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THE
LONDON WATER SUPPLY

A RETROSPECT
AND A SURVEY

SISLEY

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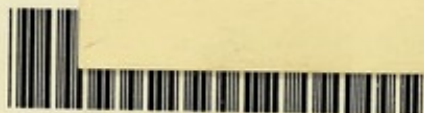
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THE
LONDON WATER SUPPLY :

A Retrospect and a Survey.

BY
RICHARD SISLEY,
DOCTOR OF MEDICINE AND
DOCTOR OF STATE MEDICINE IN THE UNIVERSITY OF LONDON.



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AUTHOR'S PREFACE.

A STUDY of Sir John Simon's book on "English Sanitary Institutions" first proved to me the great importance of the question of the London Water Supply, and a prolonged and careful examination of the evidence given to Lord Balfour's Commission proved that the question was one of great complexity. I was convinced that the only way for me to get a full grasp of the matter was first to understand clearly the details of the method by which London is at present supplied with water. I therefore wrote to the proprietors of the *Lancet* to propose that I should investigate the present state of the London Water Supply, and the scope of the present work may be best shown by quoting from the letter in which the proposal was formally made :

"The things which I think deserve attention in the case of each metropolitan water company are "

1. The source or sources of supply.
2. The method or methods of purification adopted.
3. The quantity supplied.
4. The storage capacity of reservoirs ; filter-beds.

"With regard to the method of distribution, it would be well in the case of each company to give a plan showing the position of the reservoir or reservoirs which supply the different parts of the area supplied, and a plan giving the chief arterial trunks going from each reservoir. There are some very good maps published in the last report of the Metropolitan Water Supply, but these only give the areas of distribution of the various companies. These maps were expensive and are now out of print.

"It seems to me that it is quite necessary to have definite and accurate information on all the points I have mentioned, before any just opinion can be formed as to the present water supply to London. There has lately appeared in the daily papers a good deal of scrappy information written by reporters on various matters connected with the London Water Supply. The editors of different papers seem unfortunately to treat the question of the London Water Supply rather from a political point of view, and propose schemes for the control of the water supply without any accurate knowledge as to what the water supply is. There are those who think the control of the water should be

vested in the County Council : there are those who think otherwise. All this writing appears to me beside the mark ; at any rate, these are not questions in which I am concerned or on which I propose to touch at all in these articles. . . . The questions of present interest, on which there is no accurate, up-to-date information, are : What are the sources of the present water supply ? How is the water treated, and how distributed ? These questions, and these alone, are those which I propose to treat ; and they should be treated more fully than they have ever yet been."

The proprietors of the *Lancet* having agreed that articles written on these lines should appear in their journal, arrangements were made to obtain the necessary permission from the metropolitan water companies to visit the works. As might have been expected, facilities were not granted with equal readiness by the managers of all the metropolitan water companies. Some of them, according to their account, had of late been put to a considerable trouble and expense in consequence of the policy of the London County Council, which had, they suggested, spent a great deal of money in opposing the water companies' bills in Parliament, and in making what they considered unfair attempts to purchase their undertakings below their market value. The County Council had, they suggested, tried to prove that the water companies' undertakings were of little value, and at the same time they had tried to purchase them. Such a policy, it may be pointed out, is not a new one. "It is naught ; it is naught, saith the buyer."

Unfortunately for me, the relations existing between the London County Council and the water companies undoubtedly made the task which I had undertaken a more difficult one than it would otherwise have been. In order to give an accurate account of the water companies' undertakings on the lines suggested, it was necessary that all the works should be visited. The officers of some of the water companies, however, appeared to think at first that I might get all the necessary information by the study of a book by the late Sir Francis Bolton ; and at least one of them was so obliging as to send me type-written extracts from this book, which he suggested might serve my purpose. Ultimately, however, it was arranged that I should see all the details of the various undertakings, and I have visited all the places mentioned in the descriptions which follow. For the information supplied as to the pumping arrangements, I am indebted to the engineers of the companies.

There were some points on which I should have been glad to have had more full information. It was, however, pointed out to me that I was not a Royal Commission. More than one engineer told me that if he appeared before a Royal Commission, and were asked the question that I had put to him, he would certainly answer it. The information given on some matters is less full, therefore, than I should have wished. My constant desire has been to give an accurate and unbiassed account of the present arrangements for carrying on the supply of water to London, and that the account should be as full as possible.

During this prolonged investigation one thing struck me very strongly. As a result of a year's constant work, in which I was in almost daily contact with the engineers and other employés of the London water companies, one impression may deserve to be recorded. I was profoundly struck with the loyalty of all the officers and servants to the companies in whose service they were engaged. There are emergencies in connection with water supply undertakings which cause the greatest anxiety to those whose business it is to carry out the details of the work. In such emergencies, the ungrudging way in which all the employés of the companies work is quite worthy of remark. This is doubtless in great part due to the fact that officers and servants are employed from their early days, and often remain in one service as long as they are able to work. In not a few cases, also, sons work with and succeed to the duties of their fathers. The engineers and other officers of the company are necessarily in almost daily contact with the men, and in very many, it is not too much to say in the vast majority of cases, take a personal interest in the men and in their families. In the service of most if not of all the companies a coherent body of workers has thus been formed, and on an emergency every one does his best for the company which employs him.

It has been a great pleasure to me to see the undoubtedly friendly relations which exist between the men and their officers.

The greater part of the information which follows, and the maps and plans, have been published in the *Lancet*, and are republished by permission of the proprietors of that journal, to whom I tender my thanks. I wish also to take this opportunity of

recording my acknowledgment of and thanks for the care with which the original articles were "read" and printed in the offices of the *Lancet*, a care which has considerably lightened for me a work not entirely free from the element of dulness.

The maps showing the distribution of the mains of the water companies are taken from plans given by the engineers and secretaries of the water companies. To these gentlemen I wish to express my thanks for the courtesy and kindness which I have invariably received from them. I shall always have a pleasant recollection of days passed with them on the Kentish hills, and in the valleys of the Thames and of the Lee.

SAVILE CLUB, PICCADILLY,
January 17, 1899.

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THE LONDON WATER SUPPLY

A RETROSPECT.

THE site on which London is built was by Nature bountifully supplied with water. The Thames, a large, pure river, broader than it is at the present time, abounded with salmon and other fish. On the north side of the river there were many springs rising from the gravel beds, and clear streams bore their water to the river. The district south of the Thames was marshy.

Little is known about the water-supply of Roman London, and few traces have been found of it; but this does not, of course, prove that during the Roman period there was not an adequate and well-arranged supply of water for drinking and domestic purposes. It is well known that wherever it has been possible to make a complete examination of the sites of cities which were occupied by the Romans for any lengthened period, in all cases it has been found that ample provision was invariably made for the supply of an abundant quantity of pure water. Recent excavations at Silchester show that the arrangements there were extremely good. The remains of public baths have been discovered, and from them a large sewer has been traced, and found to extend beyond the walls of the city. It is practically certain that London, like other cities in Roman times, had an adequate and well-arranged water-supply. In the case of a city like London, however, extensive changes have constantly been going on, and each generation of citizens has more or less destroyed the work of former ones. Traces of the earlier civilization are not very frequently found, and then only at a considerable depth below the soil. On the other hand, in the case of a place like Silchester, which till recently remained undisturbed from the time it fell into ruins, modern research has made it possible to see clearly how perfect the arrangements were; whilst in London the dust of ages has covered up the work which was not destroyed, and Roman work is now discovered only when deep excavations are made. From time to time a few scattered specimens

of Roman water-pipes of lead and of earthenware have been found, and some of these are preserved in the British Museum. Unfortunately, in many cases no record was made of the sites on which the specimens were found, and there is not sufficient evidence for the most imaginative of archæologists to found a plan of the London water-supply in Roman times. There were, however, so many springs and wells in and near the Roman city that it is practically certain that they afforded a sufficiently good supply to obviate the necessity of bringing water from any great distance.

In the time of the Saxon dynasty London was a walled city with seven gates: Doe Gate and Blynes or Belins Gate next to the river, Lud Gate and New Gate on

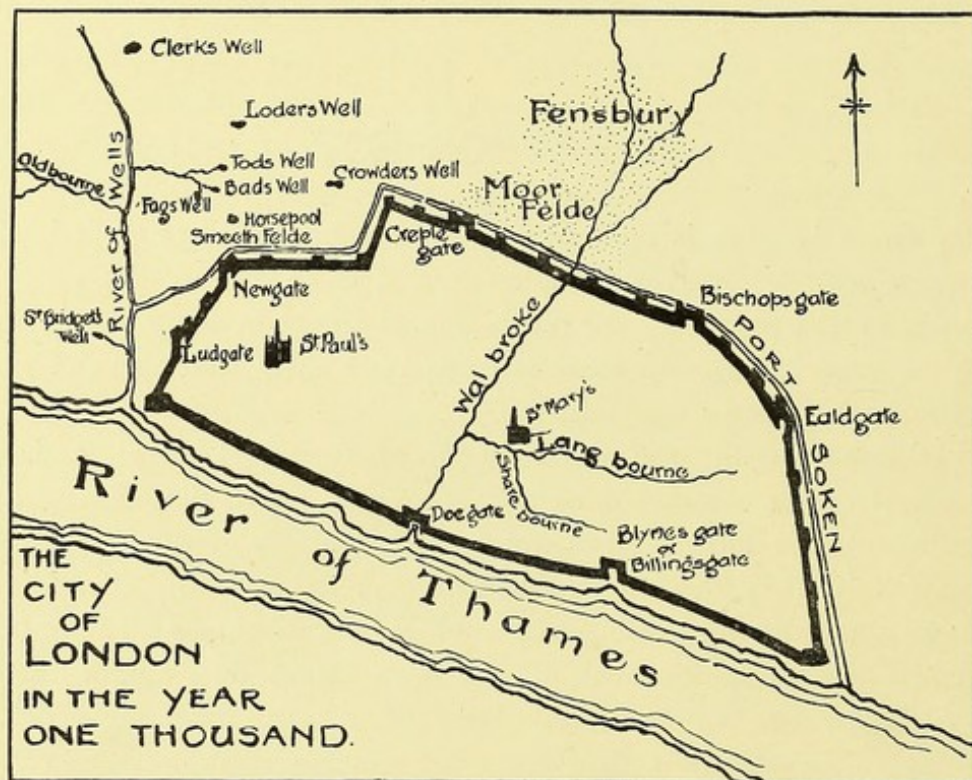


FIG. 1.—PLAN OF THE CITY OF LONDON IN THE YEAR 1000.

the west, Creple Gate and Bischops Gate on the north, and Æld Gate on the east. The streams of Share Bourne and Lang Bourne ran into Wall Brooke, which, rising in Fensbury, ran through the marshes of Moorfelde, then passed under the city wall, and, flowing in a south-easterly direction, ran into the Thames at Doe Gate. The river of Wells was beyond the city wall and to the west. Tod's Well, Bad's Well, and Fag's Well discharged their water into streams which flowed into its left bank, and the Old Bourne and the overflow from St. Bridget's Well supplied water for the rivulets which ran into the right bank. Of these streams the names only survive. The Wallbrook and Langbourne are no more seen, but they have given their names to City wards.

The accompanying map is reproduced from one in the British Museum. It shows the probable position of the wells and streams in and near the City of London in the year 1000. It is, of course, not a contemporary map, and it is here only given to show that the natural resources of London in early times were probably sufficient to supply the wants of the inhabitants of the City. Stow describes the Wallbrook as having been a fair brook of sweet water, which came from the north fields through the wall and midst of the town into the Thames, and tells us that the City was divided into two nearly equal parts by the brook, and that this division gave rise to natural municipal boundaries, which were in his day still maintained for civic purposes. There was, Stow says, a long bourne of sweet water, which of old time, breaking out into Fenchurch Street, ran down that street and Lombard Street to the west end of St. Mary Woolnoth's Church. This was the Langbourne, and there is no doubt as to the position of this stream, which is correctly given in the map. As to the Sharebourne, it seems by no means certain that the map is correct, for from the same authority we learn that from the west end of St. Mary's Church the Langbourne, turning south and breaking into small *shares*, rills, or streams, gave the name to Sharebourne Lane. The site of Crowder's Well is now occupied by Well Street, Jewin Street. At the early part of the eighteenth century the water of this well, according to a contemporary authority, was still in good repute, and was esteemed for the treatment of sore eyes, and some said it was very good for men in drink to take of this water, which had the reputation of allaying the fumes of the liquor and of inducing sobriety. Water possessing such a useful property should have been in great request, and the opportunities for testing its efficacy were not few, for at that time temperance was not a common virtue in London, nor was drunkenness a new vice if Thomas à Becket's secretary, amongst others, is to be believed.

In his account of London as seen in the reign of Henry II., Fitzstephen expresses annoyance at the number of the drunkards, and at the chastity of the city dames;* but he spoke well of the water. He tells us that there were about London on the north of the suburbs choice fountains of water, sweet, wholesome, and clear, streaming forth among the glistening pebble-stones. The quality of the water, however, soon became injured by pollution, and grossly defiled with the vilest refuse. The contamination to which the streams were subject gave rise at quite an early period to grave complaints, and the question of river pollution was formally brought before the Parliament which met at Carlisle in the twenty-fifth year of the reign of Edward I. The Earl of Lincoln complained that the pollution of the Old Bourne had become unendurable in consequence of the filth from the tanneries situated on the banks of the stream, with the result that the citizens were ordered to cleanse the river.

As time went on the amount of drinkable water which could be obtained locally

* 'Urbis matronæ ipsæ Sabinæ sunt.'

became insufficient for the wants of the people. The courses of the streams in the City became reduced in size, and in many places the streams themselves were covered by the building of houses. It became necessary for the citizens to bring some of their water from a distance. In this they followed the example of the religious, who, according to Roman traditions, had provided their houses with an abundant and pure supply. In the year 1236 a supply of spring-water—granted on the demand of Henry III. by Gilbert Sanford—was brought from Tyburn in leaden pipes, and some years later conduits were built in various parts of the City, from which water derived from this source could be obtained at any time.

The Corporation of London provided for the cleansing and repairing of the springs at Tyburn for the Great Conduit in Chepe, and the City records of 1329 give an account of the money paid for that purpose and for the beer provided for the labourers who carried out the work. The records of the City of London contain a good many entries showing the difficulties which the authorities had with regard to the conduits and to the water-supply generally. It was found necessary to appoint keepers to the conduits, and their chief duty appears to have been to see that the water was not stolen wholesale for the purposes of trade. In 1312 it was provided that brewers, cooks, and fishmongers should pay, at the discretion of the keeper of the conduit, for the water they used for business purposes. In 1337 there was a complaint that the brewers sent day after day and night after night and took tubs full of water to make their ale. After a discussion in full Court by the Mayor, Sheriffs, and Aldermen, it was decided that if any large tubs were in future sent to the conduit by brewers, they should be forfeited and retained for the benefit of the conduit.

The pipes which conveyed the water to the Great Conduit in Chepe passed from Tyburn to Constitution Hill, thence to the Mews near Charing Cross, through the Strand, to Fleet Street. The pipes were partly above ground, and therefore exposed to the weather and to accident, and in 1388 complaint was made by some of the inhabitants of Fleet Street that through the breaking of the pipes their houses had become damaged by the overflow of the water. In 1390 permission was given to certain citizens residing in West Cheap to put up a conduit near the church of St. Michael-le-Quern, and leave was given that it should be supplied from the great pipe of the conduit which was situated opposite to the church of St. Thomas Acon. An old drawing shows that there were two lines of pipes one above the other, and it seems that the water in the lower pipe could be had gratuitously by anyone who wanted it for drinking or for household use, and that a charge was made for that supplied by the upper pipe.* The money thus obtained was spent in keeping the conduit in good repair and in paying the attendant in charge of the place. As the

* An entry in the City Records, 1415, shows that the Mayor and Corporation ordered that the brewers who rented the fountain were not to draw any water from the small pipe below on pain of fine.

water-supply became more and more inadequate for the supply of the increasing population, riots occurred at the public conduits between the people who met there. So great was the scandal that the Lord Mayor found it necessary by proclamation to forbid the people who resorted thither to come armed with clubs and with staves.

Persons who lived near the banks of the Thames long continued to obtain their water from carriers, whose business it was to deliver it from the river to their houses. It seems, however, that the inhabitants of the lanes near the Thames strongly objected to the free passage of outsiders. They demanded toll, and the water-carriers, or "cobs," as they were called, were apparently a particularly truculent set of people. The men who made a trade of getting river-water for sale had not always a very easy task, for the condition of the banks was such that landing on the mud was not without danger. There is a record amongst the City archives of an inquest on the body of a water-carrier who was drowned in his attempt to land.

The Tyburn springs having proved insufficient for the supply of the conduits, the Abbot of Westminster, in the year 1438, granted to the Lord Mayor and citizens of London the privilege of taking water from the Manor of Paddington. The consideration to be paid by the City to the Abbot and to his successors was two peppercorns on the Feast of St. Peter. It was provided, however, that if this work should interfere with the ancient wells used for the supply of the Abbey, the grant should cease.

The first time in the history of London in which the supply of water became a considerable business was due to the enterprise of a foreigner. In 1582 a man named Peter Moris, Morris, or Morice, an ingenious engineer, undertook to supply the City with water pumped from the Thames. The exact nationality of Peter Morris is open to doubt, but he was a Freeman of London. He put up an engine at the first arch of London Bridge, and by means of water-wheels, which were driven by the river, he was able to force water through leaden pipes at such pressure that it was thrown over St. Magnus's steeple, to the great admiration of the Mayor and Corporation, and of the other people who had met to see the sight. Morris afterwards obtained the lease of the second arch of London Bridge, and was thus enabled to increase the amount of water supplied. Morris's supply was conducted in leaden pipes to supply houses in Thames Street, New Fish Street, and Grass Street, and as far as the north-west corner of Leadenhall. The work was completed in the year 1582, on Christmas Eve. The City authorities paid the cost of the main pipe, which conveyed the water to a standard made for that purpose. This standard, called the "Carrefour," had four spouts, which pointed in different directions, and served for the supply of the inhabitants of the houses near, who sent thither to fetch the water. It served also to cleanse the streets, and discharged water northwards towards Bishopsgate, eastwards towards Aldgate, southwards towards the Bridge, and westwards towards the Stocks Market. It seems that the amount of water first supplied

was not maintained, and Fleming, who continued Hollingshed's "Chronicles," says: "If the said water were maintained to run continually, or, at least, every tide, some reasonable quantity, as at first it did, it would have been well; but from 1566 it was much aslaked, through whose default I know not, sith the engine is sufficient to convey water plentifully." The standard at Cornhill existed until the Great Fire of London. It was, however, sometimes dry, sometimes overflowing, and was frequently indicted as a nuisance for the latter reason by the inquest of Cornhill Ward. The water business started by Morris was continued at London Bridge for a century and a half, and a tower was built on the bank as early as the reign of Elizabeth.* The Great Fire destroyed some of the property, and in consequence of this misfortune litigation occurred at the petition of Mary Morris, widow of one John Morris, and a beneficiary under his will, against her brother-in-law Thomas, and the trustees of the estate. In consequence of the fire the defendant Thomas tried to avoid paying her jointure, which was a first charge on the profits of the waterworks, and the petition was therefore brought to enforce payment. The evidence given at the trial showed that the water business was a very lucrative one. At a later period the New River Company interfered considerably with the profits, and the proprietor then sold the property to one Richard Soames, a citizen and goldsmith, for the sum of £36,000. Soames was a financier, and soon brought the business out as a company, with a capital of 300 shares of £500 each. The London Bridge Waterworks Company continued to exist until 1822, when the works were removed, just before the destruction of the old London Bridge, and the property was sold to the New River Company. X

Morris's water business soon had imitators. In 1594 Bevis Bulmer erected a large horse engine at Broken Wharf, near Blackfriars Bridge, to supply the west part of the City with water. The undertaking did not prove a success, and the site was ultimately bought by the New River Company.

A few words will suffice to describe the state of the London Bridge Waterworks Company at the beginning of the present century, and it is not without interest to note the conditions with regard to water-supply which existed at that time in an important and rich quarter of the City of London. The quantity of water supplied by the Company in 1810 was estimated at something between 3,000,000 and 4,000,000 gallons daily, and the water-wheels worked for about twenty hours each day. When the tide was very low less water was raised by water power, and the

* The lease of the first arch of the bridge was granted by the Lord Mayor and Commonalty in the year 1581 for a period of 500 years. In 1583 the second arch was granted for a period of 500 years from that date, and a lease of the fourth arch was given in 1701 for a period of 381 years. In 1761 the third arch from the north was granted for a period of 321 years; and finally, in 1767, the fifth arch from the north end, and the second arch from the south end, were let on lease to the company which had acquired Morris's business for 315 years. The arch on the south side of the bridge was used for putting up a pump for the supply of Southwark.

necessary quantity was made up by working a steam-engine. The Superintendent of the Company gave a somewhat depressing account of the state of business in the year 1821. They had at that time a very "strong enemy" against them, which had taken away many of their customers. "They were in a state of pauperism, and much to be pitied." The "strong enemy" was the New River Company, which had the power of raising water higher than the London Bridge Company could possibly do. The new fashion of building high houses was disastrous to the Company, because cisterns and water-closets were placed at an unreasonable distance above the ground in the new buildings. The distributing pipes used by the Company were made of wood, and they had not enough money to replace them by iron ones. They were unable to supply water at a higher level than the second story of a house. The Superintendent of the Company would not admit that the water supplied was of a bad quality, and he said that in many instances distillers took it in preference to any other, but he said that he never thought of drinking it in the condition in which it was supplied. The ebb tides, he admitted, brought down a considerable quantity of soil from the rivers which ran into the Thames, and the water was frequently foul, but after it had stood in a cistern for twenty-four hours it became "finer than any other water that could be produced." For his own supply the Superintendent had two large cisterns, and by drawing out the water alternately every other day he had "as clear water as could be imagined." The rates charged for supplying the tenants of the London Bridge Waterworks varied, according to the amount supplied, from a minimum of less than £1 to a maximum of over £20 per annum. The total number of customers was a little over 10,000, and sixty-eight public buildings were supplied. The method of arranging as to the price charged to customers was that the surveyor first examined the premises closely and reported to the Superintendent what he thought the consumption was likely to be, and the size of the service pipe. A price was then fixed, and if in the course of time it was found that the consumption was more or less than had been estimated, an abatement or increase in the sum charged was made, according to the circumstances of the case. Brewers, stable-keepers, and some other tradesmen, were subject to an extra charge. The amount of water considered necessary for a daily supply to a house was one butt, and any quantity above that was considered an "extra service."

With regard to the ultimate failure of the London Bridge Waterworks, it may be said to have been due not so much to complaints as to the quality of the water supplied as to the fact that the New River Company were able to supply water at a higher pressure, which enabled them to force it to the upper storeys of the London houses.

Such, briefly, is the history of the earliest of the London water businesses. It must be remembered that at the time at which it was started the people of London were not content to allow the water-supply to be left entirely in private hands.

In the reign of Elizabeth several schemes for the improvement of the water-supply were laid before Lord Burleigh. Of these one was to bring water from Uxbridge to the north of London. An Act of Parliament passed in Elizabeth's reign to allow the citizens of London to convey water from Hertfordshire to the City is not infrequently referred to as if it related to drinking-water, whereas, as a matter of fact, the Act was passed for the improvement of navigation. The first Act authorizing the supply of London with drinking-water derived from Hertfordshire was promoted by the Corporation of London, and passed in the year 1606, and a further supplementary Act was passed the following year. The Mayor and Corporation, however, did not avail themselves of the provisions of these Acts, and thus neglected a great opportunity of supplying the City with good water under their supervision. At that time, however, engineering was not a strong point amongst the members of the Corporation, and the undertaking appeared, and, indeed, actually was, one not to be lightly undertaken. It was reserved for a private citizen, Hugh Myddelton, to carry out the work. A brief history of the undertaking is given in the chapter on the New River Company.

On looking through the early records of the Corporation of London two things strike one with regard to the action of the Mayor and Corporation in all affairs connected with water. The first is that they were always extremely careful to insist on the fact that a sufficiency of water for the poor to drink was of prime importance; and, in the second place, it is seen what stringent precautions were taken to punish offenders who took a greater quantity of water than they were entitled to for trade purposes, or who stole water from public sources for their own private benefit.* The other early water businesses which were started for the supply of places north of the Thames were the New River, one at York Stairs, Strand, and two smaller ones in the East End. Of these the New River Company is the only one which still exists in recognisable form. The East End businesses are now represented by the East London Waterworks, in connection with which their story will briefly be told; and here a few words only need be added with regard to the York Buildings Waterworks, which had a somewhat curious career.

In the reign of Charles II. a patent was granted to allow waterworks to be made to supply the west end of London with water from the Thames. The undertaking was called the "York Waterworks," and the premises used occupied part of the site of

* The City Records contain an account of how a resident in Fleet Street succeeded for a time in stealing water, and the punishment that was meted out to him. On November 12, 1478, William Campion of Fleet Street was convicted of having tapped the conduit where it passed his house, and, conveying the water into his well, "thereby occasioning a lack of water to the inhabitants." The culprit was taken before the Lord Mayor and Aldermen, and punished in a rather striking manner. He was placed on horseback, with a vessel shaped like a conduit on his head, and this was filled with water which ran out of small pipes over him while he rode round to all the conduits in the City, at each of which his delinquency was publicly proclaimed.

old York House. The original works were destroyed by fire in the year 1690. In 1691 an Act of Parliament was obtained by which the proprietors of the York Waterworks were incorporated, under the style and title of the "Governor and Company of Undertakers for Raising the Thames Water in York Buildings." In the early part of the eighteenth century the Company did not confine their business to water, they speculated largely in land. A number of forfeited estates which had belonged to Scottish Jacobites were bought up at a cheap rate, with the immediate result that there was an enormous increase in the market value of the shares (£10 shares became worth £305). The waterworks were situated at the bottom of Villiers Street, under which the chief reservoir extended. Water was supplied to Piccadilly, Whitehall, and Covent Garden, and to the intervening streets. The number of tenants supplied by the York Buildings Company was just over 2,000 in 1804; in 1814 it was 2,740; and in 1818, 2,636. It was perhaps rather unfortunate for this Company that there was a fire in the district supplied by them at a time when they were unable to supply water because their own boiler had burst. The fire proved fatal to two or three people, and the fact that there was no water-supply to quench it appears to have made the Company somewhat unpopular. The undertaking was finally ruined by the competition of the newer companies. Some of the tenants went to the New River Company, some to the Chelsea, and some to the Grand Junction Company. The York Buildings Company ceased to exist in 1818. They leased their pipes to the New River Company, and sold their business for a fixed annual consideration. Before that time the Company had been losing money in accordance with the prophecy of a financial poet:

"You, that are blest with wealth by your Creator,
And want to drown your money in Thames water,
Buy but York Buildings, and the cistern there
Will sink more pence than any fool can spare."

THE METROPOLITAN WATER SUPPLY.

A SURVEY.

THE PRESENT SUPPLY.—DEFINITION OF AREAS.

LONDON at the present time is supplied with water partly by deep wells, but chiefly by various water companies. A comparatively small amount of water only is derived from the wells, which, with one exception, are all in the hands of private individuals or of companies. The quantity of water which underlies London has lessened year by year, and the level of the underground water has sunk. No statistics are available to show the daily amount which is derived from the deep wells in London. It has been computed at something like half a million of gallons daily. Whether this estimate be right or wrong, there is no doubt that the amount obtained from deep wells is but a small fraction of the total amount supplied ; compared with that supplied by the water companies it is inconsiderable.

Of surface-wells it is possible that a few remain. Some movable pumps are still used by builders in the Chelsea district, but it is unlikely that much of the water is used for drinking. Of public pumps in London few, if any, remain at the present time. One of the last to go was the historic one at Aldgate, but for years before its removal it had been supplied, not, as the people in the neighbourhood supposed, from a local source, but by water laid on from the mains of the New River Company in accordance with the directions of the tactful and sagacious Medical Officer of Health for the City of London, who, finding that the local water was extremely impure, and knowing that the inhabitants would not tamely submit (if they knew it) to any alteration in their cherished water-supply, by a pious fraud allowed them for years to pump water from the New River supply. And it was not until the pump was replaced by a tap that complaints were rife in the district. Practically, surface-wells and springs in London have ceased to exist ; deep wells affect only the few proprietors of them, and the great bulk of the water supplied is brought by the water companies.

The companies which supply London north of the Thames are : The New

River, the Chelsea, the East London, the West Middlesex, and the Grand Junction Companies. London, south of the Thames, is supplied by the Kent, the Southwark and Vauxhall, and the Lambeth Companies.

In the pages which follow a description is given of these undertakings, and it may be well here to state briefly the arrangement which will be followed. In the case of each Company, in the first place, a short history is given of its career, and this is followed by a survey of its present condition. It may be well to point out in this place that a modern water company and its arrangements are very different from the primitive methods used, for example, by the old London Bridge Company.

In the case of the London Bridge Company water was simply pumped from the river straight to the premises of the customers. In the case of a modern water company, the matter is not so simple. When water is derived from the river, it is in most cases first allowed to pass through one or more subsiding reservoirs for purification. It is then invariably filtered, and finally pumped to the premises of the consumers.

In the pages which follow we begin by describing the intake of the water from the river, then show the course which is taken by the main pipes which conduct it to the reservoirs. The situation, structure, and capacity of the reservoirs and of the filter-beds are then described, and finally a description is given of the arrangements made for pumping the water into the Company's district, the details of the distribution being shown by a plan giving the course taken by the principal mains.

A complete list is given of the places which the Company is authorized under its Acts of Parliament to supply, and a list of the places actually supplied is given also.

Finally there are statistics showing the length of the pipes, the number of hydrants, and the number of houses which are supplied, and notes on new work which is being carried on for the improvement of the Company's arrangements.

It is necessary here to say a few words with regard to the area of distribution of the water-supply, and to compare it with "Municipal London" and "Police London." In order to avoid the possibility of making confusion worse confounded, it is best to adopt in their entirety the definitions given by the Balfour Commission as far as areas are concerned. The report of the Balfour Commissioners may be, as Lord Llandaff has suggested, "Apocrypha" rather than "Gospel"; but the definition of areas may be accepted, at any rate, as the best working hypothesis.

Briefly in the Report of the Royal Commission on the Metropolitan Water Supply, presided over by Lord Balfour, the Commissioners defined the areas affected by the inquiry as follows:

Administra-
tive London
and Greater
London.

The Administrative County of London is nearly identical with the area called Registration London by the Registrar-General, but an area called Greater London by the Registrar-General includes the districts within which the Metropolitan and

City Police have jurisdiction. But neither of these areas coincides with those supplied by the London water companies. The Administrative County of London has an area of 121 square miles, but Registration London does not include the hamlet of Penge,

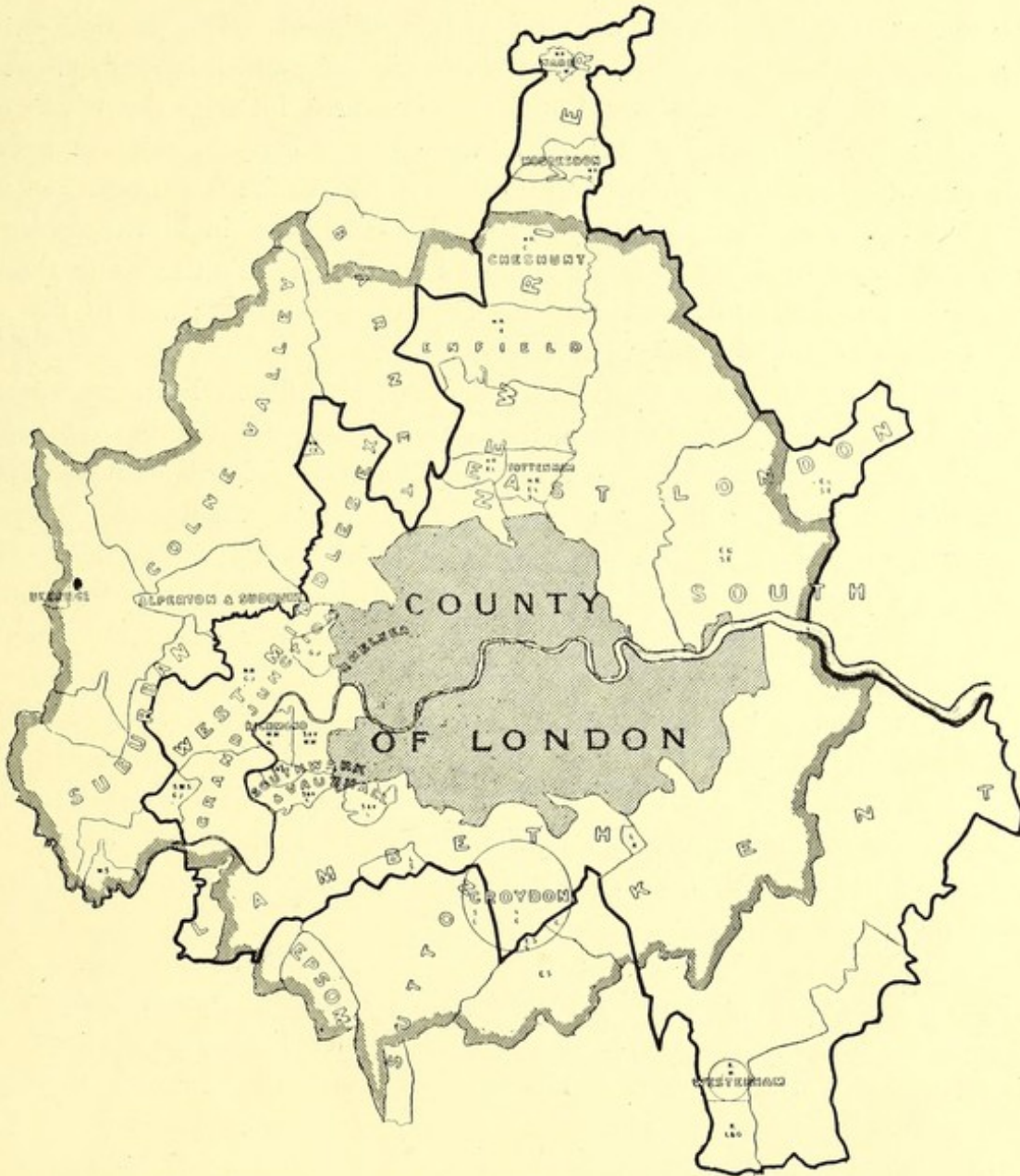


FIG. 2.—THE METROPOLITAN AREAS AS DEFINED BY THE BALFOUR COMMISSION.

The Administrative County of London is the shaded area. The shaded line defines the Metropolitan Police area.
The black line defines the area of Water London.

and the Greater London of the Registrar-General includes all parishes wholly situated within a circle of fifteen miles radius from Charing Cross, and all other parishes of which any part is included within a circle of twelve miles radius from Charing Cross. The total area is 701 square miles.

Outer Ring. The Commissioners in taking evidence gave the name Outer Ring to the area within Greater London and outside the County of London. This is the part which at the present time has the most rapidly-increasing population.

Water London. The Metropolitan water companies are eight in number; the area they supply does not coincide exactly with either of the areas mentioned. The districts supplied by these companies and the districts over which the companies have Parliamentary powers of supply are called Water London. The area includes the whole of the County of London and part, but not all, of the Outer Ring. It extends, however, beyond the Outer Ring to the north and north-east, and to the south-east and south-west. Thus the New River Company's area extends to Ware in Hertfordshire; the East London Company's area as far as Romford in Essex. To the south the Kent Company's area extends to Sundridge and Chevening in Kent; and to the south-west the Lambeth Company's area extends to Esher.

The total area of Water London is 620 square miles. In many cases the authorized Parliamentary districts of the water companies overlap one another—*i.e.*, more than one company has a right by its Act of Parliament to supply a given district. In almost all these cases the companies themselves, by private arrangements, have settled their boundaries to their mutual satisfaction. There are only two instances in which small areas are still supplied by more than one company. Within the Parliamentary districts of supply of some of the companies water is, however, supplied by other public authorities.

Private Supplies. There are also private water-supplies in London, derived from deep wells, amongst which may be mentioned those of St. George's Hospital and Bethlehem.

Board of Works Supply. The Board of Works has a well near the National Gallery, and from this source some of the water is supplied to the Houses of Parliament. The public is also indebted to the Board of Works for the bountiful supply given to the fountains in Trafalgar Square.

Fig. 3 defines the areas supplied by the eight Metropolitan water companies.

New River area. *The New River Company* supplies Highgate, Upper Holloway, Kentish Town, Highbury, Stoke Newington, part of Dalston, and the district between these places and the Thames, Hoxton, a great part of the City of London, including the Tower, and all the district along the Thames as far as Charing Cross. At Charing Cross the line of supply goes up Northumberland Avenue, takes in the northern part of Trafalgar Square, then goes in a northerly direction up the Haymarket and Poland Street. The line then extends in a northerly direction up the Tottenham Court Road as far as the High Street in Kentish Town. At the top of Tottenham Court Road the boundary area extends to the north-west to the Small-pox Hospital, Hampstead, then goes in a north-westerly direction to include the Hampstead district. Thus, roughly speaking, the districts supplied are the E.C., W.C., and the parts north

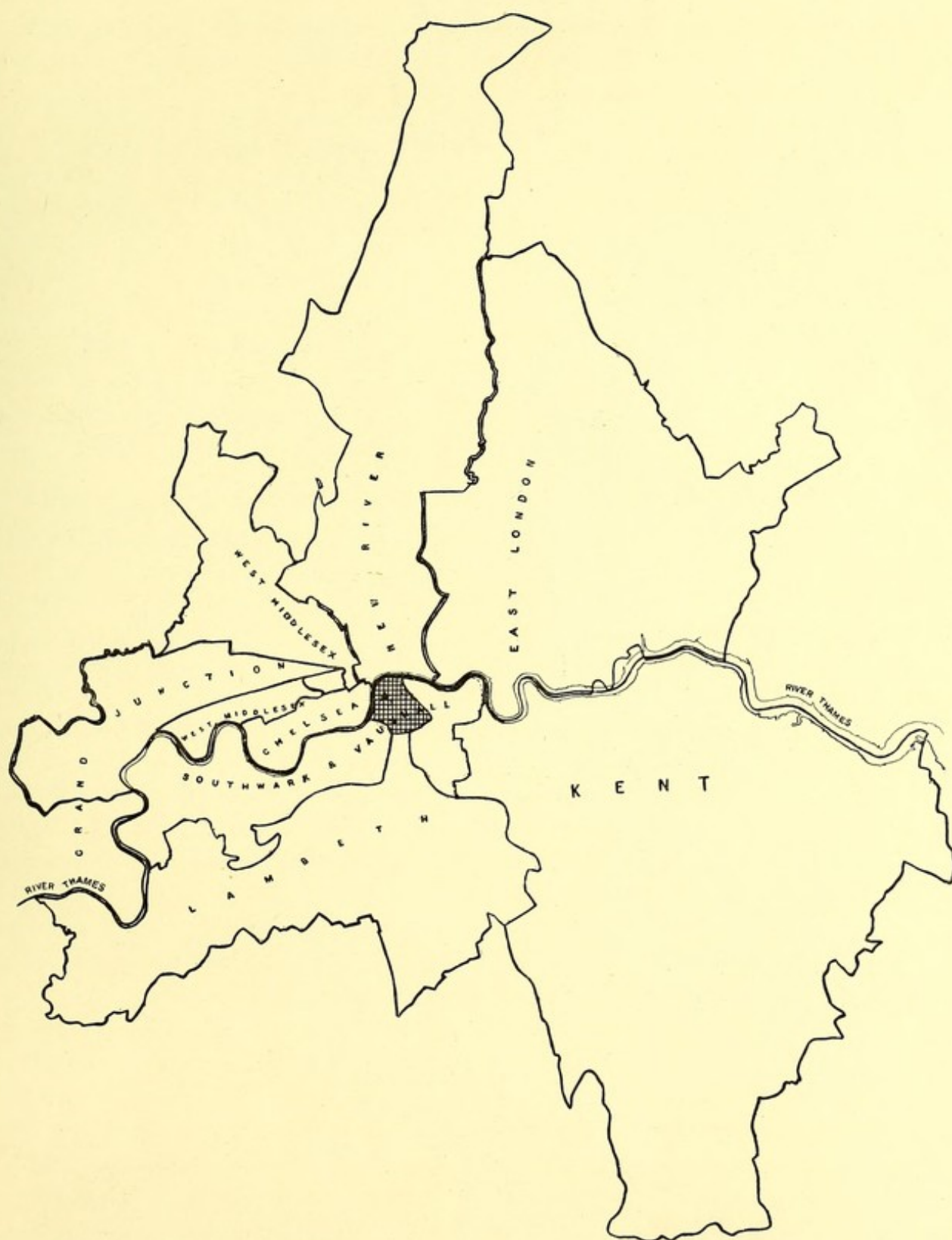


FIG. 3.—WATER LONDON: THE AREAS OF THE METROPOLITAN WATER COMPANIES.

The outlines define the areas which are partially or entirely supplied by the Metropolitan Water Companies.
The small shaded area is supplied by the Lambeth and by the Southwark and Vauxhall Companies.

of these districts. The Company also supplies districts beyond the Metropolitan area, the total area being 59,520 acres.

The Chelsea Company supplies the districts which lie to the north of the Thames from Fulham to Charing Cross—Fulham, Walham Green, Chelsea, Brompton, Knightsbridge, Pimlico, and Westminster. The northern boundary of the area of distribution runs from the Crab Tree at Fulham, up Crown Road, Lillie Bridge Road, Richmond Road, the Old Brompton Road, and then goes in a northerly direction to Prince's Gate and along Knightsbridge and Piccadilly to the north-east corner of the Green Park. The boundary then runs down the eastern side of the Green Park—that is, in the south-eastern direction—for about two-thirds its distance, and then passes to the north-east to include St. James's Palace, Carlton Terrace, and the southern part of Trafalgar Square. Here it is in contact with the New River area. The area supplied by the Chelsea Company is 3,482 acres.

The East London Water Company supplies part of Stamford Hill, Upper and Lower Clapton, Homerton, Hackney, Bow, Bromley, Poplar, Limehouse, Stepney, the London Docks, Shadwell, and the Isle of Dogs—that is to say, the parts north of the Thames from St. Katherine's in the east to the outlet of the River Lee, and in the county of Essex, West Ham, Walthamstow, Leyton, Woodford, and Loughton. The total area of supply is 50,880 acres.

The West Middlesex Company has a less compact area of distribution than the Chelsea, with whose area of distribution it comes in contact from Prince's Gate to the Crab Tree at Fulham. The West Middlesex Company supplies Hammersmith, that part of Fulham now called West Kensington, South Kensington, and Kensington, the northern boundary of this part being the Uxbridge Road. The Company supplies also the Regent's Park and Portman Square districts, and extends as far south as Oxford Street, as far north as Brondesbury, including the district of St. John's Wood. The area of the West Middlesex Company's water-supply is 17,280 acres.

The Grand Junction Company supplies the western suburbs, Shepherd's Bush, Wormwood Scrubs, and the district which is called North Kensington, Bayswater, part of Paddington, and the whole of Mayfair. The total area supplied by the Company is 29,760 acres.

The area of distribution of the companies to the south of the Thames is not so easy to follow as that of the companies on the north, because there is much more overlapping. Roughly speaking, the Kent Company supplies the south-east, the Southwark and Vauxhall the south-west, and the parts between these districts—that is, Kennington and Newington—are supplied by the Lambeth and Southwark Companies in common.

Kent
Company's
area.

The Kent Water Company has the largest area of distribution and the smallest number of customers. It supplies parts of the south bank of the Thames, from Limehouse on the west to Woolwich, but its area of distribution includes Plumstead, Shooter's Hill, Blackheath, Eltham, and Southend. The total number of acres covered is 113,280.

