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VANCOUVER WATER WORKS.

HAULING MAIN ACROSS NARROWS IN 1906.

By J. CAUSLEY, A. M. Can. Soc. C. E.

(To be read before the General Section, February 20, 1908.)

British Columbia is a very mountainous region, and the part of it comprized by the western slope of the Coast Range and Vancouver Island is subject to a heavy rainfall; consequently the towns in the coastal districts are able to obtain a plentiful supply of water.

The city of Vancouver is no exception to the general rule, but on account of its position there is some difficulty in bringing water to it. It is situated about six miles east of the Gulf of Georgia on the south shore, and between the first and second narrows of Burrard Inlet, an arm of the sea extending from the Gulf about twenty miles in an easterly direction. The city has on its southern side a small inlet called False Creek, though it should rather have been said *in* its southern side, for the town is rapidly extending far beyond the southern and eastern shores of that inlet. The ground in stretching further south rises to form a low east and west ridge named Little Mountain, and then drops off to the low land which forms the valley of the Fraser.

The main channel of the Fraser thence to New Westminster, and the North Arm of the Fraser thence to the Gulf, run in an approximately westerly direction, and the low land of the valley reaches to the

United States boundary. On the north side of the Inlet and of the Fraser valley, however, are the mountains of the Cascade, or Coast Range, and in some years snow can be seen all through the summer on the higher peaks of these mountains, and down the valleys between the spurs of which streams flow into the Inlet. One of these, the Capilano, which has been utilized by the city for a water supply, enters the Inlet at the First Narrows, or Lion's Gate (so named because it is overlooked by two peaks of the Cascades, which, from some points of view, greatly resemble two lions couchant), opposite Stanley Park, a government reserve northwest of the main part of Vancouver. A dam has been built on the Capilano $6\frac{1}{8}$ miles from its mouth, the elevation of intake being 417 feet, and the water brought down in a 36" main to the line of the Inlet. From thence it is carried across the Narrows in submerged 12" mains placed on the bed of the Inlet, and through a 30" main to a pipe-head reservoir on a hill in the park which gives the reservoir an elevation of 219 feet at the bottom and 245 feet at the top. This reservoir was built in 1893, and holds about 11,000,000 gallons of water. From it the distributing mains run to the different parts of the city.

During the past summer another dam has been built, $\frac{3}{4}$ of a mile higher up the creek, the elevation of intake being 472 feet, with a 30" and a 22" main down to the old main.

There have been seven 12" mains placed across the Narrows at various times during the past 19 years. The last one has just been put in position, and of the method of accomplishing this the writer purposes giving a short description, trusting that it may prove of some interest, for the reason that it differed from the method usually followed (with variations to suit particular cases) in such work, viz., that of building a staging, or anchoring a string of rafts along the line to be followed, slinging the pipes over the position they are intended to occupy, jointing them up and lowering the connected line into place.

This method would not have been suitable in the cases under consideration on account of the water varying from 66 feet deep at low tide to 75 feet deep at ordinary high tide. The tide is very strong, running at speeds up to 8 knots per hour; also, and perhaps the most important of all, nearly the whole of the shipping trade of Vancouver, including ocean passenger and freight steamers, from 8000 tons downwards, sailing ships towed in and out by tugs, coast steamers, rafts, coal barges, transfers towed by tugs, etc., passes through these Narrows. A system of hauling the pipes across was first put into practice by the Water Works Company, this

system being greatly improved by the late City Engineer, Colonel Tracy, M. Can. Soc. C. E., and the Water Works staff.

The first two mains were hauled across the Narrows by the Vancouver Waterworks Co., the rest of the mains being hauled by the Corporation of the City of Vancouver, which bought out the Vancouver Water Works Co. on 1st March, 1892.

The following mains were hauled across the Narrows:

First Main, 1887.—A 12" cast iron main, composed of pipes which proved to be too light, and which only lasted for 5 years. The main was condemned and taken up in 1892.

Second Main, 1888.—A 12" main, composed of rolled Calamine steel pipes, with cast iron spigots and sockets riveted to them. This main only lasted a short time, and was taken up in 1893.

Third Main, 1892.—A 12" cast iron main, hauled across for the city by contract with Captain Westcott. This main consisted of 105 lengths of 12" pipes, or a total length of 1260 feet. It was taken up in August, 1906. It had been expected that this main would last about twenty years, but, on being raised, it was found that about one-third of the pipes were nearly worn through by the continual wash of sand carried backwards and forwards over them by the ebb and flow of the tide. Most of the pipes thus rendered useless had been lying on the bed of the northern half of the Narrows, which consists of a bank of gravelly sand. The pipes which had been lying on the southern part of the bed, which consists of hard indurated sand almost like rock, were found to be still in a very good condition.

Fourth Main, 1894.—A 12" cast iron main, laid by the city by day work. It is in use at the present time.

Fifth Main, 1895.—A 12" cast iron main, hauled across for the city by contract with Messrs. Westcott & Campbell. This main consisted of 107 lengths of 12" pipes, or a total length of 1284 feet. It is in use at the present time.

Sixth Main, 1899.—A 12" cast iron main, hauled across for the city by contract with Mr. Harris, under the inspection of Colonel Tracey, then city engineer (who also supervised the laying of the 3rd, 4th, and 5th mains), assisted by Mr. S. Maddison, superintendent of the water works.

