

from June to October inclusive. During this season five times as much water falls as during the rest of the year, evaporation can no longer compensate for rainfall, and the valley is more or less flooded.

Originally built in the midst of a lake, the city has been left on dry ground by the receding waters. Lakes Chalco and Xochimilco have altitudes nearly four feet greater than the pavement of the capital. Still more imperiously do the lakes to the north dominate the city. San Cristobal and Xaltocan are about five feet, while Zumpango is over thirteen feet, above it.

The project now almost completed is a modification of the scheme projected by Simon Mendez in the time of the Spanish Government, and which in 1849 was adopted by Captain Smith of the corps of American engineers which accompanied General Scott's army. The tunnel was ultimately located under the saddle and through the ravine of Acatlan, its mouth being in the Tequixquiac, near the village of that name. The works have been begun several times, and then suspended without effecting anything of importance. In 1866 the works now nearing completion were commenced. A project proposed by Señor Don Francisco de Garay, a well-known engineer of the City of Mexico, was pronounced the most feasible. But the revolutionary struggle succeeded, and for many years the work was relegated to the background.

In 1879 engineer Don Luis Espinosa, the present director of the works, took charge of the undertaking. In the first period mentioned the cutting of Tequixquiac was excavated, and the greater part of the shafts were begun; but at that point the work was stopped by political agitations.

The present gigantic work cannot have been considered to have been seriously undertaken, with a view of completion at any cost, until the year 1885, when the City Council of Mexico submitted a project to the Government to which they offered to contribute largely in the event of its being adopted.

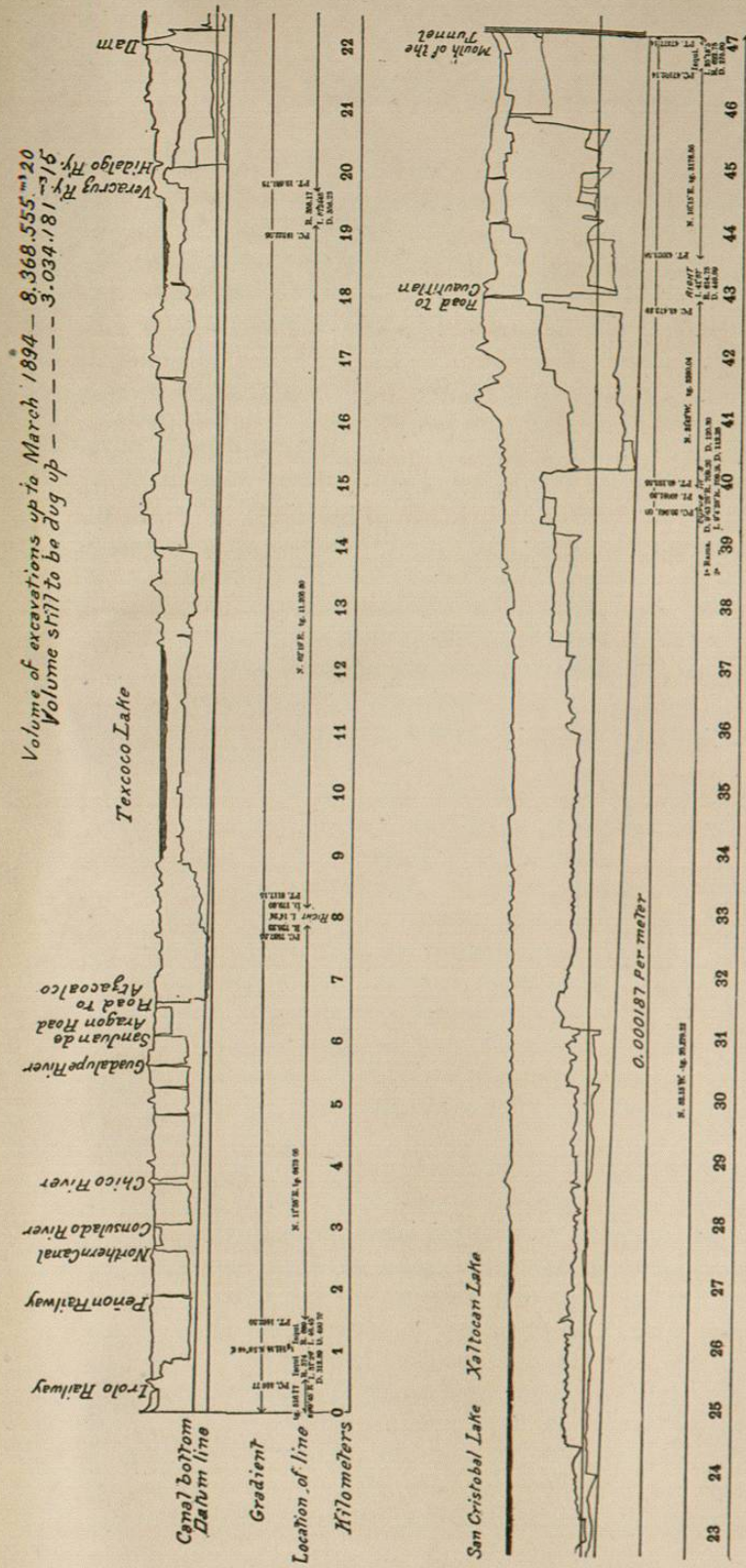
A special commission, with ample authority to deal with the funds set aside for the work, was appointed by President Porfirio Diaz. The City Council set aside the sum of \$400,000 per annum for the canal works, which sum was materially increased by the Federal Government.