Southwark
and
Vauxhall
Company's
area.

The Southwark and Vauxhall Company supplies Roehampton, Putney, Wandsworth, Battersea, Clapham, Newington, and Kennington, and part of Brixton is partly supplied by this Company and partly by the Lambeth. The area supplied by the Southwark and Vauxhall Company is 19,040 acres.

Lambeth
Company's
area.

The Lambeth Company, besides partly supplying the districts already mentioned, distributes water to Bermondsey, Rotherhithe, Peckham, and Dulwich. Its area extends through Dulwich, Forest Hill, Sydenham to the Crystal Palace, Anerley, Brockley Hill, Bell Green, and as far to the south as Beckenham. The Kent Company supplies parts of Hatcham in common with this Company. The area of distribution is 39,360 acres.

THE METROPOLITAN WATER COMPANIES.

THE NEW RIVER COMPANY.

HISTORY.

THE full style and title of the Company is "The Governor and Company of the New River brought from Chadwell and Amwell to London." A complete history of the New River and of the people and places connected with it would form a large volume. In the present brief sketch we can do no more than mention the more important points connected with the origin of the enterprise, of the difficulties which had to be encountered, and of the chief changes which have taken place since the original design was carried out. No account, however brief, would be complete if no mention were made of Hugh Myddelton, by whom the original work was supervised, if not actually designed. Unfortunately, so much fiction has been mixed up with the facts recorded of this remarkable man, that it is not easy to deal so briefly as could be wished with his share of the undertaking and his relations with the Corporation of London, which initiated the scheme, and with James I., who saved the venture from ruin by providing money for its completion.

The original project was to obtain water from two Hertfordshire springs, and to conduct it in an open and tortuous channel to some convenient place near London for the use of the City. Some writers have curiously exaggerated the greatness of the undertaking, which was a trivial one compared with the engineering feats of the Romans; nor was the idea a new one. Years before the New River was projected Sir Francis Drake, the pirate, had supplied Plymouth with water from a source seven miles distant from the town by means of a channel twenty-four miles in length. It seems probable that Drake's conduit may have suggested the New River scheme to the London citizens, and led them to get the sanction of Parliament for the project.

In the year 1606 an Act (3 Jac. I., cap. 18) was passed to authorize the Corporation of London to bring water from Chadwell and Amwell to Hertfordshire for the supply of the City. It was provided that the necessary land might be taken, but that the

owners should receive compensation, the amount of which was to be assessed by Commissioners appointed by the Lord Chancellor. The Corporation was to maintain the "cut," or river, which they were to make, and the authority over it was vested in the Commissioners of Sewers. In the following year, 1607, another Act (4 Jac. I., cap. 12) was passed by which the Corporation were enabled to convey the water, if they thought fit, through a brick or stone culvert. The first of these two Bills was strongly opposed, and the claims of a Captain Colthurst* were considered at some length by the House of Lords. The Corporation of London, however, did nothing to carry into effect the provisions of the two Acts of Parliament which they had obtained. In March, 1609, the Common Council granted to Hugh Myddelton the power to carry out the work which they found themselves unable or unwilling to do. This agreement was supplemented by an indenture, dated April 21, 1609. Myddelton commenced the work as quickly as possible. He had, however, many difficulties to contend with. The owners and occupiers of the land through which the river was to pass gave him no little trouble. It is, indeed, small matter for wonder that many of them objected to have their land taken, and that the possible evils prophesied as the result of this undertaking were grossly exaggerated.

The Record Office contains a paper entitled "The Effect of a Bill to Repeal the Acts 3 and 4 Jac. I., for bringing the New River into London," etc. The paper consists of the objections classified, and each objection is answered, the objections and answers being written side by side in parallel columns. It is, apparently, a careful compilation from a number of documents stating both sides of the question. In a different and bolder hand, not as part of the list of objections and answers, is recorded the fact that at that time Myddelton had expended £3,000 on the work in progress. Amongst the objections urged against the making of the river, it was stated that the meadows would be turned into bogs, that farms would be cut up into small pieces, and that the river was dangerous to man and to beast.†

The agitation against the New River attracted much attention in the year 1610. It seemed for a time possible that the scheme might be overturned by Parliament, and a Bill was brought in to repeal the New River Acts. A letter written on May 9 of that year says: "Much ado there is in the House about the work undertaken and far advanced already by Myddelton for the cutting of a river and bringing it to London,

* Captain Colthurst appears to have claimed the right of making the river. We do not know the exact nature of his claims. The Corporation of London declined to give him leave to do the work, but it seems that his claims had some foundation, and that he ultimately received compensation; but no particulars as to the amount are known, and the matter need not be dwelt upon further.

† It is not without interest to mention that as a matter of fact the river was almost fatal to James I. on one occasion. He happened to be riding near Theobalds, his favourite country house, with Prince Charles. His horse fell, and he was thrown into the river, which was frozen over. He was dragged out by his boots, which were alone visible. His Majesty was afterwards pleased to make some remarks with regard to the fencing of the river.

from ten to twelve miles off, through the grounds of many men, who, for their particular interests, so strongly opposed themselves to it that they are like, as it is said, to overthrow it all." The Bill in Parliament was referred to a committee, and on July 16 the report of the sub-committee was given as to the river, which they had inspected. Fortunately for Myddelton, Parliament was prorogued on July 23, and did not meet again until 1614, by which time the work was finished. This opposition, however, was not the only difficulty with which Myddelton had to contend. In 1610 there was a rival scheme for supplying London with water from the Lee at Hackney.* This must have been an anxious time for Myddelton, for there was great danger that his scheme would fail. He had made the canal as far as Enfield, but he found that he had spent all his money, the expenses of the work having proved considerably more than he expected. It is usually said that he applied to the Corporation of London for a money grant, but there does not seem to be any truth in this statement, which is given on no reliable authority, and has been copied from one book to another. Myddelton applied to James I., and the King agreed to grant the necessary money for completing the work, the conditions being that half the business should be his, and that he should pay half the past and future expenses of the work. It will be seen, from what has been said, that Myddelton displayed great sagacity in invoking the King's aid at this juncture, and from the time at which he became a part owner of the New River the rival scheme gave no more trouble. The terms on which James I. became part owner of the enterprise were by no means unfavourable to Myddelton.† In the after-history of the New River it appears that James was of considerable use in supporting the business against competition. The matter was of great importance to the financial success of the undertaking, and we will, therefore, take this opportunity of anticipating events and saying all that is necessary on the subject in this place.

It happened that in the year 1617 some brewers applied to the "City Lands" Committee for the lease of the water-houses at Dowgate, offering to maintain them and supply the conduit with water; they were to have any surplus water for their brewhouse without Cripplegate. Court influence was brought to bear against this scheme. The Lords of the Council opposed it, the reason being that it would interfere with the business of the New River. Again, in the year 1634, the Corporation petitioned the Lords of the Council that they might be allowed to bring a water-supply from Roundhead, near Tyburn, into the City. It is stated that the

* This enterprise was to be carried out by the Chelsea School of Divinity, which had been endowed by James I. The school had received less public support than was expected, and a project was started that the Provost and Fellows should enrich the college by forestalling Myddelton's undertaking, and supplying London with water on commercial principles.

† The King paid half the expenses, and was to receive half the profits; but all the management was to remain in the hands of Myddelton, it being specially provided that the King should not interfere in any way with matters of business.

Charles I.
Jan. 2. 1625.

Corporation had spent much money in laying down pipes, and that they were then stayed by the King's command, and they therefore asked the Council's leave to petition His Majesty that they might be allowed to finish the work. The desire of the Corporation of London to keep their conduits well supplied with water was a most reasonable and laudable one, and there is no doubt that the only reason which prevented James I. from readily giving his consent was, that he did not wish the water business in which he was interested to suffer. The better the supply of water provided by the Corporation, the less reason the citizens would have to buy water from the New River.

In carrying out his enterprise Myddelton had very loyal support from the Corporation of the City of London. When in the year 1610 Myddelton asked for an extension of time to carry out the work, permission was readily granted. Again, when the Bill was brought in to repeal the New River Acts the Corporation warmly opposed it on the ground that it was for the preservation of the health of the City, and that Myddelton, as the City's deputy, had already expended £3,000 on the work. And again in the year 1614 the Corporation granted Myddelton a loan of not less than £3,000.*

It is not possible here to give a full account of all the changes which have taken place in the New River since it was first constructed to the present day, and we can do no more than briefly describe the original work and mention the alterations which were subsequently made.

Myddelton's general plan in making the conduit was that advantage should be taken of the lie of the land so as to diminish the engineering difficulties to a minimum. The consequence was that the course of the New River from Chadwell to Clerkenwell was very much longer than the direct distance between those places. As a crow flies, the distance from Chadwell to Clerkenwell is about twenty miles. The course of the New River as originally constructed was over thirty-eight miles. It was not possible, however, to conduct the water the whole way simply by digging a course for it. More than one valley had to be crossed. As Stow said, in some places "it required a sprightly art again to mount it over a valley in a trough between a couple of hills, and the trough all the while borne up by wooden arches, some of them fixed under the ground very deep and rising in height above 23 feet." One of these aqueducts was at Bush Hill near Edmonton. Its length was 660 feet, and it was 5 feet wide and 5 feet deep. A similar aqueduct was made near Islington.

* This money does not appear to have been repaid until the year 1634, after Myddelton's death. The Common Council, when the loan was repaid, remitted no less than £1,000 to Myddelton's widow, on the ground that losses had been incurred by him through breaches made in the water-pipes when they were broken up for putting out fires. But a great many years afterwards also the Corporation of London made grants to Myddelton's descendants. These grants have been made as recently as the present century.

This was 460 feet long and 17 feet above ground. It was called the boarded river, and many pictures of it are still in existence. It remained till after the middle of the last century, and was removed during the years 1776-1778, when an embankment was made to take its place. The Bush Hill aqueduct was similarly replaced by an embankment during the years 1784-1785.

The completion of Myddelton's work was very gaily celebrated on Michaelmas Day, 1613, a day on which it happened that his brother, Sir Thomas Myddelton, was elected Lord Mayor of London for the next term of office. There was a pageant in which sixty labourers, carrying their tools, took part, the Lord Mayor, Aldermen, and "a worthy company beside," were present; a long speech was given in praise of the work of Myddelton and of the King, and the flood-gates were thrown open, and the water flowed into the reservoir at Clerkenwell. From this reservoir the water was supplied to the houses through wooden pipes.

In June, 1619, James I. granted a charter of incorporation,* and Myddelton was appointed the first governor of the newly constituted Corporation. Several attempts were afterwards made to get Parliamentary sanction to the provisions of the charter, but these were not successful.

During the early part of its career the undertaking was not a financial success. The citizens of London resented having to pay for their water. As time went on, the supply to the public conduits belonging to the City became more and more inadequate, and the fittings belonging to the Corporation were greatly injured by the fire of 1666. As the customers of the New River Company increased in number, it was found that the springs were insufficient to supply the amount of water necessary, and the Company therefore took some from the River Lee, which flowed near their original source of supply. Complaints were made with regard to this, and some law-suits followed. In the year 1738 an Act of Parliament (12 Geo. II., cap. 32) authorized the Company to take water from the Lee on certain conditions, amongst which were, that an annual payment should be made, and that the money should be employed for the improvement of the navigation of the Lee. The amount of water to be taken was to be regulated, and a balance-engine and gauge were erected for this purpose. Later, the Company were allowed to use a gauge made of wood, brick, or stone, on condition that the size remained constant. A gauge of marble was afterwards erected. During the early part of its career the New River Company obtained a good deal of water between Chadwell and London. This was chiefly surface-water. Of late years, however, the surface-water has been carefully excluded, and many channels have been made to intercept it and convey it into the River Lee below the intake of the Company.

The original intake of water from the Lee was near Hertford, but some years later water was also taken at Tottenham and pumped to Newington. This source of

* See Appendix A.

supply has, however, been given up. The pumping-station will afterwards be described amongst the disused ones. We may here remark that of late years a number of new wells have been sunk in the chalk, and that these supply water of a quality greatly differing from that of the Lee at Tottenham.

During the present century great changes have occurred in the demands of the public with regard to the height to which water should be supplied in dwelling-houses, and these requirements have necessitated great changes in the manner of the distribution of water by the Company. The reservoirs at Clerkenwell are $84\frac{1}{2}$ feet above the high-water level of the Thames, and this height was sufficient to supply the lower stories of houses. About the year 1810 the public generally demanded higher service, and complaints as to the deficiency of pressure became frequent. For the supply of the western part of London a windmill was used for pumping, but this, as an old writer points out, was not always satisfactory "because of the uncertainty and irregularity of its impelling cause." A horse-engine succeeded the windmill, and this in its turn was superseded by a steam-engine put up by Boulton and Watt in the year 1787. The services rendered by Boulton and Watt with regard to water-supply were considerable, and amongst other things we have to thank them for the approximately accurate knowledge we possess of the amount of water which was supplied from the date at which their engines were first used. When Boulton and Watt put up an engine, one of their conditions was that they should "derive a pecuniary advantage from the saving effected by their means in the expense of coal employed for generating the steam." They therefore put up a machine for registering the number of strokes, and it is from the figures thus recorded that the first approximately accurate information was obtained with regard to the amount of water supplied. A register kept from the years 1787-1788 records that during each of these years the amount of water pumped by the New River Company was over 4,500,000 hogsheads yearly. At this time, in addition to the steam power, a water-wheel was used for pumping the water to Islington. In the early part of the century the supply of the New River Company water was given as far westwards as Marylebone,* but owing to the severe competition of the West Middlesex and of the Grand Junction Companies, the western supply was afterwards discontinued. At one time the New River Company had about 400 miles of wooden distribution pipes laid in the streets, but in consequence of the public demand for high service, which necessitated increased pressure in the mains, the wooden pipes had to be given up. Iron pipes were put down between the years 1810 and 1820.

Nelson, the historian of Islington, gives some interesting information as to the water-supply of the district in which he was interested. He says that during the latter half of the last century a large part of Islington was not directly supplied by the New River Company. The inhabitants had to buy their water from people who

* At one time St. James's Palace was supplied. See Appendix B.

carried it round and sold it at a halfpenny a pail. At the beginning of the present century the inhabitants of Holloway obtained their water from a cart which brought it from the New River, the purveyor obtaining it from a pump at a place called Hopping Lane. In the year 1809 a man named George Pocock, who had property at Holloway, dug a well 172 feet deep, and put up a steam-engine and machinery for pumping to supply the inhabitants of the district with water. The well-water was said to be of "the finest quality, extremely soft, and consequently fit for washing and every culinary purpose." Pocock formed a small company, which was incorporated by an Act of Parliament (50 Geo. III.).* When the New River Company found that the Bill was likely to pass, Nelson says that they put down pipes through Islington "with great expedition for the purpose of supplying Holloway with water which was hitherto withheld, notwithstanding the many applications that had for years been made to them, and which the inhabitants were now about to obtain through the exertions of an individual." Nelson goes on to say that the Company pulled up a pump from which the Holloway people had been accustomed to get their water "in order to oblige them, if possible, to have the Company's pipes laid into their premises." He adds, however, that "the housekeepers in the neighbourhood very properly refused to receive water from the New River, and are now for the most part supplied from the well of Mr. Pocock." Mr. Pocock's adventure, however, proved but a short-lived success, and soon succumbed to its older rival. In this respect the fate of the little company was identical with that of many other similar enterprises of which a few words may here be said.

Among the undertakings that were bought at various times by the New River Company may be mentioned the London Bridge Waterworks, the Hampstead Waterworks, the York Buildings Waterworks, the North Middlesex Waterworks, and a private enterprise at Bush Hill Park, near Enfield. It is not necessary to enter fully into a description of these adventures. Some account has already been given of the London Bridge Waterworks, and with reference to this part of the subject, it need only be added that when the New River Company took over the business of the London Bridge Waterworks Company, it was provided that they should keep up an engine for the purpose of pumping water from the Thames, should it be necessary to supplement the supply from the New River in seasons of drought. For this purpose, after the destruction of the works on London Bridge, an engine situated at Broken Wharf† was for a time used. The engine was of 100 horse-power, and the water was taken from the Thames at a distance of from 30 to 40 feet beyond low-water level.

The northern part of London was supplied with water by a company of adven-

* An Act for supplying with water Upper and Lower Holloway, Highbury, Canonbury, Upper Islington, and their respective vicinities, all in the parish of St. Mary, Islington, in the county of Middlesex, and for other purposes relating thereto.

† Broken Wharf was situated between Blackfriars and Southwark Bridges.

turers who had obtained from the Corporation of London some of the water rights which had been conferred upon them by an Act of Parliament passed in the year 1543-1544 (35 Hen. VIII., cap. 10). This was the earliest Act of Parliament which bore on the London water-supply. By it the Corporation of London were allowed to obtain water from springs at Hampstead Heath, Marylebone, Hackney, and Muswell Hill. The Act authorized the Corporation to enter private lands and search for springs. They were not to interfere with houses, gardens, orchards, or places enclosed by brick or mud walls; but apart from this restriction they were allowed to make ditches and trenches and to lay pipes, and the servants of the Corporation had power to repair the works necessary to convey the water without interruption from the owners of the property from or through which the water was taken, it being only provided that compensation should be paid for damage actually done. In the year 1692 a company of adventurers took over these powers from the Corporation, and afterwards made ponds and reservoirs at Hampstead, which were filled by surface-water. For some years during the early part of last century the company supplied water over a considerable area, but as the population increased the sources proved insufficient. As late, however, as the year 1813 water was supplied to parts of Tottenham Court Road. The area of supply which the company nominally possessed was a large one.

The Hampstead Water Company had much trouble with the Hampstead people as to water rights. The ponds are said to have existed in the seventeenth century; the upper pond, however, was smaller than it is at present, and covered only 3 roods. The lower pond had an area of between 1 and 2 acres. The Vale of Health Pond was made in 1777. The ponds were fatal, it is said, to many incautious bathers, and there were constant conflicts between the Hampstead people and the Water Company.

Of the York Buildings Waterworks some account has already been given. The Company was finally ruined by the competition of the Chelsea, West Middlesex, and New River Companies, all of which supplied the area in which they were interested. For a time the richer companies reduced their water rates to such an extent that the York Buildings Waterworks were unable to keep their customers. The New River Company then bought up the plant and property of the Company.

The water supplied to Bush Hill Park, Edmonton, was put up for the supply of a building estate which was laid out there. A well was sunk, a tower built, and a reservoir made. This business was taken over by the New River Company.

The North Middlesex Waterworks Company carried on business at Betstile, where they sank a well and put up pumping apparatus. This business also was taken over by the New River Company.

It would serve no useful purpose to record all the changes which have been made in the course of the New River. The original length of the stream has been consider-

ably shortened, and in many places the water is now conducted in pipes ; in some the river runs on embankments. The most important improvements which have been made within recent years are that surface-water has been as far as possible excluded from the river,* and that a large number of wells have been sunk to supply the required quantity of water.

GENERAL DESCRIPTION.

The New River Company is the most ancient of all the companies which at present supply London with water. It differs from all the other companies in the fact that it possesses a large quantity of land, and is, as a matter of fact, a land company as well as a water company. With this aspect of the Company we do not deal, except in so far as the possession of rights affects matters concerning water-supply. General Description.

Roughly speaking, the Company supplies the City of London, central London, and the northern suburbs. The area of supply is bounded on the eastern side by the district of the East London Waterworks Company and the district of the Tottenham Local Board ; its southern boundary is the Thames, and on the east the area is bounded by the district supplied by the Chelsea, the Grand Junction, and the West Middlesex Water Companies. The places skirting the northern bank of the Thames are supplied from Charing Cross to the Tower. The most important places supplied are the City of London, Soho, Bloomsbury, Camden Town, Clerkenwell, Hoxton, Kentish Town, Islington, Dalston, Hampstead, Highgate, Holloway, Hornsey, Stoke Newington, Muswell Hill, Betstile, Southgate, and Edmonton.

The water is derived from the River Lee, from Chadwell Spring, and from wells at Broadmead, Amwell, Amwell Hill, Amwell Marsh, Rye Common, Hoddesdon, Broxbourne, Turnford, Hoe Lane, Highfield, Betstile, and Hornsey, and from ponds at Hampstead and Highgate. The water from the ponds is not used for domestic purposes. The water taken from the River Lee is conducted down an artificial cut, is augmented by that derived from Chadwell Spring and by that pumped from wells situated near the banks of the New River. Of this water some is filtered at Hornsey and pumped thence into the district around ; some passes on to Stoke Newington, where it is allowed to subside in large reservoirs, and is then filtered and pumped to the surrounding district. Some of the water passes on down the New River to New River Head, where it is filtered and pumped to the southern district, including the City of London. Small districts at Betstile and at Amwill Hill are supplied with pure unfiltered well water.

* A former engineer to the Company estimated that at one time something like half the amount of water which fed the river was surface-water which flowed into the stream between Chadwell and London.

The stations of the Company which are now in working order, and which are all marked on the accompanying map, are : Intake from the River Lee, near Hertford (A) ; Chadwell Spring (B) ; Broadmead, well and pumping-station (C) ; Amwell End, well and pumping-station (D) ; Amwell Hill, well and pumping-station (E) ; Amwell Marsh, well and pumping-station (F) ; Rye Common, well and pumping-station (G) ; Hoddesdon, well and pumping-station (H) ; Broxbourne, well and pumping-station (I) ; Turnford, well and pumping-station (J) ; Hoe Lane, well and pumping-station (M) ; Bush Hill, reservoir (N) ; Southgate, reservoir (O) ; Highfield (Edmonton), well and pumping-station (P) ; Bourne Hill, reservoir (Q) ; Betstile, well and pumping-station (R) ; Hornsey, reservoirs, filter-beds, and pumping-station, and Campsbourne, well and pumping-station (S) ; Crouch Hill, reservoirs (U) ; Stoke Newington, reservoirs, filter-beds, and pumping-station (V) ; New River Head, Islington, reservoir, filter-beds, and pumping-station (W) ; Claremont Square, Islington, reservoir (X) ; Camden Park Road, reservoir (Y) ; Hampstead, reservoir (Z) ; Highgate, reservoir (A A) ; Hornsey Lane, reservoir (B B) ; and Maiden Lane, reservoir (C C).

In addition to these stations, all of which are now in use, the following two disused stations are marked on the map : Cheshunt, well, reservoir, and pumping-station (dismantled) (K) ; and Tottenham pumping-station (T).

A new well is being sunk at White Webbs (see L on map). In the succeeding pages the descriptions will be arranged in the following order : 1. Survey of the New River, commencing at the intake from the River Lee. 2. The wells, pumping-stations, and reservoirs. 3. The pond water (for non-domestic supply). 4. Area of distribution and general statistics.

PRESENT CONDITION OF THE NEW RIVER : A SURVEY.

Present
Condition
of the New
River : A
Survey.

The New River was originally made to convey water from the springs of Chadwell and Amwell to London. The total length of the river when first made was just under forty miles. This distance has been considerably lessened, short cuts in a more direct route having been made over some of the valleys. At first only spring-water was conveyed, but after a time the amount proved to be insufficient, and an extra supply was taken from the River Lee.* Of late years a number of wells have been made near the banks of the river, and the water is pumped to augment the quantity which comes from Chadwell Spring and from the Lee. In a few instances water is pumped direct from the wells for the supply of customers, but the greater part is pumped into the river and goes to Newington, where, after passing through the subsiding reservoirs, it is filtered before distribution. The width of the New River varies from about 25 feet in the widest part to 17 feet in the narrowest.

* The spelling of the Lee adopted is that given in various Acts of Parliament. Cartographers, including those employed in Her Majesty's Survey Office, usually spell the Lee—'Lea.'

THE NEW RIVER COMPANY.

The part enclosed within the shaded line includes the whole of the area supplied by the New River Company. The course of the New River is shown by a dotted line. The places marked on the map by shaded squares are:

- A, Intake from River Lee near Hertford.
- B, Chadwell Spring.
- C, Broadmead Well and Pumping Station.
- D, Amwell End Well.
- E, Amwell Hill Well and Pumping Station.
- F, Amwell Marsh Well and Pumping Station.
- G, Rye Common Well and Pumping Station.
- H, Hoddesdon Well and Pumping Station.
- I, Broxbourne Well and Pumping Station.
- J, Turnford Well and Pumping Station.
- K, Cheshunt Well, Reservoirs, and Pumping Station.
- L, White Webbs Well.
- M, Hoe Lane Well and Pumping Station.
- N, Bush Hill Reservoir.
- O, Southgate Reservoir.
- P, Highfield (Edmonton) Well and Pumping Station.
- Q, Bourne Hill Reservoir.
- R, Betstile Well and Pumping Station.
- S, Hornsey Reservoir, Filter Beds, and Pumping Station; also Campsbourne Well and Pumping Station.
- T, Tottenham Pumping Station.
- U, Crouch Hill Reservoirs.
- V, Stoke Newington: Reservoirs, Filter Beds, and Pumping Stations.
- W, New River Head: Reservoir, Filter Beds, and Pumping Station.
- X, Claremont Square Reservoir.
- Y, Camden Park Road Reservoir.
- Z, Hampstead Reservoir.
- AA, Highgate Reservoir.
- BB, Hornsey Lane Reservoir.
- CC, Maiden Lane Reservoir.



FIG. 4.—THE NEW RIVER COMPANY'S WORKS.

Before describing the course of the river, it may be well to give a brief account of the work which has to be done to keep it in order, and of the way in which it is protected. The general work which has constantly to be done is that the banks of the river have to be kept in a good state of repair, the weeds which grow in the stream have to be cut, and trespassers have to be prevented from doing any damage to the water or to the banks. In order that these things may be efficiently carried out, the river is divided into twelve divisions or "walks." Each walk is under the care of two men, the senior of whom is called the "walksman," and the assistant the "walksman's mate." It is the duty of these men constantly to perambulate the river to keep off all cowans and intruders, to repair the banks where necessary, and to cut the grass on the walks which extend on both sides of the greater part of the course of the river. It may be interesting to mention, as a curious matter of etiquette which has lasted a long time, that it is usual for the walksman to look after the right or "upper bank" of the river as it is called, and for the walksman's mate to look after the left or "lower bank." During the summer a good deal of work has to be done in keeping the river free from weeds, and for this purpose extra men are employed. From May to September weeds have to be cut about once a fortnight. The river weeds grow much more freely at the upper part of the river—that is, the part distant from London—than they do at the lower part. It may be noted, however, that the American weed grows only in the lower part. Above Hornsey it is hardly to be seen, and at the upper part it does not occur at all. The way in which the weeds are cut is as follows: Several scythes, from eight to twelve in number, are shackled to a chain, to each end of which a rope is fixed. One man walks on each bank of the river, and the weeds are cut by a sawing motion, both men walking slowly forwards, and each man alternately pulling his end of the rope towards him for a distance of about a yard. After the weeds are cut they float down, and are collected by gratings placed across the river at intervals; they are removed from these and are usually taken away to manure the land.

Each walk is provided with a punt, which is used not only when it is necessary to repair the banks of the river, but for carrying any materials which may be required for repairs. The punts are of uniform pattern. They are made of iron, and are 30 feet in length, 2 feet in depth, and 6 feet in breadth.

The walks into which the river is divided are numbered from Clerkenwell upwards to Chadwell, and are as follows: (1) New River Head to Stoke Newington, (2) Stoke Newington to Hornsey, (3) Hornsey to Bowes Park, (4) Bowes Park to Winchmore Hill, (5) Winchmore Hill to Enfield, (6) Enfield to Turkey Street, (7) Turkey Street to Theobald's Lane bridge, (8) Theobald's Lane bridge to Turnford, (9) Turnford to Broxbourne, (10) Broxbourne to Rye House, (11) Rye House to Amwell, and (12) Amwell to Chadwell.

In the present survey of the river it has been found convenient to begin the

perambulation at the intake from the River Lee, and to give an account of the course of the river from that point to London. In the description which follows the left bank is spoken of as the "lower bank" and the right as the "upper bank." The distances which are given are approximate. They are not the result of accurate measurement, but in each case the distance was judged by observation and the result corrected by reference to the ordnance maps, but the figures are always given in round numbers. The maps are taken from the latest ordnance maps, but in all cases corrections have been made in places in which changes have taken place since the ordnance survey was made.

Intake
from the
River Lee.

Hertford to
Broxbourne
(see Fig. 5).

INTAKE FROM THE RIVER LEE (see Fig. 5).—The water of the New River is taken from the Lee at a point between Hertford and Ware. The present gauge-house is situated quite close to the river, and divided from it only by a towing-path. The arrangements which were formerly in use for gauging the quantity of water taken still exist in a building called the "balance-house," which is situated a few yards off. The arrangement of the intake differs from that of the intakes of all the other Metropolitan water companies, and it is the only one which is planned to give accurate results as to the quantity of water taken. The arrangement is simply a floating gauge. The principle on which it works ensures that the size of the inlet through which the water flows is constant, and the gauge is arranged to rise and fall according to the height of the river. The first arrangement of this sort was put up in the balance-house. Although it is now no longer used, it may be best to describe it first, as it is the simplest, if not the most ancient, form of floating gauge, and is not without historical interest. The house which contains it was built in 1732, when Mill was engineer to the Company, and it was rebuilt in 1770, when Mill and Milne were the engineers. A boat floated up and down according to the height of the water. This boat was suspended from one end of a large oak beam, at the other end of which there was a sluice-gate. The sluice-gate, therefore, necessarily rose and fell synchronously with the rise and fall of the boat. The size of the opening through which the water flowed being constant, and the height with reference to the water being also constant, it followed that the amount of water which flowed through was constant also.

The intake at present used is guarded by a floating boom, and the water passes through an iron grating of which the bars are about 1 inch in width and the meshes 3 inches. The boom and gratings keep out pieces of wood and other débris. The amount of water taken from the river daily is said to be 22,500,000 gallons. The sides and edges of the intake opening are formed of bronze, and the sluice-gate through which the water flows is carried by a cross-head which rests on a pair of iron boats. In consequence of this arrangement the amount of water remains constant, the depth of the intake being always 16 inches and its width 7 feet 10 inches.

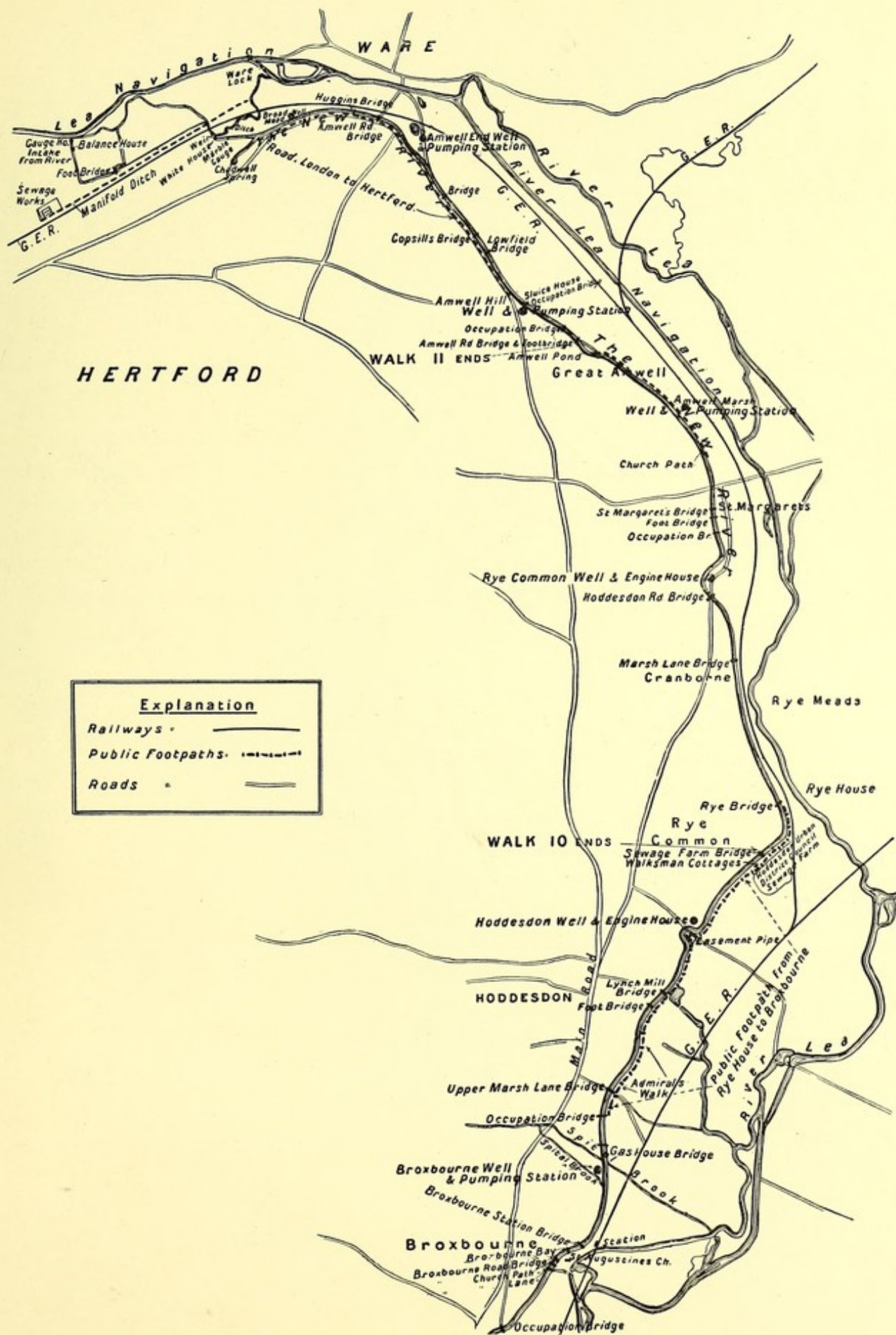


FIG. 5.—THE NEW RIVER: HERTFORD TO BROXBOURNE.

The height of the river is recorded by a float of which the index is in the sluice-house. Except in very rare instances the water is constantly flowing through this inlet from the Lee down into the New River, but there is an arrangement by which it can be shut off if necessary. The conditions which make it necessary to shut off the water are occasional floods, which cause great turbidity of the water. The supply has also to be cut off when it is necessary to do any work in the course of the stream just below the intake. The way in which water can be shut off is as follows: There are a number of iron plates 20 inches deep and 8 inches wide; each is provided with a steel "ear," which fits on to a circular iron bar $1\frac{1}{2}$ inches in diameter. By this arrangement practically the whole of the water can be shut off. During the winter of 1896-1897 this arrangement was used twice for short periods during flood.

Hertford to
Broxbourne
(Fig. 5).

COURSE OF THE NEW RIVER.—From the intake the water is conducted in an open channel, which at first passes through open meadows.

Course of
the New
River.

50 yards: Occupation bridge. From this point there is a fence with two bars, 3 feet in height. The fence is to keep off the cattle from the upper bank.

200 yards: Here there are the remains of a disused sluice.

270 yards: Iron bridge. At this point the river is close to the Manifold Ditch.

Manifold Ditch.—This ditch commences at the Hertford Sewage Works, and goes into the Lee Navigation Canal at a point below Ware Lock. The length of its course is about a mile, and the point at which it discharges into the Lee is about a mile below the intake of the New River Company. For a distance of about half a mile the ditch runs in a direction parallel with the New River, and is situated on its upper bank. The ditch has a concrete bottom, the sides forming a segment of a circle. They are lined with bricks laid on edge and set in a concrete bed. The state of the sewage effluent is said to vary considerably. The ditch is conducted under the New River in two 24-inch cast-iron pipes.

Manifold
Ditch.

250 yards: Manifold Ditch passes under the New River, and the river then goes under the Hertford branch of the Great Eastern Railway. Up to this point there is a fence on the lower side of the New River; the part between Manifold Ditch and the New River is not fenced. From the point at which the river passes under the railway the fence begins, and it runs on each side of the river for the greater part of the remainder of its course. The "standard fence" is 2 feet 6 inches in height, and has two wrought-iron rails.

50 yards: At this point is the White House sluice, which was put up in the year 1746. Here there is a weir. In case of flood the dam-boards are removed, and the water flows down a ditch into the River Lee. During the winter of 1896-1897 there was one flood during which the dam-boards were taken out. The White House contains a spoke and pocket sluice-gate, which is used in flood-time to prevent too much water from passing down the course of the river.

Hertford to
Broxbourne
(Fig. 5).

50 yards : At this point a marble gauge is situated ; the base of this is formed of marble. As originally planned, the water passed through an opening 6 feet in width and 2 feet in depth. At the present time there are easement pipes at each side of the gauge, which is no longer used for its original purpose. The easement pipes are 24 inches in diameter. At a distance of 200 yards from this point across the meadow the Chadwell Spring is situated.

Chadwell
Spring.

Chadwell Spring.—The spring at Chadwell discharges itself into a circular basin or reservoir, of which the depth at the centre is about 18 feet. The reservoir is about 20 yards in diameter, and, except at its outlet, is surrounded by turfed walks. The amount of water obtained daily is estimated at 4,000,000 gallons, but the quantity varies greatly ; it is much diminished after a dry summer. During part of the years 1892, 1893, 1894, little water rose for some days.* The amount yielded by the spring is gauged twice a week. The water is usually quite clear, but it is occasionally milky. The water from Chadwell Spring joins the branch of the New River, which conveys water from the Lee at a distance of 200 yards from the spring. At a point 100 yards further the New River goes close to the road which leads from London to Hertford. Here there is a bridge leading to Broad Mead, where there is a well and pumping-station.

440 yards from Chadwell Spring is Huggins' Shed bridge. Between the New River and Hertford Road there are high spiked railings.

200 yards : Amwell End bridge. At Amwell End there is a well and pumping-station. Near this point the river is crossed by a foot-bridge for a path which leads from the London Road to Ware Station. Near it is Amwell Road bridge.

300 yards : Red House bridge.

375 yards : Copsill's bridge.

150 yards : Lowfield bridge.

440 yards : Amwell Hill. Here there is a well and pumping-station.

Amwell
Sluice.

Amwell Sluice.—Near the pumping-station there is a sluice-house, built of wood and having a slated roof. It extends right across the river. There are three bays. The amount of water which passes down the New River is regulated at this point.

200 yards : Occupation bridge in private grounds.

150 yards : Foot-bridge and Amwell Road bridge close together. Here is the junction of Walks 12 and 11.

Amwell
Pond.

Amwell Pond.—At Amwell was one of the springs from which water was obtained for the New River. There is now no spring in the place at which it formerly existed. There are two islands in the pond which is near to the public highway, and there is here a place at which the public have a right to water horses.

500 yards : Amwell Marsh. Here there is a well and pumping-station. There

* During the summer of 1898, for the first time on record, the spring entirely failed.

is a church path from Amwell to St. Margaret's, the path passing along the lower bank of the New River for about 1,000 yards to St. Margaret's Road. Hertford to Broxbourne (Fig. 5).

150 yards : Foot-bridge. St. Margaret's Bury House is situated here on the upper bank.

100 yards : Foot-bridge, occupation road, St. Margaret's Bury.

250 yards : Occupation bridge, St. Margaret's Bury.

350 yards : Rye Common. Here there is a well and pumping-station on the lower bank of the river.

50 yards : Hoddesdon Road bridge.

440 yards : Marsh Lane occupation bridge. Here the river is close to the Great Eastern Railway, Hertford branch.

1,000 yards : Rye bridge road. This is near Rye House station, and to the historic house which has given its name to the neighbourhood. From Rye House station on the lower bank of the river a public path leads to Hoddesdon and Broxbourne ; the upper bank is fenced in.

400 yards : Hoddesdon sewage farm bridge. Here is the junction of Walks 11 and 10.

The sewage farm is on the lower bank of the river, and covers an area of from 12 to 14 acres. The sewage effluent from Hoddesdon Farm goes into the River Lee.

100 yards : On the lower bank of the river are two walksmen's cottages.

600 yards : Hoddesdon. Here on the upper bank is a well and pumping-station. Near the engine-house a 36-inch easement pipe conveys some of the water under the Essex Road and across a meadow into the river, a distance of about 200 yards. The course of the easement pipe is shown in the map.

Here is Essex Road bridge.

440 yards : Lynch Mill bridge. The public path, which begins near Rye House, follows the course of the lower bank of the New River to Broxbourne, a distance of about two miles.

100 yards : Foot-bridge to Hoddesdon.

440 yards : Admiral's Walk. Occupation bridge opposite Yew House, Hoddesdon, which is on the upper bank.

150 yards : Upper Marsh Lane bridge, Hoddesdon.

200 yards : Occupation bridge, foot-path.

250 yards : Gas House bridge.

300 yards : Broxbourne. Here there is a well and pumping-station, situated on the upper bank. At this point a branch of the Spital Brook comes to the upper bank. This brook arises in the woods about two miles away. There is a spring, and the stream also receives surface-water. It has not been used for the supply of the New River for twenty years or so. The water now is conducted by a brick Broxbourne.

Broxbourne
(Fig. 5).

channel under the New River, and flows away into the Lee. In the old cut which was formerly used to augment the supply of the New River a certain amount of water is still kept, because by doing so the appearance of the neighbourhood is improved. This is done entirely for the interests of the people who live in the houses near. When the brook is cleared out, which is done yearly, the water collected in this part of the cut is allowed to pass into the river. There is a 6-inch cock between the Spital Brook and the river.

500 yards : Broxbourne Station bridge.

100 yards : Broxbourne Bay. Here there is a sluice, worked by cogged gear. There is a fall of about 6 inches. The fall varies from 3 inches to 1 foot, according to the state of the river. St. Augustine's Church is here on the lower bank of the river.

60 yards : Broxbourne bridge.

30 yards : Broxbourne Church path bridge.

30 yards : Broxbourne Church Lane bridge.

550 yards : Occupation bridge.

(The description of the survey should now be followed on Fig. 6.)

100 yards : Broxbourne Road bridge. Here is the junction of Walks 9 and 10.

100 yards : Bridge, and occupation bridge.

30 yards : Page's Lane bridge.

440 yards : Brickfield Lane bridge and footpath.

350 yards : White Horse Lane bridge. This bridge has an easement culvert on each side to convey part of the water of the river. It is therefore called a "three-way bridge." From this bridge to Wormley foot-bridge there is a public footpath on the upper bank of the river.

300 yards : Manor Farm (Wormley) occupation bridge.

30 yards : Wormley foot-bridge. Here the public footpath crosses the river.

880 yards : Surface-water is conducted under the New River from the right to the left. There is an aqueduct over Watery Lane, Turnford. Here there was formerly a wooden trough. About 300 yards above this point was the Turnford loop of the New River, which has since been replaced by a straight cut. The site of the Turnford loop is given in the map (Fig. 6).

400 yards : Turnford. Here there is a well and pumping-station on the lower bank. From Turnford Station to Cheshunt there is a public footpath on the lower bank of the river.

600 yards : Brookfield occupation bridge.

Cheshunt.

