CHAPTER XVI.

THE SEWERAGE OF SAN DIEGO.

The case of San Diego is unique. It is the only town in the country, so far as I know, that has, of its own motion, introduced a complete system of sewerage in what may be called its foundation period. It has 38½ miles of graded streets, and it has already 38½ miles of sewers and 14½ miles of house branches. Pullman was completely severed at the outset, but the cases are somewhat dissimilar, as Pullman is owned and controlled by a single corporation, and the action taken was in no sense due to the community living there.

San Diego is the only sea-port of Southern California having a good harbor. Its superiority in this respect, and its remarkable climate, caused it to come into prominence at once on the opening of Southern California to the world by the completion of competing railroad lines. The excitement attending this opening was very great, and a large population poured into the region with great rapidity. The enterprising people of San Diego, when its population was only about five thousand, conceived the idea that full advantage could not be taken of its attractiveness as a health resort unless its sanitary condition were made conspicuously good, and the subject of sewerage was agitated in a very effective manner.

I was employed at this period to make a plan for its sewerage. It was then thought that provision should be made for a future population of 30,000. The plan for the work was submitted in January, 1887. Its estimated cost was over $300,000, exclusive of outlet works. It was decided to issue bonds for $400,000 bearing interest at the rate of five per cent. per annum. So effectively was the subject discussed and advocated that the election resulted in 1,083 votes being cast for the issue and only 34 votes against it.

The bonds were sold for a commission of $10,000, leaving a net sum of $350,000 available for the work.

Ground was broken about the middle of July, 1887, and on the 30th of June, 1888, the last pipe had been laid and the whole work substantially finished at a total cost, including outlet, of $386,108 71.

I made four visits to San Diego during the progress of the work. In April, 1887, I found a population of nearly 11,000, in August of over 20,000, and in February of about 33,000. Before my last visit in June "the boom had collapsed," and the withdrawal of speculators and of a large force that had been employed in grading streets and building sewers, both now completed, had reduced the population to less than 27,000. Evidently the stimulation of growth that had raised the excitement in Southern California to fever heat had led to excessive developments here, as in Los Angeles; but both towns are obviously established on a secure foundation, and need only wait for the effect of the development of the agricultural and commercial resources of the country, and of its advantages as a resort for pleasure and for health.

Plate VII. shows the location of San Diego with reference to its harbor and projecting headlands, and the relation of the sewerage of the city, aggregating a length of about 38 miles, with reference to the tidal flow of the channel.
The main sewer is of vitrified pipe 24 inches in diameter for a length of 6,500 feet. It is continued 1,200 feet farther with a diameter of 18 inches. The entire line has an inclination of 1 in 700. At its head there is a Rogers Field flush-tank in the course of the sewer, and filled with sewage from the region beyond, having a discharging capacity of 24,000 gallons. The discharging end of the siphon is 8 inches in diameter. The discharge of this flush-tank produces a marked effect throughout the whole length of the main. Another large flush-tank, discharging 3,000 gallons, placed at the head of a fifteen-inch sub-main running south, parallel with and next to the shore the bay. This is in like manner to be fed by the sewage of the district tributary to it.

At a distance of 1,500 feet from the lower end of this main line there is a flushing-inlet from the harbor, 12 inches in diameter, which is brought into operation at each high tide (Fig. 22). This inlet is protected by a brass valve gate, swung at the ends of long arms, against the outflow of sewage.

Man-holes are used at frequent intervals on sewers of ten inches diameter and larger. On eight-inch and six-inch sewers, oblique inspection-pipes, set in pairs and reached from the surface of the street through a man-hole cover, are used at intervals of about 300 feet (see Fig. 23).

There is an automatic Field flush-tank fed from the water-supply placed at the head, or dead end, of each lateral sewer of the system. Four-inch Y-branches are inserted for house connection opposite every lot in the city. Wherever the formation of the ground is such as to make it possible to drain a whole block by interior back drainage, a six-inch Y-branch is provided for such use, and it is understood that property owners will be allowed to make their connections in this way if they...
lay, under the direction of the city engineer, entirely through the block, a six-inch pipe-sewer with a flush-tank at its head. The prohibition against the admission of roof-water or surface-water is absolute, and it is required that all connection with the sewers, whether lateral drains to the centre of the street or the interior plumbing work of houses, shall be constructed according to specified rules and under the close inspection of a city officer employed for the purpose.

