse-power, or over 6 per cent. of the total theoretical horse-power of the country; and it will be evident that, when we have deducted all the power which by reason of the conditions above enumerated may be called unavailable, the practically available power of the country will be but an exceedingly small fraction of the total power estimated above.

The main object of this report is to give an idea of the available power of the country, describing privileges actually in use, and calling attention to locations where power could be advantageously developed. It must be remembered, however, that it is not technical availability alone which determines the value of a privilege, but that many sites where considerable power could easily be developed are commercially valueless, perhaps on account of inaccessibility, remoteness from the markets, or for other reasons; and it has been an important part of the object of this report to call attention to conditions affecting the commercial value and availability of the locations described. We shall soon have occasion to discuss briefly from statistics some of the facts bearing upon this matter. Before doing so, however, it will be well to glance at the distribution of utilized power over the country, and the changes which have taken place during the decade; and to reproduce some of the tables from the report on steam- and water-power used in manufactures, by Mr. H. Hollerith, printed in Vol. II of this series of census reports.

THE DISTRIBUTION OF UTILIZED POWER IN THE UNITED STATES.

The following table shows the total water- and steam-power in use in 1870 and 1880, with other facts of interest:

	WATER-POWER.			STEAM-POWER.			Total steam- and water-power (horse-power).
	Number of water-wheels.	Horse-power.	Average horse-power per wheel.	Number of steam-engines.	Horse-power.	Average horse-power per steam-engine.	
1880	55,404	1,225,379	22.12	56,483	2,185,458	38.69	3,410,837
1870	51,018	1,130,431	22.16	40,191	1,215,711	30.25	2,346,142
Percentage of increase	8.60	8.40	....	40.54	79.77	....	45.38

From this we see that the total amount of power used in manufactures, both steam and water, has increased 1,064,695 horse-power during the decade. Of this total increase, 94,948 horse-power, or 8.92 per cent., is due to the increase in the amount of water-power used, while 969,747 horse-power, or 91.08 per cent., is due to the increase in the amount of steam-power used. The average power of the water-wheels has slightly diminished, probably on account of the introduction of various forms of small hydraulic motors for light work.

The following table gives the total amounts of water- and steam-power in each state and territory in 1870 and 1880, with the percentage of increase, and the proportional amounts of water- and steam-power. This, however, must be regarded as an approximate comparison only:

State or territory.	WATER-POWER.			STEAM-POWER.			1870.		1880.	
	Total in 1870.	Total in 1880.	Increase.	Total in 1870.	Total in 1880.	Increase.	Water-power.	Steam-power.	Water-power.	Steam-power.
	Horse-power.	*Horse-power.*	*Per cent.*	*Horse-power.*	*Horse-power.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Total in the United States.	1,130,431	1,225,379	8.40	1,215,711	2,185,458	70.77	48.18	51.82	35.93	64.07
Alabama	11,011	11,797	7.14	7,740	15,779	103.85	58.72	41.28	42.78	57.22
Arizona	10	160	1,500.00	80 (35)	370	957.14	11.11	88.80	30.19	69.81
Arkansas	1,545	2,024	31.00	6,101	13,709	124.70	20.21	79.79	12.86	87.14
California	6,877 (5,381)	4,850	(*a*)	18,493 (17,072)	28,071	64.43	27.11	72.89	14.73	85.27
Colorado	792 (742)	1,849	149.19	1,433 (761)	3,953	419.45	35.60	64.40	31.87	68.13
Connecticut	54,395	61,205	12.52	25,979	57,027	119.51	67.68	32.32	51.77	48.23
Dakota	76	803	956.58	248	1,421	472.98	23.46	76.54	36.11	63.89
Delaware	4,220	4,785	13.39	4,313	10,643	146.77	49.46	50.54	31.02	68.98
District of Columbia	1,100	880	(*a*)	789	2,263	186.82	58.23	41.77	28.00	72.00
Florida	528	939	77.84	3,172	6,208	95.71	14.27	85.73	13.14	86.86
Georgia	27,417 (27,356)	30,007	9.91	10,826 (10,811)	21,102	95.19	71.69	28.31	58.76	41.24
Idaho	295 (92)	1,136	1,134.78	311 (191)	546	185.86	48.68	51.32	67.54	32.46
Illinois	12,953	17,445	34.68	73,091	126,843	73.54	15.05	84.95	12.09	87.91
Indiana	23,518	21,810	(*a*)	76,851	109,960	43.08	23.43	76.57	16.55	83.45
Iowa	14,249	20,363	42.91	25,298	33,858	33.84	36.03	63.97	37.56	62.44
Kansas	1,789	7,611	325.43	6,360	13,468	111.76	21.95	78.05	36.11	63.89
Kentucky	7,640	9,012	17.96	31,928	45,917	43.81	19.31	80.69	16.41	83.59
Louisiana	142	90	(*a*)	24,924 (6,628)	11,256	69.82	0.57	99.43	0.79	99.21
Maine	70,108	79,717	13.76	9,465	20,759	119.32	88.11	11.89	79.34	20.66
Maryland	18,461	18,043	(*a*)	13,961	33,216	137.92	56.94	43.06	35.20	64.80
Massachusetts	105,854	138,362	30.71	78,502 (78,450)	171,397	118.48	57.42	42.58	44.67	55.33
Michigan	34,895	34,395	(*a*)	70,956	130,352	83.71	32.97	67.03	20.88	79.12
Minnesota	13,054	28,689	119.77	7,085	25,191	255.55	64.82	35.18	53.25	46.75
Mississippi	2,453	3,449	40.60	10,019	15,001	49.73	19.67	80.33	18.69	81.31
Missouri	6,644	8,162	22.85	48,418	72,587	49.92	12.07	87.93	10.11	89.89
Montana	795 (611)	954	56.14	822 (226)	544	140.71	49.17	50.83	63.68	36.32
Nebraska	1,446	5,495	280.01	1,865	2,999	60.80	43.67	56.33	64.69	35.31
Nevada	2,538 (370)	108	(*a*)	6,007 (636)	608	(*a*)	29.70	70.30	15.08	84.92
New Hampshire	68,291	69,155	1.27	8,787	18,595	111.62	88.60	11.40	78.81	21.10
New Jersey	25,832	27,066	4.78	32,307	72,792	125.31	44.43	55.57	27.10	72.90

a Decrease.

State or territory.	Water-power. Total in 1870.	Water-power. Total in 1880.	Water-power. Increase.	Steam-power. Total in 1870.	Steam-power. Total in 1880.	Steam-power. Increase.	1870. Water-power.	1870. Steam-power.	1880. Water-power.	1880. Steam-power.
	Horse-power.	*Horse-power.*	*Per cent.*	*Horse-power.*	*Horse-power.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
New Mexico	659 (623)	932	49.60	252 (103)	427	314.56	72.34	27.66	68.58	31.42
New York	208,256 (208,106)	219,348	5.40	126,107	234,705	86.19	62.28	37.72	48.30	51.70
North Carolina	26,211 (26,200)	30,063	14.74	6,941 (6,816)	15,025	120.44	79.06	20.94	66.68	33.32
Ohio	44,746	38,641	(*a*)	129,577	222,502	71.71	25.67	74.33	14.80	85.20
Oregon	5,806 (5,760)	9,255	60.51	2,471 (2,451)	4,334	76.83	70.15	29.85	68.11	31.89
Pennsylvania	141,982	110,276	(*a*)	221,930	402,132	81.10	30.01	69.99	21.52	78.48
Rhode Island	18,481	22,240	20.34	23,546	41,385	75.55	43.97	56.03	34.98	65.02
South Carolina	10,395 (10,386)	13,873	33.58	4,537 (4,487)	11,995	16.73	69.62	30.38	53.63	46.37
Tennessee	19,514	18,504	(*a*)	18,467	33,388	80.80	51.38	48.62	35.73	64.27
Texas	1,830	2,508	37.05	11,214	28,026	149.92	14.03	85.97	8.21	91.79
Utah	2,169	3,535	62.98	331 (319)	1,164	261.76	86.76	13.24	75.39	24.61
Vermont	44,897	52,226	16.32	6,426	11,088	72.58	87.48	12.52	82.49	17.51
Virginia	41,202	37,464	(*a*)	8,410	19,710	134.36	83.05	16.95	65.53	34.47
Washington	1,412	1,185	(*a*)	1,411	3,210	127.49	50.02	49.98	26.96	73.04
West Virginia	10,195	9,454	(*a*)	17,136	28,456	66.06	37.30	62.70	24.94	75.06
Wisconsin	33,714	45,356	34.53	30,509	60,729	99.05	52.50	47.50	42.75	57.25
Wyoming	34 (0)	38	....	310 (245)	717	192.65	9.88	90.12	5.03	94.97

a Decrease.

NOTE.—In cases where two figures are given for the steam- or water-power of a state in 1870, those not inclosed in parentheses are the ones returned. Those in parentheses are the figures used in computing the percentages of increase, and have been derived from the former by subtracting power used for purposes which in 1880 were not classified under manufactures. The table thus refers to power used in manufactures as classified in 1880.

In taking the results for these tables from the census returns, it is to be observed that the classification adopted in 1880 is not exactly the same as that of 1870. Thus, from the tables it would appear that there was a falling off in the amount of steam-power used in manufactures in the state of Louisiana from 24,924 horse-power in 1870 to 11,256 horse-power in 1880. This is due to the fact that in the Census of 1870 the sugar made on the plantations direct from the raw cane was included as a product of manufacture, while in 1880 it is included with the products of agriculture. Thus, in order to make a comparison, we must deduct 18,296 horse-power (steam-power) used on the plantations from the total 24,924 horse-power, and we should then have for the industries included in the Census of 1880 an increase from 6,628 horse-power in 1870 to 11,256 horse-power in 1880. In a similar way, some of the items which in 1870 were included under the head of manufactures, such as "quartz, milled", were in 1880 classed among the statistics of mining, and their amounts had to be subtracted from the figures given for 1870. The corrected amounts, taking account of the principal items of this kind, have been included in parentheses in the foregoing table, and in all cases they have been used in computing the percentages of increase. As this report deals with water-power without reference to the use made of it, whether for purposes of manufacture, agriculture, or mining, it would have been better if, instead of subtracting from the amounts given for 1870, we had added to those of 1880, or to both, making both represent the total amount of power used for all purposes; but the necessary statistics were not at hand at the time of writing this introduction, and probably the percentages would in all but a few cases remain approximately the same. The figures given have reference, therefore, to the power used in manufactures only, as classified at the Census of 1880.

This table shows that the steam-power has increased within the decade very much more rapidly than the water-power, the proportion of water-power in the entire country having fallen from 48.18 per cent. in 1870 to 35.93 per cent. in 1880; while it has decreased in every state and territory with the exception of Arizona, Dakota, Idaho, Iowa, Kansas, Louisiana, Montana, and Nebraska. There has also been a decrease, *according to the tables, in the* actual amount of water-power used in California, the District of Columbia, Indiana, Louisiana, Maryland, Michigan, Nevada, Ohio, Pennsylvania, Tennessee, Virginia, Washington, and West Virginia; but as these figures represent the power used in manufactures only, the total power in use may nevertheless have increased in these states. In every case there has been an increase in the actual amount of steam-power used.

The following table shows the percentage of the total amount of steam- and water-power, of the total amount of water-power, and of the total amount of steam-power for each state and territory; also the rank of each state and territory in regard to amount of power used:

State or territory.	Rank in total power.	Percentage of the total steam- and water-power.	Rank in water-power.	Percentage of the total water-power.	Rank in steam-power.	Percentage of the total steam-power.
Alabama	27	0.81	23	0.96	25	0.72
Arizona	47	0.02	44	0.01	47	0.02
Arkansas	31	0.46	35	0.17	28	0.63
California	26	0.97	30	0.40	18	1.28
Colorado	37	0.17	36	0.15	36	0.18
Connecticut	8	3.47	6	4.99	11	2.61
Dakota	41	0.07	43	0.07	40	0.07
Delaware	32	0.45	31	0.39	33	0.49
District of Columbia	40	0.09	42	0.07	39	0.10
Florida	36	0.21	40	0.08	34	0.28
Georgia	22	1.50	12	2.45	21	0.97
Idaho	46	0.05	38	0.09	44	0.02
Illinois	6	4.23	21	1.42	6	5.80
Indiana	7	3.86	17	1.78	7	5.03
Iowa	18	1.50	18	1.66	14	1.55
Kansas	29	0.62	28	0.62	29	0.62
Kentucky	17	1.61	26	0.74	12	2.10
Louisiana	34	0.33	46	0.01	31	0.52
Maine	10	2.95	4	6.51	22	0.95
Maryland	21	1.50	20	1.47	16	1.52
Massachusetts	3	9.08	2	11.29	4	7.84
Michigan	5	4.83	11	2.81	5	5.96
Minnesota	19	1.58	14	2.34	20	1.15
Mississippi	30	0.54	33	0.28	27	0.69
Missouri	13	2.37	27	0.67	9	3.32
Montana	43	0.04	39	0.08	45	0.02
Nebraska	35	0.25	29	0.45	38	0.14
Nevada	46	0.02	45	0.01	43	0.03
New Hampshire	12	2.57	5	5.64	24	0.85
New Jersey	11	2.93	15	2.21	8	3.33
New Mexico	44	0.04	41	0.08	46	0.02
New York	2	13.31	1	17.90	2	10.74
North Carolina	23	1.32	13	2.45	26	0.69
Ohio	4	7.66	9	3.15	3	10.18
Oregon	33	0.40	25	0.70	35	0.20
Pennsylvania	1	15.02	3	9.00	1	18.40
Rhode Island	14	1.86	16	1.81	13	1.80
South Carolina	28	0.76	22	1.13	30	0.55
Tennessee	20	1.52	19	1.51	15	1.53
Texas	26	0.90	34	0.20	19	1.28
Utah	38	0.14	32	0.29	41	0.05
Vermont	15	1.86	7	4.26	32	0.51
Virginia	16	1.68	10	3.06	23	0.90
Washington	39	0.13	37	0.10	37	0.15
West Virginia	24	1.11	24	0.77	17	1.30
Wisconsin	9	3.11	8	3.70	10	2.78
Wyoming	45	0.02	47	(a)	42	0.03

a Less than 0.004 of 1 per cent.

From this table we see that Pennsylvania stands first in the total amount of power used in manufactures, with 15.02 per cent. of the total for the United States. New York is second, with 13.31 per cent.; Massachusetts third, with 9.08 per cent.; and Ohio fourth, with 7.66 per cent. of the total. In the amount of water-power used, New York is first, with 17.90 per cent.; Massachusetts second, with 11.29 per cent.; Pennsylvania third, with 9 per cent.; and Maine fourth, with 6.51 per cent. of the total. For steam-power we again have Pennsylvania first, with 18.40 per cent.; New York second, with 10.74 per cent.; Ohio third, with 10.18 per cent.; and Massachusetts fourth, with 7.84 per cent. of the total.

It is interesting to compare the amount of power used in each state and territory with the area of that state or territory. For this purpose the following table has been computed. In it the area of each state and territory is given, and the total amount of water- and steam-power, of water-power, and of steam-power, per square mile, with corresponding rank of each state and territory:

State or territory.	Area.	Total water- and steam-power per square mile.	Water-power per square mile.	Steam-power per square mile.	Rank in total power per square mile.	Rank in water-power per square mile.	Rank in steam-power per square mile.
	Square miles.	*Horse-power.*	*Horse-power.*	*Horse-power.*			
Alabama	51,540	0.54	0.23	0.31	28	26	28
Arizona	112,920	0.01	(a)	(a)	43	44	45
Arkansas	53,045	0.30	0.04	0.26	30	33	30
California	155,980	0.21	0.03	0.18	33	35	32
Colorado	103,645	0.06	0.02	0.04	39	36	38
Connecticut	4,845	24.40	12.63	11.77	4	4	4
Dakota	147,700	0.02	0.01	0.01	41	39	40
Delaware	1,960	7.87	2.44	5.43	9	11	8
District of Columbia	60	52.38	14.67	37.72	2	3	2
Florida	54,240	0.13	0.02	0.11	35	37	34
Georgia	58,980	0.87	0.51	0.36	25	19	25
Idaho	84,290	0.02	0.01	0.01	42	40	41
Illinois	56,000	2.58	0.31	2.27	16	25	12
Indiana	35,910	3.67	0.61	3.06	13	17	11
Iowa	55,475	0.98	0.37	0.61	23	23	22

a Less than 0.005 horse-power per square mile.

