length. The tensile strength of the steel of which these pipes are constructed is 29 per cent above the requirements of the contract.

The high-service reservoir at Mount Tabor, designated as reservoir No. 1, was the first completed. This is at an elevation of 400 feet above the low-water mark in the river below. This is used as a distributing reservoir for the districts on both sides of the river. It occupies a depression on the southern slope of Mount Tabor, and is constructed throughout of the best materials. The capacity of this reservoir is 14,000,000 gallons. It is here that the steel main of the pipe line ends. From reservoir No. 1 a cast-iron main of a diameter of 32 inches connects with the high-service reservoir of the City Park on the west side of the river. Another main from No. 1 conects with the East Side low-service reservoir. Pipes are also laid from reservoir No. 1 to conduct waste water into the sewers of the city. The gates of this reservoir are so arranged that it may be cleaned and repaired without any interruption to the flow of the water supply of the city. By this ingenious arrangement the water can be cut off from the reservoir at any time, and the supply taken direct through the gate chambers.

The dam of reservoir No. 1 is constructed of concrete and earth. The wall of concrete forming this dam is 20 feet thick at the base and six feet thick at the top. The total length of this wall is 319 feet, and it is backed by earth and rock to a thickness of about 100 feet.

The cast-iron pipe which connects the Mount Tabor reservoir with the high-service reservoir of the City Park is six miles long, and, as before stated, is 32 inches in diameter except on the submerged portion of the line under the Willamette river, where the pipe is reduced to 28 inches in diameter. The ball-and-socket joints of this submerged pipe are fully described in an article on the interesting work of sinking the pipe in the river.

Each of the four reservoirs of the Bull Run system, with the exception of the East Side low-service reservoir, is lined with concrete strengthened with twisted iron, placed at intervals of 10 feet in each direction, and anchored at intervals of 10 feet by means of iron anchors driven to a depth of from 2 to 20 feet into the slopes forming the sides of the reservoir and imbedded in concrete. All the reservoirs are provided with gate chambers. The gate chamber of each reservoir is built in the form of a tower, of handsome design, in which is placed the machinery for operating the gates by which the distribution of water in the city mains is regulated. Each gate house is so arranged that the water may be doubly screened, although this is really not a necessity, owing to the purity of the supply. There is also an automatic indicator in each gate house showing the volume of the water flowing through the pipes at any time.

Around each reservoir a concrete walk has been built. This has been constructed in such a manner that storm and surface water is carried away from the reservoirs. These walks afford a delightful promenade for visitors who are separated from the basin itself by a concrete wall surmounted by a neat iron fence. All the reservoirs have been constructed in the most substantial manner, and the effect of harmony it was possible to obtain by a little attention to the adornment of the finished work has not been overlooked by the engineers in charge.

The low-service reservoir for supplying the East Side districts occupies five acres of ground in the White tract on the north side of the Section Line road and about one-half mile southwest of the high-service reservoir on Mount Tabor. This is known as reservoir No. 2. It is rectangular in shape and is the largest reservoir of the Bull Run system. It has a capacity of 22,000,000 gallons. The surface of the water in reservoir No. 2 is 215 feet above the city base. No dam was required to protect this reservoir, as it was excavated

BRIDGE NO. 1, ACROSS BULL RUN BELOW HEAD WORKS.—Photo. by Towne.

in a tract of land the surface of which is nearly level.

Reservoir No. 2 is constructed of a double layer of brick, laid against the embankment, and this brick wall is heavily coated with asphaltum. Each brick was dipped in hot pitch and laid; then a coating of pitch and asphaltum was applied. Next, another layer of brick was laid in an opposite direction, and likewise coated with pitch, all interstices being filled. Lastly a coating of pure asphaltum was applied over the entire exposed surface.

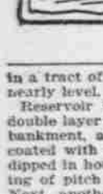
The water coming into this reservoir from No. 1 falls with force sufficient to furnish power for running from 125 to 150 arc lights to East Portland, provided that the consumption of water at the reservoir exceeds 5,000,000 gallons per day.

From the gate chambers at the western end of reservoir No. 2 are laid pipes which connect with the low-service distributing mains on the East Side, as well as with the overflow and drain pipes, which connect with the 30-inch steel sewer which has been constructed from the reservoir to form a junction with the Sunnyside sewer at Thirty-fifth and Belmont streets. The drain and overflow pipes from the high-service reservoir also connect with this sewer.

