K K 16.

CONSTRUCTION OF A CANAL AROUND THE CASCADES OF THE COLUMBIA RIVER, OREGON.

The plans for this improvement contemplate the construction of a canal 7,200 feet long, 3,150 feet of which will be in excavation across a rocky plateau on the Oregon side, and the remainder, 4,050 feet, an improved water-way 50 feet wide at bottom, closely following the shore-line below the falls and protected against the floods and currents of the river by a cribwork breakwater rising to an average height of 65 feet. The locks, two in number and combined, will be located on the lower side; they will be 300 feet long and 70 feet wide, with lifts of 12 and 14 feet respectively, and walls carried up above high-water mark. The guard gate at the upper end of the canal will be 70 feet wide, and will be connected on the north side with the upper lock by a water-tight cribwork rising above high-water mark and inclosing a basin 2,000 feet long.

This work is being carried on under a contract with Messrs. Ball & Platt, of New York City, dated October 19, 1878. The contract covers the excavation for both locks and a certain part of the adjacent canal prism, and the building of the masonry of the locks to 7 feet above the floor of the upper lock.

The contractors have also been authorized, on their own application, by the honorable the Secretary of War, under date of December 19, 1878, to construct 1,000 feet of the lower crib-work breakwater as a means of utilizing the waste stone arising from the blasting of the bowlders to be used for masonry.

Immediately after signing the contract, Mr. A. H. Ball, the senior member of the firm, after ordering some necessary machinery, repaired to the cascades, and commenced the construction of the quarters for his men. A small force was also organized to commence the drilling and blasting of the bowlders which lay over the site of the lower lock, and the draining of the small pools above first (upper) lock, which prevented his force working to advantage. The first blast was fired on the 30th of October. The work was started under very encouraging circumstances. The quarters were all constructed within 6 weeks, and the contractors showed a determination to accomplish all that was possible for human ingenuity and enterprise, but they soon met with embarrassments that practically stopped work for the winter. The manufacturers for the construction of the machinery, cranes, derricks, &c., failed to get these articles ready at the appointed time, and after their delivery at the upper landing it became impossible to transport them to the opposite shore on account of the violent winds which blew at short intervals throughout December. This condition of affairs was aggravated by the presence of large masses of floating ice in the river, which would have made the transportation across the river of machinery in small wooden scows (the only facilities then at hand) a matter of great risk and peril to boatmen and machinery, even had there been no wind. By the latter part of December floating ice so filled the river that all of the boats of the Oregon Steam Navigation Company were withdrawn, and navigation was closed for a period of two weeks. During this time the cascades force became completely shut off from all communication either way, except by land.

Under the authority contained in department letter of December 5, 1878, a steam-launch was built for service on the work, at a cost of about

$3,000, and has been in successful and useful operation since April. Two small boats belonging to the contractors have gone over the falls since the work commenced, and one life has been lost. Other casualties would have happened, involving loss of life and property, but for the timely assistance rendered by the steam-launch.

On the 4th of January Mr. A. H. Ball, senior member of the firm of Ball & Platt, died on the work, in consequence of exposure, while superintending his working force and collecting his machinery. His death was a great misfortune to the government, and was the primary cause of all the trouble subsequently experienced in the conduct of the work. In anticipation of his death, some of the laborers struck for higher wages about the 1st of January, but they were paid off and then discharged. The superintendent for the contractors had resigned at the close of the previous month, so that at the time of Mr. Ball's death there was no representative of the contractors on the ground competent to do or direct anything, nor was there any funds of the contractors available for paying the laboring force then employed. On communicating with the surviving partner by telegraph, funds were sent here, which were distributed by my direction, for necessary expenditures of labor and supplies, by my assistant engineer in local charge.