In 1887 the City Council raised a loan in London of £2,400,000 to meet the cost of the work and guarantee its successful termination. The entire responsibility of the work was now assumed by the City Council, and the Government gave authority for the Council to make and collect new taxes. Still, there was not sufficient money forthcoming, so another loan was raised in London for £3,000,000, a portion of which was held for the work.

The drainage works, when carried out, will receive the surplus waters and sewage of the City of Mexico and carry them outside of the valley, and will also control the entire waters of the valley, affording an outlet, whenever found necessary, to those which might otherwise overflow fields and towns, rendering the soil stagnant and marshy. The work consists of three parts—1st, the tunnel; 2d, a canal starting from the gates of San Lázaro, and having a length of $47\frac{1}{2}$ kilometres, or 43 miles, its line following on the eastern side of the Guadalupe range of hills and between that range and Lake Texcoco, changing its direction after arriving at the 20th kilometre to a northeasterly one, so as to diagonally cross Lake San Cristobal, a part of Lake Xaltocan, and a part of Lake Zumpango, and arriving finally at the mouth of the tunnel near the town of Zumpango; and 3d, the sewage of the City of Mexico.

The tunnel.—The contract for completing the tunnel was let to Messrs. Read & Campbell, of Mexico, but for some reason they were unable to finish the work. It was therefore continued and satisfactorily completed by the Drainage Board for a sum considerably less than the price contracted with Messrs. Read & Campbell under their superintendence as hereafter stated.

The tunnel has a length of 10,021.79 metres, or 32,869 feet ($6\frac{1}{2}$ miles), with a curved section formed by four curves respectively of the following dimensions: The upper part has a span of 4.185 metres, or 13 feet 9 inches, and a rise of 1.570 metres, or 5 feet $1\frac{1}{2}$ inches; the two lateral arches have a chord each of 2.36 metres, or 7 feet 9 inches, a radius with a chord of 2.429 metres, or 8 feet, and a rise of 0.521 metre, or 1 foot $8\frac{1}{2}$ inches; the elevation is 4.286 metres, or 14 feet, and the greatest width is the span of the upper arch. The accompanying drawings show this section. The tunnel is lined with brick, having a thickness in the upper part of 0.45 metre, or 1 foot 6 inches, and in the lower part over which the water runs, of 0.40 metre, or 1 foot 4 inches in the side arches, and of 0.30 metre, or 1 foot in the radius, this latter lining being of artificial stone made of sand and Portland cement. The elevation of the invert at the beginning of the tunnel is 9.20 metres, or 30 feet $1\frac{1}{2}$ inches below datum; at the end of the tunnel, 17.53 metres, or 57 feet 9 inches below datum. The gradient is 0.00069 for the first 2170.74 metres, or 1 in 1500 for 7120 feet; 0.00072 for the following 5831 metres, or 1 in 1389 for 19,125 feet 6 inches; 0.001 for 4921.50 metres, or 1 in 1389 for 16,147 feet; and 0.00135, 1 in 520, for 1706 feet; these changes being in accordance with changes of details made from those of the original project, in some cases modifying the dimensions of the section. Twenty-five shafts, each 2 by 3 metres, or 16 feet $6\frac{3}{4}$ inches by 9 feet 10 inches, were opened at a distance of 400 metres, or 1312



feet from each other. These served to ventilate the tunnel and to facilitate the work. The deepest of these shafts, situated on the saddle of Acatlan, has a depth of 92 metres, or 301 feet 9 inches; the shallowest is 21 metres, or 68 feet 10 inches.