An innovation which is appreciated by the public has been made in the construction of reservoir No. 2. In the center of the basin of this reservoir a fountain discharges from a five-inch nozzle, throwing a constant stream of water to a height of 100 feet. The fall from reservoir No. 1 to the low-service reservoir gives the force to this water. While the fountain in itself is an ornament that first claims the attention of visitors to reservoir No. 2, it also serves the purpose of keeping the supply of water for this reservoir in constant agitation, this being an important factor in keeping a large body of water in a fresh condition. Provision is also made for numerous jets at intervals around the edges of the entire basin. The nozzles for these jets are placed at such an angle that the water is thrown inward toward the center of the basin.

THE WEST-SIDE RESERVOIRS.

Attractively Located in the City Park, Back of the City.



THE reservoirs on the west side of the river are also intended both for high and low service. The two West Side reservoirs occupy most attractive position in the City Park on the elevation immediately west of the thickly settled district of Portland. These are surrounded by handsome concrete walks, and the grounds in the vicinity are well graded and ornamented with shrubbery. Both of these reservoirs are situated in the ravine which borders the south side of the park.

The high-service reservoir in the City Park is known as No. 3. It has a surface elevation of 290 feet above the base of the city's grades. Its total capacity is 15,000,000 gallons. The gate chamber for controlling the supply from the Mount Tabor reservoir is located at the eastern end of the basin of reservoir No. 3, and against the dam. The water flowing through the 28-inch submerged pipe under the Willamette is conducted up to the head of Jefferson street and from this latter point direct to this gate chamber, where it discharges into a large tank in the interior. This tank contains three outlets of the respective diameters of 36 inches, 20 inches and 18 inches. The largest of these pipes discharges into the reservoir direct. The 20-inch pipe connects with the low-service reservoir designated as No. 4, while the 18-inch pipe connects with the main for the high-service distributing system.

This gate chamber, as are those of all the reservoirs, is so designed that the reservoir may be emptied for the purpose of cleaning or repairing without causing any interruption of the steady flow into the city's mains.

The dam of reservoir No. 3 is constructed of concrete and twisted iron, and is 50 feet thick at the base and 20 feet in thickness at the top. It is built with curved sides of 400 feet radius fronting upon the interior of the basin, a form of design which adds materially to the strength of the dam. The carriage-way across the top of the dam is 10 feet wide, and on each side of this driveway is a walk 22 inches in width. From the top of the dam one can look over the balustrades, 3½ feet in height, into either the upper or the lower reservoirs. On the outside surface of the dam the concrete is so shaped as to resemble Roman columns and arches supporting the driveways, an effect that adds both to the appearance of solidity and attractiveness of the reservoir.

The south side park drive has been extended so as to entirely surround the reservoir. Between this driveway and the concrete walk around the the reservoir is a gentle slope of an average width of 20 feet, which will be covered with flowers and shrubbery. This walk is seven feet in width and completely encircles the reservoir. It is separated from the basin by a balustrade, 3½ feet in height, which is surmounted by a highly ornamental wrought-iron fence 6 feet high. At intervals of 100 feet along this walk for the entire distance around the basin have been placed attractive wrought-iron lamp-posts which will support arc lights. At the edge of the basin, at intervals of 50 feet along its course, are fountains, the nozzles of each being set at the water's surface. These fountains are close to the inner side of the balustrades, but they are bent at such an angle that the columns of water they throw are directed inward, falling toward the center of the basin. The object of these fountains, as before stated in connection with the description of reservoir No. 2 at Mount Tabor, is to afford a constant movement of the water, thus insuring its purity.

The lower-service reservoir at the City Park, designated as No. 4, is at an elevation of 70 feet below reservoir No. 3. The fall of water between the two reservoirs affords sufficient pressure at reservoir No. 4 to drive three Pelton wheels, which in turn drive a dynamo which furnishes power for operating three hydraulic pumps. These pumps furnish the water supply for Portland Heights, a part of Portland situated on the higher elevations of the heights west of the city. The power furnished from this source is also sufficient to run 100 arc lights which will brilliantly illuminate the park. The power-house containing the Pelton wheels, dynamo and pumps is located at the base of the dam, at a point nearly midway between the two reservoirs. None of the water entering the upper basin is wasted. It passes down over the Pelton wheels directly through the gate house to the lower reservoir.