State or territory.	Area.	Total water- and steam-power per square mile.	Water-power per square mile.	Steam-power per square mile.	Rank in total power per square mile.	Rank in water-power per square mile.	Rank in steam-power per square mile.
	Square miles.	*Horse-power.*	*Horse-power.*	*Horse-power.*			
Kansas	81,700	0.26	0.09	0.16	31	30	33
Kentucky	40,000	1.37	0.23	1.15	20	27	16
Louisiana	45,420	0.25	(a)	0.25	32	45	31
Maine	29,895	3.36	2.07	0.69	14	9	21
Maryland	9,860	5.20	1.83	3.37	12	12	10
Massachusetts	8,040	38.53	17.21	21.32	3	2	3
Michigan	57,430	2.87	0.60	2.27	15	18	13
Minnesota	79,205	0.68	0.36	0.32	27	24	26
Mississippi	46,340	0.40	0.07	0.32	29	31	27
Missouri	68,735	1.17	0.12	1.06	22	28	19
Montana	145,310	0.01	0.01	(a)	44	41	46
Nebraska	76,185	0.11	0.07	0.04	37	32	39
Nevada	109,740	0.01	(a)	0.01	45	46	42
New Hampshire	9,005	9.74	7.68	2.06	7	5	14
New Jersey	7,455	13.39	8.63	0.76	5	8	5
New Mexico	122,460	0.01	0.01	(a)	46	42	47
New York	47,620	9.54	4.61	4.93	8	7	9
North Carolina	48,580	0.93	0.62	0.31	24	16	29
Ohio	40,760	6.41	0.95	5.46	11	13	7
Oregon	94,560	0.14	0.10	0.05	34	29	36
Pennsylvania	44,985	11.39	2.45	8.94	6	10	6
Rhode Island	1,085	58.60	20.50	38.10	1	1	1
South Carolina	30,170	0.86	0.46	0.40	26	20	24
Tennessee	41,750	1.24	0.44	0.80	21	21	20
Texas	*262,290*	*0.12*	*0.01*	*0.11*	*30*	*43*	*35*
Utah	82,190	0.06	0.04	0.01	40	34	43
Vermont	9,135	6.93	5.72	1.21	10	6	15
Virginia	40,125	1.42	0.93	0.49	19	14	23
Washington	66,880	0.07	0.02	0.05	38	38	37
West Virginia	24,645	1.54	0.38	1.15	18	22	17
Wisconsin	54,450	1.95	0.83	1.12	17	15	18
Wyoming	97,575	0.01	(a)	0.01	47	47	44

a Less than 0.005 horse-power per square mile.

From this table it appears that New York, which stands first in the total amount of water-power used, stands eighth in rank as regards water-power per square mile, showing but 4.61 horse-power per square mile, while Rhode Island, which stands sixteenth in total water-power, stands first in water-power per square mile, showing 20.50 horse-power per square mile. The close agreement of the figures for the same state in the last three columns is rather remarkable.

The territory of the United States may be divided into five sections, viz: The northern Atlantic states, including all those along the Atlantic coast from Maine to Pennsylvania and New Jersey; the southern Atlantic states, including all those along the coast from Delaware, Maryland, and West Virginia, to Georgia and Florida; the northern central, or middle states, including the remaining states north of Kentucky, Arkansas, Indian territory, and Texas, and east of Montana, Wyoming, Colorado, and New Mexico; the southern central, or middle states, including the states south of the northern boundary of Kentucky, Arkansas, Indian territory, and Texas; and the western states, including all those west of the eastern boundary of Montana, Wyoming, Colorado, and New Mexico.(*a*)

The distribution of power in these sections is shown in the following table:

Divisions.	Total steam- and water-power.	Water-power.	Steam-power.
	Horse-power.	*Horse-power.*	*Horse-power.*
United States	3,410,837	1,225,379	2,185,458
Northern Atlantic	1,809,515	779,595	1,029,920
Southern Atlantic	294,186	145,568	148,618
Northern Central	1,028,680	228,770	799,910
Southern Central	210,520	47,444	163,076
Western	67,936	24,002	43,934

a This is the division followed in the report of Mr. Hollerith, from which the following tables are taken.

In the following table are given the percentage of the total water- and steam-power, of the total water-power, and of the total steam-power used in each of these five divisions:

Divisions.	Percentage of the total water- and steam-power.	Percentage of the total water-power.	Percentage of the total steam-power.
Northern Atlantic	53.05	63.62	47.18
Southern Atlantic	8.63	11.88	6.80
Northern Central	30.16	18.67	36.60
Southern Central	6.17	3.87	7.46
Western	1.99	1.96	2.01

From this we see that 63.62 per cent. of all the utilized water-power of the country, or nearly two-thirds, is in the northern Atlantic states, while the northern Atlantic and northern central states together include about four-fifths of this total. New England alone reports 34.51 per cent. of the total water-power, while all the Atlantic states together include 75.50 per cent., or nearly three-fourths.

The relative amounts of water- and steam-power in these sections of the country are shown in the following table:

Divisions.	Water-power.	Steam-power.
	Per cent.	*Per cent.*
United States	35.93	64.07
Northern Atlantic	43.08	56.92
Southern Atlantic	49.48	50.52
Northern Central	22.24	77.76
Southern Central	22.54	77.46
Western	35.33	64.67

In the following table is given the power per square mile in each of these divisions:

Divisions.	Area in square miles.	Average water- and steam-power per square mile.	Average water-power per square mile.	Average steam-power per square mile.
		Horse-power.	*Horse-power.*	*Horse-power.*
United States	*a* 2,900,170	1.18	0.42	0.75
Northern Atlantic	162,065	11.16	4.81	6.35
Southern Atlantic	268,620	1.09	0.54	0.55
Northern Central	753,550	1.36	0.30	1.06
Southern Central	*a* 540,385	0.39	0.09	0.30
Western	1,175,550	0.06	0.02	0.04

a Exclusive of Indian and unorganized territory.

It is interesting to study the distribution of water-power among the more important industries, and the proportion of water- and steam-power used in each. The following table shows for some selected industries the total amount of water-power, the percentage which this total forms of the total water-power of the country; also the percentage of water- and steam-power in the total power used in each industry:

Industries.	1870.				1880.				Average total power (steam and water) used per establishment.	Total number of establishments.
	Total water-power.	Per cent. of total water-power of the United States.	Per cent. of total power in industry.		Total water-power.	Per cent. of total water-power of the United States.	Per cent. of total power in industry.			
			Water-power.	Steam-power.			Water-power.	Steam-power.		
	H. P.				*H. P.*					
Agricultural implements	10,200	0.90	39.14	60.86	12,645	1.03	28.27	71.73	34.92	1,281
Boots and shoes (factory)	167	0.01	5.44	94.56	410	0.03	3.54	96.46	15.62	741
Cotton goods (*a*)	99,073	8.76	67.84	32.16	148,754	12.14	53.99	46.01	288.18	956
Flouring- and grist-mill products	407,950	36.09	70.74	29.26	469,987	38.35	60.94	39.06	31.79	24,258
Foundery and machine-shop products	....	....	....	....	15,364	1.25	15.34	84.66	23.79	4,209
Iron and steel	14,631	1.29	9.72	90.28	16,506	1.35	4.16	95.84	508.64	781
Lumber, sawed	326,728	28.90	50.93	49.07	278,686	22.74	33.91	66.09	32.01	25,680
Paper	41,644	3.68	78.25	21.75	87,611	7.15	70.70	29.30	179.06	692
Sashes, doors, and blinds	7,758	0.69	....	....	6,505	0.53	17.16	82.84	33.48	1,132
Silk and silk goods	789	0.07	41.29	58.71	1,562	0.13	17.73	82.27	44.72	197
Woolen goods	52,906	4.68	62.17	37.83	53,610	4.38	50.33	49.67	53.08	1,984
Worsted goods	4,634	0.41	57.81	42.19	6,302	0.51	38.34	61.66	216.28	76

a Including both specific and special cotton-mills.

The maps and diagrams accompanying the report on the *Statistics of Power used in Manufactures*, by Mr. Herman Hollerith, E. M., Special Agent of the Tenth Census, inserted in the volume on manufactures, illustrate the facts shown by these statistics.

The four maps illustrate the distribution of power used in manufactures, No. 1 being for the total power, No. 2 for water-power, and No. 3 for steam-power. "In the compilation of these maps, the county was taken as the unit, the average amount of power per square mile was computed for each county, and that county ranked from I to VI, as shown in the legend of the maps." West of the 90th meridian the amount of power used is so small that that region was not included in the maps. The fourth map shows the relative importance of water- and steam-power in various sections of the country. The following description of the plates is reprinted from the volume on the *Manufactures of the United States at the Tenth Census:*

Plate I is a graphical comparison of the statistics of power used in manufactures as returned at the Tenth Census, with similar statistics as returned at the Ninth Census. The plate shows the relation of steam- and water-power, and the distribution of the total amount of power among certain leading industries in 1870 and in 1880.

Plate II shows the distribution of power by states and territories, and the relative importance of steam- and water-power in each, as returned at the Census of 1880.

Plate III is a comparison of the statistics of power used in certain leading industries as returned at the Census of 1870 and that of 1880.

These statistics illustrate very clearly some points regarding the commercial availability and value of water-power which it may be well briefly to consider here.

In comparing water-power with steam-power, the most striking point of difference, and one which at the same time constitutes a great advantage in favor of the latter, is the fact that steam-power is mobile and may be used wherever fuel can be obtained, independently of any particular location. Mills using steam-power may therefore be located in positions most favorable for economical production and for quick disposal of the finished product. Convenient facilities for transportation constitute, therefore, a most important factor affecting the value of a water-power, and many powers which are technically all that could be desired are rendered almost valueless by the lack of this essential element, unless, as in some cases, the raw material is produced and the finished product disposed of in the immediate vicinity. A perusal of the pages of this report will show that generally water-power is much cheaper than steam-power, but the former can not be moved, the factory must be brought to the power, and unless the means of approach are easy it will nevertheless be located elsewhere and run by steam. It is not possible to illustrate this point by figures, because the conditions are so complicated, and because steam-power, as well as water-power, is largely dependent upon means of transportation.

Again, where fuel is cheap the value of water-power is correspondingly lessened; and consequently throughout the coal regions of this country there is not only an excess of steam- over water-power, but the amount of the latter per square mile is much smaller than would otherwise be the case.

Further, there are some industries for which water-power is better adapted than steam-power, either on account of the greater cleanliness connected with its use, or because the manufacture requires the use of large quantities of water, so that such mills, even were they to use steam-power, would perhaps seek a location on the banks of some stream. Thus the table on page xvi shows that, of the industries specified, the largest proportion of water-power is found in the case of paper-mills, 70.70 per cent. of their total power being water-power. These mills require large quantities of clear water for purposes of the manufacture, and the large proportion thus finds a simple explanation. Again, of the total power used in flour- and grist-mills, 60.94 per cent. is water-power, being a larger proportion than in any industry except the one just referred to. This finds its explanation in the fact that very many of these mills are small and for local use only, so that with them the question of transportation loses its importance, and water-power, on account of its cheapness, is preferred. In the case of cotton-, worsted-, and woolen-mills, which use considerable quantities of water for washing, the proportion of water-power is still above the average for the entire country. On the other hand, the proportion of water-power used in the manufacture of boots and shoes, and of iron and steel, is insignificant. In the former case this is explained by conditions of location, by the very small average amount of power per establishment, and by the smaller use of water for purposes of manufacture. In the case of iron and steel, the manufacture is not dependent upon water to any great extent; and although the average amount of power per establishment is large, it is especially questions of location and easy transportation which render the proportion of water-power so small.

It is interesting to compare the proportion of water-power in the case of iron and steel with that in the case of foundery and machine-shop products. The larger proportion in the latter case finds its explanation in the local character of many of the establishments, and their dependence to a smaller extent upon location and convenient means of transportation.

The table shows that the industry consuming the largest amount of power is the manufacture of flouring- and grist-mill products, with 38.35 per cent. of the total power of the country. Next comes lumber, sawed, with 22.74 per cent., and then cotton goods and paper, with 12.14 and 7.15 per cent., respectively.

In the special reports comprised within these volumes the conditions affecting water-power in different sections of the country have been clearly set forth, and comparisons have been drawn between the streams of different

regions as regards their general character and their adaptability for utilization. A brief glance may here be cast, however, over the water-power of the country as a whole, and some comparisons made which will perhaps render more clearly apparent the differences between its different parts.

As regards water-power, the principal points to be kept in view in considering a region are its topography and geology, and the volume of its streams. Confining our attention for the present to the Atlantic and eastern Gulf slopes of the United States, we have to consider the region stretching from the Atlantic and the Gulf westward or northward to the dividing-line or water-shed, lying somewhere within the great Appalachian Mountain system, and separating the waters flowing directly to the ocean or the Gulf from those flowing west or north to the Mississippi or Saint Lawrence basins. The mountain system in which this water-shed lies reaches in Maine a height of 1,500 or 2,000 feet, with one peak at 5,200 feet, and it attains in New Hampshire its northern culminating point in the White mountains, many of whose peaks rise above 5,000 feet. Descending, as we follow the system southward, it reaches its lowest point in New York, the valley of the Hudson and Mohawk rivers leading to the lowest crossing between the Atlantic and the basin of the great lakes, at an elevation of only 430 feet. Continuing southward, through New Jersey, Pennsylvania, and Virginia, the Appalachian system again increases in elevation, and in North Carolina it attains a second and higher culminating point, scores of peaks towering to over 6,000 feet. From this point southward, through South Carolina, Georgia, and Alabama, the system falls again, and gradually shades off into the comparatively low divide between the waters of the Gulf and those flowing into the Mississippi and Tennessee rivers. This great system of mountains, then, itself composed in great part of a series of nearly parallel chains, between which lie narrow and parallel valleys, overlooks on one side the great Atlantic plain extending eastward to the sea, and on the other the elevated table-land which forms its base on the west, and which falls gradually to the prairies of the central states. This western plateau has a comparatively uniform height of about 1,000 feet, while that of the base of the mountains on the east, starting almost from the sea-level at the mouth of the Hudson, rapidly increases both toward the north and the south, rising to from 300 to 500 feet in New England, to from 100 to 300 feet in Pennsylvania, 500 in southern Virginia, and from 1,000 to 1,200 in southern North Carolina. At the same time, the width of the Atlantic plain, from the base of the mountains to the sea, gradually increases north and south from almost nothing at the mouth of the Hudson to about 50 miles in New England, over 200 in the southern Atlantic states, and to a still greater width along the Gulf. The water-shed or divide between the Atlantic streams and those to the west and north, however, which, from almost the extreme south up as far as into North Carolina, follows the extreme eastern ridge or chain of the mountains, bends gradually to the west, completely crossing the system, until in New York it is found on the plateau forming its western base. Topographically, then, the principal distinction to be drawn on the Atlantic slope is that the streams south of Virginia take their rise and complete their course entirely on the eastern flank of the Alleghanies, while from North Carolina to New York they gradually penetrate farther and farther into the mountains, until the sources of the Susquehanna, Delaware, and Hudson are found quite on the other side of the system, on the western plateau, from which they cut through the entire system to reach the sea. In New England the mountains are more detached and isolated than in the south, but the water-shed line runs in general along their western flank.

The Atlantic plain proper may be divided into two quite distinct portions by a line passing through Columbus and Augusta, Georgia, and running northward or northeastward, leaving between itself and the coast a gradually narrowing plain, until it reaches the sea at the mouth of the Hudson, whence it follows the coast quite through New England. Speaking generally, the region between this line and the sea, comprising a quite level section, narrowing from a width of nearly 150 miles in the extreme south to almost nothing in New York, is of recent geological formation, belonging chiefly to the Tertiary and post-Tertiary periods; while the entire region west and north of this line is geologically older. In New England it is occupied almost entirely by metamorphic rocks, and south of Pennsylvania these predominate, while in the middle states—New York, Pennsylvania, and Maryland—the rocks are principally of more recent date. To this last region belongs, therefore, almost the whole of New England and much the greater portion of the middle states, while in the extreme south the eastern region is of very large area. In this eastern region, which, as we have seen, reaches its greatest width in the south, the rivers are tortuous and sluggish, running through swamps, obstructed by sand-bars, snags, or fallen trees, but navigable or capable of being made so. The natural limit of navigation is in fact the limit of the eastern region, and along the line which has been described, and which we may call the *fall-line*, the rivers pour down generally with a considerable fall in a short distance, descending from the more elevated region west or north of the fall-line to the lower eastern region or to the sea. If we understand by *middle region* the region between the base of the mountains and the fall-line, we may briefly, but rather elliptically, describe the topography of the streams by saying that in the south they are confined to the middle and eastern regions, the mountain region being small, while toward the north they drain a gradually increasing mountain region, the middle and eastern regions diminishing until in New York and New England there is no eastern region whatever.