To give an idea of the labor involved beyond the mere tunneling, it is as well to mention that the quantity of materials required per lineal yard of tunnel was 1800 bricks, 94 cement blocks, 3 cubic yards of mortar, and 70 cubic feet of volcanic stone.

Maximum discharge through the tunnel = 18 cubic metres, 635 $\frac{1}{2}$ cubic feet per second.

When the drainage board took charge of the work, it was executed by day labor both in the canal and in the tunnel, the latter having the larger amounts expended on it. But, shortly afterwards, the contract for the tunnel was let to Messrs. Read & Campbell, of London, who, after having invested a considerable sum in the work, found themselves under the necessity of cancelling their contract at the beginning of the year 1892. The Drainage Board contracted in 1887 with the Bucyrus Co. for the excavation of 1,000,000 cubic metres from kilometre 22 of the canal, and continued to handle the work, as managers, on the remaining portion of the canal.

The Canal.—In 1887, the Drainage Board contracted with the Bucyrus Company, of the United States, of which Colonel Harris was the president, for the construction of the canal.

This company started with two spoon dredgers capable of raising a maximum of 1000 cubic metres, 1308 cubic yards, a day. They commenced operations at the twenty-second kilometre. In the opinion of the board of commissioners, the Bucyrus Company was not proceeding with the work at a suitable rate of speed, for at 1000 cubic metres, 1308 cubic yards, per day, the work of dredging alone, as there were some 12,000,000 of cubic metres, 15,696 cubic yards, of excavation to do, would take about forty-three years; their contract was therefore cancelled.

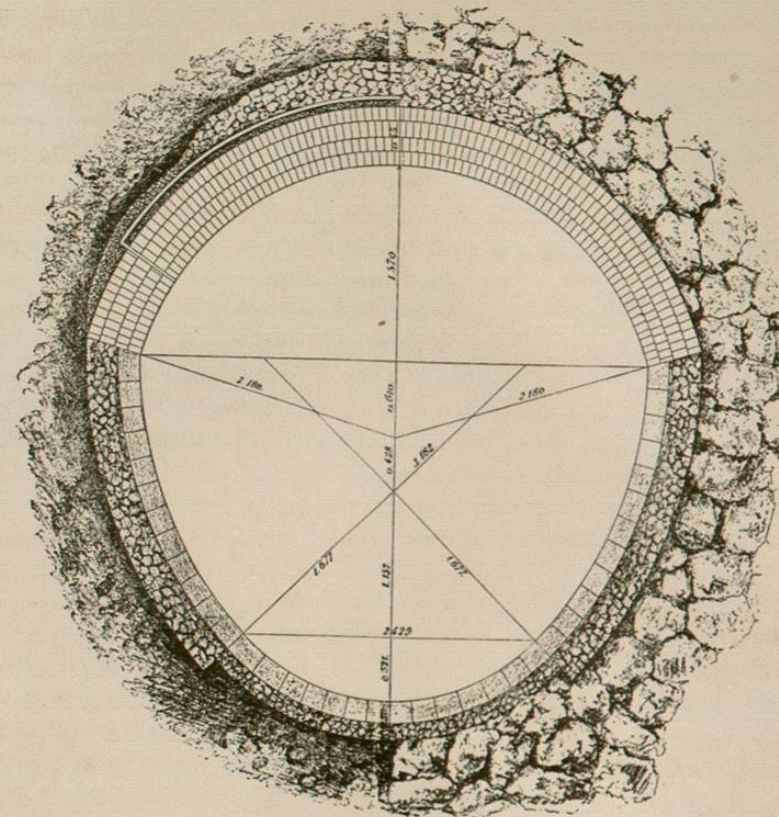
In May, 1894, the Department of Public Works of Mexico contracted with Messrs. S. Pearson & Son, of London, for the completion of the canal, modifying their former contracts of December 25, 1889, March 30, 1891, and April 18, 1893, under the following bases: the unfinished excavation in the first nine kilometres, and that between kilometre 47 and the entrance of the tunnel of Tequixquiac, are to be continued by the Board of Drainage Directors, who must have the latter portion completed to 10 metres below the surface of the soil by December 31, 1894, and to the required depth of the canal by May 31, 1895, in order that the water in the canal may settle to that level and permit the contractors to slope the walls as required by the contract. The contractors are to complete the canal between kilometres 9 and 47 for

the sum of \$3,506,000. For making the monthly estimates of the canal will be divided into two sections—kilometres 9 to 22 and kilometres 22 to 47. In the first section the provisional estimate will be 40 cents per cubic metre; in the second a sum equal to the quotient obtained by dividing the remainder of the money by the number of cubic metres to be removed. The contractors may suspend the work of the dredgers when they fall below 40 cubic metres per hour, and can proceed with the excavation in any way they wish. The excavation had to be completed by May 1, 1896, except in the parts where the dredgers cannot work. Then for each day's delay the contractors must pay \$500 fine, and after five months the contract will be rescinded.