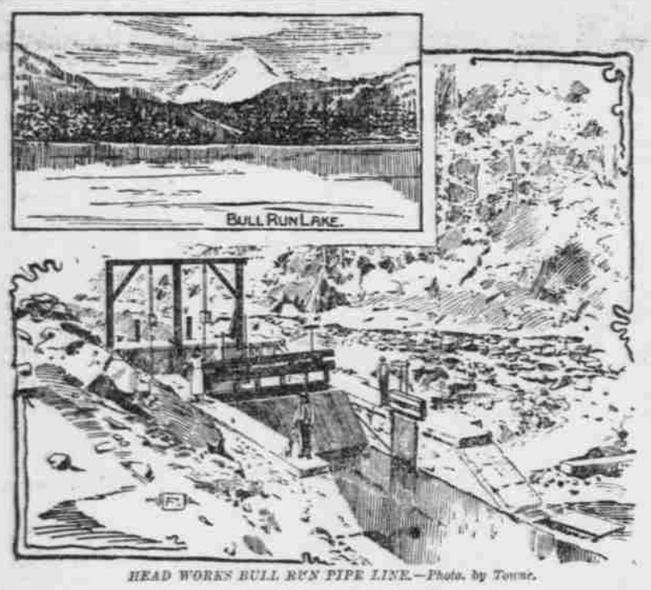
Reservoir No. 4 is located on a tract of land purchased from ex-Governor L. F. Grover and A. N. King. The reservoir site covers an area of about five acres, which has been added to the park preserves.

The basin of reservoir No. 4 has a surface elevation of 220 feet above the city's grades. Its capacity is 18,000,000 gallons. In case of accident to the pipe supplying the upper reservoir, reservoir No. 4 can be filled from pipe connecting with the main from Mount Tabor at the head of Jefferson street.

The dam of reservoir No. 4, unlike that of No. 3, is not constructed with a curved side, it occupying a position straight across the ravine. It is built like all the other dams, however, of concrete, of Portland cement, rock, gravel and sand. It is 50 feet thick at the base, and 13 feet thick at the top. The walk at the top of the dam is 16 feet wide, and is protected on either side by balustrades, 7½ feet high. Like the upper reservoir, No. 4 is encircled by a concrete walk with a parapet on the inner side surmounted by a wrought-iron fence. The arc lights are placed at intervals of 192 feet around this walk, and the fountains along the edge of the basin are arranged as they are in reservoir No. 3.

The steeper slopes in the vicinity of the two reservoirs will be covered with rough and picturesque rock work, while all the other slopes and driveway borders will be covered with flowers and shrubbery. When this work is completed, the brilliantly lighted walks surrounding the reservoirs at the City Park will be the most popular promenades in the city during the evenings of the warmer months of the year.

During the time that the reservoirs of the Bull Run system were being constructed, the work claimed the interest of thousands of visitors. The extent of this system of reservoirs could be better appreciated during the time of their construction than it can today, with a large part of the walls of the basins under water, and it is the full appreciation of the magnitude of this work gained by the people of Portland during the time that the reservoirs were being built that will be the keynote to the interest the city will always take in this matchless system of reservoirs connected with the Bull Run system.



HEAD WORKS BULL RUN PIPE LINE.—Photo. by Towne.

RESERVOIR NO. 2, MOUNT TABOR.—From a sketch by L. Pease.

COST OF THE PLANT.

Over $2,000,000 Expended by the Water Committee.

THE Portland water committee has expended on construction work up to October 1, 1894, the vast sum of $2,113,157. This includes $346,384 expended during seven years for extending the distributing system of the city. The total amount which was expended by the committee, inclusive of the purchase of the plant of the Portland Water Company and pumps, mains, etc., for the Bull Run system up to October 1, last, was $2,848,020. This has covered the cost of the headworks on Bull Run river, reservoirs, pipe lines, roads, bridges, hydraulic pumps, and pipes for Portland Heights, real estate, rights of way, telephone lines, and incidental expenses connected with the construction of the Bull Run system. It is estimated that the cost of completing the present system of city water works, as planned by the committee, will be $670,876, making the total cost of the completed plant $3,518,896. When the plant shall be completed, however, Portland will have a system of water works that will stand intact for ages, and of ample capacity to insure a constant supply of the purest water to the city for many years in the future.

It is estimated that the Bull Run system of water works will effect a direct saving in operating expenses over the old plant at Palatine Hill of from $30,000 to $35,000 a year. These figures are based on the present rate of consumption. When the daily consumption of water in Portland shall have reached 20,000,000 gallons, the committee estimates that the operating of the Bull Run plant will mean a direct saving of from $75,000 to $80,000 a year over the expense of pumping water from the Willamette river as was done in the old water-works system.