On the 11th of February Mr. Charles P. Skinner, one of the bondsmen for Messrs. Ball & Platt, reached Portland with full legal power to represent the interest of Mr. T. C. Platt; but by reason of the necessary provisions in the State laws for the protection of the interests of the heirs of the deceased partner, he could not assume control of the work except by the consent of the heirs of Mr. Ball. On the 14th of March the widow of Mr. Ball deposited with me a power of attorney for Mr. C. P. Skinner to represent the interest of her deceased husband, and since that day Mr. Skinner has been in full control of the work. The winter was an unusually severe one. December was the most favorable month for work, but as the contractors had not been able to get their machinery upon the grounds, very little work was done. When the new year opened the weather changed suddenly, and from that time till the 1st of May it seldom stopped raining, even for a single day. Especially disagreeable weather prevailed in February; from the 8th to 14th of that month there was a continuous snow-storm, which materially damaged the mess-house of the contractors, and by covering the railroad tracks on the opposite side, closed communication by the lower river for nearly a week. The rainfall, including melted snow, for February was 27 inches; for March, 16.28 inches; for April, 5.2 inches; for May, 7.07 inches; and for June, 1.73 inches; the aggregate for the five months being 57.28 inches.

Prior to May the contractors kept at work a laboring force ranging from 30 to 70 men; but from causes due principally to imperfect organization and to incompetent superintendence, the results accomplished were unsatisfactory. In May the average daily force was 87 laborers, and the progress made was more satisfactory.

The river began to rise on the 6th of February, and on the 27th, having reached 12 feet above low-water, the laboring force was driven from the level on lock No. 2 to that beyond lock No. 1.

March 3 the water began to recede, and fell gradually till the 13th, when it had reached 7.2 feet above low-water above the cascade, and 9 feet 9 inches below. It then began to rise again very regularly under heavy continuous rains, driving the contractors' force successively to higher levels until the 26th of May, when all work had to be suspended.

The water at the time of suspension stood at 23.7 feet upper gauge, and 33.7 at the lower. The water continued to rise until the 18th of June, when it reached the highest observed point of the year, the upper gauge reading 31.2 feet above low-water, and the lower-gauge 42.3 feet. The curve showing these changes accompanies this report, and also a curve showing corresponding water levels at guard gate and lower gate for the different stages.

It is to be regretted that the observations for rises of the water have necessarily extended over so short a period, but limited as they have been, the latter curve is a very interesting and important one, as by it we do not find an exact confirmation of the belief entertained at the time of the preparation of the plans for this work, that the rise of water below the main fall is always 25 per cent. greater than above. We see by an examination of the curve that the rate of change is not constant for different rises of the water, but increases by small increments as the stage decreases. The limited observations which had been made previous to the time the canal references were assumed gave rise to the placing of the reference of the canal bottom below the locks, for a draught of 8 feet at dead low-water, at about 2.5 feet too high. During the canal survey elevations of the water surface were taken along the line of the canal. The stage of water at that time was taken as 4 feet above extreme low-water, based on best information that could be gathered from persons supposed to be familiar with the river. Making a corresponding reduction, and *supposing the water to rise 25 per cent. more below than above the rapids*, the references of extreme low-water were taken as follows:

At guard gate (upper gauge)	(96′.0)
At lock No. 2 (lower gauge)	(75′.5)
Lower end of breakwater	(70′.0)

This fixed the bottom of canal above lock No. 1 at reference (88′), and that of lock No. 2 at (62′).

Systematic readings at the upper gauge were commenced December 12, and the lowest water noted was January 18, when the reference was (96′.5), the water at lock No. 2 being observed for a single reading, by leveling, to be (74′.20).

Systematic readings at the lower gauge did not commence till March 1, and the lowest water thereafter noted March 13, when the gauge read (83′); the upper gauge reading (103′.5), or 6.9 feet above the lowest observed reading of that gauge.

Extreme low-water of the canal below locks, deduced from the observations of the past winter, will be at reference (73′.4), corresponding to extreme low-water (96′) at the guard gate. As the surface at the foot of the breakwater is about 6 feet lower than at the lower gate, the reference at the former locality will be about (67′.5), instead of (70′), as previously assumed.