In the eastern region the streams are evidently of no value for water-power; in the mountain region or near their sources they are often equally valueless; hence, to compare their slopes, we should compare only those portions principally in the middle and western regions, where the economical development of power is possible, if anywhere.

The following table is therefore of interest, and it shows that on the whole the slope of the streams is pretty much the same from the Chattahoochee to the Merrimack. Only the streams of Maine and the Hudson stand prominent with a remarkably large slope in what may be called their *working* portions. Thus the middle and northern streams make up, by a greater penetration into the mountain region, for the smaller elevation of the western limit of the Atlantic plain proper.

Slope of the principal streams flowing into the Atlantic and the eastern Gulf.

Stream.	From—	To—	Distance.	Fall.	Slope per mile.
			Miles.	*Feet.*	*Feet.*
Saint Croix	Chiputneticook lake	Tide	55	383	7.0
Penobscot	Source	do	173	1,509	8.7
Kennebec	Moosehead lake	do	112	1,023	9.1
Androscoggin	Rangeley lake	do	180	1,511	8.4
Saco	Conway, New Hampshire,	do	73	412	5.6
Merrimack	Lake Winnipiseogee	do	124	500	4.0
Connecticut	*West Stewartstown*	*do*	*204*	*1,035*	*3.5*
Connecticut	Source	do	325	2,038	6.3
Hudson	North River village	do	102.5	1,039	10.1
Mohawk	Rome, New York	Mouth	115	418	3.6
Delaware	Deposit, New York	Tide	212	984	4.6
Susquehanna	Source	do	422	1,193	2.8
Potomac	Cumberland, Maryland	do	185	610	3.3
James	Clifton Forge, Virginia	do	225	1,014	4.5
Roanoke	Danbury ford (on the Dan river)	Head of navigation	208	651	3.1
Cape Fear	Haw River (on Haw river)	Foot of Smiley's falls	110	605	5.5
Yadkin	Patterson, North Carolina	Fall-line	241	1,145	4.8
Catawba	Old Fort, North Carolina	do	318	1,430	4.5
Congaree	Green River (on Broad river)	do	143	629	4.4
Oconee	Near Lula, Georgia	do	145	984	6.8
Chattahoochee	Near Gainesville, Georgia	do	215	751	3.5

In New England, and especially in Maine, the coast is abrupt, and the water deep immediately off shore. The harbors in this region are consequently excellent. In the middle and southern Atlantic states the gradual slope of the eastern division continues beyond the coast, and deep water is reached only at some distance. The harbors are here not so good as in New England.

The predominance of the metamorphic rocks in New England gives rise to a greater number of concentrated falls than anywhere else on the Atlantic slope. In the southern states abrupt falls are less frequent, although they often occur, especially on the smaller streams; but the falls of the large rivers are for the most part in the shape of long shoals or rapids, sometimes extending over a number of miles, the bed being gravel or bowlders. In the middle states, owing partly to the topography and partly to the softer character of the rocks, the slopes are for the most part gradual, and abrupt falls are, as a rule, rare. An inspection of the table on pages xxxiii and xxxiv will reveal this fact very clearly. In this respect, then, the more southern streams, and especially those of the middle states, are at a disadvantage, particularly as their width at these shoals is often very large. While, therefore, the table on pages xxxiii and xxxiv contains mention of a number of large powers on these streams, the expense of utilizing many of them would be so large that it will scarcely be attempted, requiring, as it would in many cases, very long and expensive dams and long canals. Among the larger streams, the Susquehanna river is prominent by reason of the fact that it offers not a single large utilized power, and very little power economically available, by reason of its uniform slope and great width.

Considering, now, the volume of water carried by the streams in question, it is clearly shown in this volume that as we proceed southward from New England the streams become in general more variable in flow, the freshets more violent, and the low-season flow smaller. These results are due to three principal causes: In the first place, the streams south of the Delaware are not regulated in flow by any large lakes, such as are so abundant in New England. In fact, south of the Susquehanna there is not a lake in the region considered, except one or two near the coast, where they are of no value in this connection. Moreover, the streams are not regulated by artificial storage reservoirs, as is the case so largely in New England, and, in fact, the topography of the river valleys is often such as to preclude any very extensive works of this nature. The result of this is that, while in New England the ordinary low-water flow of many of the smaller streams is in many cases doubled or even trebled by supplies drawn from storage reservoirs alone, this is not the case south of the Delaware to any appreciable extent. In the second place, the topography of the drainage basins of many of the streams in the middle and southern states explains in a measure their more variable flow. In the third place, the rainfall in New England and in parts of the middle states is distributed with a greater quantity in summer and autumn than in winter and spring, thus giving an increased supply to meet the draughts of evaporation in the summer months, while in the states south of Pennsylvania or Maryland the reverse is true, thus tending to render the streams more variable.

The southern streams, though free from the dangerous ice-freshets which sometimes occur in the north, are nevertheless subject in places to rises far exceeding any thing on record in New England. The following table shows the maximum recorded rise above low water of various streams on the Atlantic coast, and indicates to a certain extent the increasing variability toward the south; but it must be observed that this is by no means an accurate criterion from which to judge of the uniformity of flow of a stream, and that the rise depends upon so many circumstances—such as shape of the valley at the point in question, slope of the stream, width, etc.—that no certain inferences could be drawn from such data, and that of two streams the one really more constant in flow might reasonably exhibit a larger rise in freshets at a certain point than was ever reached anywhere on the other. Nevertheless, the liability of a stream to excessive rises is a very important factor in determining its value as a source of power, and in this respect the advantage must be conceded to the streams of the North. The reason of the large rises recorded on many of the southern rivers is probably to be found in the absence of lakes, in the liability to sudden and excessive falls of rain upon the elevated or mountainous regions, which discharge it at once into the water-courses, and in the small slope of the eastern or navigable portion of these streams, at the junction of which with the middle region the heaviest rises occur.

River and place.	Maximum recorded rise.	River and place.	Maximum recorded rise.
Kennebec at Augusta, Maine	25±	James at Richmond, Virginia	28.9
Merrimack at Lawrence, Massachusetts	26.5	Shenandoah at junction of forks	40+(?)
Connecticut at Hartford, Connecticut	29.8	Roanoke at Weldon, North Carolina	50
Hudson at Troy dam	22.0	Dan at Madison, North Carolina	28.4
Mohawk at Lower aqueduct	28.5	Cape Fear at Fayetteville, North Carolina	65(?)
Delaware at Easton, Pennsylvania	42.0	Yadkin at Wilksborough, North Carolina	23
Schuylkill at Fairmount dam	11.4	Savannah at Petersburg, Georgia	44
Chemung at Elmira, New York	24.0	Coosa at Wetumpka, Alabama	54
		Chattahoochee at Columbus, Georgia	42
		Chattahoochee, at Atlantic and West Point railroad	25.6

The table on pages xxviii and xxix, containing a compilation of all the principal data regarding flow which are scattered through these reports, will bear still stronger evidence to the fact that the northern streams are much more uniform in flow than those to the south. As regards absolute volume, the larger streams of the Atlantic slope discharge annually, according to varying conditions, from 25 to 60 per cent. of the rainfall over their basins, which itself varies in different localities from 38 to 56 inches.

Finally, as regards the question of accessibility, the streams of the northern and middle states have a great advantage in this respect, being generally more easy of access by rail than the streams farther south, where the topography often renders the location of a railroad most favorable along the divides; while, as regards water communication, the close proximity in the North of the lowest falls to tide-water and to the coast is an important advantage in comparison with the long stretch of tortuous and shifting channel which in the South separates the fall-line from the sea. Thus the head of navigation on the Alabama river is over 300 miles from the Gulf, and other southern streams have even longer navigable portions, while in New England navigation on the rivers is not carried over 50 miles from the coast, and rarely that.

Considering all these circumstances, it must be allowed that on the Atlantic slope the streams of New England are in all respects the most favorable for water-power; and of the New England streams few will compare with the great rivers of Maine. One can not read the list of splendid powers in that state, many still lying idle, without becoming convinced that her water-power is unsurpassed. Her lakes, many of them lying at a higher elevation than that of lake Itasca, the source of the Mississippi, or than lake Superior; her rivers, plunging over ledge after ledge of unyielding granite in their short courses from these reservoirs to the sea; her extensive woods, adding their regulating effect to that of the lakes; and her navigable bays and inlets, reaching to the last great leap of the rivers—all these constitute an array of favorable circumstances which, in spite of some opposing disadvantages, would be difficult to equal.

Crossing, now, the Alleghanies, and considering the great central basin of the continent, many of the streams present a marked contrast to those which have just been considered. Stretching from the western base of the Alleghanies to the eastern base of the Rocky mountains, a distance of from 1,200 to 1,500 miles, this immense region descends from east and west toward the Mississippi, while on the north and northeast a considerable region finds its outlet in the tributaries of the great lakes and the Saint Lawrence and of Hudson's bay.

The streams flowing into lake Ontario, descending within a short distance from the elevated plateau of New York and Pennsylvania to the comparatively low-lying lake, have a rapid fall, and offer many shoals and rapids and not a few cataracts; but the latter are not so numerous as would be expected, owing to the presence throughout the region of comparatively soft and disintegrable rocks. Flowing over these, the streams have gradually obliterated many falls which once existed, until they now flow in the gorges they have hollowed out for themselves, while the falls which still remain are gradually receding as this universal leveling tendency continues. The divide

or water-shed line between these streams and those flowing directly to the sea rises from an elevation of but 430 feet near the head-waters of the Mohawk, to 2,000 feet or more in some parts of Pennsylvania and in the Adirondacks, and the average slope of the principal streams is at least 10 feet per mile. The rainfall being greatest in summer and autumn, and there being numerous lakes in the region, the streams are as a rule well sustained, and will compare favorably as regards power with the streams of the Atlantic slope and even of New England.

Mention may here be made also of the Niagara, the mighty stream through which the accumulated waters of the enormous system of the great lakes seek their outlet, and which, in its short course of 37 miles, falls through a height of 333 feet, developing the enormous total of over 6 million horse-power, or more than five times the total amount of water-power in use in the United States in 1880. The precipice over which the principal part of the descent is made corresponds to that which occasions falls on some of the streams to the east, and, like them, it is gradually receding as the comparatively soft rocks are disintegrated. This mighty power, unrivaled as regards constancy and amount, stands apart among the powers of the country, and the detailed report concerning it must be read if even a faint conception of its features is to be gained, while it must be seen to be fully appreciated.

Farther to the west, much the greater part of the country east of the Mississippi is drained by the tributaries of the Ohio, and of these the southern tributaries, and also the two head-waters, the Allegheny and Monongahela, are very different in character from the northern ones. The former, descending rapidly from the elevated plateau or the great valley forming the base of the mountains, and which rises from an elevation of 1,500 feet in Pennsylvania to 2,600 feet at the head-waters of the New river, in North Carolina, again to fall to 1,000 feet along the upper Tennessee—descending from this elevated region very rapidly for a few miles, the southern tributaries of the Ohio soon reach the eastern border of the great central plain which stretches with a small and almost uniform slope westward to the Mississippi, and in their middle and lower portions they flow toward the west and north with a very small slope, and are navigable for long distances. Thus the Ohio itself is navigable for its entire length, while of its head-waters, the Allegheny is navigable for small steamers during about half the year to a point 123 miles above Pittsburgh, and the Monongahela is also navigable by means of locks and dams for over 100 miles. Similarly, the Cumberland is navigable for 550 miles during several months of the year, the Tennessee for 453 miles, barring one shoal, and the Green river for 175 miles. It is thus evident that none of these streams offer any facilities for water-power in their lower portions. Above the head of navigation they no doubt afford a large amount of power, but their flow is so variable and the country they drain is so wild, inaccessible, and little developed, that even here their power is of no value, and scarcely any of it is utilized. They are regulated by no lakes, and the country they drain is steep and favorable to a rapid discharge of the rainfall; the latter, too, is distributed in a way unfavorable to a uniform flow, and the result is that they are subject to heavy freshets and to severe droughts, impairing very much the value of whatever power they possess.(a) The following table shows the slope of some of these streams on their lower portions:

Slope of some of the southern tributaries of the Ohio.

Stream.	From—	To—	Distance.	Fall.	Slope per mile.	Remarks.
			Miles.	*Feet.*	*Feet.*	
Cumberland	Nashville, Tennessee	Mouth	192	79	0.41	Navigable during six months for steamers of 300 tons.
Green	Bowling Green, Tennessee	...do	175	60	0.34	Navigable by locks and dams.
Kentucky	Mouth of Middle Fork	...do	258	228	0.88	Navigable by locks and dams for 95 miles above mouth.
Licking	West Liberty, Tennessee	...do	231	310	1.34	
Great Kanawha		...do	90	86	0.96	
Little Kanawha	Bulltown, West Virginia	...do	131	200	1.53	
Monongahela	Mouth of West Fork	...do	123	132	1.07	Navigable by locks and dams for 102 miles.
Allegheny	Olean, New York	...do	255	725	2.84	

Like so many of the streams in the middle and southern Atlantic states, the falls in these streams below their extreme head-waters are generally in the shape of long shoals. Thus the fall at the principal shoals on the Cumberland is 55 feet in 8 miles; on the Tennessee, 164 feet in 36.5 miles; and likewise on the Allegheny, 11.23 feet in 6,900 feet. As an example, however, of the rapidity with which these streams descend from their elevated sources to the plateau or gentle slope in which their subsequent courses lie, Mr. Porter mentions the fact that the Cheat river, in West Virginia, descends 2,400 feet in the last 80 miles of its course to the Monongahela, while the latter falls but 75 feet in the 90 miles from the mouth of the Cheat to Pittsburgh.

The northern tributaries of the Ohio are somewhat different in character. The divide between the basin of the Ohio and that of the great lakes lies everywhere at a comparatively small elevation, from which the streams descend in both directions, flowing through an only gently undulating country and with comparatively small slopes. To quote from Mr. Porter's report on these tributaries of the Ohio: "They are already largely in use and will admit of much further development. The powers offered, though well suited to the demands of ordinary manufacturing, are not, individually, of great magnitude, for the reason that the fall at command on the principal streams is nowhere

a Thus the Little Kanawha is said to have risen 28 feet within 24 hours.

very large, while their flow is on a rather small scale relatively to the extent of area drained, and in the dry season sinks very low; so that, if their value is to be estimated on the basis of permanently reliable power, they can not take a high rank. There are probably no privileges on the northern tributaries of the Ohio which can be depended upon at all times for more than 1,000 or 1,500 effective horse-power, and even such are of unusual occurrence."

The following table shows the slope of some of these streams in their lower portions. It will be noticed that the slope is considerably greater than that of the southern tributaries of the Ohio in their corresponding portions, and, in fact, these northern streams are in almost every way better suited for the development of power:

Slope of some of the northern tributaries of the Ohio.

Stream.	From—	To—	Distance.	Fall.	Slope per mile.	Remarks.
			Miles.	*Feet.*	*Feet.*	
Wabash	Mouth of Little river	Mouth	370	385	1.0	Navigable for some distance.
Great Miami	Dayton	...do	77	298	3.9	Extensively used for power.
Do	Piqua	...do	108	422	3.9	
Scioto	Columbus	...do	110	225	2.0	Not navigable.
Do	Green Camp	...do	152	433	2.8	
Do	Extreme source	...do	210	933	4.4	
Muskingum	Dresden	...do	91	130	1.4	Navigable by locks and dams.
Do	Mouth of Walhonding river	...do	151	367	2.4	

Flowing, like the southern tributaries, over a region of recent geological age as compared with New England and other parts of the Atlantic plain, the declivity of these streams is uniform and the bed principally gravel and sand. As regards their flow, the proportion of the rainfall discharged is small as compared with that in New England, Humphreys and Abbot estimating it at 24 per cent. for the entire Ohio basin. The deep soil, the permeable underlying strata, the openness of the country, and the absence of lakes and swamps, are reasons for this fact. And not only this, but the flow of the streams is much more variable from month to month than in the New England or middle Atlantic states. The rainfall throughout almost the entire Ohio basin is generally much less in autumn than in any other season, and less in summer and autumn than in winter and spring, especially in the southern portion of the basin. This fact, with the absence of lakes and the character of the country, explains the variable discharge, which a glance at the table on pages xxviii and xxix shows to exist. Mr. Porter states the principal disadvantages on the northern tributaries to be the liability to extreme low water in summer and autumn; the heavy freshets and ice-runs; the backwater, which often lasts for a considerable period; and the difficulty of obtaining rock foundations. The power is principally used for flouring- and grist-mills. As regards accessibility, however, these streams leave nothing to be desired.