Cheshunt.—Here there is a disused well and two ponds, having areas of 8 and 13 acres respectively, formerly used as reservoirs. This water is not now used for the supply of the New River, and the flood-water which collects in the ponds is conducted under the river in a culvert and flows away to the Lee. At Cheshunt

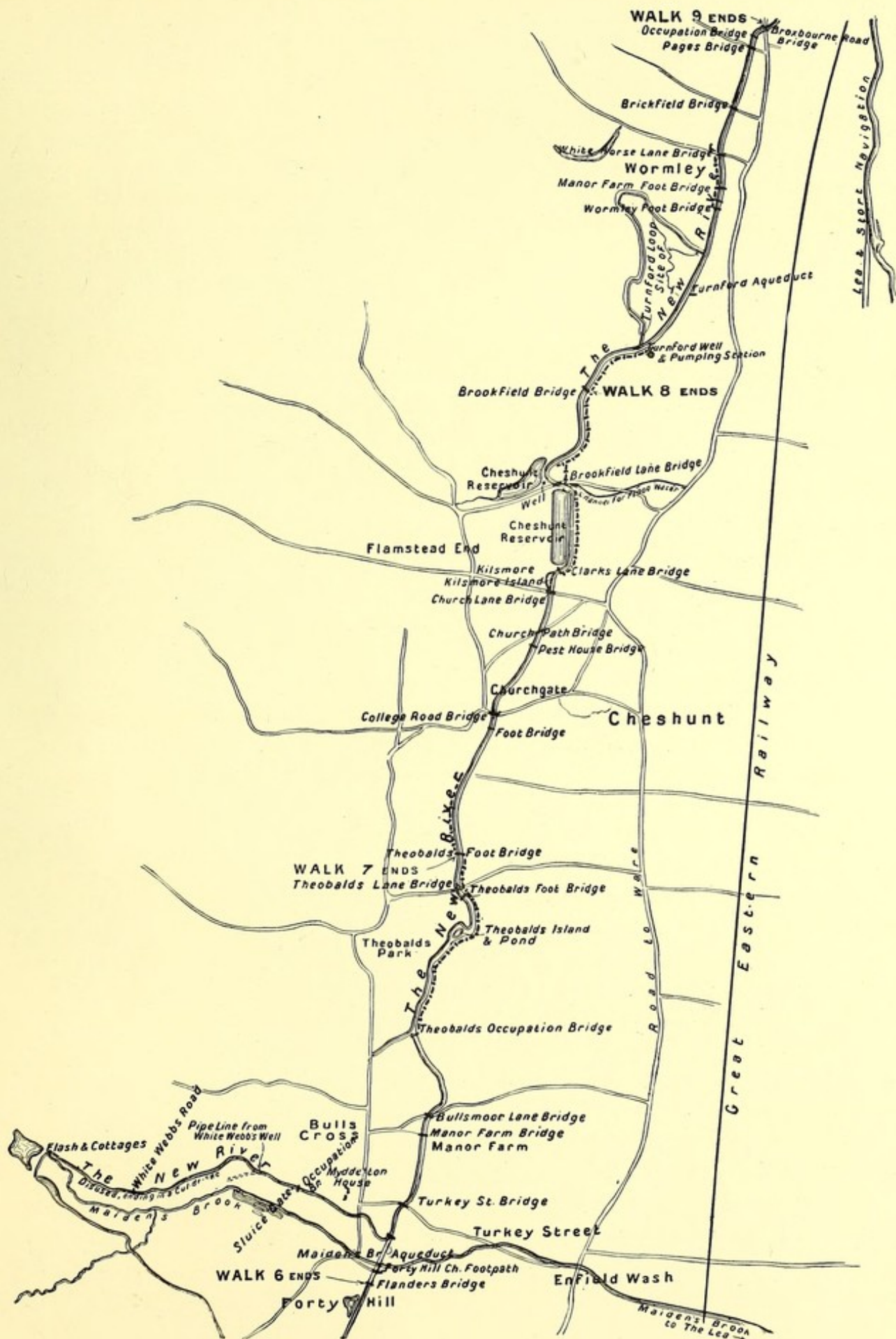


FIG. 6.—THE NEW RIVER: BROXBOURNE TO FORTY HILL.

there are two cottages, one occupied by a walksman, the other by a "gratesman"—Broxbourne to Forty Hill (Fig. 6). a labourer employed to keep the grate in working order, and who is held responsible for its efficiency. Here is Brookfield Lane bridge. From this point to Clark's Lane bridge there is a public footpath on the lower bank.

440 yards : Clark's Lane foot-bridge.

Just beyond this point is Kilsmore Island. It is near the upper bank of the river.

150 yards : Church Lane bridge, Cheshunt. One gas-main here crosses the river. On the upper bank there is a market-garden.

300 yards : Church Path bridge.

200 yards : Pest House bridge. On the upper bank at this point are situated a nursery and Cheshunt College.

600 yards : College Road bridge. Here is a tank for the supply of unfiltered water for the Cheshunt roads.

150 yards : Grove House private foot-bridge.

300 yards : At this point a path from Cheshunt Church comes to the upper bank of the river, crosses over at Theobald's Park foot-bridge, and then passes along the lower bank of the river to the south end of Theobald's Park, a total distance of about a mile and a half.

880 yards : Theobald's Park foot-bridge.

200 yards : Theobald's Lane. Here is the junction of Walks 7 and 8. From this point the river runs through Theobald's Park.

30 yards : Occupation bridge, Theobald's Park.

300 yards : Theobald's Pond and Island.

700 yards : Theobald's Park occupation bridge. Here the footpath crosses the river. Both banks of the river are private from this point.

100 yards : New river passes from Hertfordshire into Middlesex.

440 yards : Bullsmore Lane bridge. This is the public road from Bull's Cross to Waltham.

150 yards : Manor Farm (Bull's Cross) occupation bridge.

440 yards : Turkey Street bridge, Edmonton.

300 yards : Maiden's bridge. Here there is a grating. Under the bridge passes Cuffley Brook, which is in the map called Maiden's Brook. This conducts the land drainage from the country on the west side of the river and takes it into the River Lee, crossing from the upper to the lower bank.

[A short distance below Turkey Street bridge the original course of the New River has been altered. The water is now conducted across the valley in an aqueduct. The disused part of the river flowed in a westerly direction, and a portion of this part has lately been restored, and the banks have been raised. The part of the river which has lately been repaired will be used for the conveyance of water from

A Disused Loop.

A Disused
Loop
(Fig. 6).

a new well which has been dug at White Webbs. The water from this well is to be conveyed in a pipe which will open into this part of the river, and the water will flow in an open course in a direction exactly opposite to that which was taken by the water when this part was used for its conveyance to London before the aqueduct was made. The description which here follows of this part of the New River will be best understood by the study of the accompanying map (Fig. 6). The water from White Webbs will go into the open-course channel of the river at the place marked with an arrow, and from this point the water will flow in an easterly direction and join the New River just before it passes into the aqueduct over Maiden's bridge. The part to the west of the point at which a pipe will enter the river from White Webbs will still be disused. The old course of the river can be easily traced up to Flash Lane Cottage.

The following is a brief description of the course from Maiden's bridge aqueduct to Flash Lane.

300 yards : Road from Enfield to Cheshunt.

200 yards : Occupation bridge in the grounds of Myddelton House. A few years ago the water in this part of the river was stagnant. The banks of this part have been raised and turfed over. The banks have been raised to the extent of about 1 foot to 2 feet for a distance of about one-third of a mile.

300 yards : Wooden occupation bridge. Here there is a sluice-gate, which can be used for allowing the water to pass into Maiden's Brook.

200 yards : From this point goes the line of pipes to White Webbs well. From this point the river has not been cleared out, nor have the banks been raised. Weeds are growing in it.

880 yards : White Webbs Road.

200 yards : Here, near the bank, is the 18-inch pipe from White Webbs. The pipe from the well has been laid from this point to the well.

440 yards : Enfield Flash bridge. Here there is an overflow weir to Maiden's Brook.

200 yards : Above this is Flash foot-bridge. Here the "loop" of the New River ends—*i.e.*, in a cul-de-sac. The last 200 yards are next Flash Lane.

The return part of the loop has been filled up, and the ground it occupied has been taken by adjoining landowners.

From this necessary digression we return to the new course of the river.]

Maiden's
Bridge.

Maiden's Bridge.—There is an aqueduct over Cuffley or Maiden's Brook. It is about 25 yards in length, and the water of the river is conducted in two 48-inch pipes, which are visible in the aqueduct-house, which is covered with corrugated iron, and has a walk between the pipes. The pipes are about 20 feet above the level of the bed of the Cuffley Brook.

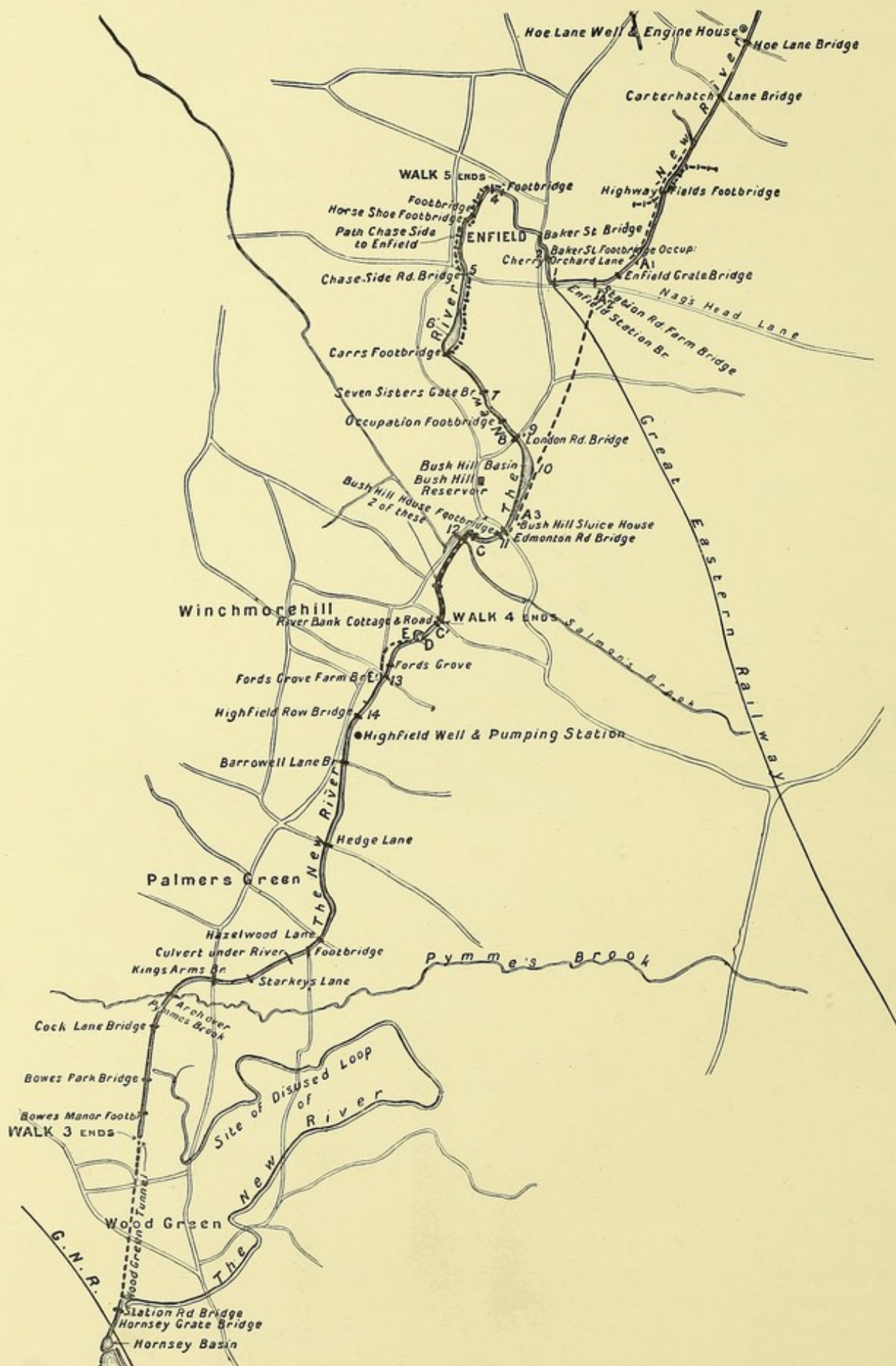


FIG. 7.—THE NEW RIVER: FORTY HILL TO HORNSEY.

50 yards : Forty Hill Church footpath.

250 yards : Pipes open into the river again. There are three pipes which open into the river. Forty Hill
to Hornsey
(Fig. 7).

880 yards : Hoe Lane. Here is a well and pumping-station on the upper bank. Close to the station is Hoe Lane bridge.

440 yards : Carter Hatch Lane bridge.

300 yards : From this point for a distance of about a quarter of a mile the bottom and sides of the river are concreted, and the sides slope as 1 in 5. The river is about 5 feet in depth at this point.

400 yards : There is here a public footpath on the lower bank for a distance of about 250 yards. The path goes from Enfield highway to Enfield town. Here, on the upper side of the river, pipes are being put to convey the surface-drainage from the land. This work is being very efficiently carried out, and there are a large number of manholes to facilitate the cleansing of the drains. The course of the surface drain is shown in the map by a dotted line; the water is conducted in an 18-inch pipe under the New River at the point marked A 1 (Fig. 7).

200 yards : Highway Fields foot-bridge. A new one is now being erected. At the part of the river which has been concreted an arrangement has been made to enable anyone who by chance should fall into the river to get out. At a distance of every 100 yards on each side there are three ladder irons, one above the other, placed in a recess. At points where public footpaths come next the river galvanized iron chains are to be suspended along the concrete walls, and this will be done in all those parts of the river which have concrete walls, and which have also public footpaths adjacent. It is worthy of note that the New River is a private property, and that no one has any right to get into it. The Company is not under any obligation whatever to put up the iron chains or the ladders.

700 yards : Enfield grate bridge.

50 yards : From this point two 48-inch pipes take the water beyond Bush Hill sluice, the course of the pipes being across gardens, under the Great Eastern Railway line, and then through fields. The river passes round the Enfield loop for a distance of about two and a half miles. Roughly speaking, half the water is conducted through the 48-inch pipes and the other half passes along the course of the river. The course of the pipes is shown in the map by a dotted line A 2 to A 3 (Fig. 7).

30 yards : Station Road Farm bridge, Enfield. On the upper bank of the river here are market-gardens. The river passes next Nag's Head Lane, which is a public road.

250 yards : Enfield Station bridge.

200 yards : Cherry Orchard Lane bridge. This part is fenced in on both sides, except the last 40 yards, along which there is a path leading to the back entrances of some houses on the river bank. There is an occupation foot-bridge in the garden of a house in Baker Street.

Forty Hill
to Hornsey
(Fig. 7).

200 yards : Baker Street bridge. The river here has Enfield Court grounds on the upper bank.

450 yards : Foot-bridge in Enfield Court grounds.

200 yards : Occupation foot-bridge. Here a surface-water culvert passes under the river, going in the direction from the upper to the lower bank—that is, from the north to the south.

Penne-
father's
Field.

Pennefather's Field.—Here there is a public footpath.

300 yards : Pennefather's foot-bridge. The public footpath here comes from the upper to the lower side of the river.

760 yards : Horseshoe bridge path. The public footpath is here on the upper bank.

25 yards : Occupation foot-bridge.

20 yards : Occupation foot-bridge.

40 yards : Public footpath from Chase Side to Enfield.

150 yards : Chase Side foot-bridge.

130 yards : Chase Side Road bridge. There is here a public footpath on the lower bank as far as the foot-bridge at Carr's Basin. On the upper bank is Chase Park.

400 yards : Carr's Basin and Carr's Island. Carr's Basin foot-bridge. Here the footpath ends.

440 yards : Seven Sisters grate bridge. Just at this point (7, Fig. 7) for a few yards the banks of the river are concreted, in order to prevent any possible contamination from the weeds which are here taken out and left in heaps to decay.

200 yards : Occupation foot-bridge.

120 yards : London Road bridge. This is the high road from London to Enfield.

Waste Gate.

Waste Gate.—There is here a cogged sluice-gate 2 feet 6 inches in width.

50 yards : Occupation bridge. Manor House, Bush Hill.

200 yards : Bush Hill Basin.

400 yards : Bush Hill sluice-house. Just below this house the water from the pipes returns to the river. It does not go through the sluice-house, but enters the river just below the sluice. The sluice-house is built across the river. Here there is an iron gate fixed in a cogged wheel and arranged with a balance weight. The gate is used to regulate the amount of water which is sent down the New River, and instructions as to the amount required are received from the head offices of the Company. In this sluice-house there are two gauge-plates which record the height of the water above and below the sluice. The fall of the river at this point varies from 10 inches to about 2 feet. Just below the sluice-house is Edmonton Road bridge, Bush Hill. Under the Edmonton Road there is an "easement" for the river—that is to say, it passes through two channels.

50 yards : Foot-bridge, Bush Hill House.

220 yards : Bush Hill House foot-bridge. It was here that the river was formerly carried over a valley in a wooden aqueduct supported on piles ; later an embankment was made. This part of the river is now lined with concrete (Fig. 7, c c'). The channel is 24 feet in width, 6 feet in depth, and the concrete extends for about half a mile. In Bush Hill Park the river passes over a brick arch. The arch was rebuilt in 1682, and under it there is a culvert which conveys surface-water, and an iron pipe for the sewage of Winchmore Hill, which goes to the Tottenham sewage works.

Forty Hill
to Hornsey
(Fig. 7).

400 yards : Bush Hill House occupation bridge.

250 yards : River-bank Cottage bridge.

150 yards : At this point an easement pipe 36 inches in diameter conveys the water to a point in the river 100 yards lower down. This cuts off a loop (Fig. 7, D). Just opposite this point on the upper bank there is the beginning of another easement pipe. A pipe 6 feet in diameter conducts the water for a distance of 60 yards ; then for 300 yards the water is conveyed in a 4-foot 6-inch pipe ; then for a distance of 50 yards again in a 6-foot pipe. The course of this easement is shown in the map (Fig. 7, E E').

550 yards : Occupation bridge, Ford's Grove.

3 yards : Ford's Grove Road bridge.

50 yards : Ford's Grove Farm bridge.

300 yards : Highfield Row bridge.

150 yards : Highfield. Here there is a well and pumping-station on the lower bank of the river.

200 yards : Barrowell Lane bridge. The bed of the river is concreted under the bridge, and for a distance of about 10 yards above and below it.

550 yards : Hedge Lane. From a point in the river about 20 yards above this bridge to a quarter of a mile below it the beds and sides of the river are concreted.

700 yards : Hazelwood Lane.

100 yards : Foot-bridge to Edmonton and Palmer's Green.

150 yards : Here a culvert passes under the New River to convey the surface-water from the western to the eastern side, whence it flows into the Lee.

300 yards : Starkey's Lane bridge.

200 yards : King's Arms bridge. Here there is an easement. From King's Arms bridge the river runs on an embankment raised about 30 feet above the surface of the land.

300 yards : Arch above Pymme's Brook which takes surface-water from Southgate, and discharges it into the Lee.

250 yards : Cock Lane bridge.

350 yards : Bowes Park bridge. Church path.

300 yards : Bowes Manor foot-bridge (disused).

400 yards : At this point the river enters Wood Green tunnel. Here is the

Forty Hill
to Hornsey
(Fig. 7).

junction of Walks 3 and 4. The tunnel is built of bricks set in cement; the upper part is arched, the lower part is slightly inverted. The width is 12 feet, the depth 9 feet. For the greater part of a mile (1,100 yards) the river flows in this tunnel.

The course of the Wood Green tunnel is under gardens between Myddelton Road, Bowes Park and Truro Road, Wood Green, under Truro Road, Wood Green Urban District Council Gardens, then under Nightingale Road, and the gardens of houses in Finsbury Road, under Commerce Road, and a piece of land which formerly belonged to the New River Company, but which has been lately given up to the Wood Green Urban District Council, with a view to its being made into a public garden. From this point the canal passes under Trinity Road, a few yards of common land, Bounds Green Road, under another piece of land, which it is hoped will be made into a public garden by the Wood Green local authorities, then under the Palace Gate branch of the Great Eastern Railway, across a public garden, under Park Avenue, and for a few yards under another public garden, where the tunnel ceases, and the water again becomes visible.

Hornsey
(Fig. 8).

40 yards: Station Road bridge, Wood Green. At this point the Wood Green Urban District Council public sewer crosses under the river in a 2-foot pipe.

70 yards: The river here passes under an arch of the Great Northern Railway main line. Close to the railway bridge is Hornsey Grate bridge. The meshes of the grate are 4 inches and the bars 1 inch in diameter. A little below this point is Hornsey Basin. Hornsey Basin has an area of about an acre. It is 16 feet deep in the centre. From it the Hornsey reservoir is fed, through a 48-inch pipe, guarded by a screw-cock. Here are the Hornsey filter-beds and pumping-station; and near by is the Campsbourne well and pumping-station.

At Hornsey there is a floating boom and a sluice house across the river. The sluice-gate is 5 feet in width and 8 feet in depth. It is arranged with balance weights and worked by cogged gear. The house contains floating dial gauges, which, however, are not now used. Rack gauges are now in general use. A rack gauge, it may be stated, is an iron rod marked with notches 1 inch apart, and the rod is fastened to an oak pile which is fixed in the river. At this sluice there is a fall of about 3 feet. The amount of fall varies from a minimum of 7 inches to a maximum of a little over 3 feet. Formerly water was pumped from this station to Maiden Lane by a three-throw pump, worked by an under-shot water-wheel. The wheel is not now in working order, and the water-power here is not at present used.

440 yards: Tottenham Lane bridge.

40 yards: Great Northern foot-bridge.

300 yards: Hampden Lane bridge. Here the Great Northern Railway is on the upper bank. This piece of the river for about a quarter of a mile is called the New Cut. It was made by the Great Northern Railway Company when their line was widened about twenty years ago.

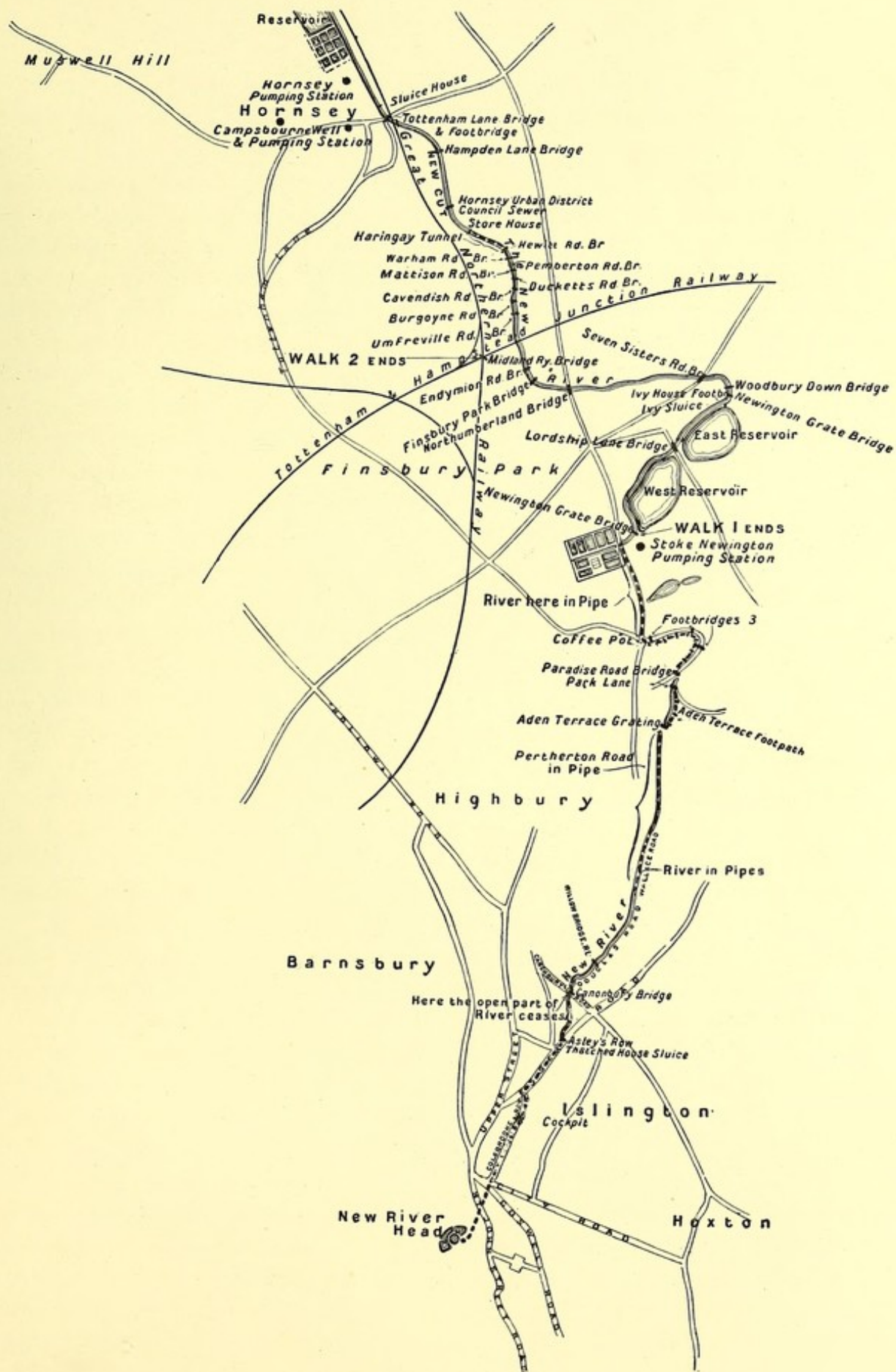


FIG. 8.—THE NEW RIVER: HORNSEY TO CLERKENWELL.

400 yards: Hornsey Urban District Council sewer passes under the river at a level of 20 feet below the bottom of the river.

Hornsey to
Clerkenwell
(Fig. 8).

100 yards: Here there is a shed for storing dam boards. These boards are 9 inches by 4 inches, and are dipped in creasote.

15 yards: Commencement of Harringay tunnel. This is guarded by a grating. Behind the grating there are two slots in the brick-work; into these the dam boards can be fixed. The distance between the slots is 18 inches, and this space can be filled with puddle. By this means all the water can be dammed back, and the work can be very quickly done. This arrangement is used only when it is necessary to clean out the tunnel, an emergency which rarely occurs. The tunnel was made in the year 1891, and it has only been necessary to cleanse it once since that date. For emptying the tunnel of the water which it contains there is a cock-pit made to receive it, and from this pit it is discharged into the sewers. The tunnel passes under the road which connects this part of the New River with Wightman Road. It then passes under the Wightman Road, and under the gardens belonging to houses in Wightman Road and Hewitt Road. The course of the tunnel is then under Seymour Road, and it ends immediately after passing it.

100 yards: Warham Road bridge. Here the river passes through a newly-developed residential neighbourhood and is skirted by back-gardens.

80 yards: Pemberton Road bridge. There are gardens down to the river on each side. Just beyond Pemberton Road the gardens are guarded on both sides by an iron fence which has four rails.

80 yards: Mattison Road bridge. Here there are open iron hurdles between the gardens and the river.

90 yards: Duckett's Road bridge. There are iron hurdles between the gardens and the river. One part is protected by a wooden fence.

90 yards: Cavendish Road bridge. On the upper bank there are iron hurdles and a piece of spiked rail.

90 yards: Burgoyne Road bridge. On one side the river is protected by a piece of oak fence and on the other by iron hurdles.

90 yards: Umfreville Road bridge. Here the river is fenced by hurdles and wooden-railing, pointed at the top. There is also remaining a piece of the "standard fencing" which was formerly used all along the river.

150 yards: Midland Railway. This is the branch line from Tottenham to Hampstead. On the day before this part of the river was visited there was a severe thunderstorm in the afternoon, and it rained very heavily for some hours. The surface-water from the sides of the railway collected in considerable quantity and covered the line, so that the traffic was for a time stopped. The water also overflowed a garden which is by the side of the railway, and washed large quantities of ballast from the line on to it, and the water overflowed and ran into the New River.

Hornsey to
Clerkenwell
(Fig. 8).

The man who had this piece of garden said that more than one such flood had occurred there during the last nine years. He stated also that at the early part of the flood the water which came down was much discoloured and had an evil smell ; that it came from the surface-water sewers at Crouch Hill, which were liable to overflow after a heavy storm. The arrangement which existed when this survey was made for conducting away the surface-water at this point was a 9-inch pipe, which passed under the river, and this pipe was certainly of insufficient size to convey all the surface-water which collects after a heavy storm. The man whose garden was inundated during the storm said that during the period of heavy rain forty 9-inch pipes would not have been sufficient. This may possibly be an exaggeration, but, be this as it may, the above-described arrangement is obviously inadequate.

Midland
Railway
Bridge.

Midland Railway Bridge.—Here is the junction of Walks 3 and 2. Here the lower bank is open ; the upper is guarded by the "standard fence."

150 yards : Endymion Road bridge. Here, on the lower bank, is Finsbury Park. This is the part which is used for playing cricket ; it is divided from the New River path by a high fence.

100 yards : Finsbury Park bridge. At this point the entrance of the path by the river is guarded from the road only by a low oak fence, so low that children can get on to it and sit on it without any trouble. Between the path and the cricket-ground there is a high wire fence, and on the upper path the standard fence between the path and the river. The day before this was visited after the thunderstorm the New River here overflowed into the cricket-ground. This is said to be a rare accident.

300 yards : Northumberland bridge, Green Lanes. Here, on the upper bank, is situated Northumberland House Lunatic Asylum, the grounds of which extend for 500 yards along the bank of the river.

100 yards : Northumberland House foot-bridge. This bit of the river goes along the hillside, the upper bank sloping gradually down to the river, and there are here some very good gardens which go down to it.

800 yards : Seven Sisters Road bridge.

300 yards : Woodberry Down bridge. There is here a footpath which is public, but the bridge is made for carriages, and there is a bar at the end which belongs to the New River Company. The public drive to the houses is from Seven Sisters Road.

30 yards : Stoke Newington grate.

40 yards : Here is the Stoke Newington Station, which consists of reservoirs, filter-beds, and pumping arrangements. The river now flows along the north side of the reservoirs. It first passes through a disused sluice-house, called the Ivy House. On the upper bank there are a number of gardens belonging to houses in the Woodberry Down Road. The water in this part of the river is only changed sufficiently often to keep it sweet. Almost all the water passes through the reservoirs. The

distance along the first or east reservoir is about a quarter of a mile. From this point the water flows from the western end of the reservoir, and is conducted for a distance of about 20 yards in the river, which passes under Lordship Lane bridge. Most of the water goes into the west reservoir, which is situated on the lower bank, and the sluice which admits it is situated at a distance of about 100 yards from the road. The river now flows along to the north of the west reservoir, and at a distance of 600 yards lower down the water which has been in this reservoir comes again into the river. Into this piece of the river, like that next the east reservoir, only enough water is allowed to pass to keep the river sweet. Almost all the water passes through the reservoir.

Hornsey to
Clerkenwell
(Fig. 8).

30 yards : Newington grate bridge. Here is the pumping-station.

50 yards : The river passes into a 54-inch pipe, and goes down the course of the Green Lanes.

700 yards : Here is a sluice-house, to which the workmen of the New River Company have given the name of the Coffee Pot. It is so called because the water comes out of the pipe through a bell-mouthed opening. Here is the junction of Walks 1 and 2. At this point the river again continues its course, passing into Clissold Park under a foot-bridge. This part of the river is protected on both sides by an iron-spiked railing, which has been put up and is kept in repair by the London County Council. There is a public footpath next to the upper bank.

350 yards : Foot-bridge.

250 yards : Foot-bridge.

300 yards : Paradise Road. The river passes under this road and then through a garden.

60 yards : Park Lane bridge. From this point there is a public footpath on the lower bank, separated from the river by a high, spiked railing. On the upper side gardens go down to the river. The path passes by Aden Terrace.

350 yards : Here there is a grating. This grating is of a new type. It is made entirely of iron, the meshes are $\frac{1}{2}$ inch in width, and the pieces of iron which form the grating are also $\frac{1}{2}$ inch in width, and about 2 inches from before backwards. The pieces of iron which form the grating are fixed on to an iron rod, and all the meshes are of exactly the same size. Here the open part of the river ceases for a time. The water is conducted in a 48-inch iron pipe, which passes for a distance of about half a mile under Petherton Road, 30 yards along Grosvenor Road, and over the North London Railway at Canonbury Station, and then along Wallace Road, at which point the pipe discharges itself again into an open channel. Wallace Road is on the upper bank for a distance of 600 yards, and then the river is crossed by Willow Bridge Road, Canonbury. Here Canonbury Grove is at the lower bank. At this point is a building which was once the ice-house of Canonbury House, a place not without historic interest.

Hornsey to
Clerkenwell
(Fig. 8).

300 yards : Canonbury bridge. The part of the river next Wallace Road is protected from trespassers by a 6-feet cast-iron fence, which extends along Paul's Road, Douglas Road, and Canonbury Road. At Canonbury bridge the river passes into a 54-inch pipe, which is at this point 2 feet below the surface of the ground. The pipe passes along Astey's Row. Here there is a space covered with grass between an iron fence and the lower side and a wooden fence on the upper side. The width of this space varies from 40 feet to 100 feet. It is the property of the Company, and is kept more or less private by the policemen on the beat.

At the end of this open space is the Thatched House sluice. The house is now tiled, and there is no sluice. The cottage is occupied by a caretaker, and there is a small garden and a cockpit. From this point the pipe passes along the middle of the Essex Road. At a distance of about a quarter of a mile the pipe leaves the Essex Road, and is conducted down Colebrooke Row in a channel 6 feet in height and 4 feet in breadth for a distance of 30 yards; and here there is a cockpit, from which water is conveyed in a 36-inch pipe for a distance of 100 yards, then in a pipe 48 inches in diameter for the rest of the distance to the round pond at the New River Company's works at Clerkenwell. The course of the main is along Colebrooke Row, then between Colebrooke Row and Duncan Terrace, across the City Road and Goswell Road. After passing this road there is another manhole, which is situated in the playground belonging to Dame Owen's School, close to the iron fence. The pipe then passes under a garden at the corner of St. John Street, Clerkenwell, down Rosebery Avenue, to New River Head, Clerkenwell.

THE WELLS, PUMPING-STATIONS, AND RESERVOIRS.

A general survey of the present course of the New River having been given, we proceed to describe the stations of the Company.

Broad Mead
Well.

BROAD MEAD WELL (see C on general Map).—At Broad Mead a boring was made in the hope that the green-sand might be reached, and that it would afford a supply of water. The bore-hole was taken down for a distance of 831 feet, the size of the bore being 20 inches at the upper part and 16 inches at the lower part. The green-sand formation was not found. A well 30 feet in depth was sunk, but no large supply of water can be obtained here. The amount has been estimated at 500,000 gallons a day, but the pumping arrangements are, we believe, not capable of raising this quantity.

Pumping Arrangements.—There is a simple horizontal engine with a centrifugal pump and a boiler of the locomotive type. The engine is of 16 horse-power. The water is pumped from the well into the river, which at this point contains the water derived from the Lee and from Chadwell Spring.

AMWELL END WELL AND PUMPING-STATION (see D on Map).—This well is 72 feet in depth. Chalk occurs at the depth of about 36 feet below the surface; the part of the well above the chalk is lined with iron cylinders.

Amwell End
Well and
Pumping-
Station.

Pumping Arrangements.—There are two reciprocating pumps, which have barrels 22 inches in diameter. These are worked by a simple condensing vertical engine of 50 horse-power. The steam is generated by two Galloway boilers. The amount of water which can be obtained here is estimated at 1,500,000 gallons daily. The water is pumped into the river through iron pipes.

AMWELL HILL WELL AND PUMPING-STATION (see E on Map).—This station is situated on the upper bank of the New River on the steeply sloping side of Amwell Hill, at a level of about 20 feet above the New River. The well is 90 feet in depth, and goes into the chalk; it has headings and a bore-hole. The shaft is lined with brick. From this shaft there are headings 6 feet in height and 4 feet 6 inches wide. From the centre of the shaft there is a bore-hole 2 feet in diameter at the upper part and 9 inches at the lower part. The bottom of the bore-hole is 161 feet from the surface. The amount of water which can be obtained daily is stated to be 3,500,000 gallons, and it is said that this quantity can be obtained day after day for a period of six months.* There is a beam engine of 50 horse-power and an inverted cylinder engine of 25 horse-power. The steam is generated by one Lancashire and one Cornish boiler. The water passes through a large brick culvert into the New River. At this station there is another small engine, which is used for pumping water into the village; the water used for this supply is pure water from the well. No water from the New River is used for the local supply.

Amwell Hill
Well and
Pumping-
Station.

AMWELL MARSH WELL AND PUMPING-STATION (see F on Map).—This station is situated on the lower bank of the river; it was completed in the year 1884.

Amwell
Marsh Well
and
Pumping-
Station.

Well.—There is a well 110 feet in depth. The quantity of water which it is said can be obtained daily from the well is 2,750,000 gallons.

Pumping Arrangements.—There are two simple vertical engines of 35 horse-power each. These work pumps through bell cranks. The steam is generated by two Cornish boilers. The water is all pumped into the New River.

RYE COMMON WELL AND PUMPING-STATION (see G on Map).—This station is situated at the lower bank of the New River.

Rye
Common
Well and
Pumping-
Station.

Well.—There is a well 200 feet in depth, lined with brick and iron cylinders to the depth of the chalk. The level of the water in this well on June 16, 1897, was 55 feet below the surface. At this date the engines were worked for twelve hours daily, and were raising about 2,500,000 gallons of water.

* Mr. Mylne, the engineer to the Company, stated in 1852, in his evidence on the Metropolitan Water Supply, that the well then yielded 2,466,000 gallons daily.

Pumping Arrangements.—There are two vertical engines with inverted cylinders of 100 horse-power each. These work the pumps through bell-cranks. Steam is generated by two Cornish boilers. The water is all pumped into the New River. It is stated that the well is able to supply from 4,000,000 to 5,000,000 gallons daily.

Hoddesdon
Well and
Pumping-
Station.

HODDESDON WELL AND PUMPING-STATION (see H on Map).—The station is situated on the lower bank of the river. The well is 55 feet in depth. Chalk was reached at a depth of 32 feet from the surface. The amount of water which can be obtained is said to be 2,000,000 gallons daily.

Pumping Arrangements.—There is a 50 horse-power vertical single cylinder engine, which works two pumps through gear. The steam for working the engine is generated by a Lancashire boiler, and the pressure used is 25 lb. All the water is pumped into the New River.

Broxbourne
Well and
Pumping-
Station.

BROXBOURNE WELL AND PUMPING-STATION (see I on Map).—The well is about 200 feet in depth. The diameter at the upper part is 16 feet. This well has two headings, one 300 feet and the other 400 feet in length. The amount of water which it is said can be obtained daily is 4,500,000 gallons. On July 16, 1897, the water level was 137 feet below the surface. It has been lowered to 145 feet.

Pumping Arrangements.—There are three engines of 180 horse-power altogether. Of these two are vertical engines with inverted cylinders, and the other a horizontal engine. The steam is generated by Lancashire boilers, and the pressure used is 65 lb. The pumps are worked through bell-cranks. There are six pumps, of which the cylinders are 14 inches in diameter and the stroke is 3 feet. The rate at which they are worked is 25 per minute.

Turnford
Well and
Pumping-
Station.

TURNFORD WELL AND PUMPING-STATION (see J on Map).—The station is situated on the lower bank of the river. The well is 170 feet in depth, and has two headings of 220 feet and 190 feet in length respectively, and a bore-hole 1,000 feet in depth. The well is said to be capable of supplying 3,000,000 gallons daily.

Pumping Arrangements.—There are two engines. One single cylinder side-lever engine works bell-cranks through gear, and an inverted cylinder engine works bell-cranks directly. The steam is generated by two Lancashire boilers, and the pressure at which the engines are worked is 56 lb. Of the pumps two have cylinders 18 inches in diameter, a stroke of 2 feet 6 inches, and work at a rate of 27; the other two pumps have a diameter of 22 inches, a stroke of 6 feet, and work at a rate of 8 strokes per minute. The water is all pumped into the New River.

Hoe Lane
Well and
Pumping-
Station.

HOE LANE WELL AND PUMPING-STATION (see M on Map).—The well is about 200 feet in depth. Chalk occurs at a depth of about 100 feet. The amount of water which it is estimated the well could supply daily is 2,000,000 gallons.

Pumping Arrangements.—The water is pumped by two horizontal engines, which together possess 170 horse-power. The steam is supplied by three Lancashire boilers. The engines work the pumps through gear.

BUSH HILL RESERVOIRS (see n on Map).—The reservoirs are situated in Bush Hill Park. A well was sunk here and a water-tower built when the estate was laid out for building purposes. The well and reservoirs were taken over by the New River Company. The well is not now used. The water for the supply of the reservoirs is pumped from Highfield, and is distributed to the surrounding district. Bush Hill Reservoir.

SOUTHGATE RESERVOIR (see o on Map).—This reservoir is situated on the highest point at Southgate Hill, near Cockfosters Road and Chase Side Road. The area occupied by the station is about three acres, and it is surrounded by a 6-foot brick wall; the reservoir occupies about one-third of the space. It is built of brick set in cement and covered by brick arches; the top is turfed over. Ventilation is effected through twenty iron gratings, 18 inches by 6 inches in size, which are placed at the sides of the reservoir. There is a circular manhole 4 feet in diameter, covered by York stone. The capacity of the reservoir is 1,000,000 gallons, and the top water level is 308 feet above Ordnance datum. The water pumped here comes from the well at Betstile, and from Highfield; it is all pure well water. The districts supplied are Southgate and Winchmore Hill. There is no electric communication between this place and the pumping-station. A man is sent to the reservoir twice a day to note the height of the water. Southgate Reservoir.

HIGHFIELD EDMONTON WELL AND PUMPING-STATION (see p on Map).

Well.—The well is about 200 feet in depth. The diameter at the upper part is 15 feet, and at the bottom 11 feet. The upper 40 feet of the shaft is lined with brick, and below that with iron cylinders to the chalk, which occurs at a depth of 116 feet. There are two headings, each about 30 feet in length. The amount of water which the well is said to be capable of supplying is 3,000,000 gallons. When visited on July 20, 1897, the level of the water in the well was 160 feet below the surface. The pumping had been going on continuously for a month. The rest level—that is, the height to which the water rises when pumping operations are discontinued for some time—is 60 feet below the surface. Highfield Edmonton Well and Pumping-Station.

Pumping Arrangements.—There is a pair of single cylinder vertical engines. The cylinders are 32 inches in diameter, the length of the stroke is 3 feet, and the rate at which the engines are worked is about 28 strokes per minute. The engines work four bucket and plunger pumps through bell-cranks. The diameter of the pump-barrel is $14\frac{1}{2}$ inches; the length of the stroke is 3 feet. The steam for working the engines is generated by three Lancashire boilers, and they are worked at a pressure of 50 lb. There is also a compound vertical engine, which had a cylinder

15 inches in diameter, and a stroke of $12\frac{1}{2}$ inches. This engine is used for pumping water to Southgate. The head of water worked against in pumping to Southgate is 250 feet. There is at this station the recording index of an electric gauge, which shows the height of the water in the Bourne Hill reservoir.

**Bourne Hill
Reservoir.**

BOURNE HILL RESERVOIR (see Q on Map).—This is situated on the south side of Dog and Duck Lane, Southgate. It is surrounded by a wall on three sides, and by a high oak fence on the side next to the road. The reservoir is built of brick set in cement, and is covered by brick arches, on the top of which there is a layer of about 2 feet of earth, which is turfed over. There are twenty-four cast-iron ventilators. The reservoir has a capacity of 1,500,000 gallons. The top water level is 195.5 feet above ordnance datum. There is a floating gauge here which is in electric communication with Highfield engine-house, from which it is about a quarter of a mile distant. The communicating wire passes along the public high-road. Water is pumped here from Highfield, and the reservoir can also be supplied from the one at Crouch Hill, which is about two and a half miles distant. The water from this reservoir supplies Edmonton and part of Southgate.

**Betstile
Well and
Pumping-
Station.**

BETSTILE WELL AND PUMPING-STATION (see R on Map).

Well.—At this station there is a well 142 feet in depth sunk into the chalk.

Pumping Arrangements.—The water is pumped by two horizontal engines of 12 horse-power each. These work pumps through gear. The steam is generated by two Cornish boilers.

The amount of water which can be obtained is estimated to be 500,000 gallons daily. It is used for the supply of the district around.