This change of references necessarily requires increased excavation along the bottom of the canal below the locks to a depth of 2½ to 3 feet, to secure 8 feet draught over miter sill of lower lock at dead low-water, unless the breakwater be so arranged as to permit the inflow of sufficient water from the river to compensate for the diminished depth in the confined water-way behind it. During April and May the assistant engineer, under instructions from this office, endeavored to sink test-pits near the guard gate, for the purpose of ascertaining the level at which bed-rock suitable for founding the masonry of the guard gate upon would be revealed. The water in the river was at so high a stage, and the intervening soil so porous, that with the facilities at his disposal

he found it impossible to keep the pits clear. This examination will be continued at low-water. It was expected when this work commenced that the contractors would use the bowlders exclusively in preparing stone for the masonry for the locks, but in April, after having repeatedly been driven from their working levels by high-water, the contractors leased a piece of land about 1½ miles above the canal and opened a quarry there, under the belief that the stone was softer and could be more easily and economically reduced. High-water has again interfered with them on their new ground, and they have temporarily suspended work at the quarry and have gone back to the bowlders on the levels near the canal above high-water mark.

The dwelling authorized to be built by department letter of October 4, 1878, for the occupancy of the government employés on the canal, was commenced about the middle of October and finished the 1st of February. It is very conveniently arranged for the comfort of all, and supplies a want which was very much felt at the commencement of the improvement. First Lieut. Charles T. Powell, Corps of Engineers, in obedience to Special Orders No. 230, paragraph 9, Headquarters of the Army, Adjutant-General's Office, Washington, October 23, 1878, reported to this office for duty, and on the 12th of May was assigned to duty in local charge of the construction of the canal, taking station on the site of the work. I invite attention to his report, to which is appended a brief history of the work from the time of the original survey.

Mr. Channing M. Bolton, assistant engineer, who had been connected with the work since November 26, 1876, was, on his own application, relieved from duty on the 21st of May. He was faithful, industrious, and efficient, and his departure was much regretted.

The contract with Messrs. Ball & Platt will expire October 31, 1879. The following is the amount of work done by them under their contract:

	Cubic yards.
Earth excavated	7,228
Loose rock excavated	4,316
Solid rock excavated	8,387
Stone for 2-class ashlar masonry prepared for laying	106
	Pounds.
Cast-iron pipes furnished	80,994

The condition of the work at the close of the fiscal year is exhibited in the sheet accompanying this report.

The appropriation of $100,000, act approved March 3, 1879, will be applied, it is expected, in building the masonry of the foundation for the guard-gate to a height of 2 feet above the water, in excavating a part of the canal prism adjoining, and in continuing the masonry of the locks and the construction of the breakwater, after the existing contract with Messrs. Ball & Platt shall have expired.

The following statistics required by the act of June 23, 1866, are respectfully submitted. The appropriations for this work have been as follows:

Act of August 14, 1876	$90,000
Act of June 18, 1878	150,000
Act of March 3, 1879	100,000
Total	340,000

Of this amount, $55,256.57 have been expended to date in surveys, preparation of plans and models, expenses of Board of Engineers, salaries of assistant engineers and draughtsmen, office expenses, payments on estimates of contractors and superintendence of construction.

The estimated cost of the project is $1,753,867; of this amount,

$500,000 can be profitably expended during the next fiscal year in continuing the construction of the locks, guard-gate, and breakwater, and in excavating the canal prism.

The Cascades of the Columbia River are in the collection-district of the Willamette. The nearest port of entry is at Portland, Oreg., 65 miles distant; the nearest light-houses and works of defense are at the mouth of the Columbia, about 160 miles distant.

The amount of revenue collected at the port of Portland, Oreg., from July 1, 1878, to June 1, 1879, was	$139,149 40
	399,440 00
The value of the imports	3,157,575 00
And of the exports	
201 vessels, with an aggregate tonnage of 274,682 tons, entered.	
201 vessels, with an aggregate tonnage of 285,650 tons, cleared.	
At the port of Astoria during the same period, the revenue collected was.	$21,071 31
	565 00
The value of the imports	1,953,033 00
And of the exports	
234 vessels, with an aggregate tonnage of 399,663 tons, entered.	
269 vessels, with an aggregate tonnage of 435,063 tons, cleared.	

By the construction of the Cascades Canal, free navigation of the Columbia River will be extended to the Dalles, a distance of 50 miles. The short portage of 13 miles from the Dalles to Celilo will then be the only obstacle to a free and unobstructed navigation of the Columbia River from Astoria to Priest Rapids, a distance of 400 miles approximately.