Portland will keep in reserve the old pumping system at Palatine Hill, which will remain connected direct with all the city mains. Portland will thus be enabled to avail itself at any time of the use of two complete water-works plants. The old plant will only be used in case of accident to the Bull Run plant, when the repairs might require a longer period than the supply of water carried by the reservoirs of the system is intended to carry the city through. With the great care which has been taken in the construction of the pipe line from Mount Tabor to the headworks on Bull Run river, the chance of accident to the line that would cause an interruption in the flow through the pipes, of more than a day or two at most, is a remote possibility; but, with the view of guarding against every possible accident to the Bull Run system which might threaten an ample supply of water from this system, the committee has wisely decided to keep the Palatine Hill station in constant repair, which will enable the city to avail itself of the use of the old system whenever it may become necessary to do so.

The construction of the Bull Run water-works plant during the period of general stagnation in business covered by the years 1893 and 1894 has proved a blessing to the working population of Portland. The vast sum of nearly $2,000,000, which has been expended on this work, has been largely distributed in this city, and, in addition to furnishing employment to a large army of men during the working seasons of two entire years, it has greatly stimulated trade among Portland's business men. All contracts for this work expressly stipulated that no Chinese shall be employed. With the exception of the steel plates for the pipe line from Bull Run to Mount Tabor, and cement for reservoirs, all materials used in the construction of this work have been manufactured or purchased in Portland.

SOURCE OF THE SUPPLY.

Bull Run Lake and the River Which Flows From It.

AMONG the legendary lore of the Cascade mountains is an account of a mad stampede of a band of cattle down the western slope of the range and across the canyon through which flows the stream that now bears the suggestive name of Bull Run. This band was being driven across the range to the cattle market of Western Oregon. In the almost impenetrable fastnesses of the wild mountain districts this band was so completely obliterated that for years subsequent the only trace of the once mighty body of cattle was the wild rush of some excited bovine in his efforts to find a safe retreat in the forests bordering the canyon from the presence of some intrepid hunter or trapper who had penetrated to the jungles of the Cascade range. It was from this famous stampede that the suggestive name of Bull Run owes its derivation, and in place of the people of Portland being supplied with water from what might have been called "Silver" or "Clear" creek they are today imbibing the crystal fluid from a stream that offers no suggestion to the visitor to its banks of the prosaic name it bears.

High up in the Cascade mountains, at a point 35 miles above the present site of the headworks on the Bull Run river, lies Bull Run lake, a limpid body of ice-cold water, which is the source of supply for the river of that name. Ten miles southeast of the lake towers the lofty peak of Mount Hood, the image of which is mirrored in the crystal clearness of this charming body of water. Separating Bull Run lake from the main range of the Cascades, on the summit of which Mount Hood rises to an elevation of nearly 13,000 feet, is a wide and deep canyon, through which flow the rushing rivers of the Sandy and Hood. The former of these streams empties into the Columbia at Troutdale, a point 15 miles east of Portland, while the other forms a junction with the same noble stream at Hood River station, on the line of the O. R. & N. Co., 44 miles further east. This deep canyon, intervening between the lake and Mount Hood, effectively protects this source of supply for Portland's water from the discolored streams which rush from under the great glaciers surrounding that lofty peak. Evidence of this complete protection of Bull Run lake from glacial water is seen in the vast quantities of scoria and sand which, ground from the rocks of the mountain by the moving glaciers, are carried down every season by the swift waters of the Sandy and Hood rivers, while the waters of Bull Run river, even during the periods of the greatest freshets, are always of a crystal clearness. The lake, too, from which Bull Run river takes its source is really a great spring, which serves as a vast reservoir, almost completely regulating the supply of water poured into the river, thus insuring a constant and comparatively even supply to the stream.

Mr. Frank T. Dodge, the clerk of the water committee, has given the most painstaking efforts to a careful study of the Bull Run river and the lake from which it is supplied. This gentleman made explorations of the entire Bull Run watershed in July, 1891. He not only took complete notes of elevations by the aid of aneroid barometers, but he also secured photographic views of most of the interesting points included within the limits of this watershed. He also made careful notes of distances, of the courses of the streams in this uninhabited and trackless region, and these data have been of inestimable value to the engineers in figuring on the construction of the Bull Run system.

Bull Run lake is about three miles in length, and is of an average width of three-fourths of a mile. It is situated at an elevation of 3500 feet above sea level. Its bottom is of broken rock and boulders, without deposit of either earth or gravel, and so clear are the waters that this bottom can be easily seen to depths of 50 feet or more. The lake has no surface inlet or outlet.

Below the lake is a deep, narrow canyon, with rocky and precipitous sides. The head of this canyon, at the point of contact with the lake, is completely filled with enormous masses of shattered basaltic rock. This forms a most effectual dam for the waters of the lake. The dam is nearly two miles wide, and is covered with a growth of scrub pine and laurel brush.