As for the Ohio itself, its fall at low water from Pittsburgh to its mouth is 430 feet, the distance being 967 miles, and the slope, therefore, 0.44 foot per mile. It offers but one opportunity for the development of power—at Louisville, Kentucky—where the fall at low water is 26 feet in 2 miles, and around which a canal is constructed. The theoretically available power is enormous, but practically not all could be economically developed.

The streams flowing into lake Erie from the south, and those draining the peninsula of Michigan, resemble in general characteristics the northern tributaries of the Ohio. They offer but little power of importance, and no sites which would yield over 1,000 gross horse-power throughout the year. Their slopes are uniform and generally small, there being but one prominent instance in all this region of a large concentrated fall, namely, Cuyahoga falls, in eastern Ohio, where the river of the same name descends 194 feet in 2 miles. The small quantity of water, however, renders this otherwise excellent site of limited importance, the available power at ordinary low-water being not over 1,000 gross horse-power. The largest stream in all this region is the Maumee river, draining 6,723 square miles, but even this affords no power of over 500 horse-power.

The remarks which have been made regarding the northern tributaries of the Ohio will also apply in general to the smaller eastern tributaries of the Mississippi; but toward the head-waters of that river, in the Northwest, an essentially different condition of things exists. It may be said that between the Appalachian and the Rocky mountains there are no connected mountain ranges. There are, however, a few isolated ranges, and of these some are found along the shores of lake Superior. Approaching, then, the head-waters of the Mississippi, we come to a region lying at an elevation of from 600 to 1,600 feet above tide, and comprising some rough and even rugged country, where the slopes of the streams are large, and where their courses lie over beds of hard metamorphic rock. The most striking feature of this region, however, is the presence of great numbers of lakes, by which the flow of the streams is regulated to a large extent, although the lakes are shallow, and the evaporation from many of them is quite equal to the inflow. Moreover, throughout this region, comprising the basins of the western tributaries of lake Michigan, that of lake Superior, of the upper Mississippi, and part of that of the Red river of the North, the rainfall is distributed in a way very favorable for constancy of flow, very much more falling in summer than in any other season. The absolute amount of rainfall is small, varying from 35 inches in Michigan and around lake Superior to

25 inches on the upper Mississippi and Red rivers, but its favorable distribution and the large number of lakes (over 8,000 in the region referred to), together with the extensive woods in some portions of the region, and the character of the country, which generally is not very favorable to quick drainage, more than counterbalance this disadvantage, and render the water-power of some of these streams even comparable with that of New England.

Perhaps the most noticeable stream in this region is the Lower Fox river, the outlet of lake Winnebago, which in its course of 37½ miles from the lake to Green Bay falls a distance of 170 feet, affording twelve large powers, with an aggregate of over 46,000 horse-power at ordinary low water, of which but a small fraction is utilized. This stream, as regards fall, constancy, and general facilities for power, is quite on a par with the best streams of New England.

Of the other streams flowing into lake Michigan, the Milwaukee, Sheboygan, and Manitowoc on the south have slopes of about 8 feet per mile, and are used principally for flouring- and grist-mills. Being unregulated by lakes, their flow is quite variable. Toward the north, in the region of metamorphic rocks, occupying northern Wisconsin, Michigan, and Minnesota, the streams descend more rapidly, but are in a wild and inaccessible country. The Menominee, flowing southeast into lake Michigan from the range of hills which borders lake Superior on the south, offers an immense amount of power, almost entirely undeveloped. It falls 970 feet in 160 miles from its mouth, descending in rapids and cataracts over ledges of upturned rock; but, although its basin is heavily clothed with timber, there are few lakes to regulate its flow. Along the southern shore of lake Superior the water-shed lies at an elevation of from 600 to 1,050 feet above the lake, and at a distance from it of about 30 miles; and the streams draining this region must offer large amounts of power entirely undeveloped. The western and northern tributaries of the lake, however, have especially large falls, for on the north shore the water-shed is 1,000 feet or more above the lake and but 8 or 9 miles distant. The rock in this region is igneous and very hard, and the streams, though generally very short and carrying but small quantities of water, descend with plunge after plunge till they reach the lake. The Saint Louis river, which enters the lake at its western extremity, and drains over 3,000 square miles, merits particular mention on account of its descent of 456 feet in the last 11 miles of its course, giving rise to one of the most magnificent powers in the West, the available horse-power at ordinary low water being estimated by Mr. Greenleaf at nearly 50,000 horse-power. The rainfall over the region draining into lake Superior is from 30 to 35 inches, favorably distributed; and although there are few lakes on the basin of the Saint Louis river, Mr. Greenleaf estimates its ordinary low-water flow at 0.4 cubic foot per second per square mile, a flow which would do credit to many a New England stream.

To the west of the Mississippi the Red river of the North is a curiously different stream. Flowing northward from about the latitude of central Minnesota, the main stream is entirely a prairie stream, its course lying in a wide and nearly level valley, and its fall from Breckenridge to the national boundary, a distance of 394 miles, being but 165 feet, or an average of only 0.418 foot to the mile. There is much drift over all this region, and along this part of the river's course no rock is found in place. The bed is nothing but gravel and sand, and the declivity very uniform, the heaviest slope being at the rate of 1.6 foot per mile for a distance of nearly 3 miles. Above Breckenridge the stream descends from the hill country of central Minnesota, and its fall from Otter Tail lake to Breckenridge, a distance of 34 miles, is at the rate of nearly 11 feet per mile. From this hill country, which is at the same time dotted with lakes, come the eastern tributaries of the stream, upon which, as well as upon the main stream above Breckenridge, lies all the available power in the basin. Over this hill region the rainfall is about 25 inches, favorably distributed, and this, in connection with the numerous lakes, renders the flow of the streams so uniform that at Fergus Falls on the main river a rise of 4 feet is not often exceeded. The western tributaries of the river, however, drain a prairie region where there are very few lakes, and where the rainfall is but about 15 inches, with a very small amount in the autumn; and these circumstances, in connection with the open character of the country, the large evaporation, and the small fall of the streams, renders their flow very variable and their water-power of no value. The Red river thus possesses the curious characteristic that at the national boundary, where it drains over 3,900 square miles, its ordinary low-water flow is about 0.07 cubic foot per second per square mile, while at Breckenridge, where its drainage area measures only about 4,747 square miles, the ordinary low-water flow per square mile is 0.217 cubic foot per second. And while at the latter point its flow is remarkably uniform, in its lower course, on account of its altered character and its small declivity, as well as owing to climatic conditions, it is visited by tremendous floods.

While the slope northward into lake Superior is rapid, the slope southward into the upper Mississippi is much more gradual. Nevertheless, the upper Mississippi and its tributaries afford more power than is to be found anywhere lower down in its basin. From the extreme sources of the river to Saint Paul, a distance of about 500 miles by the river, the fall is about 1,000 feet, and some important powers exist, while at Minneapolis is found one of the grandest powers in the Northwest, the minimum theoretical power, during 24 hours, being stated at 25,000 horse-power. The large number of lakes, the favorable distribution of the rainfall, and the topography of the country, render the flow well sustained throughout the year, while the rocky character of the streams in many places affords good facilities for utilization. Below Saint Paul the main river offers but one power, and is for the most part a navigable stream, the great highway of the central basin of the continent.

The western tributaries of the Mississippi are for the most part prairie streams, and different in character from any hitherto considered. From the eastern base of the Rocky mountains—the elevated plateau of Montana, Wyoming, and Colorado—these prairies extend in an unbroken expanse eastward to the Missouri, rising again to the comparatively low divide separating that river from the Mississippi; while more to the south their hitherto unbroken monotony is varied by the range of the Ozark mountains, among which rise several of the lower tributaries of the Mississippi. The slope of the prairies is comparatively uniform, and varies from about 2 to 5 feet per mile; they are almost entirely without woods, but covered with a rich growth of grass. Their surface is rolling and sometimes hilly, and the streams flow in shallow basins, with low divides on either side. Geologically the country is of recent formation, and, although in some portions limestone and sandstone appear at the surface, by far the greater portion of the area is covered with a deposit of drift or loess. Below these lie the harder rocks, but the rivers have not cut their way down to them, and invariably flow in beds of mud, sand, quicksand, or gravel, with very uniform slopes and scarcely any rapids. There are thus no falls whatever on the real prairie streams, and the character of the bed and banks is very unfavorable for the development of power. There are, moreover, no lakes of importance in the region, and no advantages for artificial storage. Lying in the center of a great continent, the winds which reach this region have been almost drained of their moisture before reaching even its outer confines, and from 40.7 inches at Saint Louis, the mean annual rainfall diminishes as we proceed westward, until at Fort Bridger, in Wyoming, it is but 8.4 inches, while it is less than 20 inches at most points west of the 99th meridian. The rainfall in spring and summer is much greater than in autumn and winter, and the streams lose much by the excessive evaporation which takes place throughout the region. Thus, while in New England there are probably few streams which do not discharge annually from 30 to 50 per cent. of the rainfall which falls upon their basins, Humphreys and Abbot give a ratio of but 15 per cent. for the entire basin of the Missouri river. Although the rainfall is distributed in a measure favorable for a constant flow, yet the fact that the precipitation during the winter is almost entirely in the form of snow, which remains long upon the ground and is thus of little value to the streams, has the effect of carrying the streams very low during the late autumn and winter. Moreover, the pervious character of the soil, and the circumstance that the streams have not cut down to an impervious stratum, prevents much of the water which falls as rain from reaching the streams at all. In fact, during the dry season many streams dry up entirely, or are converted into a series of sluggish pools, while beneath, in the deep pervious subsoil, there may be a considerable percolation or seepage. The consequence is that the prairie streams, when at their lowest, discharge a remarkably small quantity of water in proportion to the extent of area drained. Thus, while the discharge of large streams on the Atlantic coast rarely falls below 0.2 cubic foot per second per square mile, even the largest prairie streams fall as low as from 0.05 to 0.10 at some time of the year; and even the Missouri river, draining over 500,000 square miles, has been known to offer as low a ratio as 0.05 or less.

The slope of many of these streams is quite rapid, as the table on page xxv shows, and owing to their generally considerable width they are not subject to extremely great rises in freshets, although rises of 30 and even of 40 feet have been known in some places.

The streams to which this description particularly applies comprise the Missouri and its tributaries, especially those from the west, draining the greater part of Dakota, Montana, Wyoming, Nebraska, Colorado, and Kansas, as well as Indian territory, drained by the Arkansas and Red rivers. In the mountainous parts of this region the streams, of course, have very steep slopes, and the bed is often rock; but they are still very variable in flow, and their principal use is for irrigation, after supplying the demands of which there is often little water remaining to be devoted to power. Those streams which flow in deep cañons, like some of those in Colorado, are, moreover, topographically unfitted for its development.

The power utilized on all these streams is insignificant in amount, and is principally used for flouring- and grist-mills. When the slope of the stream is sufficient, power may be equally well developed almost anywhere, there being no rapids. The dams, on account of the yielding character of the bed, are necessarily of brush in a great many cases.

Regarding the Missouri itself, it is navigable at some periods of the year to Fort Benton, in Montana, a distance of 2,644 miles. Thirty-five miles above this are the falls of the Missouri, where the stream descends 161 feet within a distance of 9 miles. There is no power, however, utilized from the river.

The tributaries of the Missouri from the east, draining portions of Dakota, Iowa, and Missouri, resemble in general the prairie streams from the west, their flow being quite as variable and their slopes even smaller. They flow generally over the loess formation, and their beds are generally muddy and their slopes uniform. In southern Dakota, on the Big Sioux river, is the only prominent instance of a sudden fall over a rock ledge to be found in the prairie region.

The following table shows the slope of some of the tributaries of the Missouri, to which are added for comparison that of some streams in the Northwest. It shows clearly that, so far as concerns fall, these prairie streams compare favorably, in many cases, with streams on the Atlantic coast, and even in New England; it is the absence of concentrated falls, the variable flow, the shifting bed, and the general unfavorable circumstances which render them far inferior as sources of power.

Slope of some tributaries of the Missouri river, and of some streams in the Northwest.

Stream.	Tributary to what.	From what state.	From—	To—	Distance.	Fall.	Slope per mile.
					Miles.	*Feet.*	*Feet.*
Missouri river	Mississippi river	Missouri	Fort Benton, Montana	Mouth	2,644	2,464	0.93
Dakota river	Missouri river	Dakota	N. P. R. R. crossing	C. and N. W. R. R. crossing	252	157	0.62
Big Sioux river	....do	....do	Watertown, Dakota	Mouth	221	639	2.89
Little Sioux river	....do	Iowa	Cherokee, Iowa	Near mouth	79	101	1.28
Boyer river	....do	....do	Near Denison, Iowa	Mouth	59	148	2.51
Nishnabatona river	....do	Missouri	Near Atlantic, Iowa	....do	120	230	1.92
Nodaway river	....do	....do	Near Villisca, Iowa	Near mouth	91	160	1.76
Platte river of Missouri	....do	....do	Near Conception, Missouri	....do	119	321	2.70
Grand river	....do	....do	Near Gentryville, Missouri	Mouth	128	181	1.41
Chariton river	....do	....do	Chariton, Iowa	Near Keytesville, Missouri	186	403	2.17
Niobrara river	....do	Nebraska	Near source	Mouth	355+	3,829	10.78
Platte river	....do	....do	North Platte, Nebraska	....do	304	1,890	6.22
Elkhorn river	Platte river	....do	Near O'Neill, Nebraska	Near mouth	201	858	4.27
Loup river	....do	....do	Head of Middle Loup	....do	257	1,796	7.00
North Platte river	....do	....do	North Park, Colorado	North Platte	514	4,836	9.41
South Platte river	....do	....do	Denver, Colorado	Mouth	285	2,454	8.61
Kansas river	Missouri river	Kansas	Junction of forks	Near mouth	184	330	1.79
Big Blue river	Kansas river	....do	Seward, Nebraska	....do	153	384	2.51
Republican river	....do	....do	Western boundary of Nebraska	Mouth	423	2,530	5.98
Smoky Hill river	....do	....do	Wallace, Nebraska	....do	395	2,275	5.76
Osage river	Missouri river	Missouri	Ottawa, Kansas	....do	417	358	0.86
Gasconade river	....do	....do	Indian Ford, Missouri	....do	78	108	1.38
Milwaukee river	Lake Michigan	Wisconsin	Head-waters	....do	66	500	7.58
Sheboygan river	....do	....do	....do	....do	45	360	8.00
Manitowoc river	....do	....do	....do	....do	42	350	8.33
Lower Fox river	....do	....do	Lake Winnebago	....do	37½	165	4.40
Menominee river	....do	....do	Head-waters	....do	160	975	6.09
Red river of the North	Hudson's bay	Minnesota and Dakota	Otter Tail lake	Breckenridge, Minnesota	34	368	10.82
Do	....do	....do	Breckenridge, Minnesota	National boundary	394	165	0.42

The tributaries of the Mississippi from eastern Iowa offer a marked contrast to those draining the western slope. Not only is their fall very much larger, but numerous rock exposures occur along the streams, and rapids occasionally occur. The drift deposits are thick over this region, while the loess which covers so much of the western slope is almost absent here. Moreover, the streams are well sustained during the low season, by reason of the numerous springs issuing from the drift deposits, while farther west the loess is entirely lacking in springs. The rainfall is also greater here, averaging from 30 to 35 inches for the year, of which the summer yields the largest quantity, while spring and autumn come next, and are nearly equal, whereas farther west considerably more falls in spring than in autumn. The result of these circumstances is a much more uniform flow than is found in the streams farther west. Mr. Porter, in estimating the flow of these streams, assumes the low-water flow in an ordinarily dry year as from 0.06 to 0.09 cubic foot per second per square mile, while for the streams on the western slope he takes generally 0.04 or 0.05, though sometimes as high as 0.08, and for the prairie streams west of the Missouri he uses a smaller ratio still. These rivers are not navigable, and much power is utilized upon them, although a large amount is still available. The principal use of the power is for flouring- and grist-mills. There are, however, no individually large powers in eastern Iowa, probably none which will yield over 1,200 or 1,300 gross horse-power in low water of ordinarily dry years. The general slope of the country is at the rate of about 4.5 feet per mile toward the southeast, but the declivity of the individual streams is given in the following table:

Slope of the streams of eastern Iowa.