This place was formerly the property of the North Middlesex Waterworks Company.

**Hornsey
Reservoir
Filter-Beds
and Pump-
ing-Station.**

HORNSEY RESERVOIR FILTER-BEDS AND PUMPING-STATION (see S on Map, and Plan, Fig. 9).—This station is situated on the lower bank of the New River, at the foot of Muswell Hill, and just to the west of the Great Northern Railway line. The water from the New River, after passing the Hornsey grate-bridge (see Fig. 1, A), which has already been described, passes into the Hornsey basin (Fig. 1, B), a reservoir which has an area of about an acre. From the basin the water is conducted into the reservoir through a 48-inch pipe, guarded by a screw-cock.

Reservoir (Fig. 9, R).—There is an open reservoir, which occupies an area of eight acres, and is capable of holding 8,500,000 gallons of water. The sides of the reservoir are lined with Kentish rag.

Filter-beds.—There are eight filter-beds, numbered 1 to 8 respectively. Of these, No. 1 when visited in July, 1897, was being re-made. Of the others, Nos. 4, 5, 6, 7, and 8 have vertical walls. Nos. 2 and 3 have sloping walls; these will be

re-made after No. 1 has been finished. The central space between the filter-beds is used for storing sand.

The upper parts and sides of the beds are lined with blue Staffordshire bricks. The old beds are formed as follows: Sand, 2 feet; fine shingle, 2 feet; and coarse

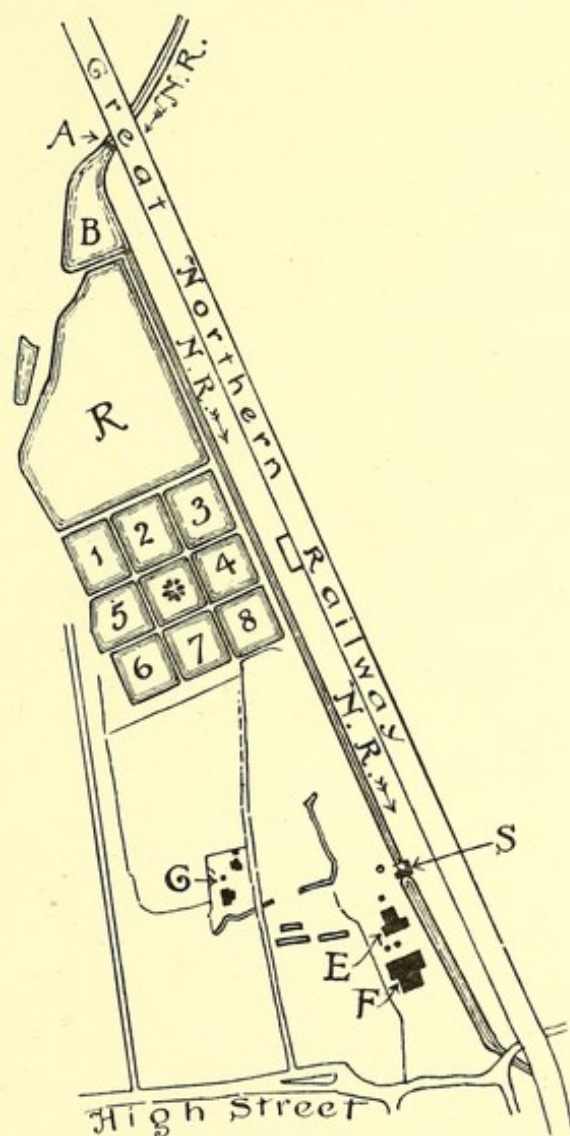


FIG. 9.—HORNSEY AND CAMPSBOURNE STATIONS.

N R, New River; A, Hornsey grate; B, Hornsey basin; R, reservoir; 1, 2, 3, 4, 5, 6, 7, 8, filter-beds; *, storing place for sand; E, Hornsey sluice engine-house; F, Hornsey engine-house; G, Campsbourne well and pumping-station; S, Hornsey sluice-house.

shingle, 1 foot. The floor of the filter-bed is formed of perforated bricks set on edge, and the filtered water is collected in a central channel, which is 2 feet 6 inches square. Each filter-bed has four 3-inch cast-iron ventilating shafts, which are situated at the sides of the bed, and none of the beds have central ventilating shafts. The sand is cleansed by washing with a jet of water working at a pressure of 100 feet head.

Engine-houses.—There are two engine-houses, close together, called the Hornsey Sluice and the Hornsey. Water is pumped from the filter-beds to Crouch Hill reservoir and to Hornsey Lane reservoir.

Hornsey Sluice Engine-house (Fig. 9, E).—Here is a pair of Worthington triple expansion pumping-engines. These pump about 2,500,000 gallons of water daily to Hornsey Lane against a head of water 250 feet. They are capable of pumping a much greater quantity. The steam is generated by three Lancashire boilers, which work at a pressure of 125 lb.

Hornsey Engine-house (Fig. 9, F).—There are four beam engines of 110 horse-power each. These are worked by steam supplied by ten Lancashire boilers.

The water, which is derived partly from wells and partly from the filter-beds, is pumped to Crouch Hill reservoir and to Hornsey Lane.

Between the Hornsey Sluice engine-house and the Hornsey engine-house there is an excellent bath-room, provided with hot and cold water, which is at the service of the workmen. The sanitary arrangements here are admirable.

At Hornsey there is a tramway over the river from the Great Northern Railway. This is used for the conveyance of coals to the engine-houses.

Camps-
bourne Well
and Pump-
ing-Station.

CAMPSBOURNE WELL AND PUMPING-STATION.—This station adjoins the one at Hornsey. (See Fig. 9.)

Well.—The well is 215 feet in depth. At the upper part the shaft is 15 feet in diameter, at the lower part 10 feet. The well is lined with brick for the upper 100 feet, then with iron cylinders. Chalk occurs at a depth of 168 feet. This well does not contain any bore-hole. The level of the water when visited on July 21, 1897, was 190 feet below the surface. The rest level is about 100 feet below the surface. The amount of water which it is stated can be pumped daily is 3,000,000 gallons. At the present time the amount pumped is on an average 1,500,000 gallons. Water is pumped to (1) the New River, and (2) Hornsey, against a head of about 10 feet.

Pumping Arrangements.—There are two compound vertical surface condensing engines; the size of the high-pressure cylinder is 18 inches, of the low-pressure cylinder 3 feet; the length of the stroke 2 feet 6 inches. The steam is generated by three Lancashire boilers working at a pressure of 80 lb. The engines work pumps of which the barrels are 17 inches in diameter, and the length of the stroke is 2 feet 6 inches. The rate at which they are worked is 30 strokes per minute.

Workshops.—At this station there is a large carpenters' shop and a well-fitted blacksmiths' shop. Here much carpentering work is done. The wood and iron-work required on the river is now carried out by the Company's own servants, and under the supervision of their own engineers.

Crouch Hill
Reservoirs.

CROUCH HILL RESERVOIRS (see U on Map).—The station is situated next Mount View Road and Ferme Park Road, Hornsey, 195 feet above ordnance datum.

The area occupied here is about 8 acres. There are two reservoirs covered with brick arches and turfed over. The slope of the sides is 1 in 6, and the reservoirs are built of brick set in cement. There is a cast-iron ventilator. Each reservoir has an entrance pit covered by an iron roof. There is an electric gauge here which records the height of the water in these reservoirs. The recording index is situated at the Green Lanes station, whence the water is pumped. These reservoirs are capable of holding 12,000,000 gallons. They are used for the supply of Islington, of Hornsey, and of part of the City. The turf over the reservoirs is used by the Northern Heights Lawn Tennis Club. A caretaker's cottage is situated here.

STOKE NEWINGTON RESERVOIRS, FILTER-BEDS, AND PUMPING-STATION (see v Stoke
Newington
Reservoirs,
Filter-beds,
and Pump-
ing-Station. on General Map and Fig. 10).—The station at Stoke Newington is situated at Green Lanes. It occupies a large area, and is divided into two by the road called Green Lanes. The part to the east of the road consists of two large open reservoirs and a pumping-station; the filter-beds are situated to the west of the road. The New River enters the eastern reservoir at its north-eastern extremity at Woodbury Down. Almost the whole of the water goes through this reservoir in the direction shown by the small arrows in the diagram (Fig. 10). A small amount of water only passes down the course of the river which is situated just to the north of the reservoir at the bottom of the gardens of the houses on Woodbury Down. The sluice at the part of the river near the inlet into the reservoir is kept almost shut, and through that part of the river which is situated just to the north of the reservoir a sufficient amount of water is allowed to pass so that a gentle flow may keep it sweet by circulation. The eastern reservoir is of somewhat irregular oval form, and covers an area of about $21\frac{1}{2}$ acres, and has an average depth of about 16 feet, except near the banks. It is surrounded by a puddle wall, which goes down to the London clay. There is a grass walk all round, and the eastern and southern sides are protected from the wind by a luxuriant thorn hedge. The available capacity of the reservoir is confined to the upper 3 feet. At the western side of the reservoir there is a disused engine-house, now occupied as a store; an engine situated here was formerly used for pumping to the reservoir at Claremont Square, but it has not been used for many years. From the eastern reservoir the water passes into the New River, and in a south-westerly direction under Lordship Road, and then into the western reservoir. The area of this is about the same as that of the one just described, and it is constructed on the same principle; that is to say, it is surrounded by a puddle wall and the bank slopes down gradually. The reservoirs together have an available capacity of about 90,000,000 gallons, and roughly speaking the water remains in them for from two and a half to three days.

Filter-Beds.—There are nine filter-beds, which have a total area of about $8\frac{1}{2}$ acres. On June 14, 1897, two of these were not in use; the one marked 3 was

being cleaned, and the one marked 5 was being re-sanded. Nos. 1, 2, 3, 4, and 5 are constructed on the same plan. The upper part of each is lined with blue Staffordshire bricks. The sides, which are lined with bricks and concrete, slope as $2\frac{1}{2}$ to 1. The composition of the filtering material is as follows: Sand, 2 feet; shingle, 3 feet. For the collection of filtered water there are two culverts. To these culverts drain-pipes, 10 inches in diameter, conduct the filtered water. These lateral pipes are arranged in lines which are at a distance of about 8 feet apart, and the pipes run into the culverts. The upper part of the culvert is flat and is covered with flagstones. Each culvert has an air-shaft, which has its outlet at the end of the bed. Filters 6, 7, 8, and 9 were built after the others, and they differ slightly in construction. The sides of these beds are nearly vertical. The filtering material consists of 2 feet of

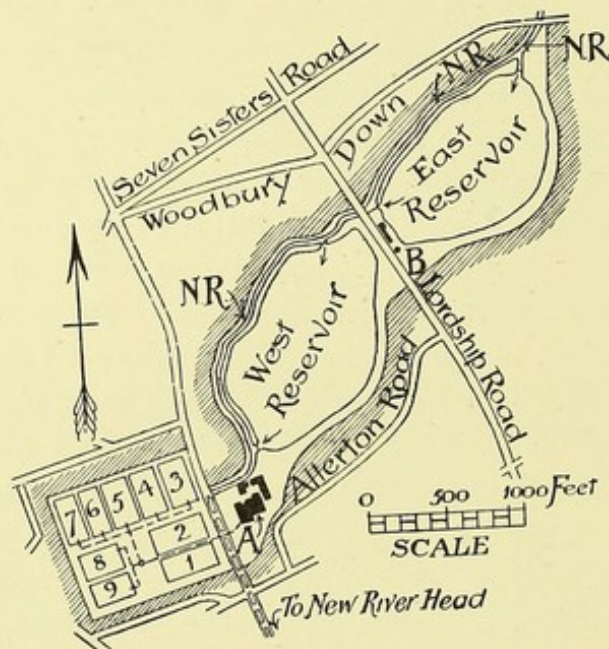


FIG. 10.—STOKE NEWINGTON STATION.

N R, New River; A, engine-house; B, disused pumping-station; 1, 2, 3, 4, 5, 6, 7, 8, 9, filter-beds.

sand and 6 inches of fine shingle (called "pea-shingle"). The method of collecting the filtered water in these beds differs from that adopted in those just described. In the newer beds the channels for the collection of the filtered water were formed of two courses of bricks built to form channels; no mortar was used. Each of these beds has one air-shaft, the outlet of which opens at the side of the bed. The other extremity of the air-shaft passes down to the bottom of the bed.

Cleaning Filter-Beds.—As a rule, a bed is used for about six weeks. It is cleaned by removing about a quarter of an inch of sand from the surface. The sand is washed in a place specially built for the purpose, which consists essentially of a number of bays formed of concrete. The sand is first placed on a hopper and subjected to jets of water at a pressure of 150 feet head. From the hopper the sand passes through troughs

into the washing bays, where it is cleaned by water which plays on it from a hose at a pressure of 150 feet. The amount of water used in washing the sand is about 3,000 gallons per cubic yard.

Rate of Filtration.—The rate of filtration is from $2\frac{1}{2}$ to 4 gallons per square foot per hour.

Gauge.—There is a simple instrument in use at this station for gauging the rapidity of the filtration. It consists essentially of a diaphragm, which is placed in the stream of water which flows from the filtered water culvert to the engine wells. The current of water acting on the diaphragm moves a lever to which an index is attached, and the index is thus able to show on a graduated gauge the rate at which the filtered water is passing out, the gauge being so graduated that it records the result in terms of gallons per square foot per hour. The arrangement is a simple one, and is certainly worthy of general adoption. The filtered water passes into a shaft 16 feet in diameter, from which it is conducted into a culvert as far as the boundary of the western part of the Company's property; it is then conducted under the road (Green Lanes) in two 48-inch pipes to the engine well.

Pumping Arrangements.—There is a compound engine having cylinders 48 inches and 77 inches in diameter respectively, and a stroke of 8 feet. This is worked at a pressure of 70 lb., and pumps the water to Crouch Hill reservoir against a head of 100 feet. As a rule, this engine is worked for about eleven hours a day, and the water supplies Hornsey, Stoke Newington, Edmonton, and part of the City.

There are two pairs of compound engines, Nos. 3, 4, 5, and 6. Of these Nos. 3 and 5 are compound beam-engines, with steam drop-valves arranged with a high-pressure cylinder mounted on a base in front of the low-pressure cylinder. The diameter of the high-pressure cylinder is 28 inches, that of the low-pressure cylinder is 46 inches, and the strokes are 5 feet $6\frac{3}{8}$ inches and 8 feet respectively. Nos. 4 and 5 are compound beam-engines with steam slope-valves. The diameter of the high-pressure cylinders is 22 inches, and that of the low-pressure cylinders 36 inches. The strokes are 5 feet 6 inches and 8 feet respectively. Of these engines Nos. 3 and 4 are worked together, being coupled on one fly-wheel 24 feet in diameter. Engines 5 and 6 are also coupled on a fly-wheel.

Another house contains a compound Worthington engine with high duty attachments. Of this engine the cylinders are 27 inches and 54 inches in diameter respectively, and the stroke is 3 feet 6 inches. This engine is capable of pumping 9,500,000 gallons of water daily, and is used for pumping water to Maiden Lane, working against a head of 150 feet. The Maiden Lane reservoir supplies the higher district.

Amount of Water Pumped.—On June 14, 1897, water was coming down the New River to Newington at the rate of 31,000,000 gallons in the twenty-four hours. Of this quantity 25,000,000 gallons were filtered at Stoke Newington, and pumped

to Maiden Lane, to Crouch Hill, and to the districts between Stoke Newington and those places. The other 6,000,000 gallons of water passed on down the New River to New River Head, Clerkenwell.

Workshops.—This station contains a large workshop, and also cottages for caretakers.

New
River Head,
Clerkenwell.

NEW RIVER HEAD, CLERKENWELL (see W on Map, and Fig. 11).—The area of the station at New River Head is about 8 acres. It is surrounded by a high brick wall. The house formerly occupied by Sir Hugh Myddelton, first Governor of the Company, was situated here, and part of it is now occupied by the offices of the Company (Fig. 11, A). In addition to these, the station contains a small open subsiding reservoir, filter-beds, pumping engines, a yard containing stores, and a large workshop. The water from the New River is received into a subsiding reservoir (Fig. 11, R), which has an area of about an acre, and is capable of holding 700,000 gallons. It is of circular form, and lined throughout with stone. The flow of water

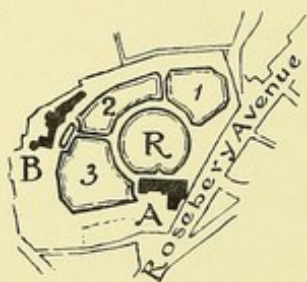


FIG. 11.—NEW RIVER HEAD, CLERKENWELL.

A, Offices; B, engine-house and workshop; R, reservoir; 1, 2, 3, filter-beds.

into it is regulated by a cock. The water has very little time to remain in this reservoir, for the amount pumped daily from the station is about 6,000,000 gallons, therefore the water in the reservoir is changed several times daily.

Filter-Beds (Fig. 11, 1, 2, and 3).—There are three filter-beds, which have a total area of about $2\frac{1}{4}$ acres. They are of somewhat irregular shape, as may be seen in the accompanying plan, which was taken from the ordnance map. The sides of the filter-beds are nearly vertical, and are lined with stone. The composition of the beds is as follows: Sand, 2 feet; shingle and stones, about 5 feet. The stones vary in size from that of a bean upwards; the smaller ones are placed at the top and the larger ones below. Each filter-bed has two culverts for the collection of filtered water. The culverts are square in form at the bottom, and are built of brick. The water at the bottom of the bed is collected into a central culvert by U-shaped pipes, which are laid in lines at a distance of about 10 feet apart. The diameter of these pipes is 6 inches. The end of each filtered-water channel is ventilated by a 4-inch iron pipe. This ventilating pipe is situated at a distance of about 4 feet from the edge of the filter-bed. The three filter-beds are all constructed on the same plan,

and differ only in shape. Near the filter-bed No. 1 there is a place for sand-washing, and a similar one is situated near bed No. 2.

Cleansing Sand.—The arrangements for sand-washing are similar to those at the other stations of the Company. Near the larger filter-bed there are three bays for sand-washing. The water is at a pressure of 120 feet, and the amount of water which is used for washing a cubic yard of sand is 3,000 gallons.

Pumping Arrangements (Fig. 11, B).—There are two engine-houses, called respectively east and west. The engine in the eastern house is in course of removal. The western house contains a beam-engine made by Boulton and Watt in the year 1810. The steam cylinder is 44 inches in diameter, and the stroke is 8 feet. There are two pumps, having barrels of 29 inches and 18 inches respectively, and strokes of 8 feet and 6 feet. The steam is generated by two Lancashire boilers, and both the engines work at a pressure of 20 lb. It may be of interest to note that when the engines were first put up the steam was generated by copper boilers, and the pressure used was only 4 lb. The water was formerly pumped through a stand-pipe; at the present time a large air-vessel is used instead. The water is pumped to the High Pond reservoir, Claremont Square, a lift of 50 feet. The new engine which will be put up is an over-head three-cylinder engine of marine type, capable of working at a pressure of 120 lb.

Workshop.—There is a large workshop in which taps and ball-valves are tested, and those found to be efficient are stamped with the Company's mark. An enormous amount of this work is now done, the number of taps tested being sometimes not less than 50,000 per week. Taps are tested to stand a pressure of 300 lb., which is about equal to a column of 670 feet of water, which, it may be noted, is a much heavier pressure than they would be likely to sustain in actual use.

HIGH POND RESERVOIR, CLAREMONT SQUARE (see x on Map).—This reservoir is situated in the centre of Claremont Square, Clerkenwell. It is on the site of a high-service pond which was formerly used. The present reservoir is covered with brick arches, supported by brick piers. The sides are nearly vertical, the slope being 1 in 12. The bottom of the reservoir is lined with York paving-stones set in cement. There are thirty cast-iron ventilators, and eight circular manholes 5 feet each in diameter. These are covered with galvanized iron sheeting. The reservoir has a capacity of 3,500,000 gallons; the top water-level is 139 feet above ordnance datum. Here there is a standpipe 45 feet in height. There is a clockwork recording-gauge here, and a tabular gauge at the pumping-station at New River Head, whence the reservoir is supplied. The water is used for high-service supply to the City. The reservoir is surrounded by a cast-iron spiked railing.

High Pond
Reservoir,
Claremont
Square.

HAMPSTEAD RESERVOIR (see z on Map).—There is a covered reservoir at the highest part of Hampstead Heath near the flagstaff. It is triangular in form, built of

Hampstead
Reservoir.

brick set in cement. It is covered by brick arches, which rest on iron joists, which are carried by iron pillars; the reservoir is ventilated by iron shafts. It is surrounded by an iron fence, and is covered by turf. Water is pumped here from Hornsey Lane, and is used for the supply of the highest districts of Hampstead. There is here a stand-pipe 40 feet in height, the top of which is 486 feet above ordnance datum, and which is used for the supply of the highest services in the immediate vicinity.

Highgate
Reservoir.

HIGHGATE RESERVOIR (see A A on Map).—The reservoir at Highgate is situated near South Grove, on the highest part of Highgate Hill. The area occupied is about 2 acres. The capacity of the reservoir is 1,000,000 gallons. The sides of the reservoir are built of brick set in cement, and the slope is 1 in 2. The depth in the centre is 12 feet. The reservoir is covered by a slate roof supported on iron joists. The water is pumped here from Hornsey Lane, and is distributed to the higher parts of Highgate. There is a stand-pipe 6 inches in diameter, and 50 feet in height, the top of which is 481·8 feet above ordnance datum. It is used for the high service of houses in the immediate neighbourhood. There is a small round house, which contains a cock-pit, and is used also for keeping tools. An iron railing surrounds the reservoir.

Hornsey
Lane
Reservoir
and Pump-
ing Station.

HORNSEY LANE RESERVOIR AND PUMPING-STATION (see BB on Map).—Water is pumped to this station from Hornsey, and is pumped hence to Highgate and to Hampstead.

Pumping Arrangements.—There is a compound beam-engine, which has a high-pressure cylinder 17 inches in diameter, and a low-pressure cylinder 29 inches in diameter. It works two pumps, which have cylinders 18 inches in diameter, and a stroke of 2 feet 6 inches. The rate at which the pumps are worked is from 27 to 28 strokes per minute. The steam for the engines is generated by two Galloway boilers, one only of which was working when visited. The steam pressure is 80 lb. The head of water worked against in pumping to Highgate is 103 feet, and to Hampstead 133 feet. For six hours a day water is pumped against a head of 150 feet over the stand-pipes at Hampstead and Highgate for the supply of the highest parts of those districts.

Another engine-house contains a simple low-pressure horizontal engine, which works a double-action pump, which has a barrel of $12\frac{1}{2}$ inches in diameter. The length of the stroke is 6 feet, and the engine works at a rate of 22 strokes per minute. This machine is not generally used, the engines first described having sufficient power to do all the pumping usually required by working for twelve hours or so daily.

This station is in telegraphic communication with Green Lanes, but not with the reservoirs at Hampstead and Highgate; so that when it is necessary to communicate with these stations a messenger is sent.

The reservoir is situated close to the engine-house on the west side of Tile Kiln Lane, next to Hornsey Lane. It is covered with brick arches, which are turfed over

at the top; the slope of the sides is about 1 in 6. The reservoir is ventilated by 6-inch cast-iron pipes; it has a capacity of 3,000,000 gallons, and the top water-level is 348·2 feet above ordnance datum. The reservoir occupies from $2\frac{1}{2}$ to 3 acres, and is protected by a high wall.

MAIDEN LANE RESERVOIRS (see c c on Map).—This station is situated on Dartmouth Park Hill, Camden Town. There are two covered reservoirs, and a cottage occupied by a street foreman, the man in charge of the arrangements for the local distribution of the water. The total area occupied is about 10 acres. The reservoirs are capable of holding 15,000,000 gallons of water. The top water-level is 232 feet above ordnance datum. The reservoirs are covered with brick arches which are turfed over at the top. Each is ventilated by sixty cast-iron ventilators, and there are ten inspection- or man-holes, which are covered with galvanized iron. There is a large cockpit adjoining the reservoirs. This is covered by brick arches. It is 30 feet in length and 20 feet in width. Through it pass two 36-inch pipes, which convey the water into the reservoirs; and there is also a 24-inch overflow-pipe which goes into the sewers. This pipe is provided with cocks, which can be opened or shut from the cockpit. The pipes are 30 feet below the surface of the ground. The pit is used for emptying the reservoirs when necessary; and when this is done the water passes first into it, and then into the sewers. It has three divisions: (1) a central one, into which the water passes before it is discharged into the sewers when the cistern is emptied for cleansing purposes; (2) the second division has a 36-inch supply and delivery pipe for the southern reservoir; and (3) the third division has a 36-inch supply-pipe for the northern reservoir. The water is pumped here from the Green Lanes station, and is used for the supply of the district.

Maiden
Lane
Reservoirs

Gauge-House.—At the south-east corner of the reservoir there is a gauge-house. It is fitted up with a battery, which records at the Green Lanes pumping-station the amount of water in the reservoir. The electric arrangements are managed by the General Post Office. The mechanism of the gauge is briefly as follows: there is a copper float, which is connected with a balance weight by a copper wire, which runs on grooved wheels, so arranged that each alternation of 1 inch in the water-level is recorded.

DISUSED STATIONS.

A brief description may here be given of the disused stations at Cheshunt and Tottenham.

CHESHUNT.—The station at Cheshunt is situated on the right side or upper bank of the New River. There are two large reservoirs here and a well. The only use which is now made of this station is that there is a smithy here. The well has not been used for years. It was found that the level of the water in it was affected by

Cheshunt.

the pumping at the station at Turnford, which is about three-quarters of a mile off. This well has, in fact, been disused since the new well has been sunk at Turnford. It is estimated that 750,000 gallons of water could be obtained daily at Cheshunt. The old machinery which is situated here consists of a single cylinder beam engine with gear-working bell-cranks. There are two large reservoirs. When these were made the idea was to store water in them, obtaining some, if necessary, from the New River, and some from the well. The water which comes into these reservoirs at the present time is derived from the surface drainage of the country around. This water is not now, and has not been for many years, used by the New River Company as a source of supply. The surplus water from the reservoirs passes under the New River in a conduit made for that purpose, and passes down into the River Lee.

Tottenham.

TOTTENHAM.—There is a disused pumping-station in Ferry Lane, Tottenham. It was formerly used for pumping water from the River Lee into the New River at a point near the Seven Sisters Road. This, however, has not been done for more than thirty years.

Pumping Arrangements.—There is a Cornish pumping engine which was worked by steam generated by three Cornish boilers. The engine is bright and clean ; the boiler fittings have been removed. A workshop and caretaker's cottage are situated here. Near the pumping-station there were formerly two mills, which belonged to the New River Company. The water was taken from the mill-tail, and the New River Company had a sluice, which was regulated so as to supply the mill-tail with water as it was required, without the necessity of its passing through the mill-race. One of the mills was burnt down many years ago, and the other has been dismantled. The water was formerly taken from the mill-tail through cast-iron gratings, with $\frac{1}{2}$ -inch spaces and $\frac{1}{2}$ -inch bars ; these remain *in situ*.

THE POND WATER (FOR NON-DOMESTIC SUPPLY).

The water which is used for drinking purposes is now entirely obtained by the New River Company from the River Lee and from deep wells, in the manner described in the preceding pages. In addition to these sources of supply the Company have the right of taking water from a number of ponds which are situated at Hampstead and Highgate. The water is not at the present time used for human consumption. The supply from this source forms a separate system, and is distributed partly for watering roads and other municipal purposes, and partly for the supply of the City of London Cattle Market at Camden Town. Cattle, it is said, prefer water derived from ponds to that obtained from wells. Although, as a matter of fact, there is no doubt that cows prefer to get water from a pond to taking well water from a pail, it does not, of course, necessarily follow that they would prefer the

water from the Hampstead and Highgate ponds to that derived from the New River, and, with regard to the supply of the Cattle Market, it may be said that when there is an insufficiency in the amount of the supply from the ponds, the deficiency is made up by filtered water of the same quality as that supplied for drinking purposes to the other part of the New River Company's City district.

The ponds at Hampstead are situated on the heath. Of those at Highgate some are in Lord Mansfield's Park, Kenwood, and some in Parliament Fields. These latter ones and those at Hampstead are well known to the public, but it is doubtful if very many people know that they are used for the supply of the Cattle Market, and that they were till recently the sources of part of the drinking water supplied to Londoners.

At Hampstead Heath there is a disused well which belongs to the Company. It is situated close to the Heath Road, and about 250 yards from Hampstead Heath railway-station. The well-house is an octagonal building, and is known locally by the name of the "pepper-box." It is now used as a turncock's residence. The well has a diameter of about 8 feet, and is bricked to a depth of 60 feet. Below this there are iron cylinders which reach down to the chalk. The water in this well is not now used, and the pumping engine has been removed, but the well in the past has supplied useful information with regard to the sinking of the underground water in the London district, for careful observations as to the height of the water in the well have now been taken for a long series of years. The level of the water on July 18, 1897, was 260 feet 4 inches from the top of the grids, which is about the same as the ground-level, and is the point from which the measurements are always taken.

HAMPSTEAD PONDS (see Fig. 12).—Of the series of eight ponds at Hampstead one has lately ceased to exist. It has been filled up and the land taken over by the London County Council, who have laid out a pleasure garden on its site. This pond, which was called No. 1, was situated between the well and Hampstead Heath railway-station. The ponds which remain are all situated higher up the heath.

Hampstead
Ponds.

Pond No. 2 is close to the well-house ; it has an area of about four acres.* It is supplied by water from the upper ponds, and by surface-water from the heath. The water-level therefore varies greatly according to the rainfall. The amount of variation is about 5 feet. On July 18, 1897, the pond was $4\frac{1}{2}$ feet "below mark," that is to say, below normal high-water mark. No water had been drawn from it for a week before this. There is a pipe guarded by a grating, which has 1-inch spaces, at the back of the well-house, and the water is used for the supply of Camden reservoir. Water comes from a pond No. 3 through a 4-inch iron pipe, and there is an earthenware drain-pipe to conduct the overflow water from Pond No. 3.

Pond No. 3 has an area of about three acres ; it is situated to the north of the

* The areas and levels here given are approximate only.

summarized as follows: Nos. 8 and 7 are kept as full as possible; No. 3 is kept full for the convenience of people who sail model yachts; No. 2 for bathers; Nos. 4, 5, and 6 are kept as full as circumstances permit.

Cistern-house.—At the southern end of Pond No. 1 there is a small house built over a cistern. The cistern is of brick rendered in cement, about 10 feet in diameter and 15 feet in depth; the pipe from the cistern conducts the water at a level of about 6 feet from the top water-level of the pond. The house contains a fireplace and is used for storing rakes and other tools, which are used for keeping the ponds in order. A 16-inch pipe conveys the water from the cistern through a garden, and then along a footpath which leads to Highgate Road; thence it passes to the reservoir at Camden Town, a distance of about one and a half miles. Water from the Hampstead ponds is conducted in a pipe which joins this one at Gordon House Lane, from which point all the pond-water is conducted to Camden Road Square.

Camden
Park Road
Reservoir.

CAMDEN PARK ROAD RESERVOIR (see Y on the Map).—This reservoir is uncovered. It is situated in an open space. The shape of the reservoir is somewhat peculiar; it may roughly be described as more or less triangular with rounded corners. The sides are built with brick set in cement and are nearly vertical, the slope being about 1 in 12. The top of the surrounding wall has a coping of York stone. The depth of the reservoir is 10 feet 6 inches. There is a large octagonal cockpit for regulating the supply. The water all comes from the Hampstead and Highgate ponds, and is not filtered. It is used for the supply of the Metropolitan Cattle Market. The water, however, is only used for the cattle; the buildings at the market are supplied with filtered water by a separate system of pipes. The reservoir is protected by a spiked iron fence, and a caretaker's cottage is situated here.

GENERAL STATISTICS.

General
Statistics.

Length of New Pipes.—The length of new pipes, ranging from 3 inches to 36 inches in diameter, laid by the New River Company during the year 1895, was three miles, in the year 1896 six miles, and in the year 1897 five miles.

New Hydrants.—The increase in the number of fire hydrants in use in the Metropolis is as follows: 1895, public hydrants, 418; private hydrants, 142; total, 560: 1896, public hydrants, 493; private hydrants, 221; total, 714: 1897, public hydrants, 388; private hydrants, 202; total, 590.

Communications with other Companies' Mains.—West Middlesex Waterworks Company (1) at the junction of Tottenham Court Road with Oxford Street, and (2) at the junction of Tottenham Court Road with Euston Road. (3) During the year 1898 a new communication was established between the Grand Junction Water Company's and the New River Company's systems by means of a main extending from Oxford

Street to the New River Head, Clerkenwell, with a branch from the West Middlesex Company's mains.

Houses under Constant Supply.—The number of houses under constant supply on December 31, 1894, was 100,668; on December 31, 1895, 109,110; on December 31, 1896, 126,409; and on December 31, 1897, 140,132.

Percentage of Houses under Constant Supply.—On December 31, 1896, the percentage of houses under constant supply was 78; and on December 31, 1897, it was 86.

Average Daily Supply per Head.—The average daily supply per head during the year 1896 was 30·6 gallons, and during the year 1897 it was 30·6 gallons.

Highest Supply.—The highest supply given is from the standpipe of the reservoir at Hampstead Heath, which standpipe is 486 feet above ordnance datum.

Dates of Maximum and Minimum Supply.—The following table gives the date of the maximum and minimum supplies and the average daily quantity supplied :

YEAR 1896.			YEAR 1897.	
	Month.	Quantity in Gallons.	Month.	Quantity in Gallons.
Maximum	July	43,127,000	July	42,006,000 daily average.
Minimum	December	32,241,000	February	32,400,000 „ „

TABLE OF STATISTICAL DETAILS COMPILED FROM INFORMATION GIVEN BY THE
NEW RIVER COMPANY FOR JUNE, 1897.

SUPPLY.	Average daily supply in gallons (filtered)				34,646,498 gallons.
	Percentage delivered for other than domestic purposes, exclusive of waste				3,349,502 „
	Total				37,996,000 „
	Number of houses supplied ...				162,169
	Number of houses on constant supply				129,017
RESERVOIRS. Subsiding and storage unfil- tered water. Storage filtered water reservoirs)	Estimated population supplied ...				1,176,000
	Number				20
	Area in acres				99½
	Available capacity in gallons ...				168,100,000
	Number				11
Storage filtered water reservoirs)	Capacity in gallons				37,540,000

TABLE OF STATISTICAL DETAILS—(continued).

ENGINES.	{	Number	44
		Horse-power	3,910
		Greatest lift	590
		Head of pressure in the district supplied	Greatest, 260; least, 40.
WATER-PIPES.	{	Total number of miles of water-pipes	Constantly charged, 649; others, 192; total, 841.
		Number of miles of water-pipes in the metropolis	Constantly charged, 592; others, 189; total, 781.
		Number of miles of streets with water-pipes constantly charged in the metropolis	389
		Number of hydrants erected within the metropolis	Public fire, 6,517; street watering, 618; private fire, 4,296; total, 11,431; and about 12,500 fire-plugs and wash-outs.
FILTERS.	{	Number of beds	20
		Area in acres	16½
		Depth of sand and other materials	5 feet 7 inches.
Sources and amount of the water filtered and pumped.	{	Springs and wells... ..	13,359,635 gallons.
		River Lee	21,286,863 „
		Total	34,646,498 „
Sources and amount of water delivered unfiltered.	{	Ponds	3,904 gallons.
		Springs and wells... ..	2,197,261 „
		River Lee	1,148,337 „

AREA OF SUPPLY.

Area of Supply.

The Act of 1852 authorizes the New River Company to supply the following places, some of which are entirely supplied and some partly supplied :

Supplied.—Barnard's Inn ; Ely Place ; Ely Rents ; Gray's Inn ; Hatton Garden ; Highgate Hamlet ; Holy Trinity ; Minories ; Lincoln's Inn ; Middle Temple ; Rolls Liberty ; Saffron Hill ; St. Andrew, Holborn, above the Bars ; St. Clements Danes ; St. George, Bloomsbury ; St. George the Martyr ; St. Giles-in-the-Fields ; St. James and St. John, Clerkenwell ; St. John the Baptist, Savoy, Strand ; St. Luke, Middlesex ;

St. Mary, Hornsey ; St. Mary, Islington ; St. Mary-le-Strand ; St. Mary, Stoke Newington ; St. Paul, Covent Garden ; St. Sepulchre Without, Middlesex ; Savoy Precincts ; Staple Inn ; Thavies Inn.

Partly Supplied.—Christchurch, Spitalfields ; City of London ; St. Anne's, Soho ; St. Botolph, Aldgate Without ; St. James, Westminster ; St. John, Hackney ; St. John, Hampstead ; St. Catherine Precincts (Docks) ; St. Leonard, Shoreditch ; St. Martin-in-the-Fields ; St. Mary, Whitechapel ; St. Pancras ; Westminster ; and Norton Folgate.

The Act also authorized the supply of "such other places, if any, in the counties of Hertford and Middlesex out of the Metropolis as the Company now [1852] supply."

The Act of 1854 authorized the supply of the following districts, one of which is entirely supplied, some are partly supplied, some not supplied at all :

Supplied.—Edmonton.

Partly Supplied.—Broxbourne, Cheshunt, Enfield, Great Amwell, Hoddesdon, St. Margaret's, Tottenham, and Wormley.

Not Supplied.—Little Amwell, St. John (without the Borough of Hertford), and Ware.

NEW WORKS IN PROGRESS AND PROJECTED.

Supply from the Thames.—An Act of Parliament was passed in the year 1896 (59 and 60 Vic., cap. ccxli.) to authorize the West Middlesex Waterworks, the Grand Junction Waterworks Company, and the New River Company, to construct new reservoirs at Staines, "and other works for affording an additional supply of water for certain districts north of the Thames." During the last Session of Parliament an Act was passed to authorize the Company to make an aqueduct to convey the Thames water into the district supplied. This Act has just been published.

White Webbs.—A new pumping-station is in course of erection at White Webbs. A well 200 feet in depth has been sunk. Below the London clay a layer of Reading or Bagshot sand was found above the chalk. The well is stated to be capable of supplying 2,000,000 gallons of water daily.

THE CHELSEA WATERWORKS COMPANY.

HISTORY.

History.

THE Chelsea Waterworks Company dates from the reign of George I. In 1722 an Act was passed for better supplying the city and liberties of Westminster and parts adjacent with water. By this Act, commissioners, undertakers, and trustees were appointed for effecting the works necessary for bringing water from the Thames into canals and ponds, from which it was to be raised into convenient reservoirs between Oliver's Mount and Hyde Park. The commissioners and trustees were formed into a corporate body under the title of "The Governor and Company of Chelsea Waterworks." In 1723 George I., by letters patent under the Great Seal, appointed the commissioners and granted a charter to enable the Company to raise the necessary funds for carrying out the work.* In 1726 the Company was authorized to convert two ponds in St. James's Park into reservoirs, and in 1727 to construct a reservoir in Hyde Park. In 1733 the authorized capital of the Company was increased, and the Company was placed under an obligation to keep books of account. By the year 1726 considerable progress had been made in the engineering work, and the canals made from the Thames served to supply reservoirs in St. James's Park, so that Whitehall and parts of Westminster were supplied with water in August, and the engines were of sufficient power to raise the water to the reservoir in Hyde Park. This reservoir was capable of holding 25,000 hogsheads (or 1,350,000 gallons) of water, and the one in St. James's Park held almost as much, so that the Company was "in a condition to serve upwards of 10,000 houses with water at a cheaper rate than the New River Company, or any other company at that time." The advertisement of the Company asserted that, if there were no other water to serve the cities of London and Westminster and parts adjacent, they would be able to supply the whole as soon as their pipes could be laid for that purpose. The severe winter of 1739-1740 caused much trouble, and "a variety of unforeseen obstacles and difficulties occurred." The works were frozen up or destroyed by the severity of that dreadful winter. In 1767 the amount of water raised was 784,000 gallons, and in 1809, 1,456,000 gallons daily. In 1809 an Act was obtained to enable the Company to take water from the Thames near Ranelagh Creek, and to lay pipes in the river-bed for a distance of 240 feet, so that water might be obtained below low-water mark. At this time the water was distributed without purification; at a later date it was allowed to subside in settling reservoirs before distribution.

* See Appendix C.

The first filter-bed in London was constructed in the year 1829, and was designed by Mr. James Simpson, engineer to the Chelsea Company. Mr. Simpson made a variety of experiments with regard to water purification during the years 1825, 1826, and in the following year began to work on a more extensive scale, being desired by the directors of the Chelsea Company to give his whole attention to the subject. It may be interesting to describe the first filter-bed that was made in London. It occupied about an acre, its sides were formed by brickwork, and it was supplied by reservoirs which had an area of about $1\frac{1}{2}$ acres. The water was first pumped into the subsiding reservoirs and passed from them to the filter-bed, the water being allowed to flow through small pipes without disturbing the sediment. By this means, to quote a contemporary account, "the greater part of the extraneous matter being separated by the deposition of its feculence whilst standing in the reservoirs, the water rapidly percolated through the gravel and sand of which the beds are formed. . . . The filter-bed, before being filled with water, had the appearance of several channels parallel to each other, formed by banks which are broad at the bottom and gradually slope on each side to a point at the top." The sides were built of brickwork, and the filtering material was formed of three different strata of gravel and sand laid over brick tunnels; the tunnels were built without mortar. Immediately over the brickwork coarse gravel was laid, above this finer gravel mixed with coarse sand, and on the top fine sand. Each of these layers was 2 feet in thickness, so that the water passed through 6 feet of filtering material. The sand and gravel were washed before they were used. The fine sand used at the top had the advantage of removing the "feculent matter," which was chiefly deposited on its smooth surface, and the accumulated sediment was easily removed by scraping. It was found that the matter deposited discoloured the sand for a depth of about 3 inches, but the greater part of the matter was deposited on the surface, so that when half an inch of the upper layer of sand only was removed, it renovated the efficiency of the filter. It was found that the inclemency of the seasons did not affect the action of the filter, and that when the ice was several inches thick filtration went on uninterruptedly.

About the year 1826 considerable improvements were made in a reservoir which the Company possessed in the Green Park. Mud which had been collecting in it for several years was removed, and the reservoir was deepened. The bottom of the reservoir was lined with hard bricks cemented together, and it was surrounded by a brick wall. At this time also the machinery for regulating the sluices was altered, and a very "ingenious contrivance" invented by Mr. Simpson obviated the necessity of replacing the upright pipe which formerly stood at its western extremity, and which is shown in a characteristic drawing of Rowlandson, now in the print-room at the British Museum. The length of the reservoir was 220 yards, the width 35 yards, and the space occupied with all its appurtenances was about 2 acres. The height above Thames high-water mark was 45 feet. At this time about 25,000 tons of

water were usually stored in the reservoir, although it was capable of holding a larger amount, and the engines pumped up the water every four days. The mains were 10 feet below the surface of the water when the basin was full, and served to supply houses in Westminster and Pimlico.

In 1852 an Act entitled "The Chelsea Waterworks Act of 1852" was passed. It authorized the Company to take water from the Thames at Seething Wells, in the parish of Kingston-on-Thames, and to construct new works in that parish, and allowed the Company to continue to take water from the Chelsea reach of the Thames for a certain time. Filter-beds were constructed at Seething Wells, and mains laid down to conduct the filtered water to service reservoirs on Putney Heath, from whence it was distributed by gravitation, passing across an aqueduct over the Thames at Fulham. These works were completed in 1856. In 1875 an Act was obtained to enable the Company to remove their intake from Seething Wells, which is below the junction of the Mole with the Thames, to West Molesey, and to put up the necessary works there for that purpose. These were completed in the autumn of the year 1877.

PRESENT STATE: GENERAL DESCRIPTION.