The waters of the lake find an underground outlet through the dam, which acts as a most effective filter. The Bull Run river heads in a number of large springs which gush from the rocks at the foot of this natural dam, 350 feet below the level of the surface of the lake. The source of these springs, it has been demonstrated, is the lake itself, communicating between the lake and the springs being formed by the passageway under the dam about two miles long. From the head of the Bull Run river the stream rushes over a bed of solid rock. There are sharp breaks in this rocky bed at several points along the course of the river, and at one point the waters make a perpendicular plunge of 110 feet. Between the source of the stream and the headworks of the Bull Run pipe line three principal tributaries add their waters to the volume of the parent stream. These tributaries join Bull Run river at distances of 5, 10 and 20 miles, respectively, above the headworks. The volume of the water carried by the stream past the headworks at the lowest stages, as before stated, is estimated at 65,000,000 gallons a day.

Bull Run river drains a watershed covering an area of about 150 square miles. Nearly all of this watershed is unfit for settlement, as it is a wild, precipitous country, difficult of access, and not susceptible of cultivation. It is this which insures the freedom from contamination of the supply of Portland's water for domestic purposes. Acting on the report of Mr. Dodge, application was made to the department of the interior for the withdrawal of the watershed of Bull Run river as a national timber reserve. The secretary of the interior appointed Mr. C. H. Loomis special agent of the United States land office to make an examination of the territory comprising the Bull Run watershed and report thereon regarding the advisability of the government's making a timber reserve of the area. Mr. Loomis secured the data for his report from Mr. Dodge, whose thorough exploration of that almost impenetrable region had made him more familiar with its topography than any other person who had been into the district before that time. The following is from a report made by Mr. Dodge to Special Agent Loomis at the latter's request:

"From the headworks of the water-supply pipe line, the whole expanse of country rising away up to the mountain tops is a rugged wilderness, unsurveyed and unknown. The only trails are those of elk, deer, etc. There is not a trace of civilization in any direction. Game of all kinds abounds, but I could see no signs that even the Indians use it as a hunting ground. The country is so rough that it is impossible to get a horse into it to pack game out. The formation of the country is volcanic; great ridges of basaltic rock cleft by deep canyons. There is no possibility of the existence of coal or valuable metals. Hardly an acre of the entire area is fit for grazing or for agricultural purposes."

On July 17, 1892, President Harrison issued a proclamation withdrawing from settlement 200 square miles of territory. This reserve includes the entire watershed of the Bull Run river, and this act of the national government will prevent the territory included within the watershed from being denuded of its timber, thus insuring an uninterrupted flow throughout the year of the stream from which Portland's water supply will always be taken.

A DEBT OF GRATITUDE.

The Water Committee and Its Great Service to Portland.

WITHOUT making an unseemly attempt to bestow praise simply because laudation is called for, it is meet in closing this article on a public work which is of some importance to every resident of Portland that some little attention be paid to the gentlemen composing the committee under whose direction this great work has been carried to a most successful completion.

In the work of the water committee Portland has had the benefits of the services of a body of representative public-spirited citizens. The committee has included among its members some of the ablest men and most prominent financiers of the Northwest. Too much cannot be said in acknowledgment of the gratuitous services rendered by the individual members of the committee. Each member has devoted time and attention to this work, the value of which services cannot be computed in dollars and cents, and it has been this disinterested work performed from a sense of public duty which is directly responsible for the early and economical completion of Portland's present great water-works plant.

Nobody will read this article without being impressed with the business-like methods that have characterized the progress of the entire work of construction. Contracts were let only to responsible people, and the stipulations of all these contracts were such that the city's interests in the work were absolutely protected. So severe were some of these stipulations and reservations which contractors had to concede, that all fmaterials used in the construction of the Bull Run system have not only met the requirements of the contracts but in many cases they were so much better than the contracts stipulated they should be that the engineers themselves in charge of the work were surprised at the results obtained. The personnel of the committee has been strong, for the reason that it contained a sufficient number of members to prevent combinations in the interest of contractors, and for the further reason that every man on this committee was a business man of recognized ability, who regarded his reputation as one of his most available assets. That these gentlemen have acted with the single purpose in view of performing the great task imposed on them to the best of their ability is evidenced by the remarkable showing they have made in handling the finances of the water committee, and in the finished work on the Bull Run water-works system, which is conceded by all engineers who have inspected it to be one of the best built systems of water works in the United States.