Stream.	From—	To—	Distance.	Fall.	Slope per mile.
			Miles.	*Feet.*	*Feet.*
Maquoketa river	Manchester, Iowa	Mouth	87	333	3.83
Wapsipinicon river	Independence, Iowa	....do	135	328	2.43
Iowa river	Near Iowa Falls	....do	215	485	2.26
Cedar river	Cedar Falls, Iowa	Mouth of Iowa river	176	323	1.84
Skunk river	Southeast part Hamilton county, Iowa	Mouth	203	551	2.71
Des Moines river	Windom, Minnesota	....do	411	853	2.08

But little need be said regarding the remaining tributaries of the Mississippi from the west. Those draining eastern Missouri, both those flowing into the Mississippi directly and those joining the Missouri, are practically of no value for power. In their lower parts they are sluggish and unsupplied with springs, and sometimes run entirely

dry. Some of them have their sources in the comparatively elevated region about the Ozark range, and in their upper parts are well sustained in flow, and fall rapidly over rocky beds, but the powers afforded are all very small.

The basin of the Arkansas river is in many respects similar to that of the Missouri. The mountainous portion, in Colorado, is similar to that of the Platte river, and doubtless power could be obtained there if it were wanted; but the streams are already more or less devoted to purposes of irrigation, and will probably soon be further used in this way, so that the subject of power is of comparatively small importance. In the prairie region the streams are very variable, being lowest in winter, and running dry nearly every year. Their slopes are uniform, their beds gravel, sand, or mud, and they are bordered by bottom-lands often several miles wide. Even the Arkansas runs almost dry at times, and near its mouth, where its drainage area is 160,000 square miles, its ordinary low-water discharge is but 0.019 cubic foot per second per square mile. The absence of facilities for storage, and the fact that more rain falls in summer than in any other season, while the precipitation in the autumn and winter is very small, together with the topography of the country, suffice to explain these facts. On the main river power is utilized at only two or three places and in but small amounts. In the upper 120 miles of its course, the river is a mountain torrent, and its slope is nearly 40 feet per mile. Eastward from the base of the mountains the prairies slope at the rate of about 8 feet per mile for 500 or 600 miles, and the declivity of the stream becomes gradually smaller as it nears its mouth, where it is at the rate of but 0.46 foot per mile for 150 miles. The principal utilization of power in the basin is in the middle country, in southeastern Kansas, where the streams can be dammed almost anywhere.

The Red river, the last important tributary of the Mississippi, is navigable for 460 miles, and is muddy and sluggish for a much greater distance. Near its head-waters it flows in a cañon, shut in by sandstone cliffs rising almost vertically for from 500 to 800 feet, while its fall is rapid over a sandy bed. Little power is utilized in its basin, and many of its tributaries from Louisiana and Arkansas, although in their upper parts they have a rapid fall over gravelly beds, go almost dry in the low season.

The following tables show the slope of some of the lower tributaries of the Mississippi, and the maximum recorded rise in freshets of some streams in the Mississippi basin and the Northwest:

Slope of some of the lower tributaries of the Mississippi.

River.	Tributary to what.	From—	To—	Distance.	Fall.	Fall per mile.
				Miles.	*Feet.*	*Feet.*
Meramec river	Mississippi river	Head spring	Mouth	172.5	390.5	2.26
Saint Francis	...do	Head-waters	...do	438.0	1,006.0	2.30
Do.	...do	Eastern boundary Butler county, Missouri.	...do	308.0	170.0	0.55
Arkansas	...do	Source	Pueblo, Colorado	155.0	5,287.0	34.11
Do.	...do	Pueblo, Colorado	Fort Gibson, Indian territory	812.0	4,208.0	5.18
Do.	...do	Fort Gibson, Indian territory	Mouth	642.0	398.0	0.62
Red	...do	Source	Missouri, Kansas, and Texas Railroad crossing.	504.0	1,919.0	5.19
Do.	...do	Missouri, Kansas, and Texas Railroad crossing.	Mouth	1,025.0	517.0	0.50
White	Arkansas river	Head of West fork	Forsyth, Missouri	257.0	1,333.0	5.18
Do.	...do	Forsyth, Missouri	Mouth	500.0	458.0	0.77

Maximum recorded rise of various streams of the Mississippi basin and the Northwest.

River.	Locality.	Rise above low water.	River.	Locality.	Rise above low water.
		Feet.			*Feet.*
Ohio river	Mouth	50+	Gasconade river	Mouth	20–25
Do.	Louisville, Kentucky	64	Des Moines river	In lower parts	25
Do.	Cincinnati, Ohio	71	Arkansas river	Near mouth	45
Missouri river	Mouth	35	Do.	Little Rock, Arkansas	33
Do.	Saint Joseph, Missouri	20	Do.	Wichita, Kansas	7½
Do.	Fort Benton, Montana	6	Red river of the North	Breckenridge, Minnesota	16
Kansas river	Topeka, Kansas	30	Do.	Moorhead, Minnesota	28
Smoky Hill river	Ellsworth, Kansas	20–23	Do.	Below Moorhead	40
Osage river	Mouth	39	Red Lake river	Crookstown, Minnesota	20

The water-power of the region west of the Mississippi tributaries has not been included in the investigations of which the results are now presented, and little can here be said regarding it. In the plateau region of the Rocky mountains—a region of table-lands and cañons—there is probably little opportunity for the development of power, while in the Great Basin region, which follows it on the west, there are few living streams. On the Pacific coast the streams descend very rapidly from the Sierra Nevada and the Coast ranges, and their slope is very

large. Even the larger streams are navigable for but very short distances. The rainfall, however, is exceedingly variable in this region, frequently not a drop of rain falling during the summer in some parts of California, while the average summer rainfall over the greater part of the state is less than 1 inch; although farther north, in Oregon and Washington territory, summer rains and thunder-showers sometimes occur. The result of this is that, particularly in California, only the streams which head far up in the Sierras and are fed during the summer by melting snows and perennial springs, are sustained during the summer time. The streams which head in the foot-hills or in the Coast range of California are mostly dry during the summer, and even the larger streams, heading far up in the mountains, are very variable. There is no doubt, however, that these streams offer an enormous amount of power, little of which has been utilized.

The following table contains a summary of data regarding flow of streams, compiled from the data presented in these reports. It serves to bring out very clearly the difference between the streams in different parts of the country. It will be seen that of the large New England streams none fall as low in discharge as 0.2 cubic foot per second per square mile; while the Potomac, larger than any stream in New England in point of area drained, falls to half that amount, and the western streams, even those of large size, fall to lower figures still:

Summary of data

	Stream.	Locality.	Drainage area.	MEAN RAINFALL. Spring.	Summer.	Autumn.	Winter.	Year.	EXTREMES OF FLOW. Maximum, cubic feet per second.	Minimum, cubic feet per second.	Ratio.
			Sq. miles.	In.	In.	In.	In.	In.			
1	Merrimack river	Lawrence, Massachusetts	4,599	10	11	13	9	43	96,000	1,400	69
2	Do	Lowell, Massachusetts	4,085	10	11	13	9	43	81,000	1,275	64
3	Concord river	....do	361	11	11	12	10	44	4,449	60	74
4	Hale's brook	....do	24	11	11	12	10	44	....	3.25	....
5	Sudbury river	Framingham, Massachusetts	78	11	11	12	10	44	3,228	2.8	1,153
6	Charles river	Newton Upper Falls, Massachusetts	215	11	11	12	10	44	....	44	....
7	Connecticut river	Hanover, New Hampshire	3,316	10	12	12	10	44	....	1,006	....
8	Do	Hartford, Connecticut	10,154	10	12	12	10	44	205,464	5,208	40
9	Housatonic river	Kent, Connecticut	758	12	12	12	10	46	....	260	....
10	Do	Birmingham, Connecticut	1,562	12	12	12	10	46	....	500	....
11	Croton river		339	12	13	13	10	48	25,380	60	423
12	West branch Croton river		20.37	12	13	13	10	48	1,100	0.33	3,327
13	Hudson river	Palmer Falls, New York	2,650	9	11	10	8	38	....	....	....
14	Mohawk river	Cohoes, New York	3,490	9	10	10	8	37	....	800-1,000	....
15	Oswego river	Oswego, New York	5,013	8	10	9½	7	34½	4,100	1,153	36
16	Genesee river	Rochester, New York	2,474	8	9½	9	7	33½	....	300	....
17	Passaic river	Paterson, New Jersey	813	12	14	12	10	48	17,913	195	92
18	Raritan river	Near New Brunswick, New Jersey	825	12	14	12	10	48	....	180	....
19	Delaware river	Lambertville, New Jersey	6,820	11	13	11	9	44	350,000	2,000	175
20	Schuylkill river	Philadelphia, Pennsylvania	1,912	12	14	10	9	45	....	310	....
21	Potomac river	Cumberland, Maryland	920	10	12	9	8	39	17,900	25	716
22	Do	Dam No. 5, Maryland	5,066	11	12	9	8	42	92,772	363	255
23	Do	Great Falls, Maryland	11,476	12	13	9	8	42	175,000	1,063	165
24	Rock creek	Hoyle's Mill, District of Columbia	64.4	11	12	11	8	42	9,800+	7.5	1,307
25	Shenandoah river	Near Port Republic, Virginia	770	12	13	8	8	41	....	128	....
26	James river	Richmond, Virginia	6,800	12	12	9	10	43	....	1,300	....
27	Neuse river	Near Raleigh, North Carolina	1,000	12	14	10	11	47	....	....	....
28	Alabama river	Near Montgomery, Alabama	16,650	14½	13½	10½	15	53½	....	....	....
29	Tallapoosa river	Fort Decatur Bluffs	4,040	14	13½	10½	14½	52½	....	....	....
30	Allegheny river	Roberts' Run ripple, Pennsylvania	6,020	10	11	9	10	40	....	2,070	....
31	Do	Near Pittsburgh, Pennsylvania	11,100	10	12	9	10	41	....	1,330	....
32	Ohio river	....do	18,732	10	12	9	10	41	....	2,271	....
33	French creek	Above Meadville, Pennsylvania	618	10	14½	9½	9	43	....	138	....
34	Kanawha river	Charleston pool, Virginia	8,900	12	13	9	10	44	118,291	1,100	108
35	Greenbrier river	Mouth of Howard's creek	810	11	12	8	9	40	....	97	....
36	Scioto	Columbus, Ohio	1,086	10	11½	8	8½	38	....	25	....
37	Lower Fox river	Foot of lake Winnebago	6,046	9	12	9	5	35	....	2,320	....
38	Red river of the North	Fergus Falls, Minnesota	1,613	6	10	4	3	23	....	....	....
39	Do	National boundary	39,577	5	8	3	2	18	....	....	....
40	Bois de Sioux river	Breckenridge, Minnesota	1,996	5	8	3	3	19	....	....	....
41	Mississippi river	Grand Rapids, Minnesota	3,636	7	12	6	3	28	....	....	....
42	Do	Aitkin, Minnesota	5,715	7	12	6	3	28	....	....	....
43	Do	Wabasha, Minnesota	55,876	6½	12	7	3	28½	....	....	....
44	Do	Rock Island, Illinois	87,842	7	12	7½	3½	30	....	....	....
45	Do	Canton, Missouri	133,995	7½	12	8	4	31½	....	....	....
46	Do	Hannibal, Missouri	137,460	7½	12	8	4	31½	....	....	....
47	Wisconsin river	Portage, Wisconsin	8,200	9	12	9	5	35	....	2,800	....
48	Minnesota river	Foot of Big Stone lake, Minnesota	920	6½	12	5	3	26½	....	11	....
49	Do	Above Redwood river	8,540	6½	11	5	3	25½	....	217	....
50	Do	Judson, Minnesota	11,940	6½	11	5	3	25½	....	397	....
51	Do	Mouth	17,230	6½	11	5½	3	26	....	1,155	....
52	Illinois river	....do	29,013	11½	11	9	8	39½	....	1,600	....
53	Des Moines river	....do	14,578	8½	13½	9	4	35	....	....	....
54	Cedar river	....do	7,715	9½	13½	8½	4½	36	....	....	....
55	Missouri river	Saint Charles, Missouri	527,000	6±	6±	4±	3±	19±	430,000	15,000	29
56	Gasconade river	Below Vienna, Missouri	3,181	12	11	8	7	38	....	450	....
57	Kansas river	Topeka, Kansas	56,354	8±	7±	6±	3±	24±	....	2,000	....
58	Big Sioux river	Mouth	7,880	6½	11	5½	3	26	....	....	....
59	Meramec river	... do	3,914	11½	12	8	7	38½	....	600	....
60	Arkansas river	Arkansas City, Kansas	44,500	3	9	3	2	17	....	675	....
61	Do	Mouth	160,000	....	....	....	....	....	....	....	....
62	White river	Sixty-seven miles below Forsyth, Missouri	5,511	13½	11	10	9	43½	....	264	....
63	Do	Mouth	27,925	13½	11	10	9	43½	....	....	....
64	Ouachita river	Camden, Arkansas	5,600	15	12	11	12	50	....	....	....
65	Do	Monroe, Louisiana	16,050	17	12	11	14	54	....	....	....
66	Niagara river	Niagara Falls, New York	....	....	....	....	....	....	....	....	....

regarding flow of streams.

Minimum flow, cubic feet per second per square mile.	Ordinary low-water flow, cubic feet per second.	Ordinary low-water flow, cubic feet per second per square mile.	Remarks and authority.	
0.30	2,800	0.60	Information given the writer for this report. Also *Transactions American Society Civil Engineers*, 1878, p. 241	1
0.31	....	....	Information given the writer for this report	2
0.17	126	0.35	C. Herschel. *Transactions American Society Civil Engineers*, 1878, p. 241	3
0.135	....	....	J. P. Frizell. See *Proceedings American Society Civil Engineers*, 1879, p. 110	4
0.036	12.5	0.16	*Transactions American Society Civil Engineers*, 1881	5
0.20	....	....	*Massachusetts State Board of Health.* Report for 1876	6
0.303	1,210	0.305	Professor Robert Fletcher	7
0.513	....	....	T. G. Ellis. Of late years the flow has been much lower	8
0.34	....	....	H. Loomis. *Report of New York Board of Public Works*, 1879	9
0.32	....	....	Measurements about 1867–1870	10
0.178	....	....	J. J. R. Croes. See *Proceedings American Society Civil Engineers*, 1879, p. 110	11
0.016	....	....	Do	12
....	200–250	0.075–0.094	Mr. Warren Curtis (estimated)	13
0.23–0.28	....	....	D. H. Van Auken	14
0.28	1,500	0.30	Not gauged. *Supreme Court decree*	15
0.12	....	....	Statements regarding power, etc.; not a gauging	16
0.24	....	....	J. J. R. Croes and G. W. Howell	17
0.22	....	....	Ashbel Welch; gauging	18
0.29	....	....	Ashbel Welch. *Transactions American Society Civil Engineers*, 1881	19
0.16	....	....	H. P. M. Birkinbine	20
0.022	....	....	W. R. Hutton. *Transactions American Society Civil Engineers*, 1881, p. 242	21
0.078	....	....	Do	22
0.093	....	....	Do	23
0.114	29	0.455	Do	24
0.167	....	....	James Herron. *Seventeenth Report of Board of Public Works of Virginia*, 1832	25
0.191	....	....	H. D. Whitcomb	26
....	193	0.193	W. C. Kerr; gauging	27
....	3,711−	0.22−	Gauging by G. B. Yuille at a stage above ordinary low water	28
....	1,420	0.35	Gauging at mean low water	29
0.34	....	....	Estimate from a gauging, by Mr. T. P. Roberts	30
0.12	....	....	"Said to be reached at times"	31
0.12	....	....	Gaugings, in 1879, by J. H. Harlow. See *Transactions American Society Civil Engineers*, 1881, p. 238	32
0.22	....	....	Gauging many years ago	33
0.123	....	....	W. R. Hutton. See *Transactions American Society Civil Engineers*, 1881, p. 242	34
0.12	....	....	Do	35
0.015	....	....	Gaugings in 1823–'24	36
0.38	2,500	0.413	Stated by United States Engineers. Stream is regulated by a large lake	37
....	602	0.410	Authority not given	38
....	2,800	0.070	Do	39
....	50	0.025	Do	40
....	960+	0.27+	Gauging at 0.4 foot below mean low water	41
....	1,743+	0.305+	Gauging at 0.2 foot below mean low water	42
....	10,000	0.179	Volume adopted for low-water discharge by government engineers	43
....	19,000	0.216	Do	44
....	26,000	0.194	Do	45
....	30,000	0.218	Do	46
0.34	....	....	United States Engineers	47
0.012	....	....	*Report of Chief of Engineers*, 1875, Appendix J, p. 53	48
0.025	....	....	Do	49
0.033	....	....	Do	50
0.007	....	....	Do	51
0.055	1,750	0.060	Major G. J. Lydecker, United States Army	52
....	....	0.090	Assumed by Mr. Porter in this volume	53
....	....	0.119	Do	54
0.028	....	....	Assumed for ordinary extremes, based on gaugings	55
0.14	....	0.18	Minimum as given by T. J. Johnson; ordinary low water as assumed by Mr. Porter	56
0.035	....	0.043	Minimum during an extreme drought; ordinary low water as assumed by Mr. Porter	57
....	....	0.025–0.027	Assumed by Mr. Porter in this report	58
0.15	....	0.18	Minimum as estimated by Mr. E. Schmidt, 1880; ordinary low water as taken by Mr. Porter	59
0.015	....	....	Measured by J. D. McKown	60
....	3,000	0.019	Estimated by Major Suter, United States Army	61
0.048	....	....	Measured by A. Livermore	62
....	3,000	0.1074	Estimated by Major Suter, United States Army	63
....	....	0.063	Estimated	64
....	....	0.037	Gauging, when river was 10 or 12 inches above low water, gave 0.050	65
....	....	....	Average flow, 166,600 cubic feet per second, according to U. S. Engineers. Principal fluctuation is due to wind	66