Vessels drawing 20 feet can reach, at ordinary stage, the mouth of the Willamette; those of 8 feet, Celilo; those of 6 feet, Lewiston, Idaho, on the Snake River; and those of 4 feet, Priest Rapids.

The commerce of the Columbia River is rapidly increasing, and is carried in boats which are distinguished for their excellence of construction, speed, and service.

It is not possible to give accurate statements relative to the amount of produce shipped both ways over the Upper Columbia by the Oregon Steam Navigation Company, but the following is an approximate estimate for the year:

	Tons.
Up freight	31,800
Down freight	34,175

The aggregate tonnage of the boats operated by this company on the upper river is about 6,500 tons.

Abstracts of proposals and contracts, money statement, river curves and chart showing work done during the year, are transmitted herewith.

HISTORY OF CANAL SURVEYS AND PROJECT.

The first government survey for a navigation improvement at the Columbia River Cascades was made during low-water, 1874, under direction of Maj. N. Michler, Corps of Engineers. This survey discovered a fall in the main rapid of 21 feet, and an additional fall of 16.3 feet distributed over the next 5 miles.

The greatest obstacle in navigation to the foot of the main rapid, was found at the gorge next below where there was a surface velocity of 9 miles per hour, in a short length of channel 200 feet wide, but which admitted of an easy enlargement of water-way. At the gorge next above the old middle landing, on the right bank, a velocity of 8.3 miles per hour was observed.

Soundings above and below the rocky plateau at the eastern end of the upper rapid and surface examinations indicated that the construction of a canal through it would not be very difficult. A general plan and estimate for a low-water canal with 3 lifts, of 7 feet each, and improve-

ment of the river below the canal, were submitted, but a detailed examination and study recommended.

A limited examination was made during the high-water of 1876, under the direction of Maj. J. M. Wilson, Corps of Engineers. It showed a main rapid fall of 15 feet, an additional fall of 29.2 feet, and a current of 15.3 miles per hour at the gorge next above the middle landing.

It was concluded that a high-water canal would be difficult and expensive. The second and last survey was made during the low-water season of 1876–'77, under the direction of Major Wilson. This survey was detailed in its character; it included all probable routes of improvement on both banks, and was subsequently extended to the Lower Cascades. Surface velocities observed did not much exceed 8 miles per hour. Levels were frequently taken to the flood-water mark of the preceding summer. Elevations of this mark were 139.4 at the head of the present projected canal, 130.0 at the foot, 124.0 at the lower end of the breakwater, and 96.0 at the Lower Cascades. The flood of 1876 is generally conceded to be the highest known, and definitely shown to be the highest, for the last 20 years, by the records of the annual high waters at the Lower Cascades, kept by Mr. Brazee, of the Oregon Steamship Navigation Company.

Ordinary lowest low-water mark, near the upper landing, was given by apparently reliable information; its elevation transferred to the head of the canal was found to be (96.0). In the transfer it was assumed that the same difference in level, about 2 feet, between the water-surfaces at the mark and at the head of the canal, would exist at extreme low-water as at the time of the survey. The difference between flood-water marks at the localities was about 1.6 feet. The elevation of (96.0) at the head of the canal is referred to in reports as *dead low-water*, and *extreme low-water*. The same authority which fixed the low-water mark gave the water of 1859 from 2 to 3 feet lower. It is now stated that the water of last winter, which read (96.5) on the upper gauge, was from 2 to 4 feet higher than the low-water of 1862 and 1859. The manner of determining low-water along the line of the canal, corresponding to the reading of (96.0) at the head, is explained in the preceding report. The comparison of low-water readings gave an extreme fall to the foot of the main rapid of 20.5 feet, and to the end of the projected breakwater of 26.0 feet.

The canal plan prepared from this survey and laid before the Board of Engineers for the Pacific Coast provided for a lockage around the main rapid at all stages on the site selected from the earlier survey. It consisted of two combined locks 250 feet by 46 feet, with an upper guard-gate, 14 and 12 feet lifts, and an extreme low-water draught of 8 feet. A crib-work breakwater 4,050 feet in length and of a height 25 feet above low-water was to extend below the locks.