Much trouble was caused by the breaking of the cables, which had been strained when used on former occasions.

Hauling began on August 24th. A cable broke before the pipes started; this was repaired, and hauling was resumed on August 28th, and continued until September 22nd. In the later part of this time it was noticed that the pipes were coming along too easily and,

on investigation being made, it was found that the cable inside them had parted, and that only four lengths of pipe were being hauled, the break being about 200 feet from low water. These four pipes were hauled to the south shore, and a chute was built at the Stanley Park end of the line; 200 feet of pipe (including the pipes already hauled to the south shore) were jointed up, hauled back to the near end of those partly across, and a joint made with a collar by a diver under water.

The contract price for hauling this main was \$3,870.00. The city furnished the plant which it had on hand; the contractor, besides supplying labour, only purchased capstans, lumber, etc., as follows:

4 capstans, at about \$35.00 each	\$140 00
8,500 feet lumber, for chute, at \$12.00 per 1,000 feet..	102 00
2,500 feet lumber, for platform, at \$12.00 per 1,000 feet	30 00
3-kegs of nails, at \$4.00 per keg	12 00
	<hr/>
Total	\$284 00

The main is still in use. In fact this, and No. 5 main, are the two which generally supplied the city with water until the new main was laid. No. 3 main, which was replaced by the new main, has been kept chiefly as a reserve.

Seventh Main, 1904.—About three years ago it was intended to place another main across the Narrows, and in the early part of 1894 a contract was made with Messrs. Robertson, Godson & Co., of Toronto and Vancouver, for the supply of cast iron pipes for a submerged main, in accordance with the following specifications:—

To be 12 inches in diameter internally, 1 inch in thickness, lengths to lay 12 feet each, of the best cast iron, strong, tough grey metal, cast vertically with the hub end down, the bell end to be bored spherically, and the spigot end to be turned where it fits in contact with the bored surface. To be tested to a pressure of 500 lbs. per square inch and hammered under pressure. To be coated with Dr. Angus Smith's preparation, or preferably with Wartz, Dove & Co.'s bitualthic solution.

The pipes were obtained from Stavely, near Glasgow, in Scotland, and weighed between 1725 and 1800 lbs. each.

The half section at a flexible joint shows the latest form of the bell and spigot of a pipe. The shape of the bell has been altered from that of the earlier forms to cause the pipes to offer as little resistance as possible in sliding along the bed of the Inlet.

The pipes were delivered at Vancouver in August, 1905, but it

was not convenient to place them in position till the latter part of 1906, when it was decided that they should be laid directly by the city, under the superintendence of Mr. S. Maddison, the manager of the water works, who had had much experience in the work of laying previous mains. Captain Westcott, who was contractor for laying two of the previous mains, and foreman on laying the steel main, was engaged as foreman of the work. This main was to take the place of No. 3 pipe line, the pipes of which were taken apart by a diver and brought to the bank.

A chute was constructed of 14" x 2" dressed plank, with 4" x 1" battens on each side—i.e., projecting 2" above the plank—supported at every 6 feet by cross pieces of 3" x 4" quartering, each on 2 posts of 3" x 4" (see sketch), from low water on the north side of the Narrows extending back the length of the main. Each length of pipe was tested separately under a pressure of 350 lbs. to the square inch. The pipes were then placed on the chute, spigot ends to the south, with a piece of 14" x 2" plank, about 2 feet long, on the bed of the chute running between the side battens under each pipe at the bell end. The piece of plank was notched out at the top side and upper end, so as to go under, support, and steady the bell, and keep the pipe in the centre of the chute. The under sides of these blocks were well greased. The spigot of each pipe was pressed home in the bell of the next one, lead run in and calked to make a tight joint. No gaskets were used, as the bells and spigots were bored and turned to make tight and flexible joints. Each joint required from 60 to 70 lbs. of lead, making about 3½ tons of lead used in all. The pipes, after being put together and jointed, were tested collectively under a pressure of 150 lbs. per square inch.

A line was pushed through the pipes with a rod made of a number of long slats of wood nailed together and a 1½ inch steel wire cable hauled through them.

Over the lower, or south, end of the string of pipes a cast iron cap 1" thick, with strengthening ridges on the outer side, and flange overlapping the end of the pipe, was placed, leaded, and calked. This cap had a 2" circular hole in the centre with a stuffing-box. Through this was passed a 2" turned rod 3 feet 6 inches long, and the hemp packing was well tightened up around it. On the inner end of the rod was an eye through which the end of the 1½ inch steel wire cable, which went through the line of pipes, was passed, doubled back on the cable, and secured with 4 clips. The outer end of the eye-bar, on which a screw thread was cut, went through a stirrup-shaped ring and was made fast to it with two nuts. To this stirrup one of the hauling cables was attached and secured in the same manner as the cable inside the pipes was secured to the other

end of the bar. By these means the cable had no tension on the front end of the string of pipes.

The end length of pipe carrying the cap, etc., was covered with a wooden lagging, bound at three places with $\frac{3}{4}$ inch wire rope. The sketch readily explains the arrangements made.

The cable on the west side of the pipes was attached to the 40th pipe by taking two turns round the pipe, bringing the end back to the cable, and fastening it with 4 clips. The cable on the east side of the pipes was secured to the 13th pipe by means of a chain, which had a round turn round the pipe, and the ends made fast to the cable with clips. Iron bands were put round the pipe and cables fastened at intervals to enable a fair pull to be taken.

On the upper, or north, end of the pipe a cap similar to the one at the south end was placed, with the exception that the 2" circular hole in the centre was through a plain boss. A 2" round bar passed through this hole. The inner end of this bar had an eye to which the cable through the pipes was attached, in the same way as the other end of the cable was fastened to the bar through the cap at the south end of the pipes. On the outer end of this bar a screw thread was cut, and the cable through the pipes was tightened up with a nut. A second nut was placed above the first one for the sake of security. A length of 12 inch pipe, 4 feet long, was fitted into the bell of the last pipe for the flange of the cap to fit on to. The whole was leaded and thoroughly calked. This was completed on Sunday, August 19th.

It had taken about a month to do this work, with a gang of about 7 men, under the superintendence of Captain Westcott. There were 109 12" pipes, making 1308 feet of pipes, whose weight varied from 1725 lbs. to 1800 lbs. each, giving a total weight of about 96.05 tons. Including lead caps, internal cable, etc., the total weight would be about 102 $\frac{1}{2}$ tons.

1800 feet, 1 $\frac{1}{2}$ " dia., and 1800 feet, 1 $\frac{1}{4}$ " dia., fresh steel-wire cables had been bought in Nanaimo, a coal mining town across the Gulf of Georgia. These cables were not new, but had been used for hoisting in the mines. Also four new 6-inch (circumference) 120 fathom Manilla ropes had been purchased, at \$160.00 each, for tackle. Six new 3-sheave blocks and two new single-sheave blocks had been made in the water works shops. The cables, on their reels, had been taken across to the north shore of the Narrows.

The end of a line was taken across, attached to the end of one of the cables, and the cable was hauled across, a snatch block and four horses being used. No power tackle was used, as the hauling had to be done in the space of about 15 minutes at slack water.

One cable was hauled across at slack water on the 15th August, one on the 18th, and one on the 19th. By 23rd August everything was ready to begin hauling. The cables had been examined by the diver and tightened up with their blocks and tackles.

To each of two of the cables was attached a tackle consisting of a pair of 3-sheave blocks with one of the 120 fathom 6-inch Manilla ropes rove through them worked by a capstan to each tackle driven by one or two horses. The other cable had two tackles, with a pair of 3-sheave blocks attached to each tackle, each tackle worked by a capstan. The drum of the capstan was 18 inches in diameter, and the lever arms 11 feet each. The cable, however, with the two tackles attached, had been left taut too long; the flood tide caught it and carried it up channel about 100 feet at the centre, drawing two lengths of pipe slightly out of line before it could be loosened. It was necessary to draw it back to the north side and haul it across afresh. This had been done by Saturday, August 25th, and everything found to be in order. Passing vessels had caused some inconvenience when getting the lines across.

Monday, August 27th.—Hauling began at mid-day at low water with four horses, *i.e.*, one at each capstan, and was also continued on the slack water in the evening, lasting altogether about five hours, and moving the main about 178 feet. The work could not be carried on longer as the tide when stronger would have caught the cables and carried them out of line. After the first hauling the manager went down in diving dress, examined the pipes that had moved, found that they had been drawn straight, and that the joints were uninjured.

Tuesday, August 28th.—Hauling was carried on from noon to 2 p.m., and from 5 to 8 p.m. The main was hauled 194 feet: in all, 372 feet. Four horses had been used, *i.e.*, one at each capstan.

Wednesday, August 29th.—Up to 7 p.m. only about 35 feet had been hauled. The horses had been doubled on two capstans and had not pulled well together; the tide also had not served well. Hauling was carried on from 7.10 to 7.30 p.m., when it was stopped by a signal from the other side (the light put out). It was found that one side of the chute had sunk where swampy ground was crossed, and that the pipes were slipping off. About 78 feet had been hauled; in all 450 feet.

Thursday, August 30th.—The chute was strengthened early in the day. In the morning the tide was not favorable for hauling, which was not begun till about 6.30 p.m. Only one capstan was doubled till about 9.30 p.m., when a second horse was put on No. 1 capstan.

Hauling was stopped about 1 a.m., as the horses were unable to work longer. About 300 feet had been hauled; in all 750 feet.

Friday, August 31st.—In the morning the pipe was examined by the diver, who went right along the part under water from end to end, and found everything in good order. There is a soft shingle bank extending from the north side to within about five hundred feet from the south side of the Narrows, and the pipes had ploughed into this for a depth of about two feet and moved boulders that were in their way. Further south the bottom is a sandy hardpan.

Hauling began about 5 p.m., and one fleet (the length of travel of the moving blocks, about 75 feet) was hauled by about 7 p.m. The tackles were then overhauled. Hauling was continued again from about 8 to 8.20 p.m., when the gripper on the eastern cable gave way. It was got in order again and operations were continued. About 12.30 a.m. the central cable slipped in the gripper and work was suspended for the night. About 150 feet hauled; in all 900 feet.

The pull was now becoming heavier.

Saturday, September 1st.—The diver went down in the morning and found everything in good shape.

Hauling began about 4.30 p.m. The pipe would not start at once, and the gripper on the central cable (No. 1 capstan) slipped at about 4.45 p.m. It had to be loosened and a fresh grip taken, when the pipe was started. The fleet was finished at 6.15 p.m. It was found from measurement that 162 feet still required to be hauled. The tackles were overhauled; a sheave in one of the blocks, which was found to be cutting (the hole had become enlarged about $\frac{1}{4}$ inch) was replaced by another, and hauling was begun again about 7.45 p.m. About 9 p.m. it was found that the head of No. 2 capstan was giving way, and work had to be suspended till a new drum could be made. 169 feet were hauled; in all 1069 feet. 155 feet remained to be hauled.

Monday, September 3rd.—A new capstan barrel had been made and placed in position, and hauling was begun at 8.15 a.m. The main was moved about 40 feet, but the tide was found to be running out too strongly, and work was stopped. The pull had become very heavy, as so much of the main was on the ground and part of it was coming up hill. Six horses were used this day, viz., two each on Nos. 1 and 2 capstans, and one each on Nos. 3 and 4.

Hauling was begun again at 11.10 a.m. A gripper slipped soon after starting. A fresh pin was put in and tightened up, and hauling was continued. Before long the rope of the tackle of No. 2 capstan got under the barrel of the capstan and had to be cleared.

The fleet was finished at 12.25 p.m. Seventy feet still required to be hauled.

The tackle was overhauled and work begun again at 1 p.m. The rope got under the barrel of No. 2 capstan again and had to be cleared. The hauling was heavy, but the pipe moved steadily. The work was finished at 2.45 p.m., the front end of the pipe being above low water. Total distance hauled, 1224 feet.

The main was tested on September 5th, under a pressure of 125 lbs. per square inch, and found to be perfectly tight.

Captain Westcott employed 11 men during hauling, as well as the diver and the drivers of the teams.

Four hundred feet of pipe were afterwards laid on the north side of the Narrows to extend the main to the valve chamber there, and 150 feet on the south side to the valve chamber at the south bank in the ordinary manner.

Cost of pipes:

109 12-foot lengths 12" pipe=1,308 feet.	
109 lengths, 1,725 lbs. to 1,800 lbs. each, average 1762.5 each.	
= 192,112 lbs.	
= 96.05 tons, @ \$40.00 per ton at C.P.R. wharf.	= \$3,842 00
Removing to north shore of Inlet.	200 00
	<hr/>
Total.	\$4,042 00

Expenses connected with hauling, etc.:

Labour, as per pay rolls July 2 to August 11, for building chute and platform, putting up capstans, placing and jointing up pipes, etc.	\$1,002 69
Labour hauling the main, August 25 to September 8.	1,163 23
	<hr/>
Total labour.	\$2,165 92*

* This amount includes 8 horses, 7 days at \$8.00 per team and man per day, say with overtime, \$10.00. \$280.00
 4 horses 3 days. 48.00
\$328.00

General wages 25 to 30 cent. per hour; Overtime, time and a half.
 Diver \$15.00 per day.

Materials used, cartage, haulage, provisions, and incidental expenses charged to the new main and taking up the old one were:

To old main	\$ 974 83
To new main	1,458 76
	<hr/>
	\$2,433 59

Fresh plant bought:

4-6" (circumference) 120 fathom Manilla ropes, @ \$160.00 each	\$640 00
2,000 feet $\frac{3}{8}$ " steel wire rope, @ 7c. per foot.	140 00
2,800 feet $1\frac{1}{2}$ " and $1\frac{3}{8}$ " steel wire cable (not new)	150 00
	<hr/>
	\$930 00

Total for materials, incidental expenses, etc., in present work by subtracting fresh plant bought in order to give current expenses \$1,503 59

Less taking up old main account 403 59

Total for materials used, incidental expenses, etc., in hauling, placing, jointing up, etc., of new main . . . \$1,100 00*

* This amount includes—Lead	\$431.93
8040 ft. lumber dressed one side for chute, at \$18.00 per thousand	144.72
2 kegs nails	8.00
2436 ft. lumber for platform, at \$17.00 per thousand	41.41
1 keg nails	4.40
	<hr/>
	\$630.06

Also charged to the new main, on September 22nd, for labour for laying, jointing, etc., the pipes above low water to the valve chambers \$ 662 28

Amount charged to labour for taking up the old main and bringing the pipes to the shore \$1,652 77

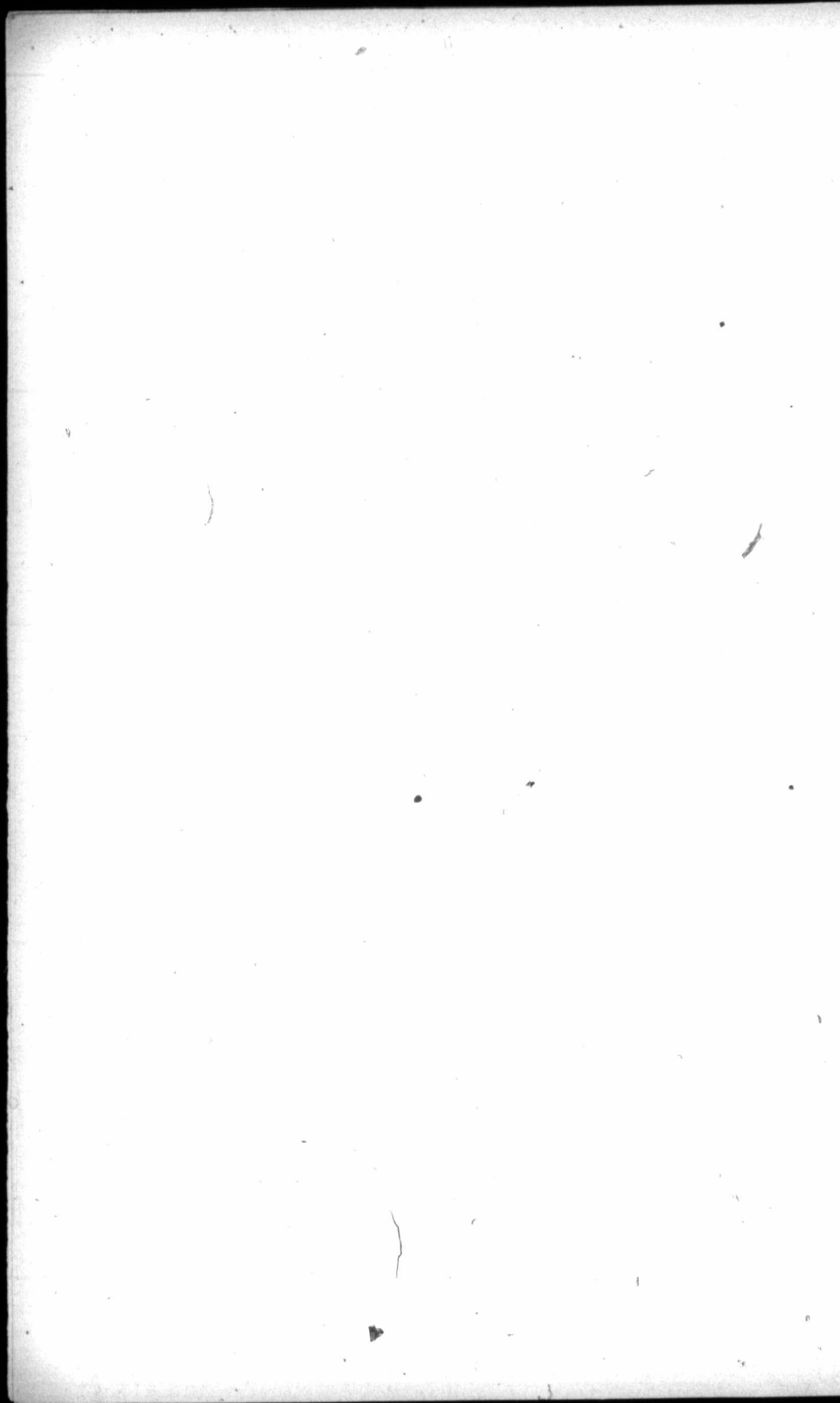
To which add the amount for materials and current expenses shown above 403 59

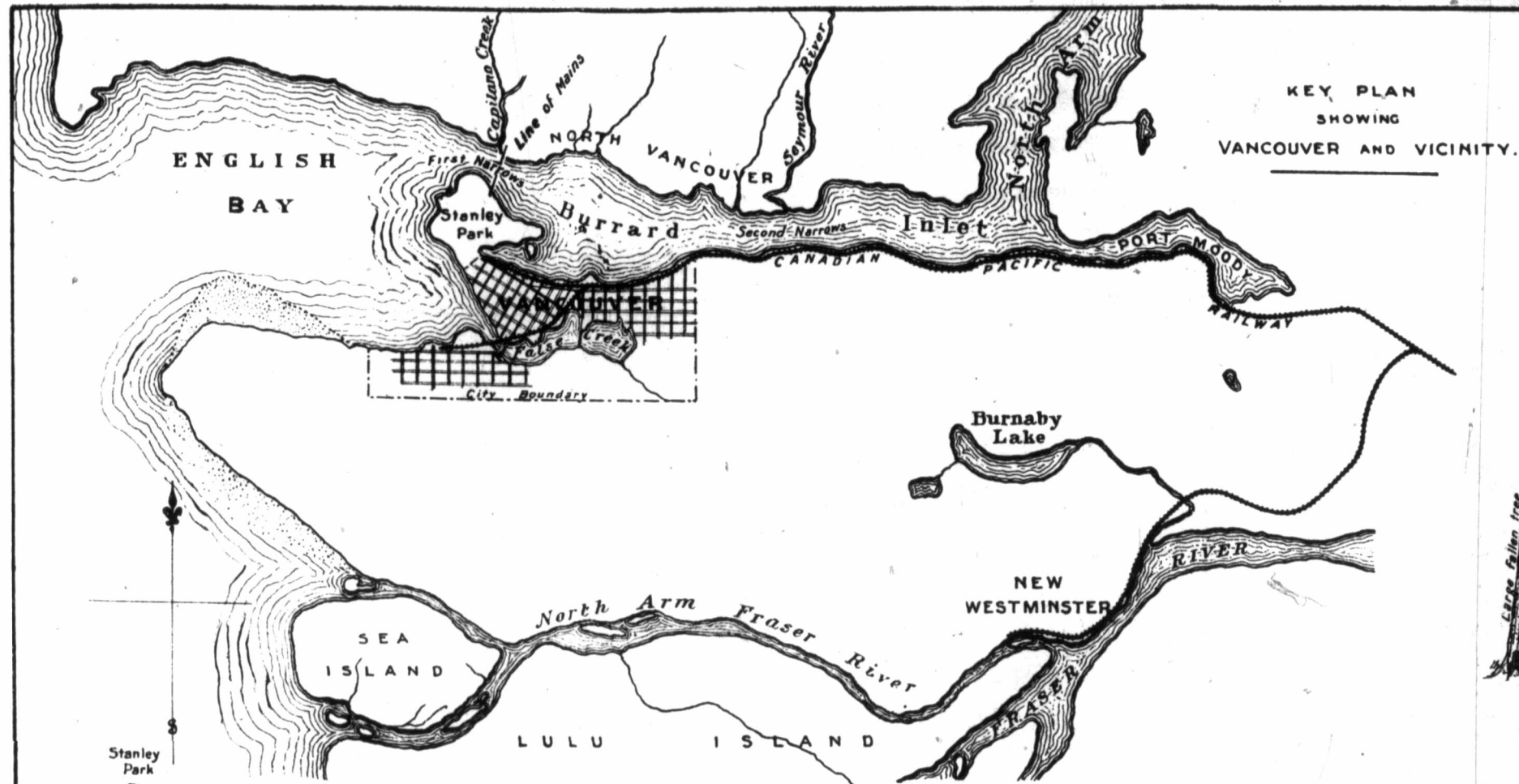
Total \$2,056 36

The writer is greatly indebted to the City Engineer, Mr. W. A. Clement, M. Can. Soc. C. E., for the use of documents and information to assist him in the writing of this paper.

The consulting engineers for the water works constructions are Messrs. Hermon & Burwell.

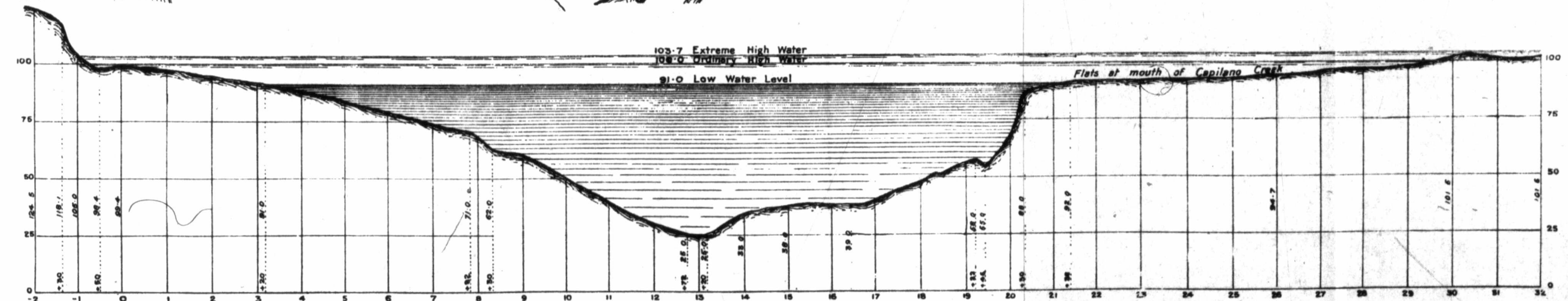
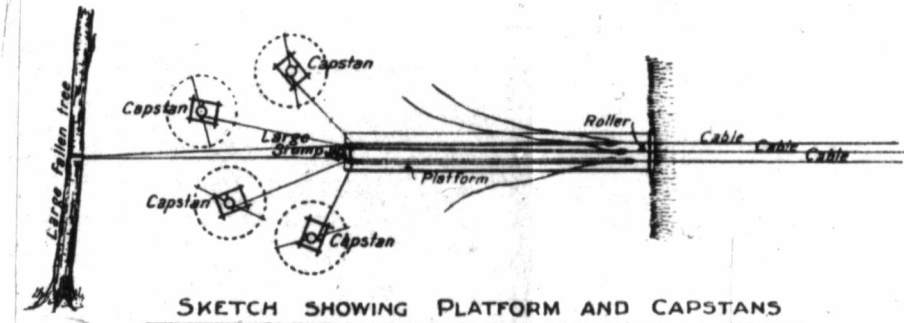
On September 29th a short main, 260 feet long, composed of some of the best pipes of the old main taken up, was hauled across the narrow part of False Creek, at Westminster Avenue Bridge, a distance of 250 feet, in $3\frac{1}{2}$ hours by two horses with one capstan and a pair of 3-sheave blocks.



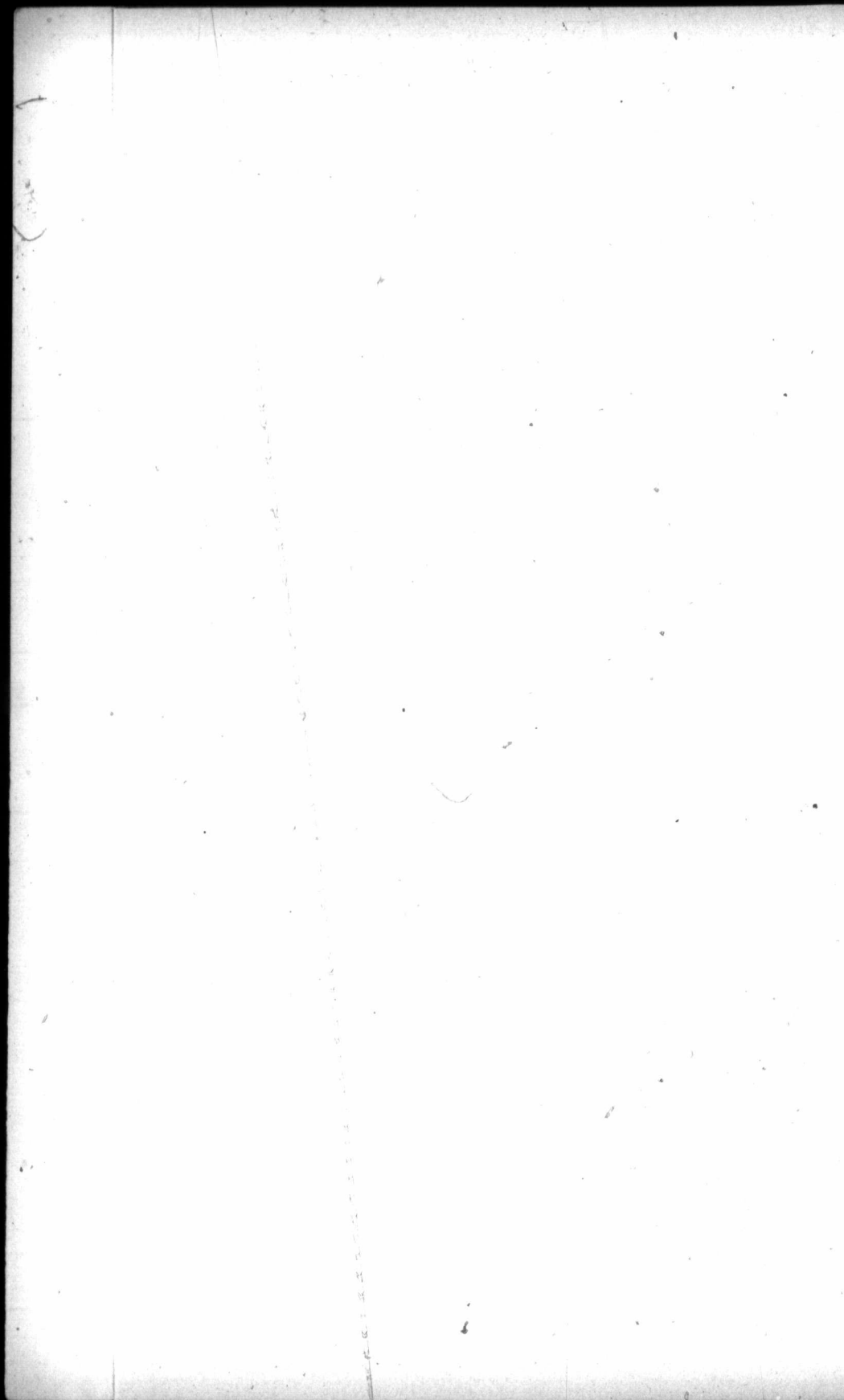


**VANCOUVER WATER WORKS
MAIN ACROSS NARROWS**

Laid August and September
1906.

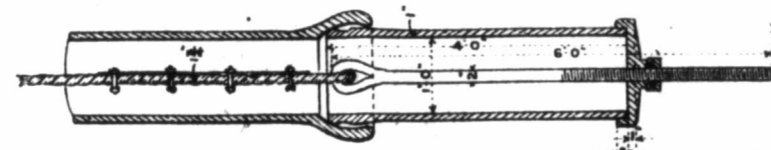


SECTION ACROSS NARROWS ON LINE OF MAINS.