The following tables contain a summary of information regarding the larger developed and undeveloped water-powers of the country, compiled from the different reports. It is not to be supposed, however, that every large power has been included. The line had to be drawn somewhere, and it was taken at about 2,000 horse-power, but it is quite possible that some powers have been omitted which are in many respects better than some which have been included. It is further to be remarked that the reports on the Mississippi river and some of its tributaries, not having been sent to press when this introduction was written, were not accessible to the writer, and the tables, as well as the general discussion, are in so far incomplete. Nevertheless a general idea will be obtained from the tables regarding the larger powers of the country, their importance, and their distribution. The table of developed powers shows that New England possesses at least ten developed powers of 10,000 theoretical horse-power or over during working-hours (although they are not all at present so developed as to be able to store the water at night), at least eighteen of over 3,000 horse-power continuously, and at about twenty of over 2,000 horse-power continuously. The basin of lake Ontario contains a dozen powers of large size, and a number exist in the middle states; but in the southern Atlantic and Gulf states there are but three, all of them large, however. West of the Alleghanies there is, with the exception of the comparatively small power at Lawrence, Kansas, not a single large developed power except in the Northwest. In the table of undeveloped power a large number of powers in the southern Atlantic states are included; but the remark on page xix must here be recalled, that on account of the comparative absence of abrupt falls on the larger streams in this region many of the powers so enumerated would admit of development only at a cost which would in many cases be perhaps almost prohibitory. It is again noticeable, however, that, excepting the powers in the Northwest, there is but one undeveloped power west of the Alleghanies of sufficient importance to be included in the table.

Large developed powers of the United States.

[NOTE.—Abbreviations in last column but one: **N. E.**, report on eastern New England; **L. I.**, report on the streams tributary to Long Island sound; **H. R.**, report on the Hudson River basin; **L. O.**, report on the streams tributary to lake Ontario; **M. A.**, report on the middle Atlantic water-shed; **S. A.**, report on the southern Atlantic water-shed; **E. G.**, report on the eastern Gulf slope; **N. W.**, report on the rivers of the Northwest; **M. R.**, report on the Missouri River basin; **N. R.**, report on the streams tributary to lakes Huron and Erie, and on the Niagara river.]

Locality.	Stream.	DAM. Length.	DAM. Average height.	Total fall available.	Gross or theoretical horse-power available.	Total fall utilized.	Horse-power utilized.	Reference in these volumes.	Remarks.
Massachusetts.		*Feet.*	*Feet.*	*Feet.*		*Feet.*			
Lawrence	Merrimack river	900	32	30	Minimum is 11,000 during working hours.	26 to 30	Minimum is 10,000 gross.	N. E. p. 25.	Nearly all the permanently available power is utilized.
Lowell	do	1,093.5	10±	33	Minimum is about 11,845 during working hours.	33	Minimum is about 11,845 gross.	N. E. p. 30.	Do.
Holyoke	Connecticut river	1,017	35±	56	24,000	56	12,260 effective horse-power of wheels in use.	L. I. p. 51.	Power estimated for low water of ordinarily dry years, during 24 hours.
Turner's Falls	do	1,000	20 to 30	62.5	22,000	41	4,320 effective horse-power of wheels in use.	L. I. p. 56.	Do.
New Hampshire.									
Manchester	Merrimack river	680	11±	50	Minimum is about 12,000 during working hours.	50	Minimum is about 12,000 gross during working hours.	N. E. p. 35.	Minimum power is here calculated, assuming a slightly larger minimum flow per square mile than at Lowell, and allowing for its use during 11 hours.
Hooksett	do	....	3 to 4	14	Minimum probably at least 1,800 continuously.	14	Rated power of wheels about 350.	N. E. p. 38.	A fine site.
Garvin's Falls	do	550	8	28	Minimum probably at least 3,000 continuously.	....	....	N. E. p. 38.	A pulp-mill being erected in 1[illegible].
Fisherville	Contoocook river	Several	Several	100	2,500 continuously in low season of ordinarily dry years.	100	Rated power of wheels about 1,000.	N. E. p. 47.	Power very wastefully used.
Franklin	Winnipiseogee river.	Several	Several	140	Minimum about 4,000 continuously.	105	Rated power of wheels about 2,500.	N. E. p. 31.	Flow controlled partially by corporations at Lowell and Lawrence.
Great Falls	Salmon Falls river.	{ 375 140	6 } 24 }	55	....	55	Rated power of wheels about 2,500.	N. E. p. 66.	Full power of wheels can not be obtained at all times.
Maine.									
Biddeford and Saco.	Saco river	....	....	40	1,700 continuously in low season of ordinarily dry years.	40	Rated power of wheels 4,600.	N. E. p. 72.	Do.
Brunswick	Androscoggin river.	....	....	55	9,000 continuously in low season of ordinarily dry years.	26 to 30	Rated power of wheels 1,500 to 2,000.	N. E. p. 79.	A fine site.

Large developed powers of the United States—Continued.

Locality.	Stream.	DAM. Length.	DAM. Average height.	Total fall available.	Gross or theoretical horse-power available.	Total fall utilized.	Horse-power utilized.	Reference in these volumes.	Remarks.
		Feet.	*Feet.*	*Feet.*		*Feet.*			
Lisbon Falls	Androscoggin river.	....	10	33	5,300 continuously in *low season of ordinarily dry years.*	18	Rated power of wheels about *400.*	N. E. p. 79.	A fine site.
Lewiston	....do	....	12	50	11,900 during 11 hours, minimum.	50	About 11,000 gross or theoretical.	N. E. p. 80.	
Livermore Falls	....do	....	7	14	3,000	29	Very small	N. E. p. 81.	Power estimated for low water of ordinarily dry years during 24 hours.
Jay Bridge Falls	....do	....	....	12	3,000	30	....do	N. E. p. 81.	Do.
Augusta	Kennebec river	956	17	17	3,500	17	About 900 effective	N. E. p. 86.	Do.
Waterville	....do	750	7	20	3,000	20	About 2,000 effective.	N. E. p. 87.	Do.
Kendall's Mills	....do	....	....	22	3,000	....	Probably small	N. E. p. 87.	Do.
Skowhegan	....do	....	....	28+	3,600	....	....do	N. E. p. 87.	Do.
Connecticut.									
Windsor Locks	Connecticut river.	1,500±	3+	33	17,000	20 to 28	1,800 to 1,900 effective.	L. I. p. 48.	Do....But a small portion of the estimated available power of the river is practically commanded *by present works.*
Vermont.									
Bellows Falls	....do	600+	....	52 to 54.5	12,000	52	7,040 effective horse-power of wheels in use.	L. I. p. 58.	Do.
New York.									
Mechanicsville	Hudson river	705	16	20	2,040	16	....	H. R. p. 10.	Do....Being developed in 1882.
Glens Falls	....do	400	5½ to 6½	42	....	42	Total power in use about 2,000 effective horse-power.	H. R. p. 16.	*Do....Supply of water* insufficient for present needs during several months of the year.
Palmer Falls	....do	600	25	80	2,270	30	1,450 to 1,500 effective horse-power.	H. R. p. 17.	Do.
Cohoes	Mohawk river	1,400	10	104	9,450	104	6,550 effective horse-power in use in 1880.	H. R. p. 22.	Do.
Schaghticoke	*Hoosac river*	Several	Several	97½	2,210	40½	About 600 effective horse-power in use in 1882.	H. R. p. 34.	Do.
Big falls	Batten kill	205	7 to 12	100	2,170	100	....	H. R. p. 40.	Do ...Being developed in 1882.
Ticonderoga	Ticonderoga creek.	Several	Several	220 to 230	8,000+	175	Over 1,700 effective horse-power of wheels in use.	H. R. p. 63.	Power estimated for ordinary minimum, during 24 hours. Fall of 220 to 230 feet occurs in 2½ miles.
Carthage	Black river	Several	Several	55	6,250	....	1,120 effective horse-power of wheels in use.	L. O. p. 9.	Power estimated for low water of ordinarily dry years, night and day. Fall of 55 feet occurs in about 4,600.
Black River	....do	....	....	16	1,800	12	265± effective horse-power of wheels in use.	L. O. p. 11.	Power estimated for low water of ordinarily dry years, night and day.
Watertown	....do	Several	Several	122	14,550	79	4,075 rated effective horse-power of wheels in use.	L. O. p. 11.	Do....Large amount of power unemployed.
Remington's mill	....do	650	4½ to 6¾	50±	6,020	30	900 rated effective horse-power of wheels in use.	L. O. p. 10.	Do. do.
Brownville	....do	100	17 to 18	17±	2,070	17±	800± effective horse-power of wheels in use.	L. O. p. 10.	Do. do.
Oswego	Oswego river	530	12	20	1,990	12 to 20	2500± effective horse-power of wheels in use.	L. O. p. 24.	Do.
High dam	....do	363	13 to 14	15	1,960	15	200 effective	L. O. p. 27.	Do.
Fulton	....do	503	13½	16	2,050	16	3,130+ effective (Fulton and Oswego Falls)	L. O. p. 28.	Do.
Oswego Falls	....do	413	2 to 3	15	1,030	15			
Outlet of Keuka lake.	....	....	....	277	5,980	63½	420 effective	L. O. p. 35.	Power estimated as the average *for a series of years.*
Rochester	Genesee river	Several	Several	263	8,070	....	6,442 effective	L. O. p. 48.	Power estimated for low water of ordinarily dry years, night and day. Fall of 263 feet occurs within about 5 miles.
Lockport	Erie canal	....	....	57	2,590 to 3,238	57	1,400± effective	L. O. p. 61.	*400 to 500 cubic feet per second* assumed as available for power.

Large developed powers of the United States—Continued.

Locality.	Stream.	DAM.		Total fall available.	Gross or theoretical horse-power available.	Total fall utilized.	Horse-power utilized.	Reference in these volumes.	Remarks.	
		Length.	Average height.							
		Feet.	*Feet.*	*Feet.*		*Feet.*				
New Jersey.										
Paterson	Passaic river	350	8	66	2,150 ±	66	About 2,350 gross or theoretical horse-power.	M. A. p. 130.	Power estimated for of ordinarily dry and day.	ow season ars, night
Lambertville	Delaware river	900 ±	2 to 3	18 ±	5,450	18	540 ± effective	M. A. p. 95.	Power estimated for of the river in lo ordinarily dry year day. Power used of Delaware and Ra Fall of 18 feet occu Water is discharg river and partly to of canal.	ntire flow season of night and om feeder tan canal. n 7 miles. partly to wer level
Trenton	do	800 to 1,000	4 to 5	10 to 15	3,000 to 4,500	10 to 15	500 ± effective	M. A. p. 94.	Power estimated for of ordinarily dry and day. Canal is Power not econo veloped.	ow season ars, night miles long. cally de-
Virginia.										
Richmond and Manchester.	James river	Several	Several	84	10,800	84	About 3,800 effective	M. A. p. 15.	Power estimated for of ordinarily dry and day. Power cally utilized.	ow season ars, night economi-
Lynchburg	do			22	1,850	16	About 700 effective	M. A. p. 20.	Do.	
At 15 dams on the	do			196	A total of 16,050	0	None	M. A. p. 23.	Power estimated fo of ordinarily dry and day.	ow season ars, night
Petersburg	Appomattox river.	Several	Several	110	2,940	78	About 1,275 effective	M. A. p. 24.	Do.	
Georgia.										
Augusta	Savannah river	1,720	10.63	50 (at low water).	13,685	50	About 3,650 (effective?).	S. A. p. 127.	Do.	
Columbus	Chattahoochee river.	Several	Several	120	34,080	50	2,100 ± effective	E. G. p. 22.	Do....Fall of 12 within naviga	eet occurs miles of waters.
Alabama.										
Tallassee Falls	Tallapoosa river	300 (wing-dam).	6 to 15	84	10,880	82	About 900 effective	E. G. p. 8.	Do....Probabl tire fall availab	ot the en 84 feet is
Wisconsin.										
Appleton	Lower Fox river	{ 700 450 417 }	{ 16 10 10 }	36	10,200	36	Perhaps 3,800 effective.	N. W. p. 27.	Power estimated f low water.	ordinary
Grand Kaukauna	do	613		50	14,182			N. W. p. 38.	Do.	
Marinette	Menominee river	Several	Several	19	3,930	19	About 820 effective	N. W. p. 62.	Do.	
Minnesota.										
Fergus Falls	Red river of the North.	Several	Several	40	6,225	83		N. W. p. 87.	Do.	
Minneapolis (St. Anthony's Falls).	Mississippi river			70	25,000	50			Estimated power is much above the mi ing 24 hours.	obably not num, dur-
Kansas.										
Lawrence	Kansas river	600	8	9	2,250	9	About 300 effective	M. R. p. 57.	Power estimated fo of ordinarily dry	ow water ars.

Large undeveloped powers of the United States.

[NOTE.—Abbreviations same as in foregoing table.]