Present
State:
General
Description.

The Chelsea Waterworks supply Fulham, Walham Green, Chelsea, Belgravia, Pimlico, and part of Westminster. The district is bounded on the west and on the south by the Thames, and extends along the bank of the river from the Crab Tree public-house to the lower part of Northumberland Avenue; the northern boundary runs along Crown Lane and the Old Brompton Road and Knightsbridge, adjoining the districts supplied by the Grand Junction and West Middlesex Companies, and on the east the district supplied by the New River Company. The intakes are at Walton, West Molesey, and Surbiton. There are subsiding reservoirs at Molesey, and filter-beds at Surbiton. After filtration the water is pumped to reservoirs on Putney Heath; from Putney it passes over the bridge which connects Putney and Fulham, and is distributed by gravitation.

The Intakes.

The Intakes.—The chief intakes are at Walton and West Molesey on the south bank of the Thames. (See Fig. 13, B and A.) The water first passes through a 1-inch grating; the gratings are 6 feet in width and 3 feet in depth. Of these gratings there are fifteen, and they are placed three deep. The gratings keep out the coarser impurities; for example, leaves, small pieces of wood, etc. They are cleansed from the river-side from a boat. From the intake two 36-inch pipes pass under the towing-path into the Company's grounds, which adjoin the towing-path. The pipes are controlled by two regulation cocks. The water first passes into a well through five bays. The bays are 6 feet on inside measurement, and are fitted with screens. Some of the screens are of galvanized iron, the newer ones are of copper

wire. The screen used is an unusually fine one, containing twenty-five meshes to the square inch. The frequency with which the screens are cleansed naturally varies according to the state of the river; sometimes it is found necessary to cleanse them twice a day. When the river is in a comparatively pure state it is not thought necessary to clean them more than twice a week, or even less often. Through the screens the water passes into a brick culvert, of which the dimensions are 4 feet 10 inches by 4 feet.

The Molesey intake (Fig. 14, A) has outside screens similar to those which have already been described. The water passes by two 30-inch pipes into a tank 20 feet

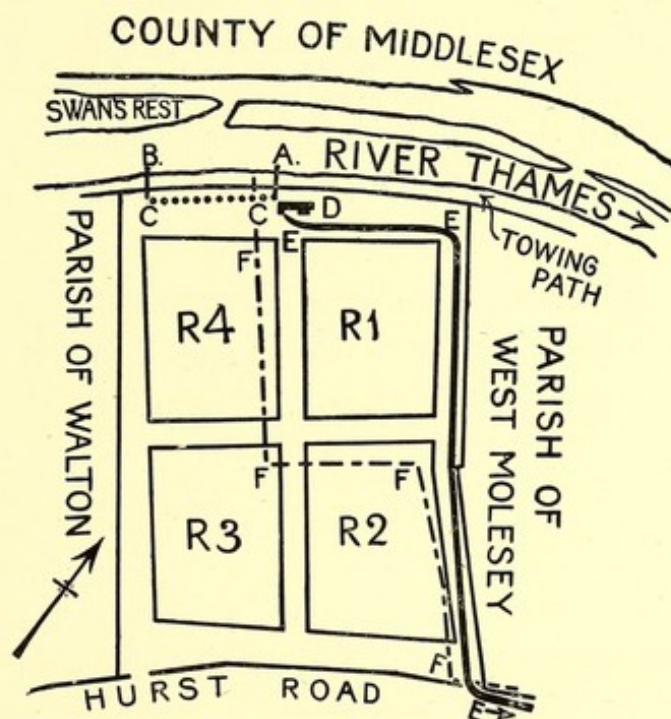


FIG. 14.—WALTON AND MOLESEY STATION.

A, The new intake (West Molesey); B, the old intake (Walton); c c, brick culvert, into which the gravel water flows; D, engine-house; E, E, main which conducts water to Seething Wells (Kingston); F, F, parish boundary; R 1, R 2, R 3, R 4, reservoirs.

in depth through a number of screens 6 feet by 4 feet. The screens are fastened on iron frames which are fixed into grooves. From the tank the water flows into the engine-house.

Water from the Gravel-Bed.—There is a brick culvert extending from the old Water from the Gravel-bed. to the new intake (see Fig. 14, c c). This culvert is used for obtaining a certain amount of water from the gravel. At the sides of the culvert iron valves are arranged. When these valves are raised the water can flow through the stratum of gravel into the culvert. The culvert is 75 feet from the river, and has fifteen valves in it—that is to say, there are fifteen places through which the water can pass into it

from the gravel-bed. The gravel-beds just outside the culvert are in part artificially made ; larger-sized stones were placed in the immediate neighbourhood of the inlets into the culvert. It is found practically that little water can be obtained from this source except during the times when the Thames is at flood. When visited on December 8, 1897, the river was 4 feet above its normal height, and the gravel water was being used, and it was understood that no water was being taken directly from the river, and that the water which was going to Seething Wells was derived entirely from the subsiding reservoirs and from the gravel-beds. The Thames on this day (December 8) was very turbid, but the water derived from the gravel was almost clear.

Engine-House.—The engine-house contains a Worthington engine of 150 horse-power, which can pump 24,000,000 gallons daily into the reservoir. In the same house there are two vertical engines of 50 horse-power each, which work bucket and plunger pumps. The steam is generated by six Cornish boilers and one Lancashire double-flue boiler.

**Subsiding
Reservoirs.**

Subsiding Reservoirs.—The water from the Thames is pumped into four subsiding reservoirs. These are situated between the Thames and the high road (Fig. 14 ; R 1, R 2, R 3, R 4). They are more or less square in form. Each has an area of about ten acres, and is capable of holding 35,000,000 gallons. The water is first pumped into one of the two reservoirs which are next the river ; having remained there for some time, it is allowed to flow into the second, then into the third, and finally into the fourth. It is found that the reservoir into which the water first flows contains a deposit three or four times as great as that found in the fourth reservoir. From Molesey the water flows by gravitation, or is pumped to Kingston. There are two pipes between these stations.

**Seething
Wells,
Kingston.**

SEETHING WELLS, KINGSTON.—The Kingston station contains the filter-beds and the engines which pump the water to Putney (Fig. 15).

Filter-Beds.—There are eight filter-beds, having a total area of seven acres. Each filter is capable of holding about 1,100,000 gallons of water. The rate at which water is usually filtered is $1\frac{3}{4}$ gallons per square foot per hour. The sand is washed by a hose and jet, under a pressure of 200 feet of water.

Engine-House.—The engine-house contains two Simpson's double-action pumps of 150 horse-power, and two bucket and plunger pumps of 150 horse-power. The steam is generated by thirteen Cornish boilers. Another engine-house contains four Simpson's engines of 600 horse-power working bucket and plunger pumps. At one time the intake of the Company was at Kingston ; now all the water is usually taken at West Molesey and Walton, and having passed through the subsiding reservoirs there, goes as described to Kingston. The old inlets by which the water was formerly

taken from the Thames at Kingston remain, and are used in cases of emergency. From Kingston the filtered water is pumped to covered reservoirs on Putney Heath.

PUTNEY HEATH RESERVOIR.—The property at Putney Heath consists of eight acres situated at a height of about 177 feet above ordnance datum. There is a stand-pipe by means of which an additional head of 22 feet of water can be obtained.

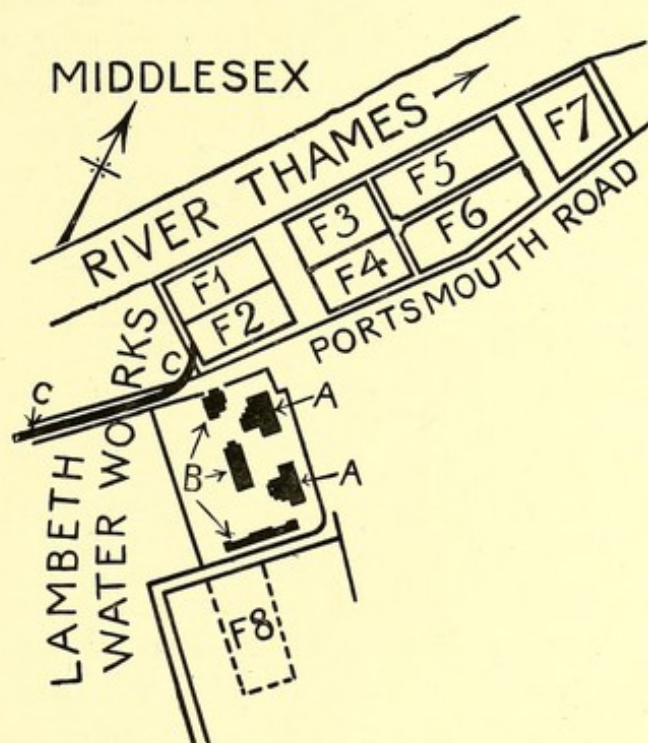


FIG. 15.—SEETHING WELLS, KINGSTON-ON-THAMES.

A, A, Engine-houses; B, office, coalshed, workshop; C, C, main from West Molesey; F1, F2, F3, F4, F5, F6, F7, filter-beds; F8, filter-bed recently completed.

There are three reservoirs, having a total capacity of 11,000,000 gallons. From Putney Heath there are three 24-inch pipes and two 12-inch pipes, which pass through Putney and over the bridge between Putney and Fulham to Chelsea, and distribute the water. The main pipes pass in the direction shown in the plan.

AREA OF SUPPLY.

The Act of 1852 authorizes the Chelsea Company to supply the following places: Area of Supply.
Supplied.—Brompton; Buckingham Palace and the precincts; Close of the Collegiate Church of St. Peter, Westminster; Kensington Palace and precincts; St. James's Palace and precincts; and Scotland Yard.

Partly Supplied.—Chelsea; Fulham; Kensington, St. Mary Abbott; St. George, Hanover Square; St. James, Westminster; St. John the Evangelist, Westminster; St. Margaret, Westminster; St. Martin-in-the-Fields; Whitehall; and Westminster Palace and precincts.

Not Supplied.—Hammersmith; Liberty of the Duchy of Lancaster; St. Mary, Paddington; St. Anne, Soho; St. Clement Danes; St. George, Bloomsbury; St. Giles, Bloomsbury; St. Giles-in-the-Fields; St. John the Baptist, Savoy, Strand; St. Marylebone; St. Mary-le-Strand; St. Paul, Covent Garden; and Savoy precincts.

The following table gives the average daily supply per head and the dates of the maximum and minimum supply per head for the years 1895 and 1896. It will be seen that in both these years the maximum supplies were given during the month of July, but the minimum supply in 1895 occurred in January, and in 1896 in February.

TABLE I.—SHOWING AVERAGE DAILY SUPPLY.

Year.	Average Daily Supply per head.	MAXIMUM.		MINIMUM.	
		Month.	Per head.	Month.	Per head.
1895	43·05 gallons	July	47·96 gallons	January	38·45 gallons
1896	42·90 „	July	51·80 „	February	38·70 „

Length of Pipes.—The length of the Company's mains in December, 1896, was 245·91 miles. In September, 1898, the number was 253·25.

Number of Hydrants.—The number of hydrants erected during the year 1895 was 333; during the year 1896, 322; and the total number on December 31, 1896, was 1,386. In September, 1898, the total number was 1,806.

Communication with other Companies' Mains.—There is a communication with the main of the Grand Junction Company, near St. George's Hospital, Hyde Park Corner.

Houses under Constant Supply.—The number of houses under constant supply on December 31, 1894, was 23,314; on December 31, 1895, 27,104; on December 31, 1896, 30,787; and on September 31, 1898, 38,085.

Total Number of Houses Supplied.—The total number of houses supplied by this Company on December 31, 1894, was 36,941; on December 31, 1895, 36,941; on December 31, 1896, 37,362; and on September 31, 1898, 38,085.

Percentage of Houses under Constant Supply.—On December 31, 1895, the percentage of houses under constant supply was 73·00; on December 31, 1896, 82·00; and at the present time 100.

NEW WORKS IN PROGRESS AND PROJECTED.

New Works
in Progress
and Pro-
jected.

Reservoirs.—At Molesey the banks of the reservoirs are being raised, and their storage capacity will be increased to the extent of 50,000,000 gallons. At Putney work is in progress to increase the storage capacity of the filtered water reservoirs.

THE EAST LONDON WATERWORKS COMPANY.

HISTORY.

THE east end of London was for a long time very inadequately supplied with water. The earliest supplies were given by the New River Company, the Shadwell Company, and the West Ham Company, but the supply was so inadequate that many persons were obliged to get water "by any casual means or circumstances placed within their power."

The Shadwell works were originated by Thomas Neale, who hired land for the purpose from the Dean of St. Paul's. A four-horse engine was at first used to pump the water, but in the year 1679 the works were enlarged, and a second four-horse engine was added to that already in use. In the year 1687 Mr. Neale obtained a charter for carrying on his business, and formed a Company in which there were thirty-six shares, some of which he was able to sell at a good price. In the year 1691 the shareholders became a body corporate by letters patent. For a long time horses only were used for pumping the water. It was not until the year 1750 that a steam-engine was put up. This engine was found to be incapable of doing the work which was necessary, but no further improvement was made until the year 1774, when one of Boulton and Watt's engines was erected. This engine was capable of raising 54,000 gallons of water an hour, and was found not only to save expense in working, but to increase very much the power of the Company to supply water. The districts supplied by the Company included the space from the Tower of London on the west to Limehouse on the east, and from Whitechapel on the north to the River Thames on the south.

A water business was started in 1745 to supply the lower part of Whitechapel, Stepney, Bethnal Green, and the villages of Bow, Stratford, and Bromley. The water was pumped by a steam-engine and by a water-wheel, and there was a reservoir at Mile End. This property was divided into four shares, and the works and those at Shadwell were bought by the London Dock Company in the year 1807.

The East London Waterworks Company was established in 1808, and purchased the Shadwell and West Ham works. The Company chose Old Ford as the best place for a pumping-station, and thirty acres on the banks of the Lee were bought. Four reservoirs, having a total area of eleven acres, were constructed. The two largest were situated on the east side of the Lee. The bottom of these reservoirs was made at the level of the bed of the river, and their depth was 10 feet. The smaller

reservoirs were 15 feet 6 inches in depth, and were situated on the west side of the river. The level of the bottoms of these was 5 feet 6 inches lower than that of the others, and was 15 feet below the surface of the water at half-tide, and their surface level was between that of the spring and neap-tides. The water from the Lee passed into the reservoirs through six openings, which had a total width of 42 feet, but differed in depth. Two of them were 4 feet 6 inches, three others were 4 feet, and one was 3 feet 6 inches. During the spring-tides the water ran into the reservoirs for about four hours each tide. During the neap-tides the water flowed in for about two hours. The reservoirs had sufficient storage capacity for a week's supply. It was usual to allow the water to remain two or three days in the reservoirs before it was used, so that it might "deposit its feculence and become clear." The reservoirs were arranged in such a way that the water from any one of them could be drawn off separately. The mud which accumulated at the bed of the reservoirs was removed from time to time. When this was done, as much water as possible was allowed to flow out at the time of the lowest neap-tides. The water which still remained in the reservoir—a depth of about 18 inches—was pumped out by the engines. An aqueduct which passed under the Lee connected the reservoirs. The Company had another reservoir at Mile End, near the Regent's Canal Bridge. This was situated 60 feet above the level of the River Lee, and was capable of holding sufficient water to supply 6,000 houses. The station at Old Ford was a little over three miles from the Thames. The Act of Incorporation of the Company provided that the whole supply of water should come from the Lee when the water flowed up during the tides and the mills were not working. It happened that, as the sluices belonging to the mills on the Lee were not always opened to the same extent, the time at which the water reached the reservoirs varied; but, as a rule, it was found that the time of high tide at Old Ford was an hour later than it was at the point of junction of the Lee and the Thames. It was stated also that the level of the surface of the Thames was 13 feet lower than that of the Lee. At the mouth of the Lee the rise of the tide was 18 feet; at the waterworks it was only 5 feet. From these observations it was concluded that the water of the Lee was pent back during the rise of the tide in the Thames, and that as four hours elapsed before water flowed into the reservoirs it was the water which had collected in the Lee between the Thames and the reservoirs which passed the inlet to the reservoirs and filled them. The rate of the flow of the Lee towards the Thames was about two miles an hour, but the water returned at a rate of about one mile an hour, and the ebb tide opposite the works lasted about three hours. It was therefore concluded that only the Lee water was taken into the reservoirs, and that the water taken by the Company contained no Thames water. In the year 1829 the Company obtained an Act to enable them to make a canal to convey water from a place near the Lee Bridge Mills, and to construct a reservoir for receiving it near their works. In 1835 there were two engines of 40 horse-power,

another of 70, and two others of 90 horse-power, which could be worked against a head of 108 feet. A water-wheel at Stratford was also used. The wheel worked generally for about twelve hours a day, and occasionally for a longer time. There was at this time an engine at Shadwell which pumped water from the Thames. The number of customers of the Company was about 45,000, and the district extended from Old Ford to Lower Clapton. From thence the boundary ran to Sun Street, Bishopsgate Street, Mansell Street, and Goodman's Fields, and southwards to the Thames at a point between the London and St. Katherine's Docks. The water was distributed through between 200 and 300 miles of pipes, varying in size from 36 inches to 6 inches in diameter. The area supplied extended to a distance of three miles from the central works, and the engines worked against a head of 120 feet of water. At this time the height of the water-service varied from 6 feet or 8 feet above the level of the Company's works. Some houses, however, were served as high as 30 feet, but the Secretary of the Company urged that as they neither professed to give high service nor made any charge for it, the difference in the height could not be reasonably a source of dissatisfaction to the tenants. The amount of water supplied daily at this period was 170,000 gallons. In the year 1828 the quantity of water pumped daily by the East London Company was 6,512,292 gallons. At this time the engines were able to pump over 8,000,000 gallons, and a new engine was being put up to increase the pumping capacity by over 3,000,000 gallons. The number of houses supplied was about 42,000. In the year 1815 the Company made an arrangement with the New River Company by which each withdrew from a part of its area of supply, and each Company authorized the other to resume its freedom of action in case of neglect or refusal on the part of the other to carry on the business there. By this arrangement no exclusive right was retained. At this time the London Bridge and the Lee Bridge Waterworks were still in the field. In 1820 the Company bought the Hackney Waterworks and Lee Bridge Mills, and obtained an Act of Parliament to enable them to remove their intake from Old Ford to Lee Bridge, from which point the water was brought down by a conduit and stored at the reservoir at Old Ford, and pumped thence for the supply of the district. In 1852 an Act was obtained to allow the Company to make a new cut in connection with the Lee for the purpose of improving the quality of the water, to construct reservoirs at Walthamstow, filter-beds at Lee Bridge, and to make an intercepting cut on the west side of the Lee from Tottenham to a point below Ponders End to prevent polluted water from entering the river near their intake. In 1867 an Act was obtained to allow the Company to make a covered reservoir at Finsbury Park, and to make works at Sunbury for the supply of Thames water. By this Act the Company were allowed to take a quantity not exceeding 10,000,000 gallons of water daily from the Thames. In 1867 another Act was passed to allow the Company to increase the number of reservoirs at Walthamstow and filter-beds at Lee Bridge, and they were

compelled to discontinue the use of, and to fill up, the reservoirs at Old Ford, and to leave off using the open canal which connected the reservoirs with the works at Lee Bridge. This alteration immediately followed the cholera visitation of 1866—a visitation of which the geographical limits were very much those of the area supplied from the reservoir at Old Ford.* In the year 1886 an Act was passed which, among other things, authorized the Company to sink wells and to make works with the object of intercepting sewage, and preventing it from getting into the river above their intake. In the year 1892 the works at Old Ford were finally given up.

Two new reservoirs have just been completed, and new wells are being sunk.

PRESENT STATE.—GENERAL CONDITION.

Present
State :
General
Condition.

The East London Waterworks Company supplies Shoreditch, Haggerston, Stepney, Limehouse, the Isle of Dogs, Bow, Bromley, Homerton, Stratford, East and West Ham, the Victoria and Albert Docks, Leytonstone, Wanstead, Woodford, Buckhurst Hill, High Beach, Waltham Abbey, Chingford, and Walthamstow. The area of supply is situated immediately to the east of that of the New River Company. The sources of supply are : (1) The Thames near Sunbury ; (2) gravel-beds in the parish of Sunbury ; (3) the River Lee ; and (4) deep wells at Waltham Abbey, Chingford, Walthamstow, and Lee Bridge. The stations of the Company indicated on the map are A, Sunbury (intake and pumping-station) ; B, Hanworth (reservoirs, filter-beds, pumping-station, and arrangements for collecting water from the gravel) ; C, Hornsey Wood (reservoir) ; D, Waltham Abbey (well and pumping-station) ; E, Chingford (well and pumping-station) ; H, High Beach (reservoir) ; I, Buckhurst Hill (reservoir) ; J, Hagger Lane (reservoir) ; K, Walthamstow (reservoir, well, and pumping-station) ; and L, Lee Bridge (well, pumping-station, and filter-beds). There are also three wells under construction. Of these stations two are situated in the Valley of the Thames, far away from the others. The remaining stations are situated in the Valley of the Lee, in the district supplied by the Company. The Thames stations are Sunbury and Hanworth.

Sunbury.

SUNBURY (see A on Map).—The station at Sunbury consists of an intake from the Thames and pumping machinery to force the water to the station at Hanworth. The intake from the Thames is situated on Wheatley's Eyot. This island is in the parish of Walton-on-Thames, in the county of Surrey, but is situated much nearer to the Middlesex bank of the river than to the Surrey bank. The stream which divides it from the Middlesex bank is only 21 yards across, and the great bulk of the water

* The area of intense cholera of 1866, according to Sir John Simon, "was almost exactly the area of this particular water-supply, nearly, if not absolutely, filling it, and scarcely, if at all, passing beyond it."

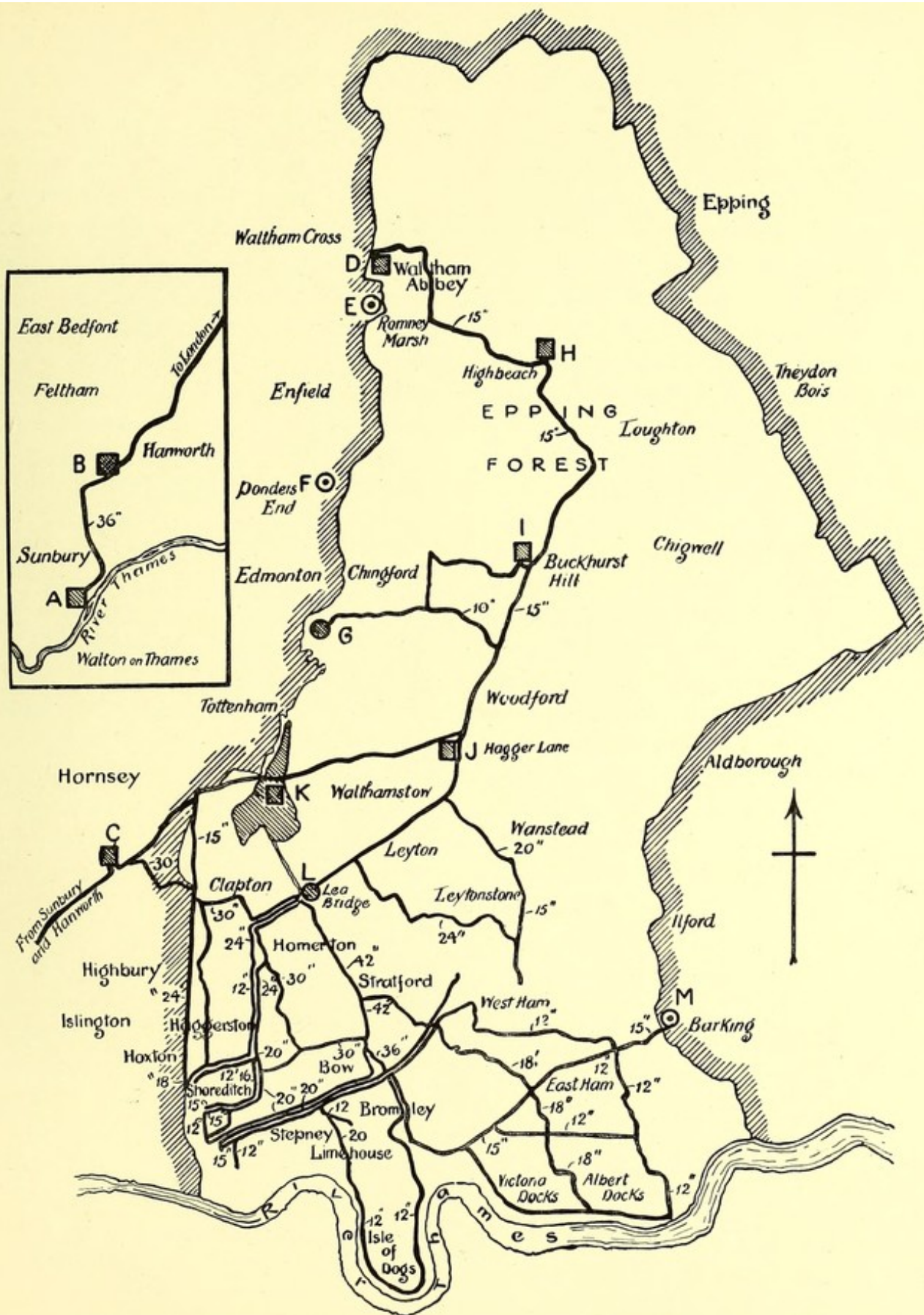


FIG. 16.—THE EAST LONDON WATERWORKS COMPANY'S WORKS.

The shaded outline with the northern bank of the river defines the area supplied by the Company. Wells are marked as shaded circles, reservoirs are marked as shaded squares. The dark lines show the course of the principal mains, the diameters being marked in inches. A, Sunbury intake and pumping-station; B, Hanworth reservoirs, filter-beds, pumping-stations, and arrangements for collecting water from the gravel; C, Hornsey Wood reservoir; D, Waltham Abbey well and pumping-station; G, Chingford well and pumping-station; H, High Beach reservoir; I, Buckhurst Hill reservoir; J, Hagger Lane reservoir; K, Walthamstow reservoir, well, and pumping-station; L, Lee Bridge well, pumping-station, and filter-beds; E, F, and M, three wells under construction.

of the Thames passes between the island and the Surrey side. The height of the water at the point of intake is 28 feet above Ordnance datum. The East London is the only Metropolitan company which takes water from the Thames above Sunbury lock. The intake is 20 feet in width and 10 feet in depth. It is guarded by a grating formed of iron bars, $1\frac{1}{4}$ inches square, placed anglewise. The spaces between the bars are about $\frac{3}{4}$ of an inch in width. These bars form the only screen through which the water passes; there is no wire netting at the intake. From the point at which the water is taken from the Thames three brick culverts pass to the backwater which divides the island from the mainland. The water is conducted under the backwater by three 48-inch iron mains to the mainland. From the bank the water is conducted through three brick culverts into an oval well 18 feet in length and 12 feet in width. From the well two egg-shaped culverts pass to the engine wells.

Engine-House.—The engine-house is built of brick. The water is pumped by two single-acting Bull engines with 54-inch cylinders, which work plunger-pumps, of which the diameters are 45 inches and the stroke 9 feet. Steam is generated by four Cornish boilers, which work at a pressure of 40 pounds. The water is pumped to the reservoir at Hanworth, a distance of about 2 miles, through a 36-inch main, which passes along the high-road. At this station there is a stand-pipe 40 feet in height. When the works were first started here the water was pumped to a cistern 12 feet in diameter and 20 feet in depth, which was placed in a water tower, and from this cistern the water flowed by gravitation to the reservoir at Hanworth. The present arrangement is that the water is pumped direct to Hanworth, and a stand-pipe is used to equalize the pressure, acting as an air-valve.

A cottage for a caretaker is situated at this station.

HANWORTH (see B on Map, and Fig. 17).—The station at Hanworth is situated in the parish of Sunbury, on the borders of the parish of Hanworth. It is called the Hanworth Station to distinguish it from the one on the banks of the river at Sunbury. The station at Hanworth consists of a reservoir, filter-beds, pumping arrangements, and a system of underground works used for collecting water from the sand.

Reservoirs (see Fig. 17, R).—The reservoir is 775 feet in length and 116 feet in width. The bottom and sides of the reservoir are cemented and the sides lined with brick. The sides are not vertical, but slope slightly (1 to 4). The reservoir has an available capacity of 5,000,000 gallons. It is supplied from Sunbury with unfiltered Thames water, and the water passes from it to the filter-beds.

Filter-Beds (see Fig. 17, F 1 to F 6).—There are six filter-beds, which have a total area of five acres. The sides are built of concrete and faced with brick. The composition of the filter-beds is as follows: At the bottom a layer of 12 inches of large stones is placed, next a layer of 6 inches of hoggin—that is to say, small stones

because, as far as we know, the arrangement here adopted does not exist elsewhere; it was first carried out here, and was invented by the engineer of the East London Waterworks Company. It will be necessary for the sake of clearness to briefly describe the conditions of the ground here met with in order to explain how it is that the arrangements made are the best that could have been adopted. The story of the origin of the works is briefly as follows: When excavations were made at this station it was found that under 3 feet of alluvial soil there was a layer of gravel about 18 feet in thickness. The lower part of this gravel was full of water, which, indeed, gave a good deal of trouble when the original works were being carried out here. It seemed to the engineer of the Company that it would be worth while to find out whether this water was of good quality for drinking. It proved to be of good quality, and it was therefore determined to collect it. The fact that the lower layers of gravel were filled with water would have caused a good deal of trouble in laying pipes in the ordinary way, because it would, of course, have been necessary to keep the water pumped whilst the excavations were in progress. The impervious nature of the underlying London clay suggested the advisability of making use of this quality by making a culvert in it for the purpose of conducting the water from the overlying gravel to a central well. In order to carry out this idea the method adopted was as follows: A number of hollow iron piles with perforations in the sides were driven from the surface of the ground right down into the London clay, so that only about 2 feet or so of the pile remained projecting above the ground, and a length of 38 feet was under the ground. A number of these piles were driven in at regular intervals in straight lines in the direction of a well which had been already sunk (see Fig. 17, *p, p, p*). The well was then pumped dry, and a culvert was dug in the London clay in the line of the piles, so that the lower part of the piles projected into the culvert (see Fig. 17, *c, c, c*). The condition of things which obtained then was that from the surface of the ground to the culvert hollow iron piles passed, and the lower parts of the piles which projected into the culvert were filled with London clay, which they had met with as they were driven down into the culvert—that is to say, the lower part of each pipe was plugged with a layer of London clay. When this clay was removed from below, the water flowed from the saturated layer of gravel down into the culvert. The culvert led to a well in an engine-house (see Fig. 17, *e*), from which it was afterwards pumped to the covered reservoir (Fig. 17, *c R*). By an arrangement of valves the water contained in each pile can be prevented from passing into the culvert below, and then after the water has been pumped out from the culvert its whole length can be explored. The perforated iron piles which collect the water from the gravel and conduct it to the culvert, which is situated in the clay beneath, were constructed for the purpose which they subserve. The arrangements are simple, ingenious, and carry out perfectly the intention for which they were made. There are altogether about twenty of these iron piles.

Small Engine-House (see Fig. 17, *e*).—Another engine-house contains two compound surface-condensing centrifugal engines of about 20 horse-power each. These are used for pumping the gravel water into the reservoir.

Covered Reservoir (see Fig. 17, *c R*).—There is a reservoir covered with brick arches and capable of holding 2,500,000 gallons. Into this reservoir the filtered water gravitates, and the water from the gravel beds is pumped, and from it the water is pumped to Finsbury Park.

Engine-House (see Fig. 17, *E*).—The water from the covered reservoir is pumped by three Cornish beam engines, having cylinders 84 inches in diameter and a stroke of 11 feet, working plunger-pumps 36 inches in diameter, and having a stroke of 9 feet. The steam is generated by ten Cornish boilers, working at a pressure of 40 pounds. These engines pump filtered water and water from the gravel to the reservoir in Finsbury Park, a distance of about 19 miles. The main through which the water passes is 36 inches in diameter.

Water from
the Lee.

WATER FROM THE LEE.—The greater part of the water supplied by the East London Waterworks Company is taken from the River Lee. The rights which the Company possess of taking water from the Lee are somewhat peculiar. The Lee Conservancy Board is empowered to use as much of the River Lee water as is necessary for filling the locks for the use of the barges which pass up and down the Lee Conservancy stream, and the New River Company and the East London Waterworks Company are allowed to take the whole of the water which is in excess of that used for purposes of navigation.

From a very early period the Lee has suffered very much from pollution by sewage and surface drainage. In the year 1852 an Act was passed to enable the East London Waterworks Company to make an artificial cut to intercept some of the sewage, which up to that time had contaminated the river near the intake of the Company. This intercepting drain will be first described, and then an account will be given of the sources of the water which is taken at Chingford for the supply of the reservoirs of the Company.

Ponders End
Intercepting
Drain
(Fig. 18).

The Ponders End Intercepting Drain.—The accompanying map shows the course of the drain, which is marked by a dotted line. The map is drawn to scale, except that the two sewage farms are diagrammatically represented. The drain passes from Ponders End through the valley to a point in the Lee Navigation Canal which is just below the Tottenham lock, a distance of about 4 miles. It was provided by an Act of Parliament that the East London Waterworks Company should be at the expense of keeping up this intercepting canal. At the present time the East London Waterworks Company differs from other Metropolitan water companies in the fact that the Company has at its own expense to keep up an intercepting drain made to prevent the pollution of the water which is taken by the Company. And

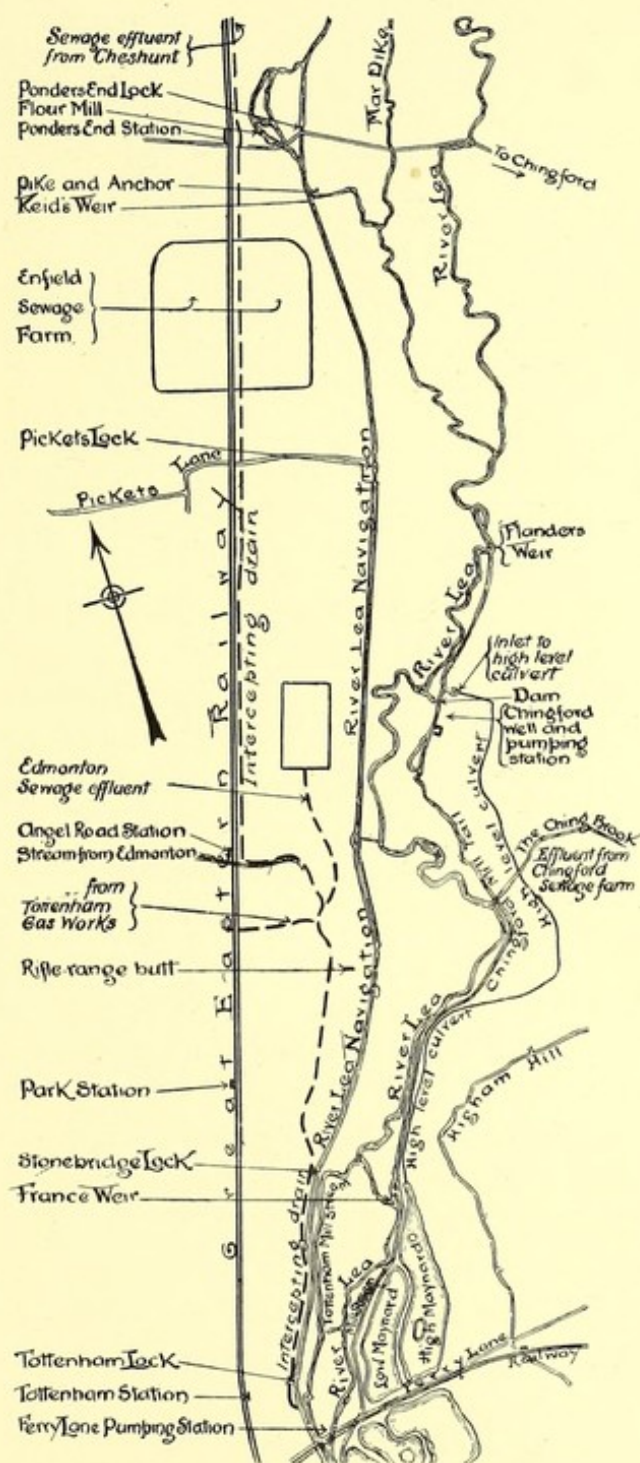


FIG. 18.—THE EAST LONDON WATERWORKS COMPANY'S INTAKES FROM THE LEE.

The map shows the course of the River Lee from Ponders End to Ferry Lane, the intakes of the East London Water Company at Chingford, the course of the aqueducts which convey the water to the reservoirs of the Company, and the intercepting drain which receives various sewage effluents and prevents them from contaminating the Lee above the intake of the Company. The map is drawn to scale, with the exception of the Enfield and Edmonton sewage farms.

this drain forms part of the property of the Company. The cut begins at a point within a few yards of the Ponders End railway-station on the Great Eastern Railway line. The intercepting drain first receives the effluent of the sewage farm of the Cheshunt Urban District Council, and it receives near this point some drains which carry surface-water down. The amount of water passing down varies very much. After a very heavy rain it is estimated that as much as 4,000,000 gallons a day may be conveyed. When visited on May 6, 1897, about mid-day, the amount at the commencement of the cut was very small, and consisted entirely of the sewage effluent from the Cheshunt district sewage farm, and the flow was roughly estimated as being at the rate of about 750,000 gallons a day. The amount, however, which passes from the sewage effluent of course varies at different times in the day. On May 6 this sewage effluent was very foul. It contained a great quantity of solid matter in suspension. Just before the stuff flows into the ditch there is an arrangement put up by the Cheshunt urban authorities by which the effluent passes through four wire gratings, which remove a good deal of the solid matter. A man is employed to constantly remove the débris and cleanse the gratings. A considerable amount of solid matter is, however, allowed to pass through into the ditch. The intercepting drain passes in a southerly course near the Great Eastern Railway line for a distance of about half a mile, when it receives the effluent of the sewage farm of the Enfield sanitary authority. On May 6, 1897, this effluent was turbid and extremely foul. The ditch continues in a southerly course, close to the Great Eastern Railway, and passes under a public road called Picket's Lane close to the signal-box of that name on the railway. The smell at Picket's Lane was, on May 6, 1897, very offensive. At this point, and at several others in the course of the ditch, it receives surface-water drains which bring the flood water from the higher ground on the west side of the line. At Angel Road the drain passes under the public high-road, and takes a turn to the east. At this point it receives a stream called Pymme's Brook from Edmonton. Having gone in an easterly direction for about 200 yards, the drain takes a southerly course. About half a mile further the ditch receives the sewage effluent of the Edmonton sewage farm, the position of which is diagrammatically given in the map. This effluent on May 6, 1897, contained extremely foul-smelling, dark-coloured stuff. The point at which the effluent reaches the drain is nearly a mile from the sewage farm, but in spite of the fact that this effluent had been flowing for that distance through an open ditch it was still extremely foul, although it must have deposited a considerable amount of its feculence in its passage through so long a course. A little further on there is an open ditch which flows in from the direction of the Tottenham and Edmonton Gasworks. A little south of this point the drain passes close to the Stone Bridge Lock; and about 200 yards south of this point it receives a stream named Carbuncle Ditch which flows from Tottenham. The ditch continues its course just to the west of the River Lee Navigation Canal, passes under the road

Ponder's
End
Intercepting
Drain.

Ponder's
End
Intercepting
Drain.

close to Tottenham Lock, and is conducted through four stone arches for a distance of about 120 yards, when it discharges itself into the Lee Navigation Canal just below the Tottenham Lock. The ditch from the beginning to the end is a foul open sewer. The East London Waterworks Company have no direct authority over the sanitary authorities who discharge their sewage effluents into the stream. The control of this matter is in the hands of the Lee Conservancy Board. The duty of the East London Waterworks Company is to keep the ditch clear. The work that is actually done is that in the spring or early summer, and again in the autumn, about six men are employed to clear out the course of the stream "from below upwards," if it be permissible to employ in this connection an expression rendered classical by the late Mr. Gray, the anatomist. The work takes about five or six weeks, and the way in which the grass grows on the banks of the ditch bears witness to the high manurial value of the matter removed from the drain.

Chingford
Intake.

Course of the Water to the Chingford Intake.—The water which is taken at Chingford by the East London Waterworks Company comes by more than one channel. This will be seen by a glance at the map. From Chingford to Ponders End the road crosses the River Lee, Mar Dyke, the River Lee Navigation Canal, and Ponders End Mill tail. Water from all these sources passes to the intake at Chingford. Some water comes down the River Lee Navigation Canal Cut from Ponders End Lock and some by the flour mills which are situated at Ponders End, and the water passes just to the west of a public-house called the Pike and Anchor. Here on the east side of the Lee Navigation Cut there is a sluice (Keid's Weir). From this point to the reservoirs the East London Waterworks Company takes charge of the bed of the stream. A short distance from Keid's Weir the stream is joined by the stream or ditch called Mar Dyke; it then proceeds in a southerly direction for about a mile, when it is joined by the River Lee, which here runs in its ancient course from a point not far from Waltham Abbey. Roughly speaking, half the water comes down this old course of the River Lee and Mar Dyke, and half from the Lee Navigation Cut near the Pike and Anchor. Over the River Lee, down which about half the water comes, the East London Waterworks Company have no authority. From the point of junction of the Lee and the cut from the Pike and Anchor, the stream flows in a more or less southerly direction to Chingford Mill. In the latter part of its course, below Flander's Weir, the water is conveyed through an artificial cut, and the surplus water, if there be any, and the rest flows over the weir into the natural course of the old River Lee. The weir is kept up by the Lee Valley Drainage Commissioners. During the flood-time a considerable amount of water flows over at this point. During the summer the whole of the water is taken by the East London Waterworks Company. The water is conveyed to the station at Chingford, from whence it proceeds in two separate channels, a high-level culvert which supplies the high-level reservoirs, and an open stream

which was formerly the mill-tail of the Chingford Mill. These aqueducts must be separately described.

CHINGFORD (see G on Map).—At Chingford there is a deep well; the upper part of it is lined with brick, and the lower part with 10-foot iron cylinders. The depth of the well is 200 feet. At the bottom of the well there is a heading which passes in a northerly and southerly direction for a distance of about 200 feet. From this well water is pumped (1) to the low-level aqueduct, by which it is conveyed to Walthamstow; (2) to Buckhurst Hill reservoir. Buckhurst Hill is entirely supplied from this well. There is a second well 60 feet in depth. This is lined with iron cylinders for about 15 feet, and the lower part with brick. It is from the bottom of this that the bore-hole goes down to a depth of 451 feet from the surface. The width of the bore-hole is 2 feet. From this well water is pumped by turbines; it all goes to Buckhurst Hill.

Chingford
Well and
Pumping-
Station.

Engine-House.—There is a quadruple expansion engine which has cylinders with the respective diameters of 12 inches, 17 inches, 24 inches, and 30 inches. The stroke is 2 feet 6 inches. The engine works two cranks, which are keeled at right angles to each other. It works two pumps, of which the buckets are 21 inches in diameter. The disc to which the bell cranks are fixed is so arranged that the crank can be put in any one of three positions. The stroke is thus regulated. During the week ending May 1, 1897, an average amount of half a million of gallons daily was pumped. The steam for working the engines is generated by two Lancashire boilers, which are provided with a feeding conveyer and automatic stoker. This is worked by a small engine.

Turbines.—The turbines are situated in a house close to the stream, and the fall which was formerly used for the Chingford Corn Mills works them. These turbines pump water from the well last described to Buckhurst Hill. They pump also water which is raised from the other well by the steam-engine which has been described. The engine-house is a well-lighted structure, and possesses a tower fitted with a sliding roof. This arrangement makes it possible to remove the well-rods without trouble. There are two cottages here. This station is in telegraphic communication with Walthamstow and with Lee Bridge.