The work of the committee in handling the business of the city water works during the time of the construction of the Bull Run system is only what can be looked for when boards of public works are made up of representative and successful citizens whose appointments are not the results of political trading. Official position in the municipalities of the leading centers of population in Europe is an honor reserved only for the best citizens, and the results of the management of the municipal affairs of many of these old cities by public boards composed only of able and highly responsible men are worthy of the most careful attention from the American people. The completion of the Bull Run system is an object lesson to the Portland people on the advantages of conducting public business in the same lines that private business of any magnitude is handled, and men who are possessed of sufficient ability to build up a large private business by the honest methods through which individual success is usually attained are the men whose aid should be sought for in the management of municipal affairs.

THE SUBMERGED PIPE.

How the Great Main Was Laid at the Bottom of the River.

CONSTANT vigilance has been necessary in the construction of the Bull Run pipe line to insure a successful completion of this important work. One of the serious problems the engineers in charge of the construction of the pipe line into Portland had to solve was carrying the line across the Willamette river at this point. In crossing the Sandy river, the stream not being navigable, the pipe was easily carried over the watercourse by bridging. The Willamette at Portland, however, is the scene of great activity in shipping. Hundreds of river steamers ply on this river, and ocean vessels of the largest tonnage ascend to Portland at all seasons of the year. The pipe could not be suspended above the surface of the water, and to sink it successfully has called for the display of inventive skill that has attracted the attention of engineers in all parts of the United States.

The difficulty of successfully sinking an iron pipe more than one-third of a mile in length and of sufficient strength to withstand the immense pressure which the principal main of a great metropolitan water-works system is submitted to can be better appreciated after a little reflection on the part of the public of the many safeguards that must be thrown around the work. The several joints of a pipe over 2000 feet long could not be fastened together and made water-tight, and then sunk as a whole. It would be equally as impossible to sink a joint at a time, and afterward fasten the many joints together under water as the work is done in the open trenches along other portions of the line. To bolt the joints together and solder them after they had been submerged would require not only a complete diving bell to protect the workman engaged on the job, but a coffer-dam covering diving bell, diver and submerged pipe would be as necessary as a locomotive is to a moving train of cars.

The difficulty of laying the pipe under the waters of the Willamette was not the only obstacle the engineers of this work had to overcome. Large ships are constantly casting their anchors in Portland's harbor, and during high winds and freshets in the river these anchors sometimes drag a little. During the high stages of the river in the rainy months, too, sunken drift frequently strikes the bottom of the stream with sufficient force to threaten the destruction of any iron pipe in its course. The principal main of the water company crossing the Willamette must not only be laid in such a manner as to insure its being hermetically tight, but it must be at a sufficient depth below the bed of the river that it can never be injured by floating drift, by abrasion or by dragging anchors of vessels.

That this work has been successfully accomplished is a most satisfactory recommendation of the contractors who had direct charge of laying this pipe. The contract for this work was awarded to the Oregon Bridge Company. This company is composed of Messrs. Franklin Riffle, Albert S. Riffle and Perry Hinkle. Both Mr. Franklin Riffle and his brother, Albert S. Riffle, are civil engineers, and they are members of the American Society of Civil Engineers. Both gentlemen are college graduates, and also graduates of a prominent school of engineering. For 10 years prior to their connection with the Oregon Bridge Company, they were prominently engaged in the location and in the construction of the Oregon Railway & Navigation Company and Northern Pacific railroad. The Oregon & Washington Territory railroad (the Hunt line) was located and built under the supervision of Franklin Riffle as chief engineer, and A. S. Riffle as chief assistant. Mr. Perry Hinkle was for 10 years connected with railroad construction work, and he subsequently for a number of years was a large railroad contractor. He is well and favorably known in this community as one of the principal contractors for the dikes along the Willamette and Columbia rivers, built under the direction of the Port of Portland commission.

The submerged pipe of the Bull Run line across the Willamette river at Portland is 2660 feet in length. The pipe for the part of the line which crosses the river here was made by the Ohio Pipe Company at their large plant in Columbus. Each joint of this pipe is 17 feet in length, and weighs five tons. One end of each joint is enlarged and turned in a lathe to a true spherical section. The socket end is made sufficiently larger than the ball end to allow for about one-inch lead backing in the joint. When the joints are connected and the space between the sockets and the ball end have been filled with lead, the pipe is flexible and can be moved in any direction about 15 deg. This allows for all play of the pipe in laying, and for any inequalities of the bottom of the trench in which the pipe rests on the bed of the river.