Locality.	Stream.	Total fall available.	Distance in which the fall in the preceding column occurs.	Estimated gross or theoretical horse-power.	Reference in these volumes.	Remarks.
		Feet.				
Sewell's falls, N. H.	Merrimack river	19	1.75 mile		N. E. p. 38.	Minimum power is several thousand horse-power continuously. See description.
Near Milton Three Ponds, N. H.	Salmon Falls river	200	About 3 miles.	Probably 2,000 to 2,500 at all times during working hours.	N. E. p. 67.	Flow controlled by mills below.
Salmon Falls, Me	Saco river	62	3,500 feet	2,400	N. E. p. 73.	Power estimated for low season of ordinarily dry years, night and day.
West Buxton, Me	do	62	About 2 miles.	2,300	N. E. p. 73.	Do.
Near Steep falls, Me	do	131	About 3 miles.	4,500	N. E. p. 73.	Do.
Rumford Falls, Me	Androscoggin river	162	About 1 mile.	13,252	N. E. p. 81.	Do.
Berlin falls, N. H	do	200	About 1 mile.	Very large	N. E. p. 81.	
Madison Bridge falls, Me.	Kennebec river	87	2½ miles	11,000–12,000.	N. E. p. 87.	Power estimated for low season of ordinarily dry years, night and day. This site is utilized to a small extent.
Caratunk falls, Me	do	30	20 feet in one pitch.	3,000–3,500	N. E. p. 87.	Power estimated for low season of ordinarily dry years, night and day.
College rapids, Me	do	20	10 feet in 10 rods.	3,000	N. E. p. 87.	Do.
Piscataquis falls, Me	Penobscot river	22		3,000–3,500	N. E. p. 93.	Do.
Island Rapids, Me	do	15	1,650 feet	2,000–2,500	N. E. p. 93.	Do.
Near Norwich, Conn	Quinebaug river	50	About 6 miles.	1,760	L. I. p. 33.	Power estimated for low water of ordinarily dry years, night and day.
Sumner's falls, N. H. and Vt.	Connecticut river	15		2,500	L. I. p. 60.	Do.
Olcott or White River falls.	do	35		4,370	L. I. p. 60.	Do......Being developed in 1882.
Falls Village, Conn	Housatonic river	95		2,700	L. I. p. 146.	Do......No power used.
Above Troy, N. Y	Hudson river	18–30		3,070	H. R. p. 10.	Do. do.
Trenton Falls, N. Y	West Canada creek	200	About ½ mile.	1,820	H. R. p. 31.	Do. do.
Lyons Falls, N. Y	Black river	64½	250 feet	1,900	L. O. p. 8.	Do ......No power used, but it is proposed to improve this privilege.
Rawson's mill, N. Y	do	16±	600+ feet	1,820	L. O. p. 10.	Do......No power used, but this privilege was formerly developed.
Below Black River village.	do	45±	¾ mile	5,320	L. O. p. 11.	Do.
Two miles below Watertown, N. Y.	do	30±	3,000–4,000	3,610	L. O. p. 16.	Do.
Portage, N. Y	Genesee river	330	2–2½ miles	5,250	L. O. p. 47.	Do.
Little falls, Md. and Va.	Potomac river	10	At dam	2,000	M. A. p. 42.	Power estimated for low season of ordinarily dry years, night and day. Dam not tight.
Great falls, Md. and Va.	do	80–90	1½ mile	20,000+	M. A. p. 43.	Power estimated for low season of ordinarily dry years, night and day.
Weverton, Md	do	25	3 miles	5,100	M. A. p. 43.	Do.
Harper's Ferry, W. Va.	do	22±	1½ mile	2,000	M. A. p. 44.	Do......Only about 125 horse-power utilized.
Do.	Shenandoah river	84	8 miles	5,150	M. A. p. 48.	Do.
Conewago falls, Pa	Susquehanna river	10±	About 1 mile.	10,800	M. A. p. 63.	Do......Formerly partly utilized.
Port Deposit canal, Pa	do	80	9 miles	94,600	M. A. p. 64.	Do......Formerly a navigation canal.
Lambertville, N. J	Delaware river	14	About 4,100 feet.	4,400	M. A. p. 95.	Do......Power being partially developed, and a fall of 9 feet, with 165 effective horse-power intended to be used (1880).
Foul rift, near Belvidere, N. J.	do	23	About 2 miles.	4,000	M. A. p. 97.	Do......Entirely undeveloped.
Weldon, N. C	Roanoke river	84	9 miles	18,500	S. A. p. 29.	Do......Old canal in existence.
Smiley's falls, N. C	Cape Fear river	27	3½ miles	2,860	S. A. p. 57.	Do.
Buckhorn falls, N. C	do	20	½ mile	2,000	S. A. p. 58.	Do......Old canal in existence.
Grassy Island shoal, N. C.	Yadkin river	36	Probably several miles.	8,080	S. A. p. 79.	Do......River very wide. No abrupt fall. Practically not all available.
Narrows of the Yadkin, N. C.	do	105	4 miles	14,910	S. A. p. 79.	Do......Practically unavailable.

Large undeveloped powers of the United States—Continued.

Locality.	Stream.	Total fall available.	Distance in which the fall in the preceding column occurs.	Estimated gross or theoretical horse-power.	Reference in these volumes.	Remarks.
		Feet.				
Bean's shoal, N. C	Yadkin river	39	4 miles	2, 320	S. A. p. 81.	Power estimated for low season of ordinarily dry year night and day. Old canal in existence.
Near Camden, S. C	Catawba river	52	5 miles	8, 850	S. A. p. 91.	Do......Old canal in existence. Power largely avai ble.
Great falls of the	...do	173	8 miles	24, 000	S. A. p. 92.	Do......Old canal in existence. A splendid power argely available.
Landsford, S. C	...do	40	2 miles	5, 270	S. A. p. 94.	Do......Old canal in existence.
Mountain Island shoal, N. C.	...do	46	3 miles	2, 300	S. A. p. 95.	Do......A splendid power. Partially utilized by a otton-mill.
Lookout shoal, N. C	...do	54	3+ miles	2, 100	S. A. p. 96.	Do.
Columbia, S. C	Congaree and Broad rivers	34	4 miles	6, 700	S. A. p. 102.	Do......A splendid power. Old canal in existence.
Ninety-nine Islands shoal, S. C.	Broad river	17. 26	$2\frac{3}{4}$ miles	3, 250	S. A. p. 108.	Do.
Summers' shoal, S. C	...do	11. 61	0.94 mile	2, 000	S. A. p. 108.	Do.
Lockhart's shoal, S. C	...do	47. 66	1.41 mile	4, 500	S. A. p. 108.	Do......Not easy to utilize completely. Perhaps 3,0 horse power easily available.
Ninety-nine Islands shoal, No. 2, S. C.	...do	50. 62	3.20 miles	2, 700	S. A. p. 108.	Do......Complete utilization impracticable.
Cherokee shoal, S. C	...do	50. 95	2 miles	2, 700	S. A. p. 108.	Do. do.
Mouth of river, S. C	Saluda river	34	$2\frac{1}{2}$ miles	3, 200	S. A. p. 117.	Do......Old canal in existence.
Blue Jacket shoal, S. C. and Ga.	Savannah river	10	600 feet	2, 350	S. A. p. 129.	Do.
Long shoal, S. C. and Ga.	......do	35	5 miles	7, 250	S. A. p. 130.	Do.
Trotter's shoal, Ga	......do	75	7 miles	9, 165	S. A. p. 130.	Do.
McDaniell's shoal, Ga	......do	30	5 miles	2, 600	S. A. p. 130.	Do.
Portman's shoal, S. C	Seneca river	60	2 miles	1, 950	S. A. p. 138.	Do.
Anthony's shoal, Ga	Broad river	*a* 40	$1\frac{1}{4}$ mile	2, 500 ±	S. A. p. 134.	Do......Fall and power can not be accurately state
Milledgeville, Ga	Oconee river	34	5 to 6 miles	2, 860	S. A. p. 145.	Do......Not a very good site.
Macon, Ga	Ocmulgee river	40 ±	10 miles	2, 450	S. A. p. 153.	Do. do.
Wetumpka, Ala	Coosa river	80 ±	12 to 15 miles	19, 360	E. G. p. 12.	Power estimated for low water of ordinarily dry years, n ht and day.
Total at 24 shoals above Wetumpka, on the Coosa river.	......do	277 ±		61, 600	E. G. p. 13.	Do......No power utilized except for a single sma grist-mill.
Etowah Mining and Manufacturing Company's privilege.	Etowah river	80	5 miles	3, 360	E. G. p. 16.	Do.
Total at 28 shoals above Columbus, on the Chattahoochee river.	Chattahoochee river	528 ±		100, 000	E. G. pp. 25, 26.	Do.
Louisville, Ky	Ohio river	26	2 miles	Very large	O. R. p. 7.	Canal around falls.
Cedars, Wis	Lower Fox river	9	(Dam)	2, 553	N. W. p. 36.	Power estimated for ordinary low water. A dam is bui across the river, but no power is utilized.
Little Chute, Wis	......do	34	6, 500	9, 644	N. W. p. 36.	Do......A dam 715 feet long and 11 feet high cr es the river, and a flour-mill uses about 100 hor power.
Rapid Croche, Wis	......do	8	(Dam)	2, 269	N. W. p. 41.	Do......A dam 525 feet long and 8 feet high crosses river, and a small amount of power is used.
Little Kaukauna, Wis	......do	7. 5	(Dam)	2, 127	N. W. p. 42.	Do......A dam 586 feet long and $7\frac{1}{2}$ feet high cr ses the river, and a small amount of power is us
Big Quinnesec falls, Wis.	Menominee river	120	Short distance	14, 905	N. W. p. 60.	Do......Would be very costly to develop full fall.
Little Quinnesec falls, Wis.	......do	80	Short distance	9, 936	N. W. p. 61.	Do. do.
Sand Portage rapids, Wis.	......do	40	6 miles	5, 078	N. W. p. 61.	Do.
Pemena falls, Wis	......do	70	2 miles	11, 115	N. W. p. 61.	Do.
White rapids, Wis	......do	20	3 miles	3, 275	N. W. p. 62.	Do.
Grand rapids, Wis	......do	25	3 miles	4, 954	N. W. p. 62.	Do.
Twin Islands rapids, Wis.	......do	10	$\frac{3}{4}$ mile	1, 995	N. W. p. 62.	Do.
Schappee's rifts	......do	7	$\frac{1}{2}$ mile	2, 024	N. W. p. 62.	Do.

a Probably not less.

Large undeveloped powers of the United States—Continued.

Locality.	Stream.	Total fall available.	Distance in which the fall in the preceding column occurs.	Estimated gross or theoretical horse-power.	Reference in these volumes.	Remarks.
		Feet.				
Grand rapids, Minn....	Saint Louis river...........	75	5 miles.......	9,645.........	N. W. p. 74.	Power estimated for ordinary low water.
Below Knife falls, Minn.	......do	154	4½ miles.......	20,451.........	N. W. p. 74.	Do.
Near mouth of........	......do	456	11 miles.......	63,293.........	N. W. p. 74.	Do......Of the total fall, 372 feet occur in the upper 4 miles. The total fall would not be available, but Mr. James B. Francis considered that three-fourths of it would be. This would give 47,469 horse-power.
Niagara river.........	From lake Erie to lake Ontario.	333	37 miles.......	6,294,000.....	N. R. p. 11.	Power estimated for average flow. No power utilized except at falls.
Do.............	Niagara falls and rapids....	213	Less than a mile.	4,000,000.....	N. R. p. 11.	Do......Total power of present wheels (1882) 5,200 effective horse-power.

The following table contains a compilation of information regarding water-power companies, prices for power, methods of regulating, etc. In it will be found, arranged geographically, all the localities where power is regularly leased, excepting some which may exist in the Mississippi basin, the report on which was, as has been mentioned, not accessible to the writer. It will be seen from this table that where power and not water is leased, the prices per theoretical horse-power range from $1 to $50 per annum. Probably the lowest price is that reported on the Lower Fox river in Wisconsin, while the highest rates (leaving out of consideration certain cases at some of the larger powers, where the use of surplus is in the nature of a violation of rule and is charged very heavily) are at Trenton, Paterson, and Passaic, New Jersey, Manchester, Virginia, and on the Great Miami river, in Ohio.

The cost of water-power in the United States.

[NOTE.—For explanation of abbreviations see table on page xxx.]

Locality.	Stream.	Available power.	Name of company owning privilege.	Rates for power.	Methods of regulating quantity of water.	Reference in these volumes.	Remarks.
Pawtucket, R. I...	Blackstone river..	....	Power owned by individuals.	Small amounts of power rented, generally with floor-space, and under special agreements.	Apertures proportioned to quantities owned.	N. E. p. 14.	Permanent power completely utilized.
Central Falls, R. I.	....do	....	....do	No power rented..............	......do	N. E. p. 14.	Do.
Woonsocket, R. I..	....do	....	....do	......do	Weirs whose lengths are proportioned to quantities owned.	N. E. p. 14.	Do.
Lawrence, Mass ...	Merrimack river..	Minimum is 11,000 gross horse-power during working hours.	Essex Company ..	$14 08 per gross horse-power per annum for constant power 16 hours per day; surplus power at from 4.7 cents to 9.4 cents per gross horse-power per day, according to amount used.	Weir and flume measurements, etc., carried on with the greatest care.	N. E. p. 25.	Permanent power nearly all utilized.
Lowell, Mass	....do	Minimum is about 11,845 gross horse-power during working hours.	Proprietors of Locks and Canals on Merrimack river.	Original cash payment and annual rent of $3 53 per gross horse-power for constant power 15 hours per day; surplus power at from 1.2 to 23.5 cents per gross horse-power per day, according to amount used and stage of the river.	......do	N. E. p. 30.	All the permanently available power is utilized.
Manchester, N. H..	....do	Minimum is about 12,000 gross horse-power during working hours.	Amoskeag Manufacturing Company.	Original cash payment and annual rent of $3 47 per gross horse-power for constant power 10 hours per day; surplus power at 5.8 cents per gross horse-power per day.	Observations on height of speed-gate and of water in pen-stock and pit.	N. E. p. 35.	Do.
Biddeford and Saco, Me.	Saco river	1,700 gross horse-power in low season of ordinarily dry years, without storage.	Saco Water Power Company.	Permanent power owned. Rate for surplus power 3.52 cents per gross horse-power per day.	Daily observations of height of speed-gate and of water in pen-stock and pit.	N. E. p. 72.	*Do.*
Lewiston, Me	Androscoggin river.	Minimum is nearly 12,000 gross horse-power during working hours.	Union Water Power Company.	$1 87 to $9 37 per gross horse-power per annum.	Measurements lately made, once for all, to determine quantity used by each mill.	N. E. p. 80.	*Nearly all the permanently available power is utilized.*
Windsor Locks, Conn.	Connecticut river.	17,000 theoretical horse-power in low water of ordinarily dry years, night and day for entire river. Practically limited by existing works to a less amount.	Connecticut River Company.	Perpetual lease of water and land. Nominal water-rental is $2 50 per square inch of orifice under a head of 30 inches, equivalent to $13 50 per annum per gross or theoretical horse-power with a fall of 30 feet, and $20 30 with a fall of 20 feet.	....	L. I. p. 48.	

The cost of water-power in the United States—Continued.

Locality.	Stream.	Available power.	Name of company owning privilege.	Rates for power.	Methods of regulating quantity of water.	Reference in these volumes.	Remark
Holyoke, Mass	Connecticut river.	24,000 theoretical horse-power in low water of ordinarily dry years, night and day.	Holyoke Water Power Company.	Rate for permanent power can not be stated; surplus power at 2.9 cents per theoretical horse-power for 12 hours.	Tests of wheels previous to setting, and daily observation of heights of gates, and of water in pen-stock and pit.	L. I. p. 51.	Greater part [illegible] util- ized pow[illegible] em- ployed for [illegible] aper- mills. Co[illegible] ider- able powe[illegible] still available.
Turner's Falls, Mass.	....do	17,600 theoretical horse-power in low water of ordinarily dry years, night and day.	Turner's Falls Company.	Usual rate has been $7 50 per annum per horse-power (not further specified), but there is no established rate for the future.	Weir measurements in the tail-races made as often as desirable.	L. I. p. 56.	Do.
Bellows Falls, Vt..	....do	12,000 theoretical horse-power in low water of ordinarily dry years, night and day.	Bellows Falls Canal Company.	Nominal rate $7 50 per annum per horse-power (not further specified).	No accurate measurements made; quantities rated for wheels in use are accepted in practice.	L. I. p. 58.	Power nea[illegible] all employed [illegible]r pa- per-mills.
Unionville, Conn ..	Farmington river.	860 theoretical horse-power in low water of ordinarily dry years, night and day.	Union Water Power Company.	Perpetual lease at $175 per mill-power per annum, a mill-power being 7½ cubic feet per second under a head of 18 feet, or 15.34 theoretical horse-power; that is, the price is $11 35 per theoretical horse-power per annum.	Quantity used determined by wheel-ratings without measurement.	L. I. p. 76.	All the per[illegible]nent power is [illegible]eady in use.
Greeneville, Conn.	Shetucket river...	Total rated power of wheels in use, 1,600 or 1,700 horse-power.	Norwich Water Power Company.	Water-rights sold with a reserved annual rental of $180 per 1,000 spindle-power.	Quantity determined by area of opening at head-gates.	L. I. p. 20.	
Occum, Conn	....do	200 theoretical horse-power in low water of ordinarily dry years, night and day.	Occum Company..	$20 per annum per horse-power (not further specified).	....	L. I. p. 22.	About 180 (? [illegible]orse- power in [illegible].
Barrett's Junction, Mass.	Swift river.......	200 theoretical horse-power in low water of ordinarily dry years, night and day.	Barrett's Junction Water Power Company.	$9 per annum per horse-power (not further specified).	....	L. I. p. 102.	About 125 e[illegible]ctive horse-pow[illegible] util- ized.
Birmingham, Conn.	Housatonic river .	1,375 theoretical horse-power in low water of ordinarily dry years, night and day.	Ousatonic Water Company.	Power leased for ninety-nine years, per square foot. *Permanent water*, $20 per annum per theoretical horse-power; *first surplus*, $12 per annum per theoretical horse-power; *second surplus*, $8 per annum per theoretical horse-power. Company does not guarantee power in any case.	Float or weir measurements made when considered necessary, but not regularly.	L. I. p. 141.	Power to b[illegible] used 12 hours p[illegible] day. Permaner[illegible] pow- er still av[illegible]able.
Do............	Naugatuck river..	Total effective (rated) power of wheels in use, 590.	Birmingham Water Power Company.	....	Flume and orifice in tail-race.	L. I. p. 148.	Permanent [illegible]ower all leased.
Ansonia, Conn....	....do	Total effective (rated) power of wheels in use, 1,600 horse-power.	Ansonia Land and Water Power Company.	Water leased by the square foot, under a head of 30 inches estimated to produce 30 theoretical horse-power. *Permanent water*, $600 per annum per square foot; *surplus water*, $250 to $500 per annum per square foot.	Accurate measurements are not attempted.	L. I. p. 148.	Ordinary p[illegible]er of privilege [illegible]lly in use.
Cohoes, N. Y.......	Mohawk river....	9,450 theoretical horse-power in low water of ordinarily dry years, night and day.	The Cohoes Company.	Perpetual lease of land and power with reserved rent amounting to $14 67 per annum per theoretical horse-power.	Weir and flume measurements, made whenever there is a change in the running of the wheels, or oftener if necessary.	H. R. p. 24.	The compa[illegible] still has pe[illegible]anent power to [illegible]ase.
Oswego, N. Y	Oswego river	1,170 theoretical horse-power in low water of ordinary years, night and day.	Oswego Canal Company.	999-year lease of water. Water leased by the "run" equal to 11⅓ cubic feet per second under 20 feet fall. Price of *first-class runs* equals $13 11 per annum per theoretical horse-power; of *second-class runs*, $9 36 to $11 24; of *surplus runs*, $6 55 to $8 74.	....	L. O. p. 25.	
Do............	....do	820 theoretical horse-power in low water of ordinary years, night and day.	Two individuals..	Perpetual lease of water by the "run", or 33⅓ cubic feet per second under a head of 10 feet. Cost of *first-class runs*, from $6 60 to $7 92, and of *second- and third-class runs*, from $3 30 to $3 96 per annum per theoretical horse-power.	....	L. O. p. 25.	
Rochester, N. Y....	Genesee river.....	8,970 theoretical horse-power in low water of ordinarily dry years, night and day.	Owned principally by the manufacturers themselves.	At one privilege power is rented at $25 per annum per effective horse-power.	Water drawn from canals over weirs, whose lengths are proportioned to amount of power owned. Weirs adjusted by commissioners appointed by the court.	L. O. p. 48.	With the [illegible]resent developn[illegible]nt, all the mills [illegible]an be run at f[illegible] capa- city dur[illegible]g only nine [illegible] ten months [illegible] the year.