The rates of inclination for lateral sewers are unusually good. In only two or three instances, and here only for short lengths and far from the upper ends of the sewer, is so light a grade as 1 to 300 used. In the more level portions of the town 1 to 100 is common, and many of the laterals are much steeper than this. Probably the houses of one-fourth of the population are already connected, and all question as to the success and efficiency of the system seems to be fully satisfied. House con-

Fig. 24. Plan of Outlet Appliances for Emptying the Sewage Reservoir in San Diego Harbor.

nection is compulsory, and it is hoped that by the end of this year the entire city will be connected, every privy, cesspool, and private drain on the whole area being finally and for ever banished.

The main sewer is continued from the shore to a sewage reservoir in the harbor, a distance of 1,100 feet with a twenty-four-inch iron pipe laid with a fall of six inches in its entire length.

The reservoir in the harbor is 200 feet square in the clear, and has a capacity, to the height of ordinary high tides, of about 1,500,000 gallons.

The sewage reservoir is constructed of creosoted lumber. 10 x 10 piles were driven into the solid bottom in two rows, ten feet and six inches apart, the two rows being connected by iron rods. The opposite faces of these two rows of piles were lined with three-inch planks spiked to them; the intervening space, ten feet in the clear, was filled with well- puddled clay, making a substantially tight enclosure around the whole area. The top of the wall is planked over at a height of about
three feet above the highest tide and is to be furnished with guard-rails. It is believed that this creosoted lumber will withstand the ravages of the teredo, at least for five or six years, to which time the construction of a concrete wall entirely around the structure has been postponed as too costly for the present financial condition of the city.

As it will be a long time before the flow of sewage and the flushing-inlet above described, from

the harbor to the main sewer, will fill the tank between tides, or indeed in a whole day, to anything like its capacity, valved inlet-gates have been provided for the admission of such an amount of sea-water as may be necessary to raise the level of the contents of the reservoir to at least the height of ordinary high tides.

The outlet from this reservoir is through an iron pipe thirty inches in diameter and six hundred feet long, laid on the floor of the harbor and delivering at the bottom of the deep channel where
there is a draught of over thirty-three feet at mean tide. This outlet-pipe opens not directly into the reservoir, but into a discharging chamber of which the gate is worked automatically by the action of the tide.

The accompanying illustrations show the arrangement and the essential details of these appliances.

Fig. 24 (page 145) is a plan, in which A is a chamber connected with the harbor by a ten-inch pipe, Aa, and containing the bell E. B is a gate-chamber connected with the reservoir by a thirty-inch pipe, RB, and with the channel by the main outlet-pipe, BB, thirty inches in diameter. C is the inlet-chamber connected with the reservoir by the channels, D and D, and with the harbor by the pipe Ce. G G is a brass gate closing against a brass seating at the end of the pipe RB, and held in place by the toggle-strut, T T, also of brass. This strut is hinged to the gate and to eyes in the opposite wall, so that the joint may open upward at jjj. k is an eye at the top of the stirrup attached to the hinge-pin of the joint, jjj, by which this joint may be lifted, the force of the stru
relieved, and the gate, G G, opened. There are no valves on the pipes A a, B b, and C c, the tide rising and falling freely in the chambers A, B, and C. The channels D and D are provided with gates, φ φ, which open to admit sea-water to the reservoir, raising the same to any desired height less than that of high tide. The gates, φ φ, are flap-gates, preventing the escape of the contents of the reservoir when the tide falls in the chamber C; φ φ are floats operating the gates φ φ and φ φ. These are adjustable, allowing these gates to be opened and closed at any desired stage of water in the reservoir. S and S are chutes carrying the inlet-water beyond the float-frame into the reservoir.

Fig. 25 (page 146) is an elevation of the same work. In the chamber A the bell E is shown suspended from a pulley, with pulley is connected by a slack rope with a support above. The bell E is of copper, having an opening at its bottom protected by wire-cloth, and at its top an air-valve, I, opening upward. It also has an air-pipe, h, opening into its upper portion and extending to a point a little higher than the extreme bottom of the bell. In chamber B there is shown an elevation of the gate G G and a cross-section of the toggle-strut T T, with its joint-pin, f j j, and stirrup adjustment at k, to which is attached a rope passing over a pulley above, under the pulley from which the bell E is suspended, and thence to a fast point. In connection with the chamber C is shown a vertical section through the gates φ φ and φ φ, the channel, D, and the chute, S, into the reservoir.

Fig. 26 (page 147) is a section through the chamber B, showing the position of the toggle-strut, T T, and the gate, G G, when open and when closed.