The dredging for the trench at the bottom of the Willamette along the course of the pipe line commenced early in August last. The contract for laying the pipes provided that they should be laid in a trench dredged to a depth varying from 8 to 22 feet below the bed of the river. The work of dredging was prosecuted day and night from the time that it was first commenced, and the work was finally completed and the trench ready for the pipe on October 15. Great trouble was experienced in dredging the trench, in the buried logs, large boulders, and other obstacles encountered which prevented easy progress. In one case the dredger came in contact with the hull of a vessel which had been under water so long that its history is forgotten. Pipe laying across the Willamette began on the east bank on September 29 last. The first 200 feet of pipe on the bank and in shallow water was connected and suspended from pile bents by rods provided with screws until the pipe-laying cradle could be used, when it was gradually lowered into position by means of wrenches.

This cradle is a most ingenious devise designed by the contractors for laying the pipe in deep water. It is a trussed frame, 100 feet in length. The upper part of the frame rests on a pivot between two barges. The lower end trails in the bottom of the trench at the bed of the river. When two lengths of pipe have been connected in the cradle above water, the scows are moved ahead carrying the cradle with them. This leaves the upper portion of the cradle clear and ready for two additional lengths of pipe. When the shallow water of the west bank of the stream was reached, the pipe in this shallow section was suscradle was discarded and the portion of pended and lowered by means of screws as was done on the east bank.

While submerged pipes of smaller diameters than that of the Bull Run pipe across the Willamette at Portland have been successfully laid in different parts of the world before this, this is the first instance a pipe line of this size has been laid in the bed of any stream. The consummation of this great work marks the completion of one of the most successful water-works systems in the United States, and it reflects lasting credit on the gentlemen who had direct charge of submerging this pipe.

The cradle and many other appliances used in laying and testing this submerged pipe were after special designs made by the contractors. To Albert S. Riffle particularly falls the honor of having made the detail plans of all the special appliances used in connection with this work. All the individual members of the Oregon Bridge Company have devoted their entire time and attention to prosecuting the work of laying this pipe, and they are all equally entitled to credit in having guaranteed the successful outcome of the undertaking.

It may be of interest, as showing the magnitude of the work of laying this pipe, to state that in each of the 131 joints of the pipe 415 pounds of lead were used. In estimating on this work no expense was spared by the engineers that would insure the permanency of the pipe after it was once laid, and the city of Portland will never be put to the trouble and expense of disturbing this pipe after the water has once been turned into the principal mains.

BRIDGE NO. 2, ACROSS BULL RUN, 4 MILES BELOW HEAD WORKS.—Photo. by Towne.

LAYING PIPE OF THE BULL RUN SYSTEM IN BED OF WILLAMETTE RIVER AT PORTLAND.—Photo. by Towne.

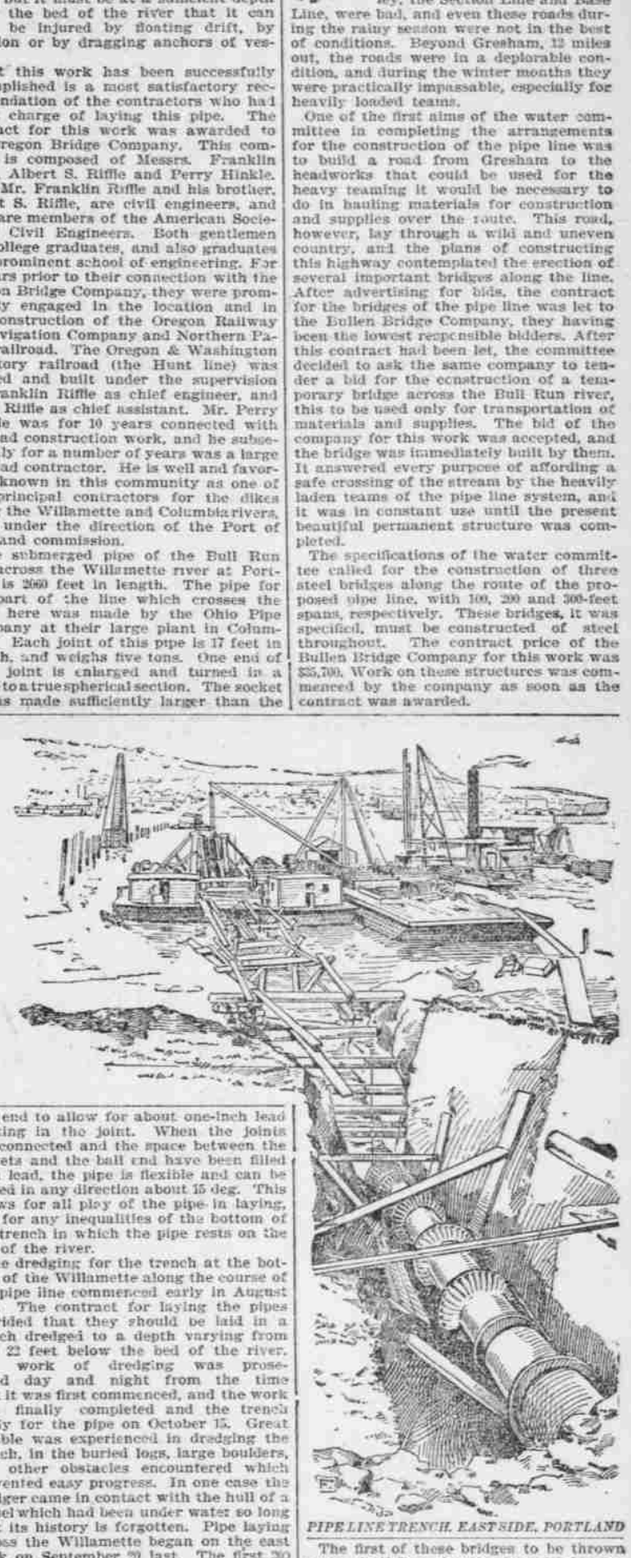
THE BULLEN BRIDGE COMPANY.