Conveyance of Water from Chingford to Walthamstow.—The high-level culvert derives its water from the east side of the artificial cut, which was formerly the mill-head of Chingford Mill. The low-level aqueduct was formerly the Chingford Mill-tail; it is an open stream throughout the whole of its course. The water which flows down it is always principally, and often entirely, supplied from the Lee, but occasionally some water is pumped into it from the well at Chingford. It supplies the low-level reservoirs at Walthamstow.

Aqueducts
from Ching-
ford to
Waltham-
stow.

The High-level Aqueduct.—The water taken by the high-level reservoirs comes from the east bank of the canal. There is here a floating boom to keep back the

High-level
Aqueduct.

weeds. The water flows into a circular bay, from which it passes through two sluices into an oval pool, which is about 160 feet in length and 80 feet in breadth. The sides of the pool are concreted, and the upper part is lined with blue Staffordshire bricks. On the east side are the openings of two D-shaped culverts (see Fig. 19). The water passes into the culverts through iron gratings which have bars about $\frac{3}{8}$ -inch in thickness and $1\frac{3}{4}$ -inch spaces. The culverts are built of brick, and rest on a foundation of concrete. The distance from Chingford to the reservoirs at Walthamstow is about two miles, and there is an available fall of 2 feet when the receiving reservoir is full. In the whole of its course the culvert is below the level of the ground, but there are a number of brick shafts which rise above the surface of the ground, and which are connected below with the culvert. These shafts are about eight in number, and are situated at pretty regular intervals. With the exception of one all the shafts are covered at the top either with paving-stones or with iron traps. The shafts facilitate the examination of the culverts, and would be of use in case it became stopped up, or in any way defective. From the intake the water passes at first in a south-easterly direction under the high-road; it then goes in a southerly

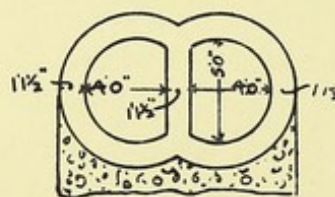


FIG. 19.—THE DIAGRAM SHOWS A SECTION OF THE HIGH LEVEL CULVERTS. THESE ARE BUILT OF BRICK AND BEDDED IN CONCRETE.

direction across a meadow to the west of the road, and later again goes under the road at a place called Folly Lane. For the latter half of its course the culvert passes on the property of the Company, except where it crosses a public footpath near Higham Ferry. The part which runs in private ground is fenced in, and for the last half mile or so the culvert runs close to the low-level aqueduct. In its course the culvert is protected from two foul streams. Of these the first is the Ching Brook, which contains the sewage effluent from the Chingford sewage farm. This brook passes under the culvert about three-quarters of a mile south of the Chingford Station; it then runs for about three hundred yards between the high and low level culverts, and is finally conducted in a westerly direction under the latter by means of iron pipes, which conduct it into the River Lee below all the intakes of the Company. The Ching on May 2, 1897, was a small stream, dark in colour, and of offensive smell. After heavy rains it contains much flood-water, but during the summer it is nearly dry, and is said to be extremely offensive. The other foul stream which is near the culvert is Dagenham Brook. This arises on the slope of Higham Hill, and is polluted by a farm. It passes to the east of the Company's property, and in part

forms its eastern boundary. It need only be added that after receiving much surface drainage, it finally goes into the Thames at Bow Creek, and that it is under the care of specially appointed Commissioners.

WALTHAMSTOW RESERVOIRS.—Before describing these reservoirs in detail, it may be best to give a brief description of their general arrangement and situation. It will be readily seen by studying the accompanying map (Fig. 20). At the western

Waltham-
stow
Reservoirs.

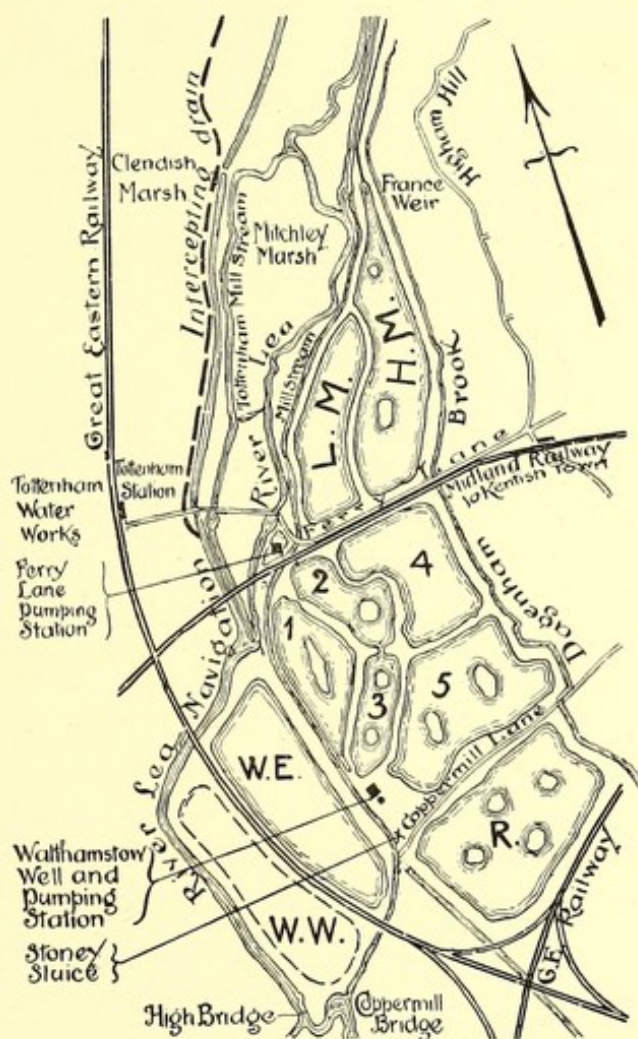


FIG. 20.—THE RESERVOIRS AT WALTHAMSTOW.

H. M., High Maynard; L. M., Low Maynard; R., racecourse; W. E., Warwick East; W. W., the part included in the dotted line shows the position of the Warwick West.

boundary of the reservoirs will be seen the Copper Mill Stream, the River Lee, and the Lee Navigation Cut. On the eastern side the reservoirs are bounded by Dagenham Brook. Two reservoirs are situated to the north of Ferry Lane, the High and Low Maynard (Fig. 20, H. M. and L. M.). Between Ferry Lane and Copper Mill Lane are situated Reservoirs Nos. 1, 2, 3, 4, and 5. Between Copper Mill Lane and the Chingford branch of the Great Eastern Railway, the Racecourse

Reservoir is situated (Fig. 20, R). The other reservoir is the Warwick East (Fig. 20, W. E.). To the south-west of this, next to the Lee Navigation Cut, is the Warwick West (Fig. 20, W. W.), which was completed during the year 1897. These reservoirs have not the same water-level. There is a series of high-level reservoirs and a series of low-level reservoirs. The high-level reservoirs are the High Maynard, Nos. 4 and 5, the Racecourse, and the Warwick East; the top water-level of these reservoirs is 35.60 above Ordnance datum. The low-level reservoirs are the Low Maynard and Nos. 1, 2, and 3; their top-water level is 26.60 above Ordnance datum.

High
Maynard
Reservoir.

High Maynard Reservoir (see Fig. 20, H. M.).—This reservoir is supplied by a high-level culvert, which brings water from Chingford and opens into it at its northern extremity. It has an area of rather over thirty-six acres, and is estimated as being capable of holding 150,000,000 gallons. The reservoir is surrounded by a puddle trench of clay, which goes down to the London clay. There are gravel walks all round, and the banks are covered with grass. There are two islands which are planted with trees. The sides of the reservoir have concrete walls in some places, but not all round. The walls have been put up only where the wash of the water caused by the wind has rendered it necessary to do so for the protection of the banks. Near the boundaries of the Company's property there is a belt of lime and poplar trees, and these do much to break the force of the wind. The islands were made chiefly because their formation was the readiest method of getting rid of the earth which was excavated in forming the reservoirs, but they also do much to check the ravages of the wind. They are planted with furze, lilac, lime and willows, and they add very greatly to the beauty of the place.

Reservoir No. 4 (see Fig. 20).—The water from the High Maynard reservoir passes to this reservoir, which is situated to the south of it, and is divided from it by Ferry Lane, and by the branch of the Midland Railway which runs from Kentish Town to Tilbury. The north and east sides of this reservoir are concreted. The greatest depth is about 25 feet. As will be seen by reference to the map, the reservoir has a somewhat irregular shape, and it has no island. Its area is rather over twenty-nine acres, and its capacity is stated to be 129,670,000 gallons. The water passes from No. 4 to No. 5.

Reservoir No. 5 (see Fig. 20).—The area of this reservoir is over thirty-nine acres, and its capacity is stated to be 170,320,000 gallons. There are two islands in it. There is a concrete wall of 6 feet or 7 feet in height round the bank. After passing through this reservoir, the water goes either to the Racecourse reservoir or to the Warwick East reservoir, which it entirely supplies. The water is conveyed to the Warwick East through a tunnel which passes through the London clay, and which is lined with brick and concreted. The culvert is of circular form, 5 feet in

diameter. A brick shaft, which comes 6 feet above the surface of the ground, passes down to this tunnel, so that when the water is pumped out it is possible to examine its whole length.

The Racecourse Reservoir (see Fig. 20) is situated just at the north of the Chingford and Liverpool Street branch of the Great Eastern Company's line, and is separated from No. 5 by Copper Mill Lane. The area of the reservoir is fifty-nine acres, and is capable of holding 270,000,000 gallons. It has four islands. The sides of the reservoir are partly supported by a sloping concrete wall. The top of the water-level is 15'10 feet above the outlet, which opens into the aqueduct which conducts the water to Lee Bridge. At the north-west corner of the reservoir there is a brick shaft into which water could be conveyed from the ballast. In case of drought if the reservoir were empty this arrangement might be used for obtaining the last water from the ballast; for if all the water were taken from the reservoir a considerable amount of residual water would be left in the ballast above the London clay. The Racecourse reservoir is supplied with water from No. 5. Between the Racecourse reservoir and the Warwick East reservoir a meter-house is being erected to measure the water which passes to the aqueduct to Lee Bridge.

Warwick East Reservoir (Fig. 20, W. E.).—This reservoir was completed in the year 1897. The area of the reservoir at the top-water level is forty-five acres, its top-water level is 35'60 feet above Ordnance datum, and it is capable of holding 210,248,000 gallons. The puddle trench which surrounds the reservoir is some feet higher than the top-water level. It is not, however, proposed to store more than the amount of water mentioned, and the reservoir will not be filled to a higher level than 35'60 feet above Ordnance datum, and indeed this could not be done without pumping. The puddle walls are, however, raised to such a height that it would be possible for the reservoir to be filled to a height of 38 feet above Ordnance datum.

Low Maynard Reservoir (Fig. 20, L. M.).—This is the first of the low-level series of reservoirs. The water which supplies it comes from Chingford mill by the low-level aqueduct. The area of the reservoir is twenty-five acres, and it has a capacity of over 62,000,000 gallons. The water from this reservoir supplies Nos. 2 and 3. The inlet to the reservoir is guarded by a sluice, which is shut as soon as the water becomes turbid. This is the duty of one man, who does nothing else but that and minor gardening operations, which insure his presence in the neighbourhood. The water passes through an iron grating, of which the bars are 1 inch in thickness and the spaces 1 inch. The size of the inlet is 8 feet by 10 feet.

Reservoir No. 1 (Fig. 20, 1).—This reservoir is situated near the Ferry Lane pumping-station. It has an area of a little over nineteen acres, and a capacity

estimated at something over 45,000,000 gallons. It has one island. The supply of water is derived from the low-level culvert, and is discharged into the aqueduct which goes to Lee Bridge.

Reservoirs Nos. 2 and 3 (Fig. 20, 2, 3).—These reservoirs are really continuous; the opening connecting them is a narrow strait, and the two parts are separated by a peninsula. The part to the south is called No. 3, and in this part there are two islands. In the part called No. 2 there is one island. The area of No. 2 is about thirteen acres, and its capacity 31,000,000 gallons, and the area of No. 3 is rather over eleven acres, and its capacity 25,220,000 gallons.

From reservoirs Nos. 2 and 3 the water goes through a culvert, and some of it passes through a circular receptacle to the aqueduct, which takes it to the Lee Bridge station. Into this receptacle four channels pass: one from reservoir No. 1 on the north; on the east side there is a conduit from reservoirs No. 2 and 3; on the west side a culvert which passes to the Copper Mill stream; and on the south a conduit which passes to the aqueduct to Lee Bridge.

Aqueduct to
Lee Bridge.

Aqueduct to Lee Bridge.—The water from the Walthamstow reservoirs is conducted to Lee Bridge through an open aqueduct; the distance is about a mile and a half. The banks of the stream are grass slopes, and there is a gravel walk on each side. The aqueduct is fenced in throughout the whole of its course. The water taken by the aqueduct is derived from: (1) Lee water which has been allowed to subside in (a) the high-level, and (b) the low-level, reservoirs; (2) well water from Ferry Lane; and (3) water from the well at Walthamstow. This water is all filtered at the chief pumping-station at Lee Bridge.

Ferry Lane
Works.

FERRY LANE WORKS (Fig. 20).—The pumping-station at Ferry Lane is situated just to the south of Ferry Lane and to the north of reservoirs Nos. 1 and 2.

Filter-Beds.—There are at Ferry Lane three filter-beds, which together occupy an area of about one acre. The walls are built of brick. The bed of the filter is constructed as follows: A layer of large stones 9 inches in thickness, above this a layer of hoggins 9 inches in depth, and at the top 2 feet of sand. Each filter-bed has one central culvert, no lateral ones. The water used to supply the filter-beds is drawn from reservoir No. 4, or from the Copper Mill stream. The water pumped from Ferry Lane is obtained also from the deep well at Walthamstow.

Well.—The water is pumped by a triple expansion engine, which has cylinders with a diameter of $21\frac{1}{2}$ inches, 33 inches, and 55 inches respectively, and a stroke of 3 feet 3 inches; this works three plunger pumps each 26 inches in diameter. The quantity raised is 224 gallons at each stroke. Steam is generated by three Lancashire boilers, and the engine is worked at a pressure of 135 pounds. An automatic stoker is used. The water is pumped to Hornsey Wood reservoir and to Hagger Lane, Woodford. The head of water worked against in pumping to Hornsey Wood is

125 feet, and in pumping to Haggard Lane it is 176 feet. The station is lighted by electricity, which is generated by a turbine worked from the high-pressure mains.

WALTHAMSTOW WELL AND PUMPING-STATION (Fig. 20).—There is a well 199 feet in depth, which has fourteen bore-holes. The water is pumped by an engine with cylinders 27 inches, 40 inches, and 57 inches respectively in diameter, which has a stroke of 5 feet, and works a pump of which the bucket is 26 inches in diameter and the stroke 5 feet. Each stroke raises 230 gallons of water. The engines work at a pressure of 95 pounds. The pump rods are worked by means of a disc. There is another engine with cylinders 24 inches and 44 inches respectively in diameter, and a stroke of 6 feet. This works a pump which has a stroke of 6 feet, and buckets of which the diameters are $22\frac{1}{2}$ inches. The quantity of water pumped is 206 gallons per stroke. The steam for working the engines is generated by four double flue boilers of marine type. The water raised from this well flows by gravitation to Ferry Lane or to Lee Bridge through the aqueduct. Walthamstow Well and Pumping-Station.

LEE BRIDGE (L on Map, and Fig. 21).—The station at Lee Bridge is situated partly in the county of Middlesex and partly in Essex. It is bounded on the north by Lee Bridge Road, on the west by the Hackney cut of the Lee Navigation, and on the south and east by the Hackney marshes. The station is divided into two parts by the River Lee, which is the county boundary. The Middlesex part of the station contains filter-beds, a pumping engine, and turbines. The water which flows down the old course of the River Lee is regulated by sluices, one of which is situated at its junction with the Hackney Navigation Cut, and the other at the point at which the river leaves the Company's property. The sluices are in charge of the Lee Conservancy Board. The part of the station which is situated in the county of Essex is divided into two by the aqueduct which brings the water from the Company's reservoirs at Walthamstow. The part of the station which is situated to the west of the aqueduct contains the offices of the Company, engine-houses, and one set of filter-beds. It is the custom of this Company to name their engines. Those which are situated here are the "Victoria," "Triples," "Prince," and "Princess." To the east of the aqueduct there are two sets of filter-beds and an engine-house for the "Duke" and "Duchess," the "Prince Consort," and horizontal engines. The well is also situated here. At the southern part of the station near the Lee a well is being sunk. The bulk of the water pumped from Lee Bridge comes from the Walthamstow reservoirs through the aqueduct (Fig. 21), but a small quantity is obtained from the deep well at this station. No water is taken from the River Lee at this point. The water from the aqueduct passes both to the Essex and Middlesex filter-beds through culverts guarded by copper-wire gratings, of which the meshes are about $\frac{1}{20}$ th of an inch in diameter. These gratings are cleansed twice every day, and sometimes more frequently. The water to the Middlesex beds passes in an aqueduct Lee Bridge Station.

Lee Bridge. under the Lee, and that for the Essex beds in the course marked in the plan (Fig. 21, c, c, c).

Middlesex
Part of the
Station.

Middlesex Part of the Station: Filter-Beds.—There are six beds, which occupy six acres. The sides of the filter-beds are built of brick at a slope of $1\frac{1}{2}$ to 1. Each has a central and two lateral culverts to receive the filtered water. Water passes into these channels through perforated bricks. The filtered water well is 100 feet in diameter, and is situated at the point marked by a circle in the centre of the nest of beds. The composition of the beds is the same as that of those at the Essex part of the station, and will be given with the description of them.

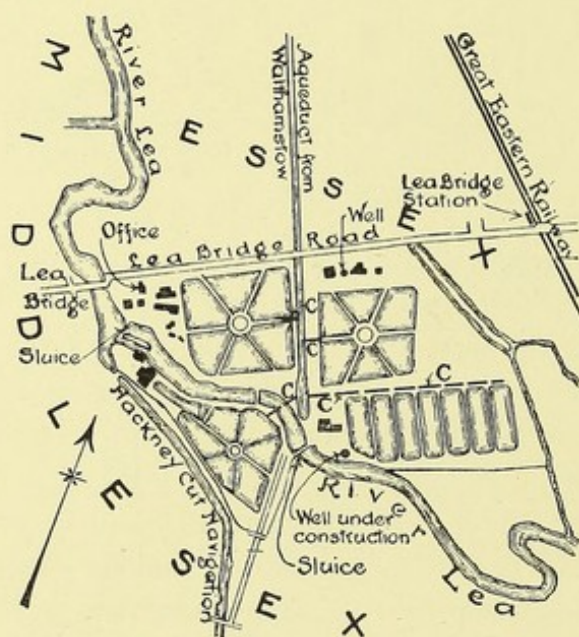


FIG. 21.—THE STATION AT LEE BRIDGE.

The letters c, c, c, show the course of the culverts which pass from the aqueduct to the filter-beds.

Pumping Arrangements: "Victoria."—This is a Cornish pumping engine having a cylinder 100 inches in diameter and stroke of 11 feet, which works a pump of which the diameter is 50 inches. This engine is used for pumping water through a stand-pipe 48 inches in diameter and 120 feet in height for the supply of the middle level district, which embraces Mile End, Stratford, West Ham, Hackney, and Bethnal Green. The head of water worked against is about 100 feet. The pump raises 150 cubic feet per stroke, and works at a rate of 10 strokes per minute. The engine is therefore capable of pumping over 13,000,000 gallons daily. The steam is generated by eight Cornish boilers worked at the pressure of 35 to 40 pounds. Some of the water used by the boilers is softened by the Porter-Clarke process.

Turbine-House.—Near the "Victoria" engine-house there is a house which contains two turbines, which make use of the water-power of the River Lea in flood-time. The turbines are of the Girard type, and work three plunger pumps 10 inches in

diameter, which have a stroke of 2 feet. The pumping capacity is 20·4 gallons per revolution. In the same house a small turbine is worked by pressure from the water mains for the generation of electricity for lighting the station; the water thus used is returned again to the filter-bed.

Water which was filtered at this station was formerly conducted by a culvert to the Company's station at Old Ford, which has since been given up. The part of the aqueduct which is situated at the Lee Bridge station still remains, and is used for another purpose. Into it the water from some of the filter-beds is allowed to flow when they are emptied for cleansing purposes. In time of drought, when all the available water is required, this is pumped back on to the filter-beds. The machinery used for this purpose is a portable steam-engine and two small hydraulic engines. There is an arrangement by which the hydraulic engines are set to work by means of a float; by this means the pressure of the water from the mains is used when necessary for pumping the water out of the old aqueduct back to the filter-beds, and as the float arrangement works automatically no supervision is necessary.

The Essex Part of the Station.—There are three sets of filter-beds on the Essex part of the station. Of these two sets are arranged round a central well, and, like the Middlesex beds, are of somewhat peculiar form (see Fig. 21). The beds forming the third set are more or less rectangular in form.

The Essex
Part of the
Station.

Old Essex Beds.—These six filter-beds have a total area of six acres. The sides are built of brick with a slope of $2\frac{1}{2}$ to 1. A channel for the filtered water runs in the centre of each, and there are two lateral channels which conduct the water into the central one. The air ventilators in connection with the filtered water channels pass through the side walls of the filter-beds. There is no central ventilating shaft. The composition of the filter-bed is as follows: Rough ballast, 9 inches; hoggin, 9 inches; sand, 2 feet. When the sand is scraped off for cleansing purposes the total thickness is not denuded to a greater extent than 6 inches before the washed sand is replaced. The thickness of the sand used for filtration is not reduced to a depth of less than 1 foot 6 inches. The filter-beds are during the summer cleansed about once a month, and once in six weeks during the winter months. The rate of filtration averages 1,000,000 gallons per acre in twenty-four hours. Another set of beds similar in all respects is situated to the east of the aqueduct.

New Essex Beds.—This series of filter-beds consists of six, which occupy an area of about six acres. All these beds are oblong with rounded corners, excepting one, which has an irregular form. The beds have concrete walls, and are lined with Staffordshire bricks at the upper part. Each bed has one central air shaft as well as shafts in the side walls.

Cleansing Sand.—At this station three methods are adopted: (1) Sometimes the sand is washed by the water at a pressure of 100 feet; (2) sometimes it is washed by

Lee Bridge Station. water at low-pressure "hand washing"; and (3) sometimes a special apparatus is used.

Engines. The pumping engines on the Essex side, to the west of the aqueduct, are the "Triples," the "Prince" and "Princess," and a set of turbines.

The "Triples."—The engine-house is a well-lighted structure lined with white tiles. It contains three vertical triple expansion engines, of which two are generally kept working; the engines are fitted with Corliss valve gear. The diameter of the cylinders is as follows: High pressure, 20 inches; intermediate, 34 inches; low, 57 inches; the stroke is 4 feet, and the diameter of the pump is 30 inches. Each engine is capable of pumping 357 gallons per stroke, and the rate at which the engines work is from sixteen to twenty-four revolutions per minute. The head of water worked against is about 100 feet, and the engines are used for pumping to the district. The amount which can be pumped daily by each of these engines is 12,000,000 gallons. Steam is generated by six Lancashire boilers, which work at a pressure of about 120 pounds.

"Prince" and "Princess."—The house containing these engines is situated just at the east of the offices. The engines are of the Cornish type; the diameter of the cylinders is 84 inches, and the stroke 11 feet. They pump water into a stand-pipe 140 feet high, which is situated in the chimney. The head of water worked against is generally about 140 feet. The steam is generated by ten Cornish boilers, which work at a pressure of from 38 to 40 pounds. These engines work two pumps, of which the plungers are 45 inches in diameter and the stroke 9 feet, the rate being generally nine or ten strokes per minute. The amount of water pumped is 623 gallons a stroke. The engine-house contains an electric indicator for recording the height of water in the reservoir at Finsbury Park.

Turbines.—Two Hercules turbines actuate two sets of double-acting pumps, which deliver 26 gallons of water per revolution into the mains supplying the Essex district. The head of water worked against is generally about 180 feet.

At the part of the station to the east of the aqueduct are situated the well, the "Duke" and "Duchess" (horizontal) and "Prince Consort" engines. There is also a residence for the foreman of the Lee works.

"Duke" and "Duchess."—These are two compound engines, of which the diameters of the cylinders are 23 inches and 39 inches, the length of the stroke being 4 feet 6 inches and 6 feet 6 inches. These engines work bucket and plunger pumps. The diameter of the buckets is 2 feet 3 inches, and of the plunger 1 foot 7 inches; the stroke is 5 feet 7 inches. Each delivery, therefore, amounts to about 139 gallons. The head of water worked against is 174 feet, and the water is pumped to Hagger Lane, Woodford, and Forest Gate. In an adjoining house there is a compound horizontal tandem engine having cylinders with the respective diameters of 23 inches and 40 inches, and a stroke of 3 feet. This engine works pumps of which the

diameters are 22 inches and the stroke 3 feet. The amount pumped per revolution is 99 gallons. The engine is used as an auxiliary for pumping to Haggar Lane. Lee Bridge Station.

Well.—The well is 200 feet in depth. It has two series of headings—one series at a depth of 200 feet from the surface, and the other at a depth of 140 feet. Altogether there are 7,000 feet of headings. One canal goes in the direction of Walthamstow, the second in an easterly direction, and the third towards the south-west. This well is only used when there is a scarcity of river water. The amount of water pumped from it has been as great as 3,000,000 gallons per day. The engine used for raising the water is a compound tandem well engine, which has cylinders of 24 inches and 44 inches in diameter respectively and a stroke of 6 feet. The pump is worked through bell cranks. The diameter of the bucket is $22\frac{1}{2}$ inches, and the length of the stroke 6 feet. The capacity per stroke for the pumps is 206·6 gallons. This engine, the "Duke" and "Duchess," and the tandem engine, are worked by steam generated by two Lancashire and three Cornish boilers worked at a pressure of 70 pounds. Well.

"Prince Consort."—This engine received its name from the fact that it assists the "Victoria." It is of marine type, with cylinders of 21 inches, 33 inches, and 56 inches respectively in diameter; it has a stroke of 3 feet 3 inches, and works three plunger pumps, which have strokes of 3 feet 3 inches and a capacity of 361 gallons per revolution. The steam for working the engine is generated by three Lancashire boilers, one of which is fitted with an automatic stoker. The steam pressure used for working the engine is 125 pounds. The head of water worked against is 107 feet, and the water supplies the district directly without the intervention of any reservoir or stand-pipe.

The works at Lee Bridge are fitted with an apparatus for carrying coal from the Lee Navigation Canal. The arrangement, which works well, is that a continuous chain provided with lateral arms runs in a cast-iron channel; in this way the coal is conveyed from the barges to elevators which are situated at the engine-house. At the eastern extremity of the Company's premises there is a line of rail which joins the Great Eastern Railway; some coal comes in this way by trucks.

Meter-House.—There is a house at this station fitted up for testing taps and meters. It was found by the engineer of the Company that a very large amount of water was wasted in the districts supplied because the taps which were fixed in the dwellings of the poor were of very inferior quality, and soon got out of order. When this was the case there was, of course, a continual loss of water. The Company tests any taps which are sent for that purpose. They are re-leathered without expense to the customers.

Offices.—The office of the chief engineer and the draughtsman's rooms are situated at Lee Bridge, and the station is in electric communication with the City offices and with the stations at Walthamstow, Chingford, and Haggar Lane.

Waltham Abbey.

WALTHAM ABBEY (see D on Map).—The station at Waltham Abbey is situated just to the west of the Lee Navigation Canal and opposite the Government cordite factory, and about half a mile to the south of the Abbey church. Here there is a well 200 feet in depth, with about 600 feet of headings running in various directions under the property of the Company. There are ten bore-holes, which pass from 90 feet to 150 feet below the level of the heading. The upper part of the wall is lined with iron cylinders 10 feet in diameter. Chalk occurs at 123 feet below the surface of the ground, which is here 65·5 feet above Ordnance datum. The upper 80 feet of the well has outside the cylinders an external lining of brick and cast-iron cylinders, of which the diameter is 11 feet. Water is pumped by a triple expansion engine of marine type, which has cylinders with diameters of 18 inches, 30½ inches, and 51 inches respectively, and a stroke of 3 feet. The deep-well pumps are worked off the main shaft by bell-cranks. There are two pairs of buckets, of which the diameters are 18 inches. It may be of interest to note that this is the first triple expansion engine which was ever erected for the pumping of water. The steam for working the engine is generated by four water-tube boilers. The amount of water raised daily is about 750,000 gallons, and it is pumped to the districts of Waltham Abbey, Loughton, Woodford, Buckhurst Hill, and Chigwell. The head of water worked against is about 330 feet. On May 12, 1897, the engine was being overhauled, and was not at work. The engine-house is very well lighted by large windows, and is lined with white tiles. For artificial lighting electricity is generated by a small vertical high-speed engine. A cottage for the foreman is situated here.

High Beach.

HIGH BEACH (see H on Map).—Here is a reservoir capable of holding 2,500,000 gallons of water. It is covered with brick arches and turfed over. The top water-line is 371 feet above Ordnance datum. Water is pumped here from Waltham Abbey and from Haggar Lane, and it goes to supply the Essex high-level district.

Buckhurst Hill.

BUCKHURST HILL (see I on Map).—There is a reservoir at Buckhurst Hill capable of holding 800,000 gallons of water. It is covered with brick arches and turfed over. The top water-level is 271 feet above Ordnance datum.

Hornsey Wood.

HORNSEY WOOD (see C on Map).—This station consists of a covered reservoir situated in the south-east part of Finsbury Park, near the Seven Sisters Road. It is of oblong form, and covered by brick arches. It is capable of holding 5,000,000 gallons. The top water-level is 141 feet above Ordnance datum. The Thames water is pumped here from the Hanworth station through a 36-inch main, and the Lee water from Lee Bridge through a 30-inch main. It serves for the supply of the western part of the Company's district. There is an electric indicator which shows the height of the water in the reservoir; the index is at the station at Lee Bridge. The communicating wire passes underground to Harringay Station, then along the

Midland Railway to the Lee Navigation Canal, and down the towing-path. The reservoir is turfed over, and there are tennis-courts over it. The surface of the ground is in the possession of the London County Council.

HAGGAR LANE (see J on Map).—At this station there are two reservoirs and machinery for pumping to High Beach. The older of the reservoirs is capable of holding 3,000,000 gallons; the top water-level is 171 feet above Ordnance datum. It is covered with brick arches, which have a layer of earth with a little grass growing on it. The newer reservoir has a capacity of 7,000,000 gallons, and the top water-level is 181 feet above Ordnance datum. It is covered with arches built of concrete and supported by steel girders. A layer of burnt clay has been placed on the top. The reservoirs are supplied with water from Lee Bridge and from Walthamstow. Haggar Lane.

Pumping Arrangements.—There are two horizontal condensing engines with 24-inch cylinders, which work plunger pumps. The steam is generated by five Cornish boilers working at a pressure of 50 pounds. The water is pumped for the supply of the High Beach reservoir and district, and occasionally to Buckhurst Hill reservoir. The head of water worked against in pumping to High Beach is 205 feet. As a rule one engine only is used. It is worked night and day, and pumps about 500,000 gallons of water. The grounds of this station are about five acres in extent; they are fenced in and planted with trees. There are two cottages for employes of the Company, and a small workshop.

Communications with other Companies' Mains.—There are two communications with the mains of the Grand Junction Water Company: (1) at Kew, (2) at Campden Hill. The Company can also, if necessary, supply the New River Company with water at Stoke Newington. If this were done, the filtered water used by the East London Waterworks Company would pass into the New River, and would be filtered again in the ordinary course by that Company. The New River Company have indirectly supplied the East London Company with unfiltered water when there has been a lack of it. The arrangement made simply was that the New River Company did not take the whole of the amount of water which they were authorized to take at Ware, and so the water was allowed to flow down the Lee, and was received at the ordinary intake of the East London Waterworks Company at Chingford. During the years 1896 and 1898 water was supplied by the New River Company in this way, and during the latter year water was supplied also by the Southwark and Vauxhall and the Kent Companies.

Length of New Pipes.—The length of new pipes ranging from 3 inches to 24 inches laid in 1895 was $24\frac{1}{4}$ miles, and during the year 1896 was $21\frac{1}{4}$ miles.

Hydrants.—The number of hydrants erected during the year 1895 was 15, and during the year 1896 it was 1,406.

Houses under Constant Supply.—The number of houses under constant supply on December 31, 1894, was 179,167; on December 31, 1895, 180,500; and on December 31, 1896, 186,364. During the autumn of 1898 the supply was intermittent.

Percentage of Houses under Constant Supply.—On December 31, 1896, the percentage of houses under constant supply was 99.

Highest Supply given.—The highest supply given is at High Beach, 370 feet above Ordnance datum.

Average Daily Supply per Head.—The average daily supply per head for the year 1896 was 33 gallons. These figures are arrived at by the engineer of the Company as follows: The amount of water supplied is estimated from the known volume delivered by the pumps. The population is estimated from the figures given at the last census, with an addition for the new houses supplied. It is generally known that in different districts the average number of people per house differs very widely. As a rule, however, this fact is not allowed for by water companies in estimating the amount of their water-supply—that is to say, a general average figure is taken to represent the whole district under supply. In the case of the East London Company an attempt is made to find the average of the population per house in each district which is supplied by the Company. In this way a factor is found which is used in the calculation of the increase in each separate district. The population is worked out for each month in the case of each district supplied by the Company, and the mean population is obtained by adding together the numbers arrived at for each month, and dividing the whole sum by twelve.* This method of calculation of course involves a very large amount of clerical work.

Dates of the Maximum and Minimum Supply.—The following table gives the date of the maximum and minimum supplies, and the average daily quantities supplied:

YEAR 1895.			YEAR 1896.		YEAR 1897.	
	Month.	Quantity in Gallons.	Month.	Quantity in Gallons.	Month.	Quantity in Gallons.
Maximum	February	59,160,000	June	46,870,000	July	45,842,000
Minimum	August	40,750,000†	August	32,760,000†	March	37,648,000

* The average population per house in different districts supplied by the Company is found to be: Shoreditch, 8.90; West Ham, 6.39; East Ham, 5.95; Wanstead, 5.68; and Leyton, 5.83.

† Intermittent supply during drought.

TABLE OF STATISTICAL DETAILS GIVEN BY THE EAST LONDON WATERWORKS COMPANY FOR THE YEARS 1896 AND 1897.

		1896.	1897.
SUPPLY.	Average daily supply in gallons...	40,000,000	41,000,000*
	Percentage delivered for other than domestic purposes, exclusive of waste	About 23 per cent.	25 per cent.
	Number of houses supplied ...	188,435	192,264
	Number of houses on constant supply	186,798	190,572
	Estimated population supplied ...	1,251,000	1,274,735
RESERVOIRS. Subsiding and storage unfiltered water Storage filtered water reservoirs ...	Number	9	10
	Area in acres	238	314
	Available capacity in gallons ...	815,000,000	1,215,000,000
	Number	7	8
	Capacity in gallons	13,800,000	20,800,000
ENGINES.	Number	31	31
	Horse-power	5,590	5,590
	Greatest lift	500	500
	Head of pressure in the district supplied	40 feet to 350 feet.	40 feet to 350 feet.
WATER-PIPES.	Total number of miles of water-pipes	897	918
	Number of miles of water-pipes in the metropolis	456	462
	Number of miles of streets with water-pipes constantly charged in the metropolis	185	185
	Number of hydrants erected within the metropolis	3,628 public; 2,761 private; and 7,076 fire-plugs.	3,628 public; 2,761 private; 7,076 fire-plugs.
FILTERS.	Number of beds	34	34
	Area in acres	31	31
	Depth of sand and other materials	2.0 feet sand; 0.6 inches hoggin; and 1.0 foot coarse gravel.	2 feet sand; 6 inches hoggin; and 1 foot coarse sand.

EAST LONDON COMPANY.—The Act of 1853 authorizes the East London Company to supply the following places:

Supplied.—Artillery Ground, Bethnal Green, Bow, Bromley, Chigwell, Chingford, Clapton, West Ham, East Ham, Homerton, Leyton, Leyton (Low), Leytonstone,

* This figure is lessened by reason of the drought causing the interruption to the constant supply in July, August, and the beginning of September.

Limehouse, Loughton, Mile End (Old Town), Mile End (New Town), Old Ford, Poplar, Ratcliff, St. George-in-the-East, Shadwell, Spitalfields, Stamford Hill, Stepney, Stratford-le-Bow, Walthamstow, Waltham Abbey, Waltham Holy Cross, Wanstead, Wapping, and Woodford.

Partly Supplied.—Hackney, Whitechapel, Bishopsgate, Ilford, St. Botolph Aldgate, Shoreditch, Tottenham, and Woolwich (north of the Thames).

Not Supplied.—Islington, Newington, St. Luke Old Street, Barking, Dagenham, Dalston, Holloway, Kingsland, Romford, Shacklewell.

The Company occasionally supplies a small amount of water in bulk to the Cheshunt Urban District Council, Hertfordshire.

NEW WORKS IN PROGRESS.

New Works in Progress.

Lee Bridge.

LEE BRIDGE.—Near the "Prince Consort" engine-house a well is in course of construction. The depth at present is about 145 feet, and the chalk was reached at 85 feet. The diameter of the well is 12 feet, and iron cylinders have been sunk to the level of the chalk.

Ramney Marsh.

RAMMEY MARSH (see E on Map).—A well is being sunk at Ramney Marsh. The ground-level here is 58 feet above Ordnance datum. The well has reached a depth of 66 feet from the surface, and at this depth the work is still being carried on in the London clay. There was about 1 foot of surface soil, and 18 feet of ballast above the London clay. The upper 25 feet of the well is surrounded by iron cylinders, of which the diameters are 15 feet and brickwork, of which the internal diameter is 14 feet; the lower part is lined with iron cylinders, of which the outside diameters are 12 feet.

Ponders End.

PONDERS END (see F on Map).—The new station here is situated at a level of 40 feet above Ordnance datum. A new well is being sunk here; the depth reached is 109 feet, at which level chalk has been reached.

Barking

BARKING (see M on Map).—This place is situated at 10 feet above Ordnance datum. A new well is being sunk here. The depth reached is 200 feet. Some headings have been driven at the bottom of the shaft. Chalk was reached at a level of 145 feet.

Ferry Lane.

FERRY LANE.—At this station a new well is being sunk; the depth now reached is about 140 feet, and at this depth the upper level of the chalk is situated.

The Company was authorized by an Act passed in the year 1897 to construct two additional reservoirs in Tottenham, Edmonton, and Chingford. The proposed capacity of the new reservoirs is about 1,000,000,000 gallons.

THE WEST MIDDLESEX WATERWORKS COMPANY.

IN the early part of the present century an engineer named Dodd projected some History. new waterworks to supply the West-end of London, and in the year 1806 an Act was passed to allow the scheme to be carried out. Hammersmith, Kensington, Paddington, and part of Marylebone were to be supplied, and Mr. Dodd's original plan was to make the works at Hammersmith, but later he wished to have them at Poole's Creek, near Fulham. The shareholders of the Company disapproved of the change of plan. Mr. Dodd left their service, and in 1807 a new engineer was employed and the works were constructed at Hammersmith as originally proposed. Wooden pipes were at first used for the conveyance of the water, and stone ones were afterwards adopted, but as these proved unsatisfactory cast-iron pipes were substituted in the following year. In 1809 land was bought on Campden Hill, and a reservoir capable of holding over 3,500,000 gallons was constructed there. This was done with the intention of supplying parts of the district of Marylebone, but difficulties were placed in the way of this extension. The original Act of Parliament authorized the Company to supply "certain parishes and places as well as parts adjacent." The Company construed the expression "parts adjacent" to mean the whole of Paddington and Marylebone, but the select vestry of Marylebone objected to the pavements being taken up for laying the pipes. In 1810 the Company obtained an extension of their authorized area of supply, and this difficulty was therefore overcome. In 1825 a reservoir was built on Barrow Hill, near Primrose Hill. It was constructed to contain 4,750,000 gallons of water, and was situated at an elevation of 190 feet above Ordnance datum. This reservoir was supplied from Hammersmith. In 1838 subsiding reservoirs were made at Barnes, and the water from them was taken to the engines at Hammersmith through a pipe laid in the bed of the river. An Act of 1852 (15 and 16 Vict., cap. 159) provided that water for the supply of London should not be taken from the tidal portion of the Thames. The West Middlesex Company selected Hampton for their new station, the intake was removed, and engines were put up to pump water to the subsiding reservoirs at Barnes. These works were completed in the year 1855. Filter-beds were made at Barnes, and the reservoirs at Barrow Hill and Kensington were covered over. In 1860 the filtering area was enlarged and the pumping power increased. In 1866 the Company obtained Parliamentary authority to supply parts of Hampstead, Hendon, Willesden, and part of Acton, in the county of Middlesex, and a reservoir was made

near the Finchley Road 323 feet above Ordnance datum. Afterwards a second 36-inch conduit was laid across the Thames from Barnes to Hammersmith, and a covered reservoir was constructed at Willesden. In some of the districts a constant supply of water was given as early as the year 1872. In 1886 the Thames Conservancy entered into an agreement by which the Company were allowed to take from the river 4,500,000 gallons of water in addition to the 20,000,000 gallons which they had previously taken. In 1896 large reservoirs were completed at Barn Elms and two others were begun.

GENERAL DESCRIPTION.

General Description.

The West Middlesex Waterworks Company's area of supply includes Hammersmith, Earl's Court, the Regent's Park district, Portland Town, Kilburn, Child's Hill, Willesden, and extends as far north as Hendon. The district supplied by the Company is bounded on the west by the Grand Junction district, on the south partly by the Chelsea district and by the Thames, and on the east by the New River Company's area of supply. The Company's stations are: Hampton, intake; Barnes and Barn Elms, reservoirs and filter-beds; Hammersmith, pumping-station; Campden Hill, reservoir; Barrow Hill, pumping-station and reservoir; Kidderpore, reservoir; Willesden, pumping-station and reservoir; and Shoot-up Hill, reservoir.

Hampton.

HAMPTON.—The intake is at Hampton, and the Thames is the sole source of supply. The unfiltered water is pumped through mains which pass through Twickenham, cross under the Thames at Richmond, then run through Mortlake and Barnes, where the storage reservoirs and filter-beds are situated. From Barnes the filtered water crosses the Thames to Hammersmith, and is pumped thence to the district in the immediate neighbourhood and to the reservoirs at Campden Hill (Kensington), Barrow Hill (Primrose Hill), and to Willesden. There are also reservoirs at Kidderpore (Hampstead) and Shoot-up Hill, and these are supplied by pumping from Barrow Hill and Willesden.

Intake.—The whole of the water supplied by the Company is taken from the Thames at Hampton. The water first passes through a coarse-meshed iron screen placed in front of an intake bay. The bars of the screen are placed $\frac{3}{4}$ -inch apart. The width of the inlet is about 30 feet, and the height of the Thames is regulated by the Thames Conservancy, so that the water does not fall to a lower level than 2 feet from the top of the pipes. There are two mains, each 48 inches in diameter. The water first passes into a screen-house.

Screen-House.—The water passes through two screens of galvanized iron, of which the meshes are $\frac{1}{4}$ inch. These screens prevent small leaves and other débris from passing in. They are arranged so that they can be drawn up to be cleaned;

the cleaning is done with a broom always once a day, and more frequently if necessary. From the screen-house the water passes in two 48-inch mains to a circular shaft 20 feet in diameter, from which the water is distributed to the various engine-wells.