These contractors carried out the work of the canal in two different ways—by hand work with centrifugal pumps to draw off the water which filtered into the work, and by means of enormously powerful Couloir dredgers which have a capacity for 3000 cubic metres of excavation per day, and which throw the excavated earth to a distance of more than 200 metres from the centre of the canal. They had five of these dredgers at work, and by means of them excavated to a depth of 20 metres or 65 feet, raising the earth to an elevation of more than 16 metres, 52½ feet, so as to empty it into the shoots, along which it was carried by a stream of water that delivered it at a considerable distance from the dredger. The dredgers have now done their work, and they have been taken to pieces and most of them sold as old iron, and some of their engines packed and transferred to the harbor works at Veracruz. The portion of the canal contracted for was completed to the satisfaction of all concerned in eight years.

The level of the bottom of the canal above the datum line adopted is 2.25 metres, or 7 feet 4 inches, and the mouth of the tunnel is 9.20 metres, or 30 feet ½ inch below the same datum, supposed to pass 10 metres, or 33.80 feet below the bottom of the Aztec calendar stone, since transferred to the National Museum, but marked on the wall of the Cathedral. The level of the ground at the beginning of the canal is 7.60 metres, or 24 feet 8 inches, and at the end 15.86 metres, or 52 feet above datum. The uniform slope of the canal is at the rate of 0.187 per kilometre.

The canal has a depth, at its commencement, of 5.50 metres, or 18 feet, which in the last few kilometres is increased to 20.50 metres, or 67 feet 3 inches. The side slopes were projected with a batter of 45 degrees, and the width of the bottom is 5 metres, or 18 feet for the first 20 kilometres, or 12½ miles, and 6.50 metres or 21 feet 2 inches in the rest of the canal. The first 20 kilometres, or 12½ miles, may be considered as a prolongation of the net of sewers in the city, and will receive only the water that passes through them. The flow is calculated for an average of 5 cubic metres, or 176½ cubic feet, although, when heavy



(Drainage of the Valley of Mexico.)

VERTICAL SECTION OF THE TUNNEL.

rains require it, they can receive a greater volume; the rest of the canal communicates with Lake Texcoco, and will be utilized in controlling its waters,—the lowest in the valley,—which can be made to flow into the canal from all parts. Hence the canal has been built to carry the largest flow that can pass through the tunnel, or 17.5 cubic metres, 618 $\frac{2}{3}$ cubic feet, per second. The cutting is through a strictly clay formation, comprising occasional thin strata of sand and sandstone.

For accommodation of railroads, wagon roads, and water-courses, it was necessary to construct five aqueducts of iron to carry rivers, four iron bridges for the passage of railroads, and seven bridges for vehicular traffic.

The sewage.—The sewers of the City of Mexico form a network of covered channels, located sometimes in the middle and sometimes on the sides of the streets, these being almost always gorges, communicating with a system of secondary sewers that empty into a collecting sewer discharging into the canal of San Lázaro, which transports the sewage to Lake Texcoco. If the water is high in the lake, water backs up into the sewers and saturates the soil under the houses and streets. As this has been the condition for several centuries, the state of the subsoil under the city can be better imagined than described. The death-rate touches 40 per 1000—the highest in the civilized world. Mexico's elevation of over 7000 feet is all that saves it from a pestilence. Malarial and gastric fevers are almost continually epidemic.

For a century the problem has been settling into one of pure sanitation. The plans which the Government has been working since about 1883, though called plans for draining the valley, really seek to get a fall sufficient to dispose of the sewage. In fact, in the original plan, from considerations of economy, care was to be taken to keep out of the projected canal all water both from the surface of the valley and from the rivers. The Consulado and the Guadalupe rivers were to be carried over the new canal in iron aqueducts. The drainage system was thus to be simply a part of the sewage system of the city.