On the approved recommendation of the Board of Engineers, the width of the locks was increased to 50 feet, the length to 300, and the height of the breakwater raised to exclude flood-water from the waterway behind it. The Board reported that the difficulties of future navigation might render necessary an extension of the breakwater 1.5 miles, to join with Bradford's Island, improvement of the island channel, and the construction of an additional lock of 10 or 12 feet lift. The Board also reported that sliding of the slope of the adjacent shore was apparent at a point between the lower end of the projected canal and Bradford's Island, and indicated that a protective wall might be rested upon a stratum of sandstone beneath the overlying material to guard the canal from being filled up by future slides.

Subsequent to the report of the Board of Engineers an increased width of locks to 70 feet was authorized, for reasons stated by Major Wilson in his letter recommending the increase.

The following are the dimensions and references of the canal as prepared under the direction of Major Wilson, and since adopted:

	Feet.
Total length	7,200
Width at guard-gate and in locks	70
Width of canal at bottom	50
Length of locks	300
Height of lifts	14 and 12
Depth over miter-sills at low-water	8
Width of crib-work breakwater at bottom	30
Width of crib-work breakwater at top	12
Average height of breakwater below locks	65
Width of lock walls at base, one-half of the height.	
Width of lock walls at coping	5
Height of guard and upper gates	54
Height of middle gate	58
Height of lower gate	30
Reference of extreme low-water at head of canal	(96.0)
Reference of extreme high-water at head of canal	(139.4)
*Reference of extreme low-water at foot of canal	(75.5)
Reference of extreme high-water at foot of canal	(130.0)
†Reference of extreme low-water at foot of breakwater	(70.0)
Reference of extreme high-water at foot of breakwater	(124.0)
Reference of canal bottom	(88.0)
Reference of bottom of lock No. 1	(76.0)
Reference of bottom of lock No. 2	(62.0)
Reference of coping guard-gate and upper gate walls	(142.0)
Reference of top of canal crib-work	(142.0)
Reference of coping of lock walls	(134.0)

The walls of the guard-gate and locks to be connected on the outer side by a crib-work of close-sided, continuous structure, filled with stone and a puddled core. On the inner side wing-walls of similar crib-work are to be run to the high ground of the adjacent bank. The crib-work below the locks not to be puddled, otherwise similar in its construction to the crib-work above. The guard-gate to be moved by hand, the lock-gates and culvert-valves by water-power; the locks filled and emptied by culverts and iron pipes in the side walls.

Money statement.

July 1, 1878, amount available	$229,529 30	
Amount appropriated by act approved March 3, 1879	100,000 00	
		$329,529 30
July 1, 1879, amount expended during fiscal year	42,452 19	
July 1, 1879, outstanding liabilities	2,333 68	
		44,785 87
July 1, 1879, amount available		284,743 43
Amount (estimated) required for completion of existing project		1,424,338 00
Amount that can be profitably expended in fiscal year ending June 30, 1881		500,000 00

Abstract of contracts for the construction of a portion of the canal around the Cascades of the Columbia River, Oregon, in force during the fiscal year ending June 30, 1879.

Number.	Name and residence of contractors.	Date of contract.	Subject of contract.	Remarks.
1	Ball & Platt, New York City	Oct. 19, 1878	Excavation, masonry, &c.	Contract expires October 31, 1879.

*Subsequently deduced to be 73.4. †Subsequently deduced to be 67.5.

Abstract of proposals for the construction of a portion of the canal around the Cascades of the Columbia River, Oregon; opened by Major John M. Wilson, Corps of Engineers, October 1, 1878.