The cost of water-power in the United States—Continued.

Locality.	Stream.	Available power.	Name of company owning privilege.	Rates for power.	Methods of regulating quantity of water.	Reference in these volumes.	Remarks.
Lockport, N. Y	Erie Canal	2,590 to 3,238 theoretical horse-power.	Lockport Hydraulic Company.	Perpetual lease or absolute purchase. Price from $8 33 to $11 11 per annum per theoretical horse-power.	Amount judged from wheel-ratings, with occasional measurements in the tail-races.	L. O. p. 61.	Water-power reliable for the greater part of the year, but not always.
Niagara Falls, N. Y	Niagara river	About 4,000,000 theoretical horse-power in ordinary stage, night and day.	Niagara Falls Hydraulic Power and Manufacturing Company.	When company maintains water-wheels and main shafting, the price is $10 per horse-power (not further specified) per annum. When manufacturers supply their own wheels, price is $7 per horse-power per annum up to 1,000 horse-power, and less for larger powers.	Not stated	N. R. p. 14.	Enormous power still available.
Passaic, N. J	Passaic river	About 800 theoretical horse-power in low season of ordinarily dry years, night and day.	Dundee Water Power and Land Company.	About $33 33 per annum per gross or theoretical horse-power for 12 hours a day.	No regular measurements made. Prices based on a measurement made, once for all, several years ago.	M. A. p. 132.	
Paterson, N. J	do	About 2,150 theoretical horse-power in low season of ordinarily dry years, night and day.	Society for Establishing Useful Manufactures.	$750 per annum per square foot of orifice under a head of 2.75 feet to center, equivalent to about $36 per annum per theoretical or gross horse-power.	No regular measurements made. Orifices in flumes or apertures in turbines used as basis of calculations.	M. A. p. 130.	All the permanent power already utilized.
Raritan, N. J	Raritan river	216 theoretical horse-power in low season of ordinarily dry years, night and day.	Raritan Water Power Company.	Nominal price, $300 to $400 per annum per square foot of orifice under a head of 30 inches to center of orifice.	None, except, perhaps, by orifices.	M. A. p. 126.	Power not economically developed.
Trenton, N. J	Delaware river	3,000 to 4,500 theoretical horse-power in low season of ordinarily dry years, night and day.	Trenton Water Power Company.	$3 and $4 per square inch under a head of 3 feet; equivalent to about $37 50 and $50 per annum per theoretical horse-power.	No measurements made regularly. A measurement was made several years ago, once for all, and prices fixed accordingly.	M. A. p. 94.	About 500 gross horse-power utilized.
Fredericksburg, Va	Rappahannock river.	1,860 theoretical horse-power in low season of ordinarily dry years, night and day.	Fredericksburg Water Power Company.	From $5 to $15 per horse-power (not further specified).	No measurements made.	M. A. p. 86.	
Manchester, Va	James river	Can not be stated	City of Manchester.	50-year leases at $4 per annum per square inch of orifice under a head of 3 feet, corresponding theoretically to between $20 60 and $42 10 per annum per theoretical horse-power, according as the fall is 20 or 14 feet.	No precautions taken to regulate exactly the amount of water used.	M. A. p. 15.	Generally sufficient water for all mills at present running.
Augusta, Ga	Savannah river	13,635 theoretical horse-power in low season of ordinarily dry years, night and day.	City of Augusta	$5 50 per horse-power (not further specified).	Optional with city engineer.	S. A. p. 127.	Price *probably* refers to gross or theoretical horse-power.
Hamilton, Ohio	Great Miami river		Hamilton and Rossville Hydraulic Company.	Water leased in "mill-stone powers"; price is equivalent to from $19 09 to $44 05 per annum per theoretical or gross horse-power.	Water delivered over fixed iron weirs.	O. R. p. 48.	Permanent power completely utilized.
West Hamilton, Ohio.	do		West Hamilton Hydraulic Company.	$200 per annum per "run", which equals 375 cubic feet per minute.		O. R. p. 40.	Do.
Middletown, Ohio	do		Middletown Hydraulic Company.	$28 04 per annum per theoretical horse-power. Company reserves right to shut off water 30 days in the year.	Fixed weirs	O. R. p. 49.	Do.
Franklin, Ohio	do	600 theoretical horse-power in low water of *ordinarily* dry years, night and day.	Franklin Hydraulic Company.	$29 37 per annum per theoretical horse-power.	None, on account of abundance of water.	O. R. p. 50.	Permanent power not all utilized. Effective power *of wheels in use*, 280 horse-power.
Dayton View, Ohio	do	270 theoretical horse-power in low water of ordinarily dry years, night and day.	Dayton View Hydraulic Company.	$36 71 per annum per theoretical horse-power, in 99-year leases.		O. R. p. 51.	150 ± effective horse-power of wheels in use.
Dayton, Ohio	Mad river		Dayton Hydraulic Company.	$30 21 per annum per theoretical horse-power.	Adjustable orifices	O. R. p. 52.	
Do	Miami and Erie canal.		Cooper Hydraulic Company.	The greater part at $24 75 and $27 93 per annum per theoretical horse-power.	Fixed apertures	O. R. p. 63.	

The cost of water-power in the United States—Continued.

Locality.	Stream.	Available power.	Name of company owning privilege.	Rates for power.	Methods of regulating quantity of water.	Reference in these volumes.	Remarks.
Appleton, Wis	Lower Fox river..	10,200 theoretical horse-power at ordinary low water.	....	Power leased with necessary land. A 500 to 1,000 horse-power site at $1 to $2 per annum per horse-power; a 100 to 300 horse-power site at $3 to $4 per annum per horse-power; a 50 horse-power site of one-half acre at $2 to $3 per annum per horse-power.	....	N. W. p. 19. p. 27.	
Kaukauna, Wis....	....do	14,182 theoretical horse-power at ordinary low water.	Kaukauna Water Power Company.	A 100 to 300 horse-power site at from $2 to $5 per annum per horse-power.	....	N. W. p. 20. p. 38.	
Lawrence, Kans...	Kansas river......	2,250 theoretical horse-power at low water of ordinarily dry years.	Mr. J. D. Bowersock.	$20 per horse-power	Power not measured, but estimated approximately.	M. R. p. 57.	

The following table contains condensed information regarding water-power used from navigation canals, w ih rates for power, etc.:

Water-power used from navigation canals.

[NOTE.—For explanation of abbreviations, see table on page xxx.]

Canal or company.	Conditions of lease.	Rates for power.	Methods of regulating.	Total amount of power used; effective horse-power.	Reference in these volumes.	Remarks.
New York State canals.	Surplus water only; policy of the state is not to dispose of any more power; water entirely drawn off at times.	Leased to highest bidders....	....	2,391	L. O. p. 64.	Excluding power at fe ior- dams.
Delaware and Raritan canal.	Surplus water only; no guarantee, and water entirely drawn off at times.	Nominal price, $3 per square inch under a head of 3 feet, but special agreements often made.	None	....	M. A. p. 96.	Principal use of powei on the feeder-canal, at im- bertville, New Je oy, where about 540 l eso- power is used.
Lehigh Canal and Navigation Company.	Surplus water only; water drawn off at times.	From $1 to $4 per square inch of aperture under a head of 3 feet to center of orifice, according to the fall and other circumstances.	Standard orifice put in....	About 800...	M. A. p. 107.	Company still has omo power to dispose of.
Schuylkill Navigation Company.	Surplus water only; but quantity so regulated that a steady power can be maintained.	For mills running 10 hours per day, $6 per square inch per annum; for mills running 24 hours, $7 50 per square inch per annum, under a head of 3 feet to center of aperture.	Flume measurements where turbines are used, and standard apertures for other wheels.	About 1,750.	M. A. p. 104.	
Pennsylvania canal....	Surplus water only; no guarantee of water or power, and water drawn off at times.	Perhaps $2 to $5 per horse-power per annum, but no regular rates.	None	About 400 ..	M. A. p. 63.	Considerable power is vail- able at the locks, out 5,700 theoretical rse- power in all over tl on- tire canal.
Chesapeake and Ohio canal.	Surplus water only; no head or quantity guaranteed; water drawn off at times.	$2 50 per square inch per annum, in 20-year leases.	Water leased by square inch of opening, and a standard orifice is specified.	Perhaps 1,500	M. A. p. 41.	Principal use of powe s at Georgetown, D. C., iere about 1,200 horse- wer is utilized.
James River and Kanawha canal.	Surplus water only	According to location, $3, $1 10, and 70 cents per cubic foot per second for each foot fall, equal to respectively $20 41, $9 68, and $6 16 per gross or theoretical horse-power per annum.	Water delivered through an orifice.	....	M. A. p. 17.	This canal is now ban- doned.
State of Ohio	At dams on Muskingum river; surplus power leased under 30-year leases, and at expiration of lease power sold by auction; state reserves right to shut off water one month in the year.	No uniformity in rates.......	Leases specify that water shall be taken over weirs, but practically they are not used.	1,100 to 1,200 rated power of wheels.	O. R. p. 36.	
Ohio State canals	Surplus water flowing around a certain lock; or water sufficient for a certain number of runs of stones; or a certain number of cubic feet per minute. Right reserved to shut off water for 30 days per year.	...do	Practically none	6,618	O. R. p. 59.	Many powers still 1 util- ized.

Finally, the following table shows the power utilized, by drainage basins, only the larger streams being specified. From this it is seen that the basin of the Blackstone is the one in which there is the greatest amount of water-power utilized per square mile, while in the basins of the Missouri, Arkansas, and Red rivers the utilized water-power is practically *nil* in proportion to the area drained:

Stream.	Drainage area.	Utilized net or effective horse-power.	Utilized power per square mile.	Approximate rank.
	Sq. miles.		*H. P.*	
Blackstone river	458	19, 994	43. 655	1
Taunton river	337	4, 097	12. 157	4
Charles river	281	3, 362	11. 964	5
Merrimack river	4, 916	88, 818	18. 067	3
Saco river	1, 753	8, 129	4. 637	15
Presumpscot river	726	5, 430	7. 479	9
Androscoggin river	3, 698	15, 741	4. 257	18
Kennebec river	6, 404	11, 277	1. 761	20
Penobscot river	8, 785	9, 200	1. 047	28
Saint Croix river in Maine	1, 674	772+	0. 461	45
Saint John river in Maine	7, 998	862±	0. 108	53
Connecticut river	10, 924	118, 026	10. 804	7
Thames river	1, 460	30, 523	21. 050	2
Housatonic river	1, 933	21, 159	10. 946	6
Hudson river	13, 366	82, 910	6. 203	13
Passaic river	962	8, 159	8. 481	8
Raritan river	1, 098	4, 977	4. 533	16
Delaware river	10, 100	43, 355	4. 293	17
Schuylkill river	1, 912	12, 096	6. 326	11
Susquehanna river	26, 233	70, 283	2. 670	19
Potomac river	14, 500	18, 790+	1. 296	25
Rappahannock river	2, 700	2, 371	0. 878	33
James river	9, 700	13, 323	1. 374	24
Roanoke river	9, 200	8, 426	0. 916	31
Tar river	3, 000	2, 571	0. 857	34
Neuse river	5, 299	3, 250	0. 613	39
Cape Fear river	8, 400	7, 121	0. 848	35
Great Pee Dee river	17, 000	8, 121	0. 478	43
Wateree river	5, 225	5, 158	0. 987	29
Congaree river	7, 965	7, 654	0. 961	30
Savannah river	10,000-11,000	11, 778	1. 122	26
Ocmulgee river	6, 000	3, 100	0. 517	41
Oconee river	5, 400	3, 486	0. 646	38

Stream.	Drainage area.	Utilized net or effective horse-power.	Utilized power per square mile.	Approximate rank.
	Sq. miles.		*H. P.*	
Alabama river	23, 700	10, 169	0. 429	46
Tallapoosa river	4, 935	2, 445	0. 495	42
Coosa river	10, 610	6, 257	0. 590	40
Appalachicola river	19, 580	12, 980	0. 663	37
Chattahoochee river	9, 100	9, 785	1. 075	27
Flint river	8, 420	3, 204	0. 381	48
Black river, New York	1, 857	13, 029	7. 016	10
Oswego river	5, 013	31, 488	6. 281	12
Genesee river	2, 490	13, 898	5. 568	14
Allegheny river	11, 107	19, 340+	1. 741	22
Monongahela river	7, 625	5, 795	0. 760	36
Beaver river	3, 030	4, 602	1. 519	23
Little Kanawha river	2, 290	500	0. 222	50
Muskingum river	7, 740	7, 066	0. 913	32
Scioto river	*6, 400*	*3, 008*	*0. 470*	*44*
Great Miami river	5, 400	9, 489+	1. 757	21
Dakota river	22, 000	228	0. 010	63
Big Sioux river	7, 880	673	0. 085	56
Tributaries of the Missouri river in southeast Dakota.	32, 110	1, 034	0. 032	62
Tributaries of the Missouri river in western Iowa.	10, 000	2, 265	0. 227	49
Tributaries of the Missouri river in northern Missouri.	*17, 000*	2, 958	*0. 174*	51
Platte river and tributaries	90, 000	4, 157	0. 046	59
Kansas river and tributaries	59, 750	6, 501	0. 109	52
Osage river and tributaries	15, 282	1, 347	0. 088	55
Gasconade river and tributaries	3, 700	386	0. 104	54
Missouri River basin	527, 000	21, 012	0. 039	60
Eastern Iowa slope	35, 995	15, 410	0. 428	47
Eastern Missouri slope	*18, 800*	*1, 466*	*0. 078*	*57*
Arkansas river	188, 143	7, 076	0. 038	61
White river, Arkansas	27, 925	2, 146	0. 077	58
Red river	92, 700	778	0. 008	64

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Special Agent, Tenth Census.

NEW YORK, N. Y., *December*, 1885.

I have examined the above summary, prepared by Mr. Swain, in connection with the various reports to which it relates, and give it my unqualified indorsement.

It was originally arranged that this summary should be prepared by Mr. Swain and myself jointly, but the pressure of other duties has prevented me from taking any part in it except to examine and approve it. I regard it as a most thorough, complete, and scholarly abstract and presentation of the results of the reports.

W. P. TROWBRIDGE.