Engine-House.—There is one of Simpson's horizontal engines, which is capable of pumping 24,000,000 gallons of water a day to Barnes. The steam is generated by five Cornish boilers. The second engine-house contains two vertical Worthington engines, each of which is capable of pumping 16,000,000 gallons a day to Barnes. The steam for these engines is supplied by four Lancashire boilers, and the arrangements are such that either of the engines can be worked by either set of boilers. There are no subsidence reservoirs or filter-beds at Hampton, but the water, after passing through the screens which have been described, is pumped direct to Barnes.

Course of the Mains.—Two 36-inch iron pipes convey the water along the high-road to Richmond. At Richmond they go under the river a few yards below the bridge, and then along the high-road to Barnes. There is a connection with the Southwark Company's mains opposite the Black Horse public-house at Marsh Gate, near Richmond.

BARNES AND BARN ELMS.—The subsidence reservoirs and filter-beds are all situated at Barnes, where the Company possess one hundred and ninety-six acres of ground near the banks of the river (see Fig. 23). Barnes and
Barn Elms.

Subsiding Reservoirs.—There are now in use seven subsiding reservoirs. Into the first reservoir the water passes through a bell-mouthed opening, and the water flows out after the manner of a miniature fountain. This arrangement was devised by the late Dr. Tidy to insure that the water should become aërated as much as possible. The area of this reservoir is seventeen acres, and it is capable of storing 57,000,000 gallons of water. From the first reservoir the water passes to the second, which is at a lower level, the fall being 4 feet 6 inches. Some of the water falls over in the form of a cascade, but the greater part passes through a tunnel. The second reservoir has an area of about five and a half acres and a storage capacity of 17,750,000 gallons. The third reservoir is at the same level as the first, has an area of about seven acres, and a storage capacity of 18,750,000 gallons. A caretaker's cottage is situated between these three reservoirs. A fourth reservoir, situated near Hammersmith Bridge, has an area of about seven and a half acres, and a storage capacity of 24,000,000 gallons. Three other large reservoirs have just been completed at Barn Elms. The slopes forming the sides of the new reservoirs are lined with concrete and brick at the upper part, and at the top of the slope is a flat berme and a breast-wall. This arrangement is designed to prevent the water from being blown over in windy weather. The total area of the reservoirs is one hundred and seventeen and a half acres, and their total capacity 397,500,000 gallons.

Filter-Beds.—The filter-beds are situated between the London Road and the river, and between the third and fourth reservoirs. The number of the filter-beds is fourteen, and their total area seventeen and two-thirds acres. Nos. 1, 2, and 3 have an area of one and one-third acres; No. 4 has an area of two and a quarter acres; No. 5 has an area of one and three-quarter acres; Nos. 6 *a* and 6 *b* have an area one acre each; Nos. 7, 8, 9 and 10 have an area of one and one-sixteenth of an acre each; and No. 11 has an area of one acre. The filtering material consists of 2 feet 6 inches of sand resting on 1 foot of ballast. The only difference in the arrangement of the filters is that for the collection of the filtered water. The greater

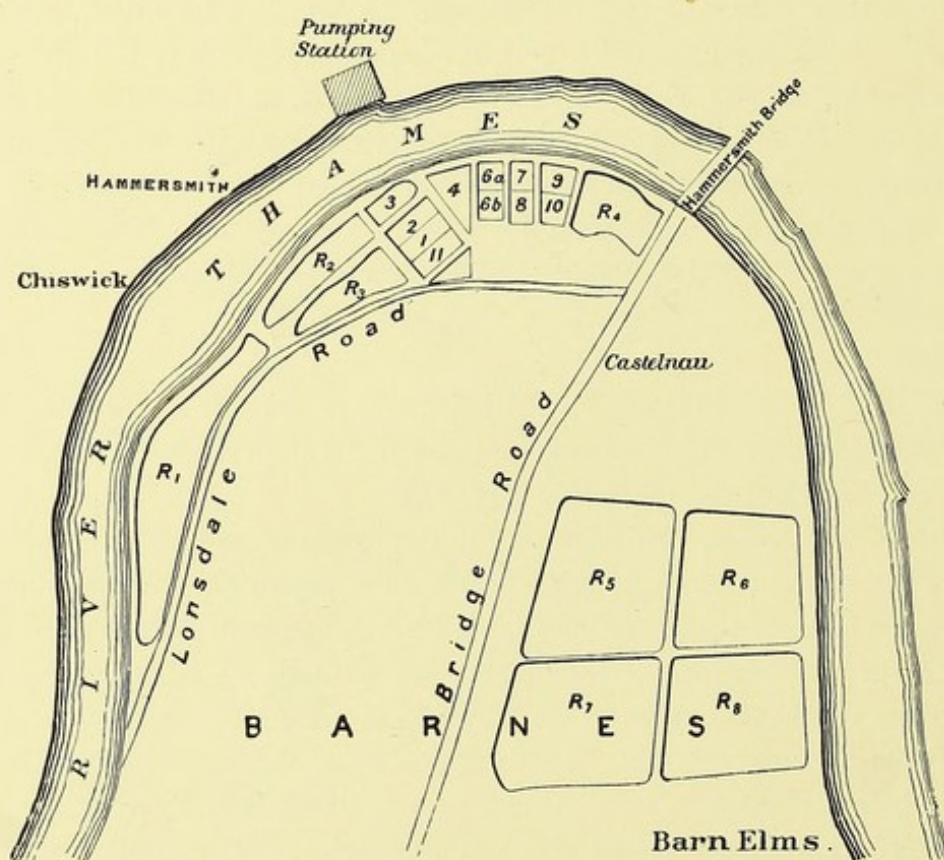


FIG. 23.—THE RESERVOIRS AND FILTER-BEDS AT BARNES.

number of them have earthenware collecting drains, placed at intervals of 30 feet, to conduct the water to the central collecting channel. Four of the filters (Nos. 7, 8, 9, and 10) rest on square earthenware tiles, which are placed quite close together; one (No. 11) is floored with stones, and has no collecting channel except the central one. The size of the ballast varies from about $\frac{3}{8}$ inch up to 2 inches, the smaller ones being placed at the top and the larger ones at the bottom. The rate at which filtration is carried on is on an average one and one-third gallons per square foot per hour. After filtration the water passes under the Thames in two 36-inch iron pipes to Hammersmith pumping-station. The pipes can be seen in the bed of

the Thames at low water, and it is proposed shortly to construct a tunnel in the clay under the Thames and to run the pipes in this.

HAMMERSMITH.—The chief pumping-station is at Hammersmith, whence the water is distributed to the district, to the reservoir on Campden Hill, and to the subsidiary pumping-stations at Barrow Hill and Harlesden. From Barrow Hill the water is pumped to Kidderpore and to Shoot-up Hill, if required. From Willesden it is re-pumped for the supply of Shoot-up Hill reservoir. At Hammersmith there are four Cornish engines capable of pumping 14,000,000 gallons into the district daily. There are three compound beam engines capable of pumping 13,500,000 gallons a day. There is also a compound Worthington engine which can pump 5,500,000 gallons a day, and two triple expansion Worthington engines capable of pumping 3,500,000 gallons. The steam is generated by thirty-two Cornish boilers.

CAMPDEN HILL, KENSINGTON.—The reservoir is situated at an elevation of 120 feet above Ordnance datum on the eastern slope of Campden Hill rather below that of the Grand Junction Company, which is situated on the other side of the road (and is marked by the tower, which is a conspicuous object from a distance). The reservoir is built of brick, and is not covered with earth at the top. It is capable of holding 3,762,000 gallons of water, which is pumped here from Hammersmith. One 21-inch main from Hammersmith passes down the south side of the Company's property. The overflow from the reservoir passes into a brick drain of about 2 feet by 1½ feet.

There is a house for the assistant engineer, and a cottage for the turncock here.

BARROW HILL.—The Company's station on Barrow Hill is next the open space on Primrose Hill. The height above Ordnance datum is 190 feet. There is a covered reservoir built on arches and capable of holding 4,750,000 gallons of water.

Engines.—There is a single cylinder beam-engine capable of pumping 1,200,000 gallons daily, a single cylinder horizontal engine capable of pumping 1,750,000 gallons and a compound horizontal fly-wheel engine capable of pumping 2,930,000 gallons daily. The engines are worked by six Cornish boilers.

The assistant engineer's house and two cottages are situated at Barrow Hill.

SHOOT-UP HILL.—On the plateau at the highest point of Shoot-up Hill is a reservoir built on arches. It is 250 feet above Ordnance datum, and is capable of holding 6,000,000 gallons of water. Water can be supplied to this reservoir either from Willesden or from Barrow Hill (Primrose Hill). The quantity of water taken is regulated by a 16-inch screw-cock situated at the bottom of the hill.

This reservoir formerly belonged to the Grand Junction Company.

Kidderpore. KIDDERPORE.—At an elevation of 323 feet above Ordnance datum there is a reservoir capable of holding 2,500,000 gallons. The reservoir is covered in with brick arches, and the roof is not earthed over. A caretaker's cottage is situated here.

Willesden. WILLESDEN.—At Willesden there is a pumping-station and a reservoir. There are two compound horizontal fly-wheel engines capable of pumping 2,000,000 gallons each daily. The steam is generated by two Cornish boilers. The water is pumped to Shoot-up Hill. The reservoir, which is situated 190 feet above Ordnance datum, and is covered by strong brick arches and earth, is capable of holding 2,500,000 gallons.

Statistics. *Length of Pipes.*—In 1895, 16,708 yards of new pipes, ranging from 3 inches to 48 inches in diameter, were laid. In 1896 the length was 16,723 yards. The total length of pipes on December 31, 1896, was 480 miles; and on September 30, 1898, it was 492 miles.

Number of Hydrants.—The number of hydrants erected in 1895 was 156, and in 1896 was 204. The total number on December 31, 1896, was 942; and on September 30, 1898, it was 1,481.

Communication with other Companies' Mains.—Filtered water—Grand Junction: (1) At the junction of Edgware Road and Bayswater Road; and (2) at Kilburn. New River: (1) At the junction of Tottenham Court Road with Oxford Street; and (2) at the junction of Tottenham Court Road with Euston Road. Unfiltered water—Southwark and Vauxhall: At Marsh Gate, near Richmond.

Houses under Constant Supply.—The number of houses receiving constant supply on December 31, 1894, was 50,985; on December 31, 1895, 55,933; on December 31, 1896, 64,701; on December 31, 1897, 70,498; and on September 30, 1898, it was 72,916.

Total Number of Houses Supplied.—The total number of houses supplied on December 31, 1894, was 78,486; in December, 1895, 79,644; in December, 1896, 80,697; in December, 1897, 81,825; and in September, 1898, it was 82,990.

Percentage of Houses under Constant Supply.—On December 31, 1896, the percentage of houses under constant supply was 80; on December 31, 1897, 86; and on September 31, 1898, it was 88.

Average Daily Supply.—In 1895 the average daily supply per head was 35.66 gallons. In June the maximum was attained, the amount per head being 40.59 gallons, and the minimum occurred in the month of February, the amount per head being 31.52 gallons. In the year 1896 the average daily supply was 34.5 gallons. The maximum supply was given in July, and amounted to 39.8 gallons per head. The minimum supply was given in December, and amounted to 31.3 gallons per head. In the year 1897 the average daily supply was 35.43 gallons. The

maximum supply was given in July, and amounted to 38·66 gallons per head. The minimum supply was given in December, and amounted to 31·23 gallons per head. During the month of September, 1898, the average daily supply amounted to 38·27 gallons per head.

AREA OF SUPPLY.

The Act of 1852 authorizes the West Middlesex Company to supply the following places: Area of Supply.

Partly Supplied.—Chelsea (St. Luke, west of the boundary defined in the Act*), Chiswick (St. Nicholas), Ealing (St. Mary), Fulham (All Saints), Hammersmith (St. Paul), Kensington (St. Mary Abbott), Paddington, Soho (St. Anne), St. Mary-lebone, St. Pancras (south of Fig Lane), Westminster (St. Margaret), and so much as lies within the town of Kensington.

Not Supplied.—Barnes (St. Mary), Battersea (St. Mary), Bloomsbury (St. George), Brentford (Old), Brentford (New), Hanwell (St. Mary), Heston, Hounslow, Isleworth, Kew (St. Anne), Mortlake, Putney (St. Mary), Richmond (St. Mary Magdalene), Strand (St. Mary-le-), St. Clement Danes, St. Giles-in-the-Fields, St. Paul (Covent Garden), Westminster (St. James), and Wandsworth (St. Mary).

The Act of 1866 authorizes the supply of Willesden, which is wholly supplied. Partly supplied: Acton (north of Great Western Railway), Hendon, and St. John (Hampstead).

NEW WORKS IN PROGRESS AND PROJECTED.

THE STAINES RESERVOIRS.—An Act passed in the year 1896 (59 and 60 Vic., cap. 241) authorized the West Middlesex Waterworks Company, the Grand Junction Waterworks Company, and the New River Company, to construct new reservoirs at Staines. The work is now in progress. New Works in Progress and Projected.

PARLIAMENTARY PROCEEDINGS.—A Bill has recently been deposited at the Private Bill Office, and will be brought before Parliament during the next Session. By this Bill it is sought, amongst other things, to obtain authorization for further powers for the abstraction of water from the Thames.

* Section 32 of the West Middlesex Waterworks Act, 1852, is so framed as to enable the Chelsea Company to exact a penalty from the West Middlesex Company in the event of the latter supplying within a certain defined part of the eastern portion of the parish of Chelsea.

THE GRAND JUNCTION WATERWORKS COMPANY.

HISTORY.

IN the year 1798 the Grand Junction Canal Company obtained an Act of Parliament (33 Geo. III., cap. 33) to enable them to supply water to the inhabitants of Paddington and the places adjacent. The project was not, however, at once carried out. In November, 1810, an announcement was made in the newspapers that "works are now constructing and reservoirs making, under the direction of Mr. Rennie, the engineer, with powers to effect their purpose far superior to any other in the kingdom, and calculated to give to the inhabitants and streets supplied an abundance of pure and excellent soft water even in the upper stories of houses or other buildings." It was pointed out that the height above the Thames from which the water was to be taken enabled the proprietors to convey it at a very small expense to the parishes of Paddington, Marylebone, and St. George, Hanover Square, and to the new streets which were then being built in those districts. The advertisement went on to say that the "grand main at present casting" was 30 inches in diameter, and it was announced that a Company would be started for carrying out the work as a business distinct from that of the Grand Junction Canal Company. A favourable account was given of the water which was to be supplied, and it was said to be "excellent for all culinary and domestic purposes." "It is also," the prospectus went on to say, "lighter, and contains less foreign matter than the Thames water." It was added that additional reservoirs were being made, and streams of water "of the finest quality" were being used, and that there would be a sufficient supply for 40,000 houses. It was obvious, the advertisement stated, that the undertaking would be attended with great public benefit, and the proprietors believed that they had "reason to feel confident of the liberal support of the public." The Company for carrying out the new undertaking was formed under an Act of Parliament passed in the year 1811 (51 Geo. III., cap. 1, 69). The expense incurred in carrying out the work proved to be considerably more than was expected, and the Company at first experienced considerable difficulties with regard to raising new capital when it became necessary to do so. A great deal of money was lost because the Company at first used stone distributing-pipes, which were recommended by Mr. Rennie. It was soon found that these were very unsuitable for the purpose, and it became necessary to substitute iron pipes. At first the Company obtained their water from the Grand Junction Canal, which in its turn was supplied by the river Colne and the

river Brent. Water was also obtained from a reservoir of nearly a hundred acres **History.** which was fed by streams of the Vale of Ruislip. It was said that these sources were remarkably pure, and that the water was superior both in softness and transparency to that derived from the Thames. Experience, however, proved that the water was not by any means perfect, and the directors acknowledged that the quality of the water taken from the canal "had disappointed the expectations of the projectors of the original plan," for it was found to be impossible to keep the land drainage out of the canal and the Ruislip Reservoir. It was discovered also that the waters of Brent were "so foul that it was necessary to prevent their entering the canal," and a like necessity caused the waters of the Ruislip Reservoir to be conducted by a tunnel under the canal. In short, the supply from both these sources proved unfit for the use of the waterworks. In consequence of this, arrangements were made for obtaining water from the Regent's Canal Company, but the supply proved inadequate, and complaints were made both as to the quantity and quality supplied to the customers. The Company at length decided to obtain water from the Thames, and about four acres of land were bought at Chelsea. The site chosen was between the Royal Naval Hospital and the Chelsea Waterworks. The water was obtained through a conduit-pipe laid into the bed of the river, and was pumped by steam-engines to the station at Paddington, a portion of the site of which is now occupied by Talbot Square and Norfolk Square. There were three reservoirs at Paddington capable of holding 153,000, 139,000, and 65,000 hogsheads respectively. Thames water was allowed to remain for some time to settle before it was pumped for the supply of the customers. The higher parts of the districts were supplied by pumping from Paddington over a standpipe 61 feet higher than the reservoir, which was 85 feet above the Thames high-water mark. For the low-service supply the water flowed directly from the reservoirs. In the year 1830 the district supplied was chiefly Paddington, and the places between Oxford Street on the north and the Green Park on the south. In the year 1831 the directors of the Company adopted a rather ambitious scheme for supplying the whole of the Metropolis with water. It was proposed to supply Middlesex, Surrey, and part of Buckinghamshire, and the scheme included deepening and embanking some miles of the River Colne from its entrance into the Thames near Staines. Water was to be conducted through a canal 27 feet in width and 4 feet 6 inches in depth, and was to have two footpaths, one on each side. The work would have been one of considerable magnitude. The conduit was to pass over no less than twenty-six rivers, streams, and sewers, over thirty roads, lanes, and footpaths, and one of the aqueducts, it was said, would have been about three times the length of Blackfriars Bridge. There were also to be two tunnels, each 1,000 feet in length. The Bill for carrying out the project was referred to a committee of the House of Commons in April, 1831, and it was not passed. In the year 1835 the Company was authorized to remove their intake from the Thames at

Chelsea to Brentford, just above Kew Bridge. When in the year 1852 an Act was passed compelling all the Metropolitan water companies to take their supply from some part above the tidal river, an Act was obtained by the Company to authorize them to remove their intake to Sunbury.

PRESENT STATE—GENERAL DESCRIPTION.

Present State : General Description. The Grand Junction Waterworks Company supplies Sunbury, Hampton, Teddington, Hounslow, Sutton, Isleworth, Brentford, Hanwell, Ealing, Acton, Shepherd's Bush, Notting Hill, part of Bayswater, Paddington, Hyde Park, and Mayfair. The water is derived chiefly from the Thames at Hampton, but a small quantity is obtained from the gravel-beds there. The Company's stations are: Hampton, intake, arrangement for taking water from the gravel-bed, reservoirs, filter-beds, and pumping-station; Kew Bridge, Brentford, reservoirs, filter-beds, and pumping-station; Hanger Hill, Ealing, reservoirs, pumping-station; Campden Hill, reservoirs, pumping-station.

Hampton. HAMPTON (see Fig. 25).—The Hampton station is situated in the parishes of Hampton and Sunbury, Middlesex. A map is given showing the part of the station in which changes are going on, and it may be best to briefly describe the general arrangements of the station before going into detail.* At the eastern extremity of the works there is an engine-house marked E on the plan, and next to this the part cross shaded, marked A, is an old reservoir which is now in progress of conversion into filter-beds; further to the west is a covered reservoir, R C; five filter-beds, marked F 1 to 5; and a small engine-house G. Still further to the west there is a reservoir R; beyond this another engine-house, having to the north of it a preliminary filter-bed, F 6. At the part marked B another preliminary filter is being converted into two beds of the ordinary type. F 7 and F 8 are preliminary filters. The land immediately to the west of these belongs to the Southwark and Vauxhall Company, and beyond this, in the part marked I, there is an arrangement for filtering river water through gravel-beds. Immediately to the south of this on the island is the new intake of the Company D; D' shows the old intake. With regard to the pumping arrangements, it may for the sake of clearness be best to say in this place that the work to be done is of three kinds. Firstly, water has to be pumped from the river to the filter-beds. Secondly, water after filtration here is pumped directly for the country district. Thirdly, water is pumped to Kew Bridge, where it is filtered for the supply of the London district. Roughly speaking, the amount of the local supply is 6,000,000 gallons, and the amount pumped to Kew Bridge is 14,000,000 gallons daily.

* The work has been completed. A summary of the improvements effected is given on p. 117.

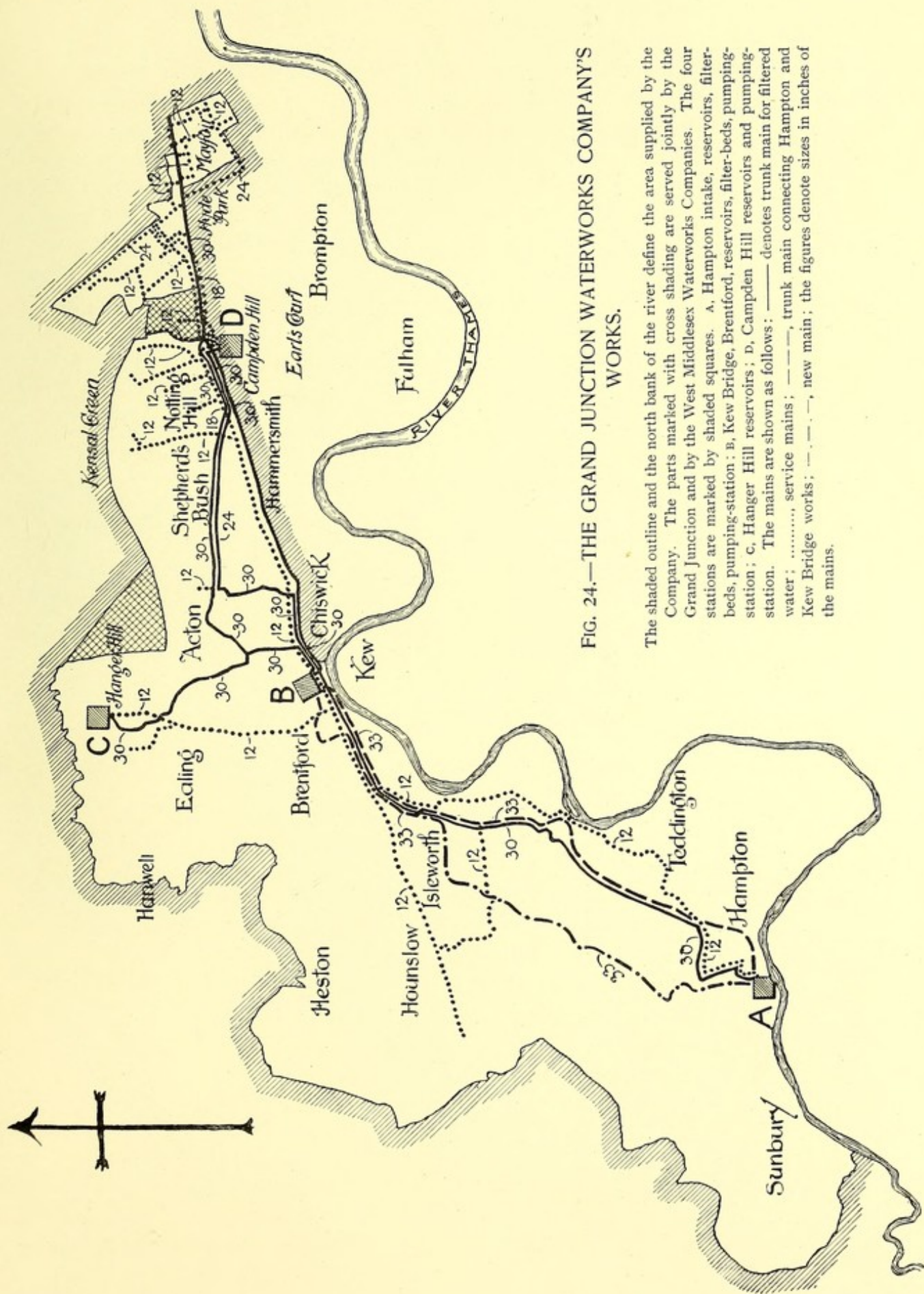


FIG. 24.—THE GRAND JUNCTION WATERWORKS COMPANY'S WORKS.

The shaded outline and the north bank of the river define the area supplied by the Company. The parts marked with cross shading are served jointly by the Grand Junction and by the West Middlesex Waterworks Companies. The four stations are marked by shaded squares. A, Hampton intake, reservoirs, filter-beds, pumping-station; B, Kew Bridge, Brentford, reservoirs, filter-beds, pumping-station; C, Hanger Hill reservoirs; D, Campden Hill reservoirs and pumping-station. The mains are shown as follows: — denotes trunk main for filtered water; service mains; - - - - new main; the figures denote sizes in inches of the mains.

Intakes.—The chief intake of the Company is from the Thames, and is situated Intakes. on a small island which is separated from the Middlesex shore by a backwater about 20 yards in width. At the part of the bank at which the water is taken there is a bay about 40 feet across, and the intake is protected by a floating boom. There are four gratings, formed of bars, which are placed about 3 inches apart, and the depth of the gratings is 2 feet 6 inches. These are cleared as occasion requires. In the autumn, when the river contains a large number of dead leaves, it is found necessary to keep a man constantly at work at it, but at other times the boom keeps off most of the débris. Through the gratings the water flows into a chamber, of

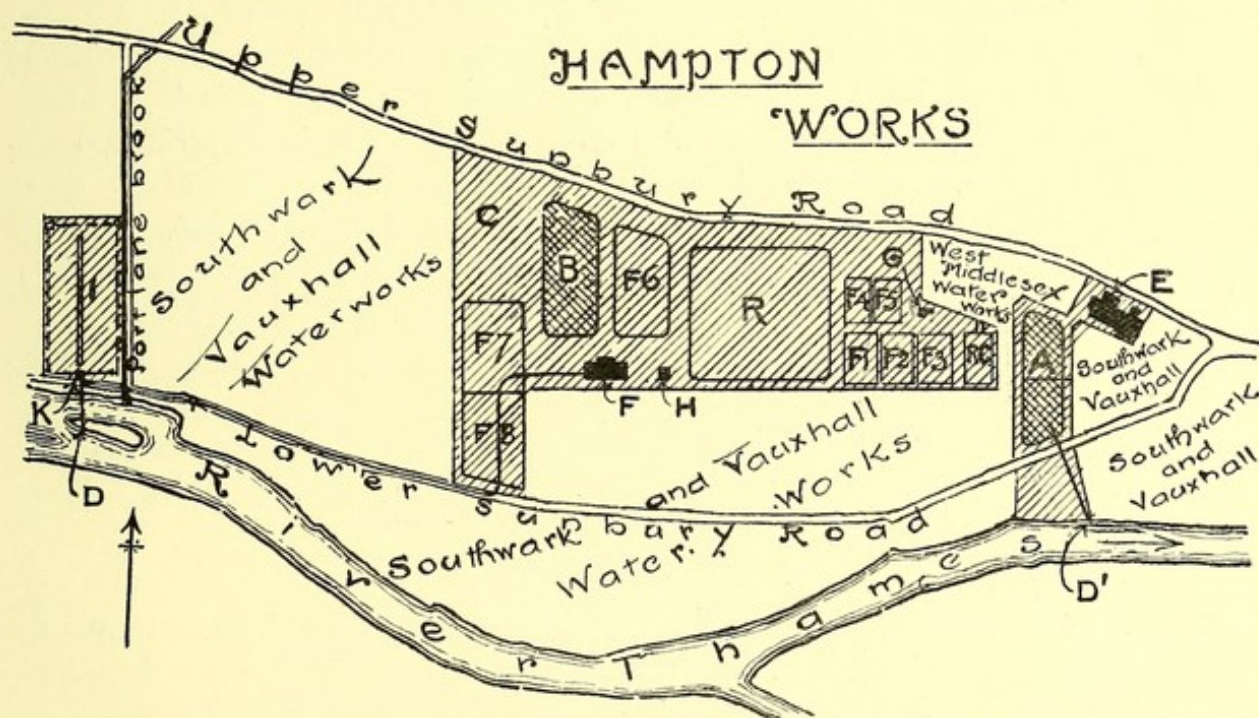


FIG. 25.—THE HAMPTON STATION.

Alterations are in progress at the parts cross-shaded and marked A and B; C is spare land; D, intake on the island; D', old intake; E, engine-house; F, Reidler engine-house; F 6, F 7, F 8, preliminary filter-beds; F 1, F 2, F 3, F 4, F 5, filter-beds for the local supply; G, house for diagonal engine; H, house for horizontal engines; I, meadow containing arrangements for collection of gravel-water; K, inspection chamber; R, reservoir; R c, covered reservoir.

which the walls are some feet above the highest flood-level, so that it is possible to go there whatever the state of the river may be. The height of the walls of the chamber is 11 feet above the mean summer level of the river, its size is 24 feet by 6 feet, and there is a grating on the top. Into the chamber situated to the west the water passes through three 30-inch sluices, and after going through the chamber it is conducted across the backwater in two 30-inch pipes. On the foreshore there is an inspection chamber (Fig. 25, K), 6 feet by 18 feet inside measurement. The water is received into this, and is then conducted to the engine-house (F) by two 36-inch pipes. A second intake also situated on the island conducts the water into a smaller reception chamber, which is situated on the eastern side, and adjoining the

Hampton. one just described. The chamber is separated from the other by a brick wall. On the island three layers of open jointed pipes were placed to receive water from the layer of ballast which is situated there. The line of pipes is about 8 feet below the mean summer level of the river. Two of these lines of pipes are still in working order, but it is found that very little water is collected by them except in flood-time. The water thus collected passes into the chamber with that taken from the river, and is then conducted to the mainland under the backwater through a 30-inch pipe. On the foreshore there is another arrangement for collecting water from the ballast. A line about 50 yards in length of 24-inch pipes is laid with open joints at a depth of about 8 feet below the mean summer level. The water thus collected from the ballast on the island, the water taken from the Thames, and the water collected from the foreshore in the pipes just described, is conducted through a 30-inch pipe to an engine-house H. A certain amount of water is also obtained by a special arrangement situated in a meadow just to the north of the Lower Sunbury Road (Fig. 25, 1), and this water passes with that derived from the sources just mentioned. The old

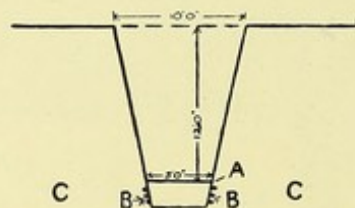


FIG. 26.—SECTION OF FILTER-TRENCH.

A, Surface of filter-bed; BB, openings for passage of water; CC, gravel-beds in meadow.

intake marked D' is situated between those of the Southwark and Vauxhall and the West Middlesex Companies, and from this source the water is taken for the supply of the filter-beds.

Gravel-water System.—From the foreshore inspection chamber which has been described a 24-inch iron pipe conveys the water for a distance of about 40 yards to the meadow, passing in its course under the Lower Sunbury Road, and conducting it into a filter-screen. The filter-screen is an arrangement of unusual character. A trench (Fig. 26) 12 feet in depth and 60 yards in length was dug in the meadow. The lower part of the trench is 6 feet in width, and the upper part 10 feet; the sides are concreted to a depth of about 15 feet from the surface, but the lowest part is perforated by small drainage-pipes. The bottom of the trench is filled with washed and screened ballast and fine shingle to a depth of 3 feet. The water flows in by gravitation from the inspection chamber, and its height is regulated by a cock. As a rule it is kept at about 1 foot below that of the mean summer level of the river, and as the surface of the filter-screens is 2 feet below this, the depth of water above the screen is, of course, about 1 foot. The water which covers the filter-screen gradually percolates through the filter-screen and then into the ballast, which is situated in the

meadow, and after passing for about 150 feet or so through this natural filter, it is collected by a layer of pipes which were laid in the ballast for that purpose. This series of collecting pipes surrounds the filter-trench (Fig. 27, c, c). The pipes are situated 12 feet below the mean summer level; they are of earthenware, 24 inches in diameter, and are laid with open joints. They conduct the water to two brick shafts (see Fig. 27, D, D), which are in a line with the 30-inch main, and the water passes from them into this main. The surface of the filter-screen is cleaned in the same way as that of an ordinary filter—that is to say, the surface is skimmed off to a depth of about 1 inch every month or so.

Pumping Arrangements.—The water passes by gravitation through the two 36-inch pipes previously described to an engine-house called the Reidler House, marked F on Fig. 25. It is pumped thence either to the reservoir (see Fig. 25, R) or to the preliminary filter-beds (see Fig. 25, F, 6, 7, 8).

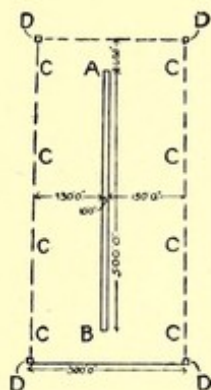


FIG. 27.—DIAGRAM OF GROUND PLAN OF THE ARRANGEMENTS FOR COLLECTING WATER FROM THE GRAVEL-BEDS.

A, B, Filter-bed, into which the river water is introduced; c, c, collecting pipes; D, D, D, D, brick shafts—the two at the lower part of the diagram represent the ones which discharge the water into the main which conducts it to the engine-house.

Engine-House.—The engine-house contains two pairs of Reidler engines, one pair high-lift, the other low-lift, a centrifugal and a Worthington engine. The low-lift Reidler engines pump the water into the reservoir R and into the preliminary filter-beds, F 6, 7, 8. The centrifugal engine is used for the same purpose. The high-lift Reidler engines pump the water from the preliminary filters and from the reservoir to Kew Bridge. The Worthington engine is used for the same purpose.

Low-lift Reidler Engine.—This engine has cylinders of 11 inches and 20 inches, and a stroke of 27 inches. It works double-action plunger pumps, the cylinders of which have a diameter of 23 inches. It therefore lifts 165 gallons per stroke, and it is worked at the rate of 60 revolutions per minute.

High-lift Reidler Engine.—This engine has cylinders with diameters of 21 inches and 39 inches, and a stroke of 36 inches. The diameter of the pump cylinder is 20 inches. It is worked at a rate of 60 revolutions per minute.

Hampton.

The Worthington Engine has cylinders $9\frac{1}{2}$ inches, 14 inches, and 25 inches, and a stroke of 2 feet 3 inches. It works a plunger pump, which has a cylinder 30 inches in diameter. It pumps 48 gallons per stroke, and the number of revolutions is from forty-five to fifty. These engines are worked by seven Lancashire boilers at a pressure of 90 pounds. The head of water worked against in pumping to the reservoir is 28 feet, and in pumping to Kew 130 feet.

Horizontal Engine-House.—This house contains two horizontal engines having cylinders of 16 inches and 21 inches in diameter respectively. These work three-throw pumps, which raise the water brought from the river and the gravel-beds through the 30-inch pipe, and raise it to the reservoir and to the filters which are used for the local supply. The pumping capacity is 11,000,000 gallons per day, but about 6,000,000 gallons only are usually required.

Filters: Preliminary Filter (Fig. 25, F 6).—This has an area of three acres, and it is surrounded by a puddle wall taken down to the London clay. The filtering material consists of 2 feet of sand and 4 feet of screened ballast. The filtered water is collected by three 24-inch earthenware pipes, which conduct it to the Reidler engine-house. There are no cross drains.

Preliminary Filter-Beds (F 7 and 8).—There are two beds called “preliminary” filter-beds, each of which has an area of about one and three-quarter acres. The upper parts are lined with blue Staffordshire bricks; the upper 2 feet of the walls are vertical, and the lower part is formed of concrete at a slope of $2\frac{1}{2}$ to 1. The bed of the filter is formed as follows: Sand, 2 feet 6 inches; ballast, 1 foot 6 inches to 2 feet. The ballast is thicker at the centre than at the sides of the bed, and the floor slopes gradually towards the centre, where it is 6 inches deeper than it is at the sides. When cleansed the sand is reduced in thickness from 2 feet 6 inches to 2 feet. The filtered water is collected in earthenware pipes 12 inches in diameter, which are laid with open joints, and conduct the water into a central culvert.

Storage Reservoir (see Fig. 25, R).—This reservoir covers an area of about ten acres; the upper part is lined with blue Staffordshire bricks, and the walls, which are built of concrete, have a slope of 3 to 1. It is surrounded by a puddle trench, which goes down to the London clay. The reservoir is 22 feet deep, and is said to be capable of storing 45,000,000 gallons of water. The water for the supply of this reservoir comes from the river in part through a 36-inch main, and the gravel water is also pumped here.

Water for the London district is pumped from Hampton to Kew and filtered there. For the local supply the water is filtered at Hampton and distributed directly to the district.

Filter-Beds.—The five filter-beds which are used for the local supply (see Fig. 25, F 1 to F 5) have an area of three-quarters of an acre each. They are of oblong form; the upper part is lined with Staffordshire bricks. The walls of Nos. 4 and 5 are nearly

vertical. The filtering material is formed of 2 feet 6 inches of sand and 2 feet of shingle. For the collection of the filtered water there is a central culvert, of which the sides are built in part with perforated bricks to allow the passage into it of the filtered water. The upper part of the culvert has stone covers. Water is conducted to its perforated sides through land drain-pipes 2 inches in diameter. These filter-beds have no ventilators. The sides of beds Nos. 1, 2, and 3 have a slope of 2 to 1. In other respects they are similar to filters 4 and 5.

Cleansing Filter-Beds.—As a rule filter-beds are cleansed once a month, and in early summer more frequently. The sand is always washed by means of an apparatus made of cast-iron hoppers with ejectors. The pressure of the water used is about 150 feet. It is found that 4,500 gallons of water are used in washing a cubic yard of sand. When the sand was washed by means of high-pressure without this hopper arrangement, no less than 7,000 gallons of water were used in washing a cubic yard. The sand is very efficiently washed by the arrangement in use at this station.

The Rate of Filtration.—The maximum rate of filtration is $2\frac{1}{2}$ gallons per square foot per hour. As a rule the rate is $1\frac{3}{4}$ gallons per square foot per hour.

Pumping Arrangements for the Country District.—For the local supply of water a "diagonal" engine situated in a house marked G and two pairs of beam engines are used. The diagonal engine is one of unusual form, is capable of pumping 176 gallons per stroke, and works at a rate of 14 strokes per minute. The steam for working the engine is generated by three Lancashire boilers, and the pressure used is 80 pounds.

Covered Reservoir.—There is a reservoir covered by concrete arches built on steel girders which are supported by brick piles. This reservoir is capable of storing 3,000,000 gallons. The water from it is used entirely for the local supply. It passes to the engine-house (marked E), and is pumped by the beam engines.

Engine-House (Fig. 25, E).—The western part of the engine-house contains two beam engines, which have cylinders 24 inches and 48 inches in diameter, and a stroke of 8 feet. These work bucket and plunger pumps. The diameter of the bucket is $29\frac{1}{2}$ inches, and that of the plunger 21 inches. The steam pressure used is 60 pounds. The head of water worked against is 150 feet. The pump discharges 236 gallons per stroke, and the rate is about 12 per minute. There is an electrical communication between this house and Hampton Court Palace. The Company have arranged to supply water there in case of fire. The engine is worked by four Lancashire boilers at a pressure of 60 pounds.

Bull-Engines.—There are three direct acting Cornish engines of the Bull type. Of these one has cylinders of 70 inches in diameter, and two have cylinders of 68 inches. These engines were formerly constantly used for pumping water to Kew, but they have not been much used since the erection of the Reidler engines in 1891. Of these engines two are capable of pumping 559 gallons per stroke, and were

worked at a rate of about 12 a minute, and the other is capable of pumping 695 gallons per stroke, and was worked at a rate of about 11 strokes per minute. The steam for these engines was supplied by four Cornish boilers at a pressure of 40 pounds.

The Course of Mains from Hampton to Brentford.—A single 33-inch main conveys the water through Twickenham and Isleworth. The course of the main is along the high-road. From Isleworth—that is to say, for the last two miles—the water is conducted in two 33-inch mains.

Kew
Bridge
Works,
Brentford.

Kew Bridge Works, Brentford (see Fig. 24, B, and Fig. 28).—The Kew Bridge station is situated at Brentford in Middlesex. The area is about twenty-six acres. It consists of reservoirs, filter-beds, and a pumping-station, which are situated

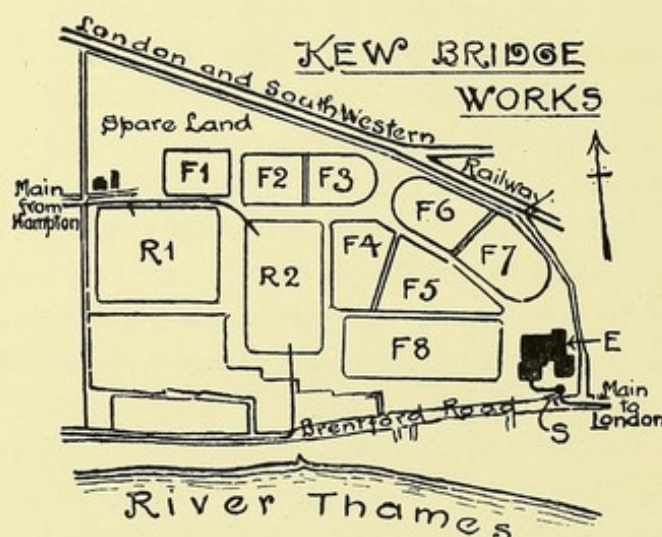


FIG. 28.—KEW BRIDGE STATION, BRENTFORD.

R 1, R 2, Reservoirs; F 1 to F 8, filter-beds; E, engine-house; S, stand-pipe tower.

to the north of the Brentford Road. There is a store-yard and a house for the assistant engineer to the south of the road.

Reservoirs.—There are two reservoirs, an upper and a lower. The upper reservoir is capable of holding 14,000,000 gallons of water. Its depth in the centre is 14 feet. The slopes are lined with brick and concrete, and the bottom and sides are puddled. The lower reservoir is situated at a level of 8 feet below the other. Its depth in the centre is 10 feet. It is capable of holding 8,000,000 gallons. The upper reservoir is supplied by both the 33-inch mains. The lower reservoir is supplied from both mains and also from the upper reservoir, from which the water flows to it in the form of a cascade.

Filter-Beds.—There are eight filter-beds, which have a total area of about eight and a half acres. They are of somewhat irregular shape, but they are con-

structed on the same lines. They have from $2\frac{1}{2}$ feet to 3 feet of sand, and from 2 feet to 2 feet 6 inches of ballast. The only differences in them consist in the arrangements for the collection of filtered water, the presence or absence of ventilators, and the fact that two of them possess large filtered-water chambers beneath. Filter No. 1 has an area of three-quarters of an acre; it has a central filtered-water channel and a small ventilation pipe in connection with the filtered-water channel on one side. Filters Nos. 2 and 3 have chambers for the storage of filtered water beneath them. These are covered with brick arches, the upper parts of which form the floors of the filter-beds. Each is capable of holding 1,000,000 gallons. No. 4 has an area of one and a quarter acres. The arrangement for collecting filtered water is by means of ballast. There are no drain-pipes at the bottom. Two air-ventilators are situated over the filtered-water culverts. No. 5 has an area of one and a quarter acres. There are ventilators at the sides, and one central one in communication with the filtered-water channel. No. 6 has an area of three-quarters of an acre, and it has no central air-shaft. No. 7 has an area of three-quarters of an acre, and two ventilating shafts. No. 8 has an area of one and two-thirds of an acre. It has three large air-shafts built of brick communicating with the filtered-water culvert. The water from all the filter-beds passes into a well situated near the engine-house, and from this it is conducted to the various engine-wells.

Kew Bridge,
Brentford.