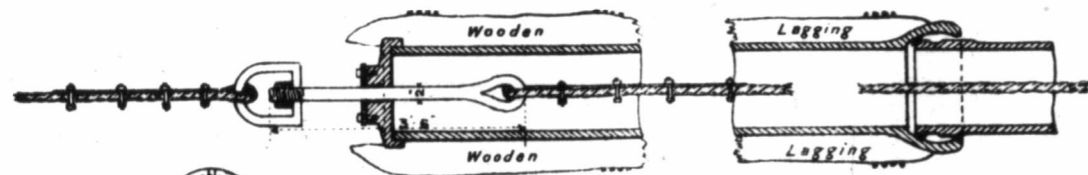




CAP



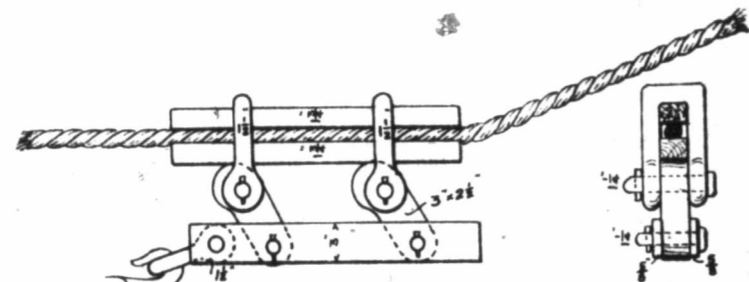
Longitudinal Section
NORTH END OF MAIN



Longitudinal Section
SOUTH END OF MAIN



CAP



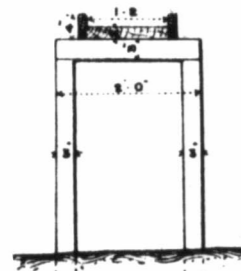
Side Elevation

End View

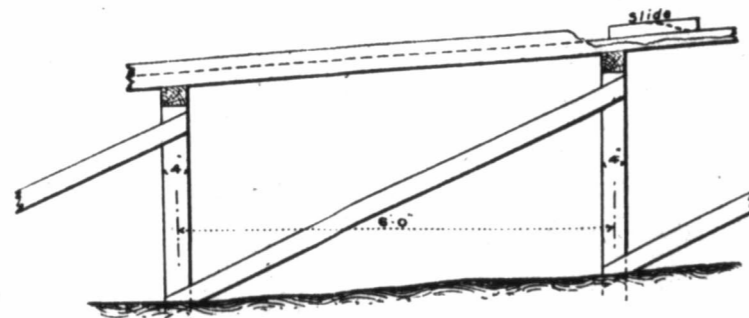
GRIPPER



CLIP

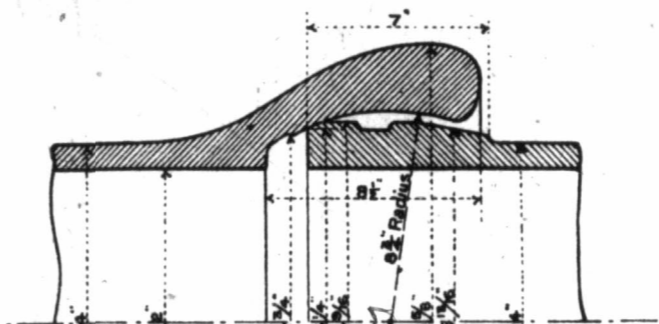


Cross Section



Side Elevation

CHUTE



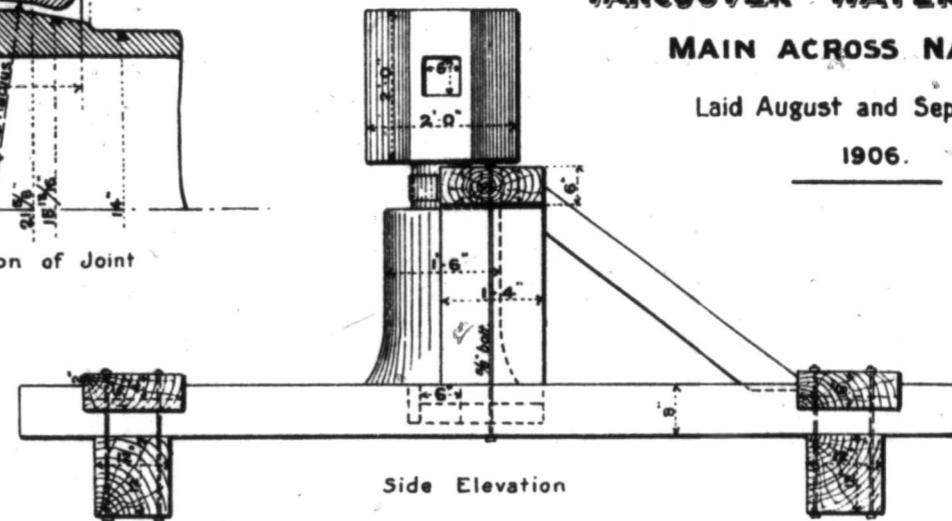
Half Longitudinal Section of Joint
PIPES

VANCOUVER WATER WORKS

MAIN ACROSS NARROWS

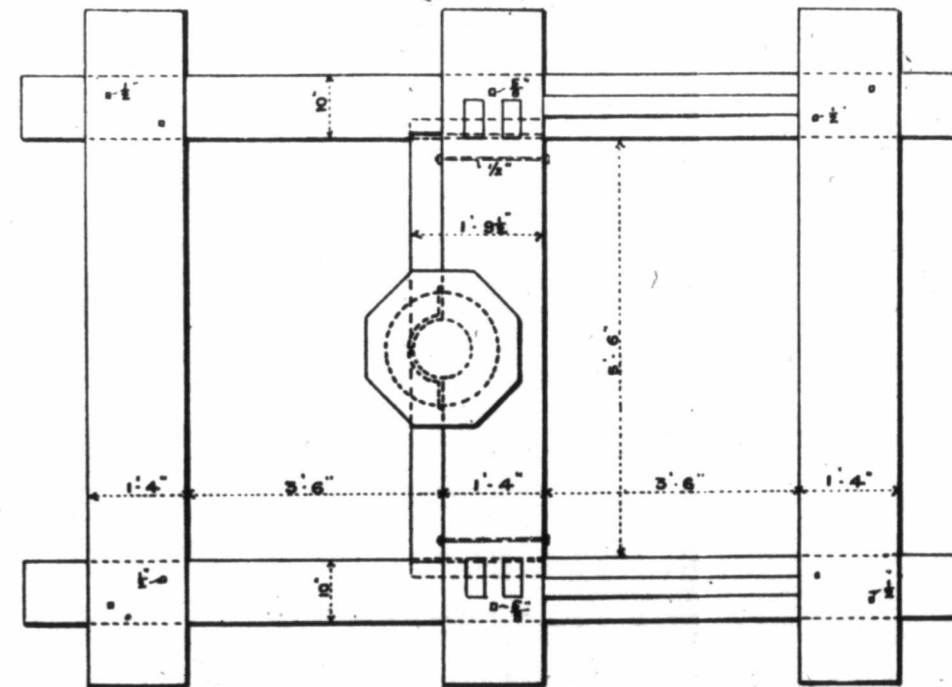
Laid August and September

1906.



Side Elevation

CAPSTAN



Plan