The operation of the apparatus may best be explained in connection with Fig. 25, wherein the gate is represented as being closed and locked by the extended position of the strut, T T (as shown in solid lines in Fig. 26). The bell is empty and is suspended a little below high water mark. As the tide rises it enters through the wire-cloth screen at the bottom of the bell and rises through it, forcing out its contained air through the valve I. As the tide falls, air is excluded by the valve I and water is retained in the bell. When the tide-water outside of the bell shall have fallen far enough to have developed sufficient weight of its contents the bell falls, drawing down its pulley and producing twice its motion at the stirrup of the strut. This breaks the toggle, the pressure from within aids in opening the gate, and the bell is again submerged by dropping into the falling tide-water. The continued falling of the tide draws the bell down either to the extreme point to which the bent strut (Fig. 26, dotted lines) will allow it to fall or to a higher point, at which it may be stopped by the check-rope above its pulley. By the weight of its contained water it holds the gate open until the tide shall have fallen below the mouth of the air-pipe, h. This is to be adjusted by the length of the check-rope, so as to be unsealed about one hour before dead low water. As soon as air is admitted at this point—the water draws out of the bell, which then becomes lighter than the gate and strut, and these drop to their normal position to await the falling of the next tide. The position of the bell may be adjusted either by the check-rope above or by the rope that supports the flying pulley, so as to cover a considerable range of the tide, allowing the gate to be opened and closed early or late or for a longer or shorter time.

The opening and closing of the gates φ φ on the inlet channel D is effected by the floats f f on the reservoir side of the wall. The gates close by gravity, being tripped when the stop φ rises to the desired point. They are opened by the drawing down of the lever arm r, by the cross-bar, w, on the vertical stem of the float. Both stops can be set at any point desired. When the contents of the reservoir rise to the appointed level the lever is tripped and the gates close. As the reservoir is discharged on the falling tide, the floats f f become weights which, by the cross-bar, w, lower the lever arm, r, which is caught and held by the latch shown at g. As the inlets D are below the ordinary reach of the tide there is a considerable inflow during its higher stages tending not only to dilute the accumulated sewage in the reservoir but also to give head for its delivery during the falling tide.
While this apparatus is automatic in its working, the tides of San Diego Harbor are such that it will require adjusting—say, twice a month—on the approach of spring tides and on the approach of neap tides.

Gaugings taken in connection with this work, extending from May 5 to September 11, 1887, showed the following variations:

<table>
<thead>
<tr>
<th>Highest high water</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lowest &quot; &quot;</td>
<td>5.5</td>
</tr>
<tr>
<td>&quot; low</td>
<td>10.6</td>
</tr>
<tr>
<td>Highest &quot; &quot;</td>
<td>6.1</td>
</tr>
</tbody>
</table>

The extreme range is 8.6. The least range is 0.6. During spring tides there is a difference between the high tides of the morning and evening and between the low tides of the morning and evening of about two feet.

This makes the extreme range between the highest high tide and the lowest low tide of one day about seven feet. During neap tides the variation is much less, often immaterial.

To meet these varying conditions, when the tides have settled to a tolerably uniform run approaching the period of neap tide the gate can be adjusted to discharge at each tide. As the variation increases, making a wide range between the highest high tide and the lowest low tide, the best effect will be secured by adjusting the parts to open and close the gate early and late in the ebb of the highest tide only, allowing the discharge under these strong tides to take place only once a day.

The area of San Diego Harbor inside of the position of the reservoir is about 12½ square miles. The average rise and fall for this area will be not far from 4 feet, rarely less than 2 feet.

The immense amount thus to be discharged at all tides must flow mainly through the narrow ship-channel, toward which the shallower waters of the bay are constantly tending during the ebb. It is believed that sewage discharged in the full flow of the ebb tide, but not later than one hour before low tide, will be carried beyond Ballast Point and mainly beyond Point Loma, with no probability of its return in any perceptible degree to the waters of the harbor or to the shore inside of Ballast Point.

This is the first application ever made of this particular method of operating the outlet gates of a sewer and the first instance, so far as I know, of the application of automatic apparatus to the emptying of a sewage reservoir into a tidal outlet during a given portion of the ebb tide. It is not unlikely that the details of the machinery will have to be modified in some respects, but the short time during which the San Diego outlet has been in operation seems to have demonstrated the practical success of the process.

The accompanying map of the city (Plate VIII) shows the complete alignment of the sewers, with the location of man-holes and flushing-tanks.