Pumping Arrangements. — A Worthington engine capable of pumping 5,000,000 gallons a day is used for the supply of the London district. It is worked at a pressure of 125 pounds. The head of water worked against is 180 feet. This engine pumps 104 gallons per stroke, and the rate at which it is worked is 35 strokes per minute. A Cornish engine of the Bull type, having a cylinder of the diameter of 70 inches and a stroke of 10 feet (and which therefore pumps 253 gallons per stroke), is worked at the rate of 12 strokes per minute. A Cornish pumping-engine, having a cylinder 65 inches in diameter and a stroke of 10 feet, pumps about 2,500,000 gallons a day to Ealing, working against a head of 235 feet. This pump is worked at a rate of 12 strokes per minute. Another engine, called the East Cornish, is also used for pumping to Ealing. This engine has a cylinder of 65 inches and a stroke of 9 feet. An engine called the West Cornish is used for pumping to the London district. It has a cylinder of 65 inches, and pumps 140 gallons per stroke, usually working at a rate of 14 strokes per minute. The steam for the Worthington engine is generated by a water-tube boiler, and the engine is worked at a pressure of 125 pounds. The other engines are worked by steam, generated by one Lancashire and fifteen Cornish boilers at a pressure of 40 pounds. Two other engines, called the "Ninety" and "The Hundred," are used for pumping to London. Of these, the cylinder of one is 90 inches, and the stroke 10 feet 6 inches. The diameter of the cylinder of the other engine is 100 inches, and it has a stroke of 11 feet. The water pumped by the Cornish

engines passes through a stand-pipe 200 feet in height. The stand-pipes are situated in a brick tower. There are two pipes for conducting water up and two for its return, and an overflow pipe. The rising main is 6 feet in diameter at the base, and the return pipe 3 feet. The Worthington engine pumps directly into the main. The station contains a cottage and a large workshop. There is also a store-yard situated to the south of the Brentford Road next to the river, the site of the former intake of the Company.

Hanger
Hill, Ealing.

HANGER HILL, EALING (see Fig. 24, c, and Fig. 29).—This station is situated at the highest point of Hanger Hill, 200 feet above Ordnance datum. It consists of two uncovered reservoirs, and a tower containing a cistern. The high service reservoir is concreted at the sides and bottom, and lined at the upper part with blue

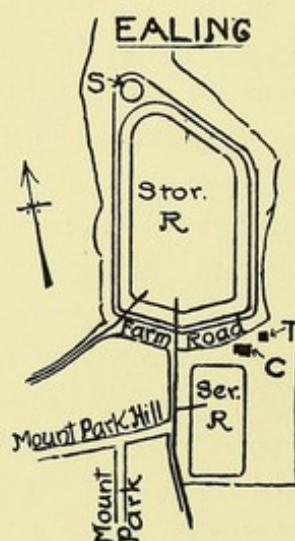


FIG. 29.—HANGER HILL STATION.

s, Strainer; Stor. R, storage reservoir; Ser. R, service reservoir; c, cottage; t, tower.

Staffordshire bricks. It is capable of holding 3,000,000 gallons of water. There is another reservoir of which the top water-level is 7 feet below that of the one just described. It is capable of holding 54,000,000 gallons. Its depth in the middle is 35 feet. Its shape is somewhat irregular; the sides slope as $1\frac{1}{2}$ is to 1. They are lined with concrete for the lower 10 feet, and above with pressed bricks laid on edge, and set in cement on a concrete bed. This reservoir is provided with an outlet tower fitted with five valves placed at different heights, so that water can be drawn off at some point a few feet below the surface of the water, no matter at what level the surface of the water may be. Water for the supply of this reservoir is pumped from Kew. Before it is distributed it passes through a strainer. The strainer is in reality a filter-bed. It is a circular shaft 60 feet in diameter, and is provided at the bottom with 2 feet of fine shingle. Before distribution all the water

from this reservoir passes through the strainer. The reservoirs are separated one from the other by a public road; both are fenced in. Near the high-service reservoir there is the tower containing a cistern, of which the outside dimensions are 16 feet by 16 feet by 8 feet. The water is pumped into it by a small gas-engine. This water is used for the high-service supply of the houses in the immediate neighbourhood. A caretaker's cottage is situated here.

CAMPDEN HILL (Fig. 24 D, and Fig. 30).—This station is situated 130 feet above Ordnance datum on the highest part of Campden Hill, just to the north of Airlie Gardens and next to the Campden Road, which separates it from the reservoirs of the West Middlesex Water Company. There are three covered reservoirs, a pumping-station, three cottages, and an office. The total area is about five acres. The reservoir which was first constructed (see Fig. 30, O R) is covered with brick arches built on iron girders, which are supported by brick arches. It is ventilated by

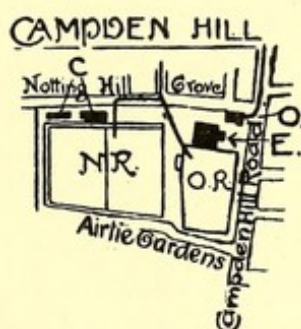


FIG. 30.—CAMPDEN HILL STATION.

C, Cottages; O, office; E, engine-house; N R, new reservoirs; O R, old reservoir.

means of iron shafts. The bottom of the reservoir is lined with concrete, and the sides slope 1 in 4. The capacity of the reservoir is stated to be 4,000,000 gallons. The top is covered by a thin layer of earth and is turfed over. The two newer reservoirs (Fig. 30, N R) are covered with arches built on brick piers, and are ventilated by perforated bricks at the sides. The slope of the sides of these reservoirs is less oblique than in the older one. The maximum depth of water to which they are filled is 19 feet, and they are stated to have a capacity of 7,000,000 gallons each. The western reservoir and part of the middle one are partly covered with concrete, and the top is let to a lawn-tennis club.

Pumping Arrangements.—There are three Cornish engines. Of these, two have cylinders 70 inches in diameter, and a stroke of 10 feet. The third engine has a cylinder 90 inches in diameter, and a stroke of 10 feet. There are nine Cornish boilers. The water is pumped into a stand-pipe, of which the top is 288·4 feet above Ordnance datum. The stand-pipe is situated in the tower which is such a

conspicuous object on Campden Hill. The high pressure is obtained for the high-service supply of Maida Vale and the Park Lane district.

Communica-
tions with
other Com-
panies'
Mains.

Communications with other Companies' Mains.—The mains of the Company communicate with those of the West Middlesex, the Chelsea, and the East London Waterworks Companies; with the West Middlesex Company's by a 24-inch main in Edgware Road, opposite Kilburn Park Road; with the West Middlesex Company's from the same 24-inch main into a 21-inch main at the junction of Edgware Road and Bayswater Road; with the Chelsea Company's 24-inch connection at Hyde Park Corner; with the East London Company's connection from the 36-inch main into Kew works; and with the East London Company's mains into service mains in the Grand Junction Road and neighbourhood.

Statistics.

Length of New Pipes.—The length of new pipes ranging from 3 inches to 7 inches laid in 1895 was 4,762 yards, and during the year 1896 was 9,516 yards.

Hydrants.—The number of hydrants erected during the year 1895 was thirty-five, during the year 1896 eight, and during the year 1897, ten.

Houses under Constant Supply.—The number of houses under constant supply on December 31, 1894, was 59,443; on December 31, 1895, 60,150; on December 31, 1896, 60,910; on December 31, 1897, 61,859.

Percentage of Houses under Constant Supply.—On December 31, 1896, all the houses were under constant supply, and they have been so since that date.

Highest Supply given.—The highest supply given is at about 200 feet above Ordnance datum.

MAXIMUM AND MINIMUM MONTH OF SUPPLY.

YEAR 1895.			YEAR 1896.		1897.
	Month.	Quantity in Gallons.	Month.	Quantity in Gallons.	Month.
Maximum	June	22,382,109	July	22,618,801 daily average.	July.
Minimum	January	17,686,913	March	16,987,660 „ „	February.

The average daily supply per head for the year 1897 was 49·03 gallons. In July, 1897, the daily supply per head rose to 56·00 gallons, and in February it was 44·80 gallons. The average daily supply per head for the month of September, 1898, was 53·93 gallons.

TABLE OF STATISTICAL DETAILS GIVEN BY THE GRAND JUNCTION WATERWORKS COMPANY.

		FOR THE YEAR 1896.	FOR SEPTEMBER, 1898.
SUPPLY.	Average daily supply in gallons ...	18,796,284	22,041,429
	Percentage delivered for other than domestic purposes, exclusive of waste ...	20 per cent.	
	Number of houses supplied ...	60,544	63,067
	Number of houses on constant supply ...	60,544	63,067
	Estimated population supplied ...	411,663	408,674
RESERVOIRS.	Number ...	5	5
Subsiding and storage unfiltered water ...	Area in acres ...	17	17
Storage filtered-water reservoirs	Available capacity in gallons ...	64,500,000	64,000,000
	Number ...	7	
	Capacity in gallons ...	76,000,000	76,000,000
ENGINES.	Number ...	25	
	Horse-power ...	3,716	
	Greatest lift ...	235 feet.	
	Head of pressure in the district supplied ...	155 feet.	
WATER-PIPES.	Total number of miles of water-pipes ...	445 $\frac{1}{2}$	460 $\frac{3}{4}$
	Number of miles of water-pipes in the metropolis ...	191 $\frac{1}{8}$	191 $\frac{3}{4}$
	Number of miles of streets with water-pipes constantly charged in the metropolis ...	135 $\frac{5}{8}$	136 $\frac{1}{4}$
	Number of hydrants erected within the metropolis ...	1,615	1,616
FILTERS.	Number of beds ...	17	21
	Area in acres ...	21 $\frac{3}{4}$	24 $\frac{1}{4}$
	Depth of sand and other materials ...	<i>Old pattern :</i> Sand 2 feet 6 inches ; hoggin, 6 inches ; fine gravel, 9 inches ; coarse gravel, 9 inches ; boulders, 1 foot. <i>New pattern :</i> Sand, 2 feet 6 inches ; gravel, 6 inches ; drains, 3 inches.	

WORKS RECENTLY COMPLETED AND IN PROGRESS.

HAMPTON.—1. Six acres of preliminary filter-beds at this station have been converted into filters of the most recent type, and two new filters having a combined area of two and a half acres have been constructed.

Works
Recently
Completed
(Hampton).

**Staines
Reservoirs.**

New Reservoirs at Staines.—An Act of Parliament was passed in the year 1896 authorizing the West Middlesex, Grand Junction and New River Companies to construct reservoirs at Staines. The work is in progress.

AREA OF SUPPLY.**Area of
Supply.**

The Act of 1852 authorizes the Grand Junction Company to supply the following places, two of which are entirely, and the others partly, supplied by the Company :

Supplied.—Brentford, Ealing.

Partly Supplied.—Hammersmith, Kensington, St. Mary Abbots, Paddington, St. George, Hanover Square, St. James, Westminster, and St. Marylebone.

The Act of 1861 authorizes the supply of the following places, almost all of which are entirely supplied by the Company : Acton, Bushey Park, Chiswick, Hampton, Hampton Court, Hampton Wick, Hanworth, Isleworth, Teddington, Twickenham, and Whitton. (Hampton Court Palace has a separate and private supply.) Parts of Ealing and Isleworth were excluded by this Act. The Act of 1878 authorizes the supply of Heston and Hanwell (which are entirely supplied by the Company) and the previously excluded parts of Ealing and Isleworth.

THE KENT WATERWORKS COMPANY.

HISTORY.

THE Kent Waterworks Company possesses the rights of an old-established institution which dates back to the reign of William III. The present Company has also absorbed quite a number of small undertakings, which have been started at different times (see Fig. 31). In 1701 letters patent were granted at the request of the inhabitants of Sayes Court* and East Greenwich, giving to the patentees liberty to break up streets and grounds in those places for the purpose of laying pipes to convey water, and a monopoly was granted for this work, all other persons being prohibited under pains and penalties for a period of 500 years from interfering with the water-supply in these parishes. The result of this privilege was that waterworks were made at Ravensbourne, and these continued to be worked till the year 1808. In the following year an Act was passed incorporating the proprietors of the waterworks, and it was provided that the Company should buy the letters patent which had been granted by William III. and the rights and privileges which belonged to them and the works which were already in existence. The Act of 1809 prohibited the Company from supplying water in such a way as to directly or indirectly affect those rights without the consent in writing of the people concerned or till the old waterworks were bought. Ultimately the patent was bought, and "The Company of Proprietors of Kent Waterworks" became under the provisions of the Act possessed of all the privileges, authorities, duties, and offices given by the letters patent. The manors of Sayes Court and East Greenwich included the towns of Greenwich, Deptford, and the adjoining districts, and under the Act of 1809 the authorized limits of supply were the two parishes of Deptford and the parishes of Greenwich, Lee, Lewisham, and Rotherhithe. A year before this Act of Incorporation was passed the Town Commissioners of Woolwich had obtained Parliamentary powers to supply the town of Woolwich with water, and in 1810 the Commissioners came to an arrangement by

* It may, perhaps, be permissible to leave dull details for a moment to recall the fact that the Royal Manor of Sayes Court is a place of considerable historic interest. It was granted by Charles II. under his great seal to John Evelyn, a second son of the then head of that family—a family which Surrey has, as in the case of the Onslows, attracted from Shropshire. Mr. John Evelyn, "a most ingenious and polite gentleman, well versed in useful learning," is best remembered by the world at large by the Diary he left and by his book on trees. The family seat at Wotton, to which he afterwards succeeded, still shows the results of his love of practical gardening. At Sayes Court lived for a time Peter, Czar of Muscovy, generally known as Peter the Great.

supplied, and later contracts were made for the supply of the Royal Arsenal, the Admiralty establishments, the Dockyard at Woolwich, the Royal Observatory, the Royal Naval Hospital, and His Majesty's Dockyard and Victualling Yard at Deptford. As in the case of some other companies, the profits made were for a time chiefly used in the outlay necessarily involved in extending the area of supply.*

In 1850 and 1852 Acts were passed enabling the Company to increase their capital. About the middle of the present century an establishment called the Plumstead, Woolwich, and Charlton Consumers' Pure Water Company was started. A well was constructed, and the necessary plant was put up by the Company, which, however, afterwards became bankrupt, when the plant was bought by the Kent Waterworks Company. In 1860 the North Kent Company was started with an idea of supplying Dartford, Crayford, Bexley, Wickham, Erith, Eltham, Chislehurst, and Bromley. The business of this undertaking was taken over by the Kent Company in 1864, and at the same time fresh capital was raised, and a schedule of water-rates was prescribed. The Company's area now included the places just mentioned. In 1867 the Local Board of Dartford sold their waterworks, which were acquired by the Kent Company, and the Company's area was thus extended to a district having a total area of about 68 square miles. In 1877 the Bromley Rural Sanitary Authority requested the Kent Company to supply their district, and the Dartford Rural Sanitary Authority made a similar request. The result was that the Kent Waterworks Act of 1877 was passed, and extended the limit of supply to the following places, viz.: Swanscombe, Stone, Darenth, Wilmington, Sutton-at-Hone, Farningham, Eynsford, Foots Cray, North Cray, St. Paul's Cray, St. Mary Cray, Orpington, Farnborough, Chelsfield, Keston, West Wickham, and Hayes, and the portion of Beckenham known as Shortlands. The Company's district of supply was thus extended to an area of 120 square miles. In 1885 the Bromley and the Sevenoaks Rural Sanitary Authority requested the Kent Waterworks Company to supply parts of their districts. The necessary Act of Parliament was obtained in 1888, and the Company's limits of supply were thus extended to an area of about 178 square miles, of which about 30 only are within the county of London, the remainder being in the county of Kent. When the Company as at present constituted began their business by taking over the Ravensbourne Waterworks, the undertaking was a comparatively small affair.

The works were situated on the banks of the river, and consisted of a pump which was worked by a water-wheel. The machinery was designed by Smeaton. The water was distributed through wooden pipes. A few years later a pair of steam-

* The early struggles of the Company are rather plaintively but hopefully referred to in a will of one of the proprietors, dated 1815: 'I am possessed of shares in the Kent Waterworks. They originally cost £100 each. God knows how they will go on; at all events they will want time to grow. I therefore leave them to'. The testator left the shares to his 'opposite neighbour's' daughters.

engines were put up by Boulton and Watt, and these engines are still working. Un-filtered water was used till the year 1844, when the first filter-bed was made, and in 1850 a subsidence reservoir was made, and more filter-beds were constructed. The reservoir is still in existence; it is situated to the west of the river, but it has for years been disused as a source of water-supply, and remains as a piece of ornamental water in the garden of the engineer. The water of the Ravensbourne was insufficient to afford a supply, and in 1857 a deep well was sunk in the chalk. An abundant quantity of pure water was found, and from the year 1862 the entire district of the Company has been supplied by well water. New wells have been sunk as occasion required. All of them are in the chalk except the one at Westerham, which is in the lower greensand.

GEOLOGY OF THE DISTRICT.

Geology of
the District.

The Kent Waterworks Company derive all the water they supply from deep wells; it is therefore of interest to note the geological character of the district. The Company's area is bounded on the north by the River Thames, and to the south it extends beyond the North Downs. A diagram (Fig. 32) shows the arrangement of the geological strata.

At the extreme south Westerham is on the lower greensand, a formation which contains extremely good water, much less hard than the water found in the chalk.

Passing northwards, there is next a narrow layer of gault, an almost impervious clay formation; then farther northwards there is a narrow band of upper greensand. Still farther northwards is the range of the North Downs, which run in a direction nearly due east and west, the eastern end running to the sea just south of Deal. In a westerly direction the downs run just to the north of Reigate and Dorking to Guildford, and from the west of Guildford towards Farnham. Near Westerham the crest of the chalk escarpment is generally over 600 feet above the sea-level. The ground falls from the crest sharply to the south; towards the north and the north-east the slope is more gentle. The diagram (Fig. 32) shows the position of two of the chalk wells at Orpington and Crayford, and the position of the river-beds of the Cray, the Darent, and the Thames.

On the North Downs there are patches of clay with flints and loam. These patches are irregularly distributed. From Westerham to Orpington the section shown in the diagram runs in a north-north-easterly direction; from Orpington to Purfleet the section runs in a north-easterly direction. Between Orpington and the line of the London, Chatham, and Dover Railway there are springs. There are patches of lower tertiary beds between this point and Crayford, which is on the chalk.

The depth of the level of water in the chalk varies. For example, on March 25, 1897, the level of the well at Orpington was about 60 feet below the surface of the

ground. In a dry summer the level has been as low as 90 feet below the surface. In estimating the water-bearing capacity of a district like that described it is necessary to know not only the area, but the amount of rainfall, and it must be borne in mind that to be on the safe side it is necessary to reckon only the percolation which would take place during a dry year. Through a chalk district water finds its way to the sea in different ways. Some of the water rises in springs, which break out at the foot of the chalk escarpment; some of it in wet seasons breaks out in streams in the higher levels, but during dry periods these streams do not run at all. Some, again, break out in springs in the lower ground. Much water, however, passes in underground channels; through chalk its passage is slow. Some of this underground water passes through fissures and in the lines in which flints occur. It passes also in large amount through faults in the chalk, which are water-bearing channels. It may be remarked in passing that a well which happens to be sunk in the course of one of these faults will afford a bountiful supply, and headings which are made in

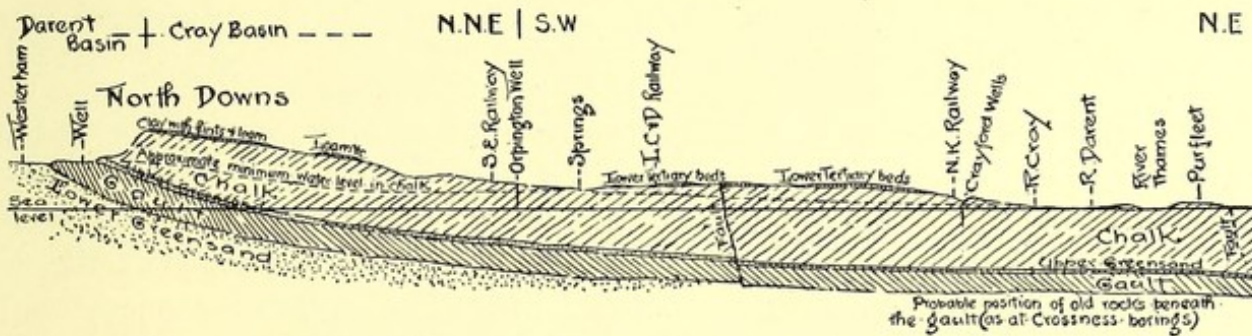


FIG. 32.—DIAGRAM SHOWING SECTION OF THE GEOLOGICAL STRATA FROM THE NORTH DOWNS, NEAR WESTERHAM, ACROSS THE RIVER THAMES TO PURFLEET.

connection with the deep wells in the chalk are made more or less in the hope of coming across one of these channels.

The average of the rainfall over the district is estimated to be about 26 inches. It is less than this over the lower ground, and at Greenwich is about 24 inches; but on the higher levels it rises to 30 inches. It is a difficult or impossible matter to determine how much of the rainfall is available for the supply of wells which are constantly pumped. At one time 6 inches a year of the total rainfall was supposed to be the amount which it was likely could be used. Later the estimate was considerably raised, when it was thought that as much as 12 inches might be available. The present amount of water used daily by the Kent Company is estimated at about 18,600,000 gallons. According to some evidence that was given before the last Royal Commission on the Metropolitan Water supply, it was stated that the Company's Parliamentary area would be likely to afford a supply of 30,000,000 to 40,000,000 gallons daily.

PRESENT STATE : GENERAL DESCRIPTION.

Present
State :
General
Description.

The whole of the water supplied by the Kent Waterworks Company is obtained from deep wells, and is delivered direct to their customers. There are therefore no depositing reservoirs and no filter-beds. The reservoirs of the Company are for the temporary storage of water. The stations of the Company are : Deptford, wells, pumping-station, reservoirs, and offices ; New Cross, reservoir ; Woolwich Common, reservoir ; Plumstead, well and pumping-station ; Plumstead Common, reservoir ; Greenwich Park, reservoir ; Chislehurst, reservoir ; Shortlands, wells and pumping-station ; Crayford, wells and pumping-station ; Dover Road, Shooter's Hill, pumping-station ; Shooter's Hill, reservoir and stand-pipe ; Farnborough, wells and pumping-station ; Cowlass Hill, Farnborough, reservoir ; Dartford, reservoir ; Layham Farm, West Wickham, reservoir ; Knockholt, reservoir ; Wilmington, wells and pumping-station ; Westerham, well, pumping-station, and reservoir ; Betsom's Hill, reservoir ; Pilgrim's Way, well and pumping-station ; and Eltham, reservoir. There are new wells at West Wickham and Southfleet.

Deptford.

DEPTFORD (see A, Fig. 33).—The station at Deptford is on the site of the original works of the Company ; part of it is to the east and part to the west of the river Ravensbourne. The part on the west side of the river consists of the offices of the Company, the engineer's house, a well called the Garden Well, the old engine-house, and a large garden containing the reservoir which was formerly used. The Ravensbourne is crossed by a bridge, on the site of the old water-wheel, which was used for pumping. The fall in the Ravensbourne at this point is not now made use of. To the east of the river there is an enclosed space containing two wells (the New Well and the Bath Well), engine-houses, and two covered reservoirs. This is the site of the filter-beds which were used when the river was the source of the water-supply.

The *Garden Well* derives its name from its situation. The ground-level here is 20 feet above Ordnance datum. The depth of the well is 100 feet, the diameter at the top is 15 feet, and at the lower part 12 feet. The upper 15 feet are lined with brick, the lower part is lined with iron cylinders. There are some headings in this well and a bore-hole. The water from this well is pumped by some of the original machinery put up by Boulton and Watt. There are two engines of 50 horse-power (nominal), and these work force-pumps, which raise 42 gallons per stroke, and work at about the rate of 16 strokes per minute. The steam is generated by three Cornish boilers. The water is pumped to the high-level district in connection with the reservoir on Woolwich Common.

The *New Well* was sunk in the year 1868. It is 100 feet in depth, and has headings. It is lined with iron cylinders to a depth of about 75 feet. The water is

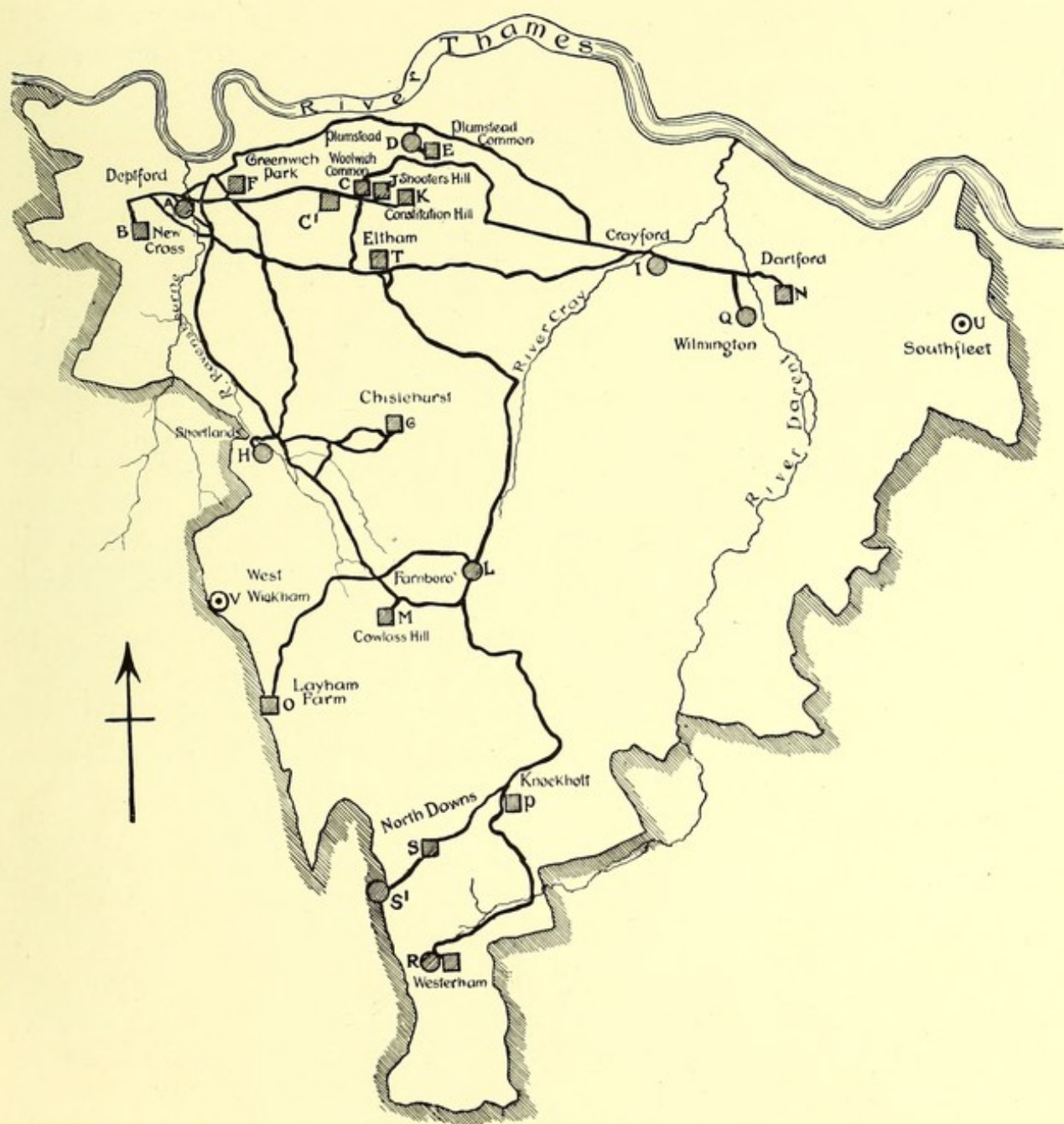


FIG. 33.—THE KENT WATERWORKS COMPANY'S WORKS.

The shaded outline with the southern bank of the river defines the area supplied by the Company. Wells are marked as shaded circles. Wells under construction are marked as plain circles around a central dot. Reservoirs are marked as shaded squares. A, Deptford well, pumping-station, and reservoir; B, New Cross reservoir; C, Woolwich Common reservoir; C', Dover Road, Shooter's Hill, pumping-station; D, Plumstead well and pumping-station; E, Plumstead Common reservoir; F, Greenwich Park reservoir; G, Chislehurst reservoir; H, Shortlands well and pumping-station; I, Crayford well and pumping-station; J, Shooter's Hill reservoir; K, Shooter's Hill stand-pipe; L, Farnborough well and pumping-station; M, Cowlass Hill, Farnborough, reservoir; N, Dartford reservoir; O, Layham Farm, West Wickham, reservoir; P, Knockholt reservoir; Q, Wilmington well and pumping-station; R, Westerham well, pumping-station, and reservoir; S, Betsom's Hill reservoir; S', Pilgrim's Way well and pumping-station; T, Eltham reservoir; U, Southfleet, Gravesend, well; V, West Wickham well.

pumped by two Cornish engines; of these one works a lift-pump, which raises 300 Deptford. gallons per stroke, and the other a force-pump, which distributes 200 gallons per stroke. The latter works against a head of 180 feet, and pumps the water to the reservoir at New Cross. The steam is generated by five Cornish boilers, working at a pressure of 35 pounds.

The *Bath Well* gets its name from a neighbouring street, Cold Bath Street. It was sunk in the year 1874. The depth of the well is 100 feet, and it has headings which extend for 80 feet to a bore-hole which is situated beneath a disused well. The diameter of the well is 10 feet, and the upper part is lined with iron cylinders to a depth of 70 feet. The water is raised by a Cornish engine (brought here from Charlton, dated 1859), which works a lift-pump and a force-pump. The lift-pump raises 240 gallons per stroke from the well, and of the water so raised the force-pump lifts 100 gallons per stroke to Greenwich Park, working against a head of from 150 to 160 feet. The remainder of the water raised by the lift-pump flows to the covered reservoir. The steam for the engine is generated by three Cornish boilers, working at a pressure of 35 pounds. Near the Bath Well is a disused engine-house.

There are two reservoirs capable of storing 2,000,000 gallons. The reservoirs are covered by concrete arches built on brick walls, and the arrangement of the walls insures a circulation of the water in the reservoir.

According to the report given by the secretary of the Company, the engines at Deptford have a total horse-power of 858.

NEW CROSS (Fig. 33, B).—The station at New Cross is situated in Jerning- New Cross. ham Road, Hatcham, not far from the church dedicated to St. James. It consists of a reservoir, built of brick, arched over, and covered with turf. It is capable of holding 1,750,000 gallons. The top-water level is 163 feet above Ordnance datum.

WOOLWICH COMMON (Fig. 33, c).—There is a covered reservoir on Woolwich Woolwich
Common. Common. It is situated to the south-west of the Royal Military College, and to the south of the road between the college and the Herbert Hospital. The part of the Common which is occupied by the reservoir is enclosed by low iron railings to keep off cattle. The reservoir is of oblong form, covered by brick arches, and turfed over. It is capable of holding 1,500,000 gallons, and is situated 248 feet above Ordnance datum.

PLUMSTEAD (Fig. 33, D).—The station at Plumstead consists of a well and Plumstead. pumping-station. The well is 136 feet in depth, and is lined by brick to a depth of 78 feet, and there is a bore-hole 600 feet in depth. On March 25, 1897, the water-level was 107 feet below the surface. After pumping, the level has been as low as 112 feet below the surface. Usually the well is pumped for from twelve to sixteen out of the twenty-four hours. The water is pumped by a rotative engine of 60 horse-power, which works a pair of lift-pumps and four force-pumps driven through

tooth-gearing. The steam is generated by two Cornish boilers, working at a pressure of 30 pounds. The amount of water pumped daily averages about 750,000 gallons. From this well Plumstead and Woolwich are supplied directly, and some of the water goes to the reservoir on Plumstead Common.

**Plumstead
Common.**

PLUMSTEAD COMMON (Fig. 33, E).—The reservoir, built in the year 1854, is situated at a height of 170 feet above Ordnance datum. It is covered by brick arches, which are supported by iron girders. The reservoir is divided into two parts internally. It is capable of holding 650,000 gallons. There is sufficient land here for another reservoir of the same size.

**Greenwich
Park.**

GREENWICH PARK (Fig. 33, F).—This reservoir is situated at the highest part of Greenwich Park, not far from the Royal Observatory. The original reservoir was built by the Admiralty to store water to be used in case of fire at the Dockyard, the Victualling Yard, or the Greenwich Hospital (now the Royal Naval College). It was made about the year 1845, just after a destructive fire had occurred at the Tower of London. The reservoir is circular in form, and is now covered over by brick arches, which are supported by iron joists. It is capable of holding about 1,125,000 gallons, and the top-water level is 158 feet above Ordnance datum. The water is used for the supply of Deptford and Greenwich. There is an electrical apparatus here, connected with an index at the Deptford station, which shows the height of the water in the reservoir, which it is necessary for the Company to know, because under the terms of their agreement with the Government Department a sufficient amount of water has to be constantly kept here, so that it may be available at all times in case of fire. The electrical apparatus was put up and is kept in working order by the Post-Office authorities at the expense of the Company.

Chislehurst.

CHISLEHURST (Fig. 33, G).—This station is situated at the upper part of Bickley Park, near Chislehurst Common. There is a reservoir, built of brick, covered with arches, and turfed over. It has a capacity of 450,000 gallons, and the top water-line is 315 feet above Ordnance datum. The water is supplied from Shortlands, and is distributed to the Bromley district.

Shortlands.

SHORTLANDS (Fig. 33, H).—The station at Shortlands is situated 130 feet above Ordnance datum. There are here two deep wells sunk into the chalk. The wells are about 80 feet in depth, and lined with iron cylinders. From the bottom of the wells bore-holes pass to a depth of 200 feet. The natural water-level is about 10 feet below the surface of the ground. After pumping, the level has sunk to a level of 34 feet 6 inches below the surface. The amount of water pumped averages 2,250,000 gallons daily. It is raised from the well to the ground-level by two lift-pumps and forced into the mains by two piston and plunger pumps, worked by two

inverted Cornish engines, for which the steam is generated by four Cornish boilers. These wells supply Chislehurst reservoir, Deptford, and Lewisham.

CRAYFORD (Fig. 33, 1).—This station is situated 30 feet above Ordnance datum. **Crayford.** There are three wells here. The one first made is 28 feet in depth, the second 34 feet, and the third 48 feet. The wells are lined with iron cylinders. Each well has a bore-hole about 200 feet in depth. Wells No. 2 and No. 3 are generally used. The water has been as low as 28 feet below the surface in No. 2, and as low as 35 feet below the surface in No. 3. At this station pumping is continuous, and the amount of water obtained averages 3,500,000 gallons daily. The water is raised to the surface by lift-pumps, and forced into the mains by three-throw plunger pumps, worked by two rotative beam-engines. The steam is generated by six Cornish boilers. No. 2 engine pumps to the high-level reservoir at Woolwich Common, and No. 3 to Plumstead and Woolwich. The well No. 1 is now dry. The pumping arrangements consist of a lift-pump and a direct acting force-pump, worked by a horizontal engine. The united horse-power of the three engines is 186 (nominal).

DOVER ROAD, SHOOTER'S HILL (Fig. 33, c¹).—There is a pumping-station **Dover Road, Shooter's Hill.** here. A pair of 24 horse-power horizontal engines work direct acting force-pumps for the supply of Shooter's Hill. Some of the water passes through a stand-pipe (see Fig. 33, k) situated on the summit of the hill, and of which the highest point is about 470 feet above Ordnance datum. The engines are worked for about six hours a day.

CONSTITUTION HILL, SHOOTER'S HILL (Fig. 33, j).—There is a reservoir here, **Constitution Hill, Shooter's Hill.** covered with brick arches, capable, theoretically, of holding 300,000 gallons, but it is not filled. It stands at a level of 320 feet above Ordnance datum. The higher parts of Plumstead and Abbey Wood are supplied from this source.

FARNBOROUGH (Fig. 33, l).—The Farnborough station is situated 220 feet **Farnborough.** above Ordnance datum, near Orpington railway-station on the South-Eastern Railway. The chalk is here about 30 feet below the ground-level. There are two deep wells about 15 feet apart, but connected below by a gallery. The upper 30 feet of the wells are bricked, and there are iron cylinders below this level. On March 25, 1897, the water-level was about 60 feet below the surface of the ground. Occasionally in summer the water-level is as low as 90 feet below the surface. The average amount of water pumped daily is from 2,500,000 to 3,000,000 gallons. There are four engines and pumps at this station. A pair of plunger pumps, worked by a double-cylinder Cornish engine of about 120 horse-power, pump water to Sidcup, Eltham, and Woolwich. A piston and plunger pump (No. 1), worked by a Cornish engine, pumps the water to Farnborough and Chislehurst. A small engine of the Worthington type is used for pumping to the reservoir at West Wickham and to

Keston. Another small engine of the Worthington type pumps water to Knockholt reservoir. The steam for these engines is generated by six Cornish boilers, four working at a pressure of 100 pounds, and the other two at 35 pounds. There is an apparatus at this station for softening the water used for the boilers.

A workman's cottage is situated here.

Cowlass
Hill,
Farn-
borough.

COWLASS HILL, FARNBOROUGH (Fig. 33, M).—There is a reservoir at Cowlass Hill, near Farnborough. It is square in form, covered with brick arches, and turfed over. It is capable of holding 1,400,000 gallons. The top-water level is 439 feet above Ordnance datum.

Dartford.

DARTFORD (Fig. 33, N).—Here there is a reservoir of circular form, 60 feet in diameter, and 20 feet in depth. It is covered by arches of brick resting on rolled joists, supported partly by a central iron column. The capacity of the reservoir is theoretically 370,000 gallons, but it is not filled. The top-water level is 130 feet above Ordnance datum.

West
Wickham.

WEST WICKHAM (Fig. 33, O).—The station to which this name is given is situated close to the highroad about three miles from the village of West Wickham on Layham Farm. There is a circular reservoir covered with brick arches and turfed over. It has a capacity of 250,000 gallons. The top-water level is 550 feet above Ordnance datum. The reservoir is enclosed by an iron fence.

Knockholt.

KNOCKHOLT (Fig. 33, P).—The station is situated near to, but on higher ground than, the well-known Knockholt Beeches, which are a landmark for miles round. There is a reservoir covered with brick arches and turfed over. The top-water level is 795 feet above Ordnance datum. The water is pumped here from Farnborough, and is used for the supply of Knockholt, Brasted, and Westerham.

Wilmington.

WILMINGTON (Fig. 33, Q).—The station at Wilmington is situated at the extreme northern extremity of that parish, about a mile south of the town of Dartford, near the Dartford powder-mills, in the Valley of the Darent, and not far from the river. Two wells, pumping apparatus, and workmen's cottages are situated here. The wells are about 100 feet in depth, lined with iron cylinders, and bricked at the upper part. One of the wells (No. 1) has a short gallery in the chalk; the other (No. 2) has a longer gallery ending in a bore-hole about 200 feet in depth. The water-level varies from 40 feet to 80 feet below the ground-level, which is 30 feet above Ordnance datum. The amount of water pumped daily varies from 3,000,000 to 6,000,000 gallons. The water is pumped by a pair of compound rotative beam-engines of 260 horse-power, which work two lift-pumps for raising the water from the wells, and two pairs of force-pumps, which send the water through a 24-inch main to Eltham reservoir.

WESTERHAM (Fig. 33, R).—The Westerham station is situated on the out-^{Westerham.}skirts of Equerry's Park. It consists of a well 70 feet in depth, pumping arrangements, and a reservoir. The water is pumped by an overshot water-wheel, and the stream which turns it has a fall of about 15 feet. The amount of water pumped daily is about 25,000 gallons. It is pumped to a reservoir situated on an eminence hard by, at a height of 444 feet above Ordnance datum. The reservoir is a covered one, and is capable of holding 60,000 gallons. The village of Westerham is supplied partly from this source and partly from Knockholt.

BETSON'S HILL (Fig. 33, S).—This hill forms part of the North Downs, and^{Betsom's Hill.} on the map the station is marked too far to the east. It is nearer the boundary. There is here a covered reservoir built of concrete, capable of holding 68,000 gallons. The top-water level is 818 feet above Ordnance datum. The reservoir supplies a few houses on the hill. The water is pumped as occasion requires by a portable engine from a well (Fig. 33, S¹) situated at the foot of the downs, close to the Pilgrim's Way, and the boundary between the counties of Kent and Surrey.

ELTHAM (Fig. 33, T).—The station at Eltham is situated at the eastern end^{Eltham.} of the village of that name, at a height of 240 feet above Ordnance datum. There is a circular reservoir covered with brick arches, capable of holding 3,000,000 gallons. The internal arrangements of the reservoir insure a circulation of the water, which comes in at the outer circle, and makes three circuits before it passes out at the centre. All the water is pumped into and passes out of the reservoir every day. The property here is about three acres in extent, and there is room for another reservoir of the same size. There is a garden enclosed on three sides by a high brick wall. There is also a small house between the reservoir and the road.

Length of New Pipes.—The length of new pipes, ranging from 3 inches to^{Statistics.} 20 inches, laid in 1895 was 10½ miles, in 1896 15½ miles, and in 1897 about 15½ miles.

Hydrants.—The number of hydrants erected during the year 1895 was 274, during the year 1896 it was 613, and during the year 1897 it was 338.

Houses under Constant Supply.—The number of houses under constant supply on December 31, 1894, was 61,312; on December 31, 1895, 66,750; on December 31, 1896, 71,463; on December 31, 1897, 80,755; and on September 30, 1898, 80,755.

Percentage of Houses under Constant Supply.—On December 31, 1896, the percentage of houses under constant supply was 85; on December 31, 1897, 93.

Average Daily Supply per Head.—The average daily supply per head for the year 1896 was 32·17 gallons. These figures are arrived at by the Company as follows: Average daily supply, 16,069,991; average population, 500,286. The difference between the figures given by the Company and those given by the water

examiner appointed by the Local Government Board is caused by the fact that whereas the secretary to the Company makes no allowance for "slip quantities in the pumps," an allowance for this is made by the water examiner to the Local Government Board. The daily average supply per head, as given by the water-examiner of the Local Government Board for the year 1897, was 30·21 gallons, and for the month of September, 1898, it was 34·94 gallons.

Date of Maximum and Minimum Supply.—The following table gives the date of the maximum and minimum supplies, and the average daily quantities supplied :

YEAR 1895.			YEAR 1896.		YEAR 1897.
	Month.	Quantity in Gallons.	Month.	Quantity in Gallons.	Month.
Maximum	June	19,875,709	July	19,392,072 daily average	July.
Minimum	December	15,156,144	November	14,621,294 „ „	February.

Communication between the Company's Stations.—With the exception of the electric communication between the Greenwich reservoir and the Deptford station there is no direct communication between the Company's various stations.

AREA OF SUPPLY.

Area of Supply.

The Act of 1809 authorizes the Kent Waterworks Company to supply the following places, some of which are entirely supplied and some partly supplied :

Supplied.—Deptford (St. Nicholas), Deptford (St. Paul), Greenwich (St. Alphege), Lee, and New Cross (within the Manor of Hatcham).

Partly Supplied.—Rotherhithe and Lewisham.

The Act of 1811 authorizes the Company to supply the following places, of which some are entirely supplied, one is supplied in part, and some are not supplied at all :

Supplied.—Charlton, Plumstead, and Woolwich (south of the Thames).

Partly Supplied.—Peckham.

Not Supplied.—Bermondsey and Peckham Rye.

The Act of 1864 authorizes the Company to supply the following places, which are entirely supplied : Bexley, Bromley, Chislehurst, Crayford, Dartford, Eltham, Erith, and Wickham.

The Act of 1877 authorizes the supply of the following places, which are entirely supplied : Beckenham (part of), Chelsfield, Foots Cray, North Cray, St. Mary Cray, St. Paul's Cray, Darenth, