THE SEWERS AND SEWAGE FARMS OF BERLIN.

In August, 1894, the Prefect of the Seine sent a French government engineer, Mr. F. Launay, to Berlin to investigate the system of sewerage and sewage disposal of the German capital. The report of this engineer, published in the "Annales des Ponts et Chaussées," of September, 1895, praises these works highly. The city has a population of about 1,000,000, including the suburbs, and an area of 15,586 acres; in 1874 it was without a sewage system, while in 1894 the total length of sewers was 462 miles, and over 22,000 acres of land was embraced in the tracts used for purifying the sewage. In 1892, after the construction of the sewers had been followed by a fall in the death rate from 32 to 20 per 1,000. "The most surprising feature in this great work," according to Mr. Launay, "is the rapidity with which it was planned; the methods, once studied out and adopted, were carried out without cost or delay.

The city was divided into twelve independent districts, corresponding with slight differences in topography. Each of these basins was called a "spoon," and was provided with a pump and a system of sewers receiving both storm water and house sewage, and a pumping station for forcing the sewage to the pumping stations. The part of the city south of the Spree as far as the Landwehr Canal comprises three systems: System I. is on the east, while the west systems II. and III. are separated by a line running from the Anhalt railway station to the Spittel market. North of the Spree are Systems IV. and V. To the south of the Landwehr Canal and separated from the Anhalt railway station by the Potsdam and Dresden railways, are Systems VI. and VII., while the east and west respectively, these also take in parts of Charlottenburg and Schöneberg, which are connected with the Berlin sewerage system by reason of a special agreement between the authorities of the cities. System VIII. comprises the Moabit district at the west of the city, and System IX. extends to the northwest. Finally, Systems X., XI. and XII. extend from the north to the east around the outskirts of the city. The island of Cölln is connected with System III. and the island of Berlin with System IV. The district adjoining the Zoological Gardens is connected with System VIII. by a spoor, 282 ft. long, across the Spree. Systems I. to VII., inclusive, and XII. are now in use; System XI., where the district is not yet built up, has not been begun, and the remaining two are incomplete.

The city is situated on a great sandy plain, with barely perceptible differences in elevation, and on this account the location of the pumping stations was a delicate problem. Wherever possible an attempt was made to select the lowest point in the system in order to give the sewers a grade corresponding with the natural slope of the surface. It was also necessary to keep near the public waterways in order to make as efficient as possible the interceptors which will be explained later. In the outskirts of the city, where the length of the force mains to the fields was reduced, it was possible to adopt less powerful pumps and to reduce in a corresponding measure the expenses of construction and operation. In some cases, the solution of a site for the stations was determined solely by the possession of suitable property for the purpose by the city. When the location of the pumping station had been settled a system of channels was devised. In fixing upon the maximum of run-off per second from any surface the following assumptions were made: Maximum for household waste, 0.054 cu. ft.; for rainfall, 0.2; or, together, 0.354 cu. ft. per sec. per acre. The sections of the sewers were determined, according to the Kytelwin formula for full pipes. The pumps are all horizontal; some of the engines are compound, controlling two pumps, and others are single, with one pump. But all the pumps in any one plant are alike in every part. The boilers are all tubular, and the buildings themselves are handsomely furnished and contain hoists for the inspector and chief mechanic, dining-room, baths and places for drying the clothes of the workmen. The pumps are all of the piston type, with 4 cylinders, excepting for a few small ones in System III., where a centrifugal pump is installed. The pumps in System IX., recently established, are of the piston type, with 4 cylinders, 150 strokes per minute, on the Reider system.

Each radial system is subdivided into basins, each of which has a collector connecting the basins in suspension, which might otherwise clog the pipes. The foot-roads on the basin on the other side of the gravity, or where the arrangement of the pump does not permit this, a special channel leads from the sump to the suction pipe. The sewers themselves, for three-quarters of their length, are made of vitrified cappell piping, ranging from 8 to 16 ins. in diameter, in diameter, into two equal parts, by a vertical grating of iron bars parallel to each other. The velocity of the flow in the sewage is checked by the sudden enlargement of the section of channel and by the sand, and the grating catches mud in suspension, which might otherwise clog the pipes. The foot-roads on the basin on the other side of the gravity, or where the arrangement of the pump does not permit this, a special channel leads from the sump to the suction pipe. The sewers themselves, for three-quarters of their length, are made of vitrified cappell piping, ranging from 8 to 16 ins. in diameter, in diameter, into two equal parts, by a vertical grating of iron bars parallel to each other. The velocity of the flow in the sewage is checked by the sudden enlargement of the section of channel and by the sand, and the grating catches mud in suspension, which might otherwise clog the pipes. The foot-roads on the basin on the other side of the gravity, or where the arrangement of the pump does not permit this, a special channel leads from the sump to the suction pipe. The sewers themselves, for three-quarters of their length, are made of vitrified cappell piping, ranging from 8 to 16 ins. in diameter, in diameter, into two equal parts, by a vertical grating of iron bars parallel to each other. The velocity of the flow in the sewage is checked by the sudden enlargement of the section of channel and by the sand, and the grating catches mud in suspension, which might otherwise clog the pipes. The foot-roads on the basin on the other side of the gravity, or where the arrangement of the pump does not permit this, a special channel leads from the sump to the suction pipe. The sewers themselves, for three-quarters of their length, are made of vitrified cappell piping, ranging from 8 to 16 ins. in diameter, in diameter, into two equal parts, by a vertical grating of iron bars parallel to each other. The velocity of the flow in the sewage is checked by the sudden enlargement of the section of channel and by the sand, and the grating catches mud in suspension, which might otherwise clog the pipes. The foot-roads on the basin on the other side of the gravity, or where the arrangement of the pump does not permit this, a special channel leads from the sump to the suction pipe. The sewers themselves, for three-quarters of their length, are made of vitrified cappell piping, ranging from 8 to 16 ins. in diameter, in diameter, into two equal parts, by a vertical grating of iron bars parallel to each other. The velocity of the flow in the sewage is checked by the sudden enlargement of the section of channel and by the sand, and the grating catches mud in suspension, which might otherwise clog the pipes. The foot-roads on the basin on the other side of the gravity, or where the arrangement of the pump does not permit this, a special channel leads from the sump to the suction pipe.
to them, but also provide a place for water pipes, telegraph and telephone cables and other underground furniture. In Berlin, considerations of economy led to a reduction in the cost of maintenance provided. When the waste-water commerce to act in that city it is figured that the proportion of household waste to rainfall is 1 to 1.5; and with a water consumption of 60 litres (16 gallons) per head per day, the proportion of excremental matter is 1 to 100. This corresponds to a dilution of 1 in 1,000; a rate which descends to 1 in 15,000 when the waste contains no solid excrement.

The pumping mains, leading to the sewage farms, have their upper side buried about 3.3 ft. below the normal street level, and they generally follow the undulations of the surface, having air-vents at all high points, which are opened daily. The diameter of the cast-iron pipe used varies from 2½ to 3½ ft., and riveted iron pipe is employed in crossing streets and railways. The house connections in Berlin are worthy of note. Building is regulated by a police ordinance of July 14, 1874, and by a municipal ordinance of Sept. 4, 1874. The police ordinance requires every owner of a house to make a connection with the sewers, either by a waste pipe or by a special connection to be used for the water-closets alone. All the old privy vaults have disappeared, and it is forbidden to build new ones. The house owner has six weeks from the date of notice to present to

The actual surface of the city drained by the present eleven radial systems is about 13,120 acres; the streets included represent a length of 74 miles, covering a superficial area of 5,300 acres. The total length of all the sewers, on April 1, 1894, was 450 miles, not including the relief sewers. The number of manholes and inspection shafts together was 10,950, and there were 14,204 catch-basins.

The entire service of maintenance, up to the limits of the sewage farms, is under an inspector having under him a number of special inspectors, the latter being responsible for the systems. The inspector has under his charge at each lifting-plant a chief-mechanic, 3 to 7 engineers, 2 to 4 firemen, coal-handlers, etc. For the maintenance of the sewers of any system he has from 2 to 4 foremen with 6 or 12 workmen. Each foreman directs three laborers or more, according to the district assigned him. A district includes from 1,000 to 2,000 houses, and from 35,000 to 80,000 inhabitants; it also includes from 1½ to 2½ miles of sewers, with 250 to 500 manholes, 450 to 690 catch-basins and from 1,500 to 2,000 house connections. The foreman is responsible for the care of tools, the inspection and cleaning of the sewers, and notes daily the amount of water used in cleaning the sewers and the quantity of sand taken from them. He examines all the house connections and stays in touch with them. The foreman supervise the regular flushing of the sewers and, at night, the cleaning of the same from sand. The sewers are generally cleaned once in each period of three nights and four days. The pipe sewers are flushed once in three days; one night answers for the examination of the masonry sewers, and for the other three nights the pipe-sewers are being cleaned by the passage of a special brown through them. In cleaning the larger sewers, two workmen, provided with boots, are employed; one of these pushes before him with a scraper all the mud, rags, paper, etc., and the second workmen follows with a broom and cleans up the invert. These men usually enter at the head of a sewer at 7 a.m., and by 5 p.m. arrive at the sum of the pumping plant. During this time a third workman follows along the street and opens the manhole plates in advance of the two below, thus giving them pure air. It is also usual to have a man at the grating in the central sum to prevent it from being stopped by rags and paper.

The flushing is commenced at the highest point in any sub-system. The flushing tank is filled from the water mains, after the opening leading to the sewer has been closed by a stopper connected with the street by a chain. The tank is emptied and the water is then used to flush the preceding catch-basin. The flushing stream flows down the system. The broom-cleaning of the pipe-sewers referred to is done in the same manner, an oilied cord attached to it is passed down one of the manholes into the pipe; to this cord is fastened a tared cable fixed to a cylindrical broom of "plasawa" fiber which has another cable fixed to the other end, so that if one cable breaks the broom can be hauled out of the sewer. Two workmen, one to push the broom forward by the aid of a reel; another takes away with a shovel the sand coming to a manhole, and a fourth man manages the rear cable and regulates the flow of distribution water for the cleaning of the sewer. Usually, three brushes of different diameters are used, one after the other, the last having the same diameter as the pipe. The sand is usually removed from the large sewers at night. For this service from 5 to 7 men are required, and the deposit is only removed when it acquires a depth of about 6 ins. From the pump chambers into the sewer. The workmen load the sand into buckets which are carried by four men, two to each bucket, to the nearest manhole, where two other men lift them to the street.

This somewhat antiquated method of cleaning has of late years given way to an automatic flushing device. This is essentially a dam made of planks and cut to conform with the inside of the sewer. This dam is made in sections, united by bolts for convenience in passing it into the sewer, and is provided with rollers above and below, and is kept in an upright position by a rear brace and guide rollers. It acts as a dam and permits the water to escape under a head through the opening at the bottom, cutting away and driving before it the sand in the sewer. This device is especially serviceable in the sewers under 2½ ft. in height into which it would be difficult for workmen to enter. A new device, here illustrated, is also being used in clearing the pipe sewers on a similar principle. In this the plank dam is replaced by a metal dam having a section equal to three-fourths of that of the pipe.
point exceeds 5 ft. The land acquired is in two grounds, the one on the northeast of Berlin and about 1.8 miles from the edge of the city; the other lies to the south and is about 7.2 miles distant. Of the 220 acres included in these fields, about 78% is represented by irrigation fields.

The remainder is taken up by courts, garages, and secondary conduits, some in pottery and most of them in the form of open drains, buried at least 1.6 ft. and having suitable fall. The principal conduit, leading from the pumping station, is a rectangular pipe in a stand-pipe of the same diameter as the pipe. The branches of the distribution pipes terminate at high points and are closed with valves, the diameter of the pipe descending to 10 ins. There are about five of these conduits to every 247 acres of irrigated land, and the pipes end in "swan-necks," with the cooping water falling into a clear basin or into trenches, and then places the pipes empty into a rectangular basin, 15 x 40 ft., 6½ ft. deep. These basins deposit the sediment in them is made through the channels of which the water is suspended in the air.

The beds for "running culture," or for cereals, carrot, potatoes, beans, fruit trees, etc., are arranged as at Gennepiellers (Paris sewage farm; see Engineer News, Aug. 25, 1895), in grooves and furrows. The furrows are from 65 to 50 ft. long; they are about 10 ft. wide and their depth is from 10 to 15 ins. The ridges thus formed are from 3 to 5 ft. wide, c. to c.; they are generally united in great beds, 20 to 30 ft. wide and in series of water ditches at a distance of 100 ft. The prairie or grass beds are usually 200 ft. long by 120 to 150 ft. wide, and they are watered for the first time six days after being formed. Other beds, in which other plants are set apart for winter use, or for vernalization, no kinds of cultivation being attempted. The beds receive the water in successive beds from 12 to 18 ins. deep, kept in place by dikes.

The experience with the Berlin sewage farms, as at Gennepiellers, proves that there is no burning out of the soil, no swamp-formations, and no necessity for reducing the dose of sewage water at the end of a certain time.

Periodical and methodical analysis will show the constancy of the affluents, or purified sewage as being clear, pure, inodorous and free from microorganisms. No epidemic has justifiable the smallest increase in the amount of sewage water. The health of the people living on these irrigated fields, carefully controlled by medical inspection, in every way, shows that the city of Berlin has not hesitated to establish homes for convalescents upon these fields; one at Blankenbeuern, for 40 men; another at Heinersdorf, for 40 men; a third at Maleharten, and a fourth at Blankenfelden. These axioms are confirmed by the physicians and are well fitted.