The excavated materials have been tipped on each side of the canal at their natural slopes, and a towpath near the canal level provided. Sluice gates will direct the city drainage either to the canal or to Lake Texcoco. A sluice gate at the junction of the smaller with the larger part of the canal will control the flow of Lake Texcoco, and another sluice gate will be placed at the entrance of the tunnel.

Completion of the work.—As this paper goes to press, the drainage works of the Valley of Mexico are practically finished, as the waters of the valley have been for several years passing through the canal and the tunnel to their outlet in the river which takes them to the Gulf of Mexico, and the company with whom the canal was contracted is now giving the finishing touches to the sides and bottom of the canal and

will deliver it to the Government Board of the Drainage Directors in January, 1898. It was agreed with the contractors that the portion of the canal between the City of Mexico and the 20th kilometre, which is comparatively difficult, because the ground is very loose, and the excavations to be made yet do not exceed 200,000 cubic metres, will be made directly by the Board as soon as the other portion of the canal has been finished; this last section of the work is expected to be finished in June, 1898, when the waters of the City of Mexico will leave the valley by the drainage works here mentioned.

The canal and six-mile tunnel through the mountain range have a total length approaching thirty-seven miles. The present works will take rank with the great achievements of modern times, just as the immense "cut" of Nochistongo, their unsuccessful predecessor, was the leader among ancient earthworks in all the world. The completed system will have cost \$20,000,000.

I have dwelt on these works at some length, because their importance to the City of Mexico can hardly be overestimated. Instead of being one of the healthiest cities in the world, as it should be with its magnificent climate and situation, Mexico, unfortunately, has a terribly heavy death-rate, due principally to want of drainage and generally bad sanitary condition. When the existing danger of floods is removed, and the sanitary evils are remedied by a proper system of drainage, the increased security that will be enjoyed by life and property will certainly have its effect on the prosperity of the city. Property will rise in value, the population will grow with rapidity, not to mention the tide of tourists that will set in from the United States, and this will mean larger revenues for the municipality.

I could not well finish this paper without paying General Diaz, President of Mexico, a just tribute for the great interest he has taken in having this gigantic work brought to a close during his administration. To his exertions in this regard, and to his commanding position in Mexico, more than to anything else, this happy result, now in sight, is due. So after a weary search of centuries for relief, the beautiful Valley of Mexico will gain its deliverance not only from the engulfing floods, but from the sanitary evils which have long resulted from defective drainage.

Contract for the Sewage System of the City of Mexico.—The complement of the drainage works is the construction of a proper sewage system in the City of Mexico, which will carry all its refuse out of the Valley of Mexico, and on June 8, 1898, a contract was signed at the City of Mexico by the Drainage Board with Messrs. Vezin & Co., of Paris, to do such work.

HISTORICAL NOTES ON MEXICO.

Mr. Walter S. Logan, a prominent lawyer of New York, with business interests in Mexico, chiefly in the State of Sonora, and a personal friend of mine, read a paper entitled "A Mexican Lawsuit" before the Law Department of the American Social Science Association, at their annual meeting at Saratoga, on the 5th of September, 1895, and requested me to be present at the same. I received at the same time an invitation to attend that meeting, which I suppose I owed to Mr. Logan, from Professor Francis Wayland, President of the Law Department of that Association. Wishing to oblige Mr. Logan, and at the same time to hear his paper read, for I had no doubt that it would do justice to Mexico, as Mr. Logan is friendly to that country, I determined to attend the meeting, and I reached Saratoga late on the afternoon of the day on which it was to be held. I found at the hotel at which Mr. Logan and most of the other gentlemen of the Association were stopping, and where I myself lodged, a printed notice that Mr. Logan would read his paper that evening, and that I would make some remarks afterwards. I was considerably disturbed by this, as it is always difficult for a diplomatic representative of a foreign country to speak in public, and I was not prepared to speak before so enlightened an audience.

At the appointed time we went to the meeting, and Mr. Logan read his paper. While he was reading it I noted certain incorrect statements made, in good faith, no doubt, by Mr. Logan, but which presented Mexico in a rather unfavorable light. I found myself in a very difficult position, because, considering myself as Mr. Logan's guest, I did not think it would be proper for me to criticise his paper; but, at the same time, being the official representative of Mexico, I could hardly permit his mistakes to pass unnoticed. I was placed in the same position as the guest who, while present at a dinner to which he had been invited, should hear his host make incorrect and even uncomplimentary remarks about his house or his family, although made unintentionally. No matter how bad taste such conduct showed if made intentionally, it would be still worse taste for the guest to notice