Important Work of This Company on the Pipe Line Bridges.

ONE of the most difficult questions connected with the construction of the Bull Run pipe line was the one of transportation. The roads from Portland out to the headworks, with the exception of the main traveled thoroughfares of Powell's Valley, the Section Line and Base Line, were bad, and even these roads during the rainy season were not in the best of conditions. Beyond Gresham, 12 miles out, the roads were in a deplorable condition, and during the winter months they were practically impassable, especially for heavily loaded teams.

One of the first aims of the water committee in completing the arrangements for the construction of the pipe line was to build a road from Gresham to the headworks that could be used for the heavy teaming it would be necessary to do in hauling materials for construction and supplies over the route. This road, however, lay through a wild and uneven country, and the plans of constructing this highway contemplated the erection of several important bridges along the line. After advertising for bids, the contract for the bridges of the pipe line was let to the Bullen Bridge Company, they having been the lowest responsible bidders. After this contract had been let, the committee decided to ask the same company to tender a bid for the construction of a temporary bridge across the Bull Run river, this to be used only for transportation of materials and supplies. The bid of the company for this work was accepted, and the bridge was immediately built by them. It answered every purpose of affording a safe crossing of the stream by the heavily laden teams of the pipe line system, and it was in constant use until the present beautiful permanent structure was completed.

The specifications of the water committee called for the construction of three steel bridges along the route of the proposed pipe line, with 100, 200 and 300-feet spans, respectively. These bridges, it was specified, must be constructed of steel throughout. The contract price of the Bullen Bridge Company for this work was $35,700. Work on these structures was commenced by the company as soon as the contract was awarded.



PIPE LINE TRENCH, EAST SIDE, PORTLAND

The first of these bridges to be thrown across Bull Run river is about 700 feet below the headworks. It is the smallest of all the bridge structures on this line, having but a single span of 100 feet. The bridge is built entirely of steel, resting on a steel cylinder pier on one side and a solid rock foundation on the other. This bridge has capacity for carrying two pipes of 42 inches diameter, each full of water, but at the present time only a single pipe is laid across the bridge. The second crossing of Bull Run is about two miles below the headworks. This bridge has a span of 200 feet, with approaches of about 70 feet at each end. The total length of the span and the approaches is 337 feet. The floor of the bridge is about 112 feet above the water surface of the river below. It is also entirely built of steel, and has accommodations for carrying two pipes full of water, as have all the bridges on the line. This is one of the most graceful and sightly structures spanning any stream in the state. The country in the vicinity of the bridge is of a wild and rugged nature, and, standing as it does at a height of more than 100 feet above the water's edge, it is suggestive of grandeur and that beauty of outline which is never noted in low structures. The third bridge on the line is the pretentious one over the Sandy river, near the mouth of Bull Run. This bridge is a single span of 320 feet, with an approach of about 100 feet on the east side of the stream. This magnificent steel bridge rests on a steel cylinder pier at its eastern end, based entirely on solid rock. The western pier rests on steel bents which reach to the water's level. The foundation for these piers was obtained by making an excavation of 40 feet in solid rock.

The entire cost of these three bridges and the cost of building the temporary bridge over the Bull Run did not exceed $50,000. This is a remarkably low price for three bridge structures of this character built in a wild mountainous district where all supplies had to be hauled in wagons for distances ranging from 25 to 35 miles.