As to cost, the following items are interesting: The cost of daily wages to the workers is 48 to 60 cts., with lodging, to the foremen of irrigation; 24 to 30 cts. to the workers who instead of lodgings, receive 60 to 110 cts. of potatoes per year, or the land for cultivating them. The occasional laborers receive from 36 to 60 cts. to the same hourly rate of 24 to 25 cts.; and workers caring for the fruit trees receive 60 to 72 cts. per day. Work is sometimes given as a task, and in this case the daily wages range from 10 cts. to 50 cts. At certain points the field work is done by vagrants taken from the hovel of the Berliners, sent to the fields under guard and lodged in barracks.

The system of managing the sewage system in the city of Berlin, for the year 1893-94, was about $394,000; of which $12,000 was for the personal and professional wages. In addition to this sum $380 was spent for gaging and $1,050 was set aside for the hospital for sick or injured workers. Under the operation of general radial systems, for the same year, was about $310,000. The average quantity of water taken from each house, etc., for the year 1893-94 is shown in the following summary of a detailed table for each radial system:

<table>
<thead>
<tr>
<th>System</th>
<th>Total quantity of water in gallons</th>
<th>Total quantity of water in cubic yards</th>
<th>Total quantity of water in tons</th>
<th>Total quantity of water in cubic feet</th>
<th>Total quantity of water in acre-feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radial 1</td>
<td>16,345,000</td>
<td>39,750</td>
<td>795</td>
<td>39.75</td>
<td>2.3</td>
</tr>
<tr>
<td>Radial 2</td>
<td>1,991,000</td>
<td>4,980</td>
<td>99.5</td>
<td>4.98</td>
<td>0.3</td>
</tr>
<tr>
<td>Radial 3</td>
<td>1,051,700</td>
<td>2,630</td>
<td>52.7</td>
<td>2.63</td>
<td>0.1</td>
</tr>
<tr>
<td>Radial 4</td>
<td>604,000</td>
<td>1,490</td>
<td>30.0</td>
<td>1.49</td>
<td>0.09</td>
</tr>
<tr>
<td>Radial 5</td>
<td>502,000</td>
<td>1,225</td>
<td>24.5</td>
<td>1.23</td>
<td>0.08</td>
</tr>
</tbody>
</table>

The total quantity of sand and refuse matter of all kinds taken from the drainage system in one year amounts to 150,000 cu. ft. of the pumps, and three specimens of the effluent from the vegetable and fruit farms, the grass lands, and finally from the winter outflow.

Cross Section. Longitudinal Section

DEVICE FOR CLEANING SEWERS

Oval Sewers. Pipe Sewers.

Yearly cost to 100,000 cu. ft. of receiving the drainage system of Berlin, up to March 31, 1894, was about $225,000,000. Of this about $14,000,000 went for the drainage system and $7,100,000 for the sewage farm, about $4,000,000 of the latter being for the cost of land.

The radial systems I. to X. and XII., excepting the suburbs of Charlottenburg and Schöneberg, include 22,101 houses, of which 22,001 are drained and united to the drainage system. The correspondence cost is $4,790,000, and the amount of sewage removed annually is 16,791,017,000 gallons.

From these elements we may arrive at the following conclusions: The cost per inhabitant has been $12.54, of which $9.15 were for the drainage system, and $4.39 for the irrigation fields.

The annual cost of administration and maintenance, the clearing and care of the sewers, and for machinery, is $327,000; the maintenance of the sewage farms costs annually $101,000; interest upon capital amounts to $1,046,000; a total annual cost of $3,850,000. The revenue from 22,001 houses amounts to $750,000, and the revenue from the products of the sewage farms is $446,000; a total of $1,785,000. The difference of $715,000 between expenses and revenue is covered from general receipts of the municipality.

The author concludes by comparing Berlin with Paris, as follows: Berlin has not quite 25,000 houses to 1,501,000 inhabitants; while Paris has 82,000 houses to 2,500,000 inhabitants; amounting to an average of 70 persons per house in Berlin and 20 persons houses in Paris, in the daily outflow of sewage water is 40,750,000 gallons, of which the excremental matter would amount to $2,000,000, or 1.4%. While the filtering soil on the Berlin sewage farms is thin, porous, and permeable and only permits an average dosage of 4,000 gallons per acre per day for the whole year, the deep sandy soil of the Valley of the Seine will admit of a dosage of some 11,000 gallons per acre per day.