Names and residences of bidders.	Excavation.			Masonry.				Iron.		If required.	
	1,000 cubic yards of earth, more or less, per cubic yard.	5,600 cubic yards of loose rock, more or less, per cubic yard.	45,900 cubic yards of solid rock, more or less, per cubic yard.	650 cubic yards of first-class arch masonry, more or less, per cubic yard.	190 cubic yards of first-class ashlar masonry, more or less, per cubic yard.	900 cubic yards of second-class arch masonry, more or less, per cubic yard.	1,800 cubic yards of second-class ashlar masonry, more or less, per cubic yard.	6,800 cubic yards of rubble masonry, more or less, per cubic yard.	100,000 pounds of cast-iron pipes, more or less, per pound.	10,000 pounds of wrought-iron bolts, &c., per pound.	370,000 feet of timber and plank, more or less, per M.	1,100 cubic yards of concrete, more or less, per cubic yard.	Totals.
Bell & Platt, New York City*	$0 40	$0 60	$1 60	$18 00	$18 00	$13 00	$13 00	$7 50	$0 08	$0 10	$16 00	$7 50	$14, 170 00
Walter Doty, Fort Edward, N. Y	45	1 00	1 45	27 00	18 00	11 00	14 00	8 75	06	12	35 00	6 00	19, 550 00
William A. Murphy, Chicago, Ill	49	1	1 24	21 98	17 98	17 98	14 47	10 59	5.73	8½	17 39	6 74	13, 848 30
Montgomery & Thompson, Portland, Oreg	20	45	1 75	21 00	21 00	15 00	15 00	8 00	07½	09	13 00	4 00	9, 210 00
Schuyler & Schuyler, San Francisco	30	60	1 65	20 00	20 00	16 00	17 50	9 00	07½	11	14 50	5 50	11, 415 00
Haus Thelsen, Portland, Oreg	50	2 00	3 35	35 00	30 00	30 00	28 00	9 00	08	08	30 00	12 00	24, 300 00
Wells, Timberman & Co., Keokuk, Iowa	75	3 00	4 75	19 00	18 00	17 00	17 00	12 00	08	06	12 00	11 00	16, 540 00

* Contract awarded.

REPORT OF LIEUTENANT CHARLES F. POWELL, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Cascade Locks, Oregon, June 30, 1879.

SIR: I have to submit a report of the operations upon the construction of the Cascades Canal for the present year, and, by your direction, a history of the canal surveys and project.

The work of preparing ground for construction was commenced by Messrs. Ball & Platt, of New York, contractors, October 21, 1878. The work continued with good progress until January 4, 1879, when the death of Mr. Ball, who was the managing contractor, caused a suspension. It was resumed on the 19th instant, following, with a light force, under a temporary superintendence. On February 13, a representative of the surviving member of the contracting firm arrived on the ground and took charge of its interests. The low-water season had about expired, however, and, commencing on February 24, it was necessary, by the continued general rise of the river, to move the working force and implements from the lock-pits at the foot of the canal to consecutive levels towards the head, or to suspend all work of excavation until the recession of high water, which could not be expected until the late summer. The contractors desired to work on the line of the canal, and were permitted to do so.

By the end of May the high water had flooded the entire canal site, and further work has remained impracticable.

About the middle of April the contractors opened a quarry on the left bank of the river, 1 mile above the canal, and continued to get stone therefrom until June 2, when the river rise prevented. Since that time, and previously at intervals, they have cut stone from bowlders in the vicinity of the canal. The quarry stone works easily; it is thought to be a feldspathic basalt. The bowlder is a harder variety of basalt. The contractors have placed upon the ground from these sources 106 cubic yards of stone, roughly squared and dressed. They have also delivered 80,994 pounds of cast-iron filling-pipe. Plate number 1, accompanying herewith, shows the progress of excavation along the canal axis. The excavated material consists of bowlders, gravel, and sand.

During the year a frame building, for government office and quarters, has been erected, a small landing-pier constructed, and a steam-launch procured for government use.

Corners of canal reservation, on ground not likely to be disturbed, have been marked by monument stones.

Measurements of surface velocity of river, from the head of the breakwater to a point 3,500 feet below the foot, were lately made. The following are the results of greatest velocities obtained; a steamer could not avoid current of such velocities in ascending at high-water times:

Locations.	Velocities (miles per hour).
From station 30 to station 40	15.1
From station 40 to station 60	16.4
From station 60 to station 70	18.0
From station 70 to station 80	17.4
From station 80 to station 90	14.6
From station 90 to station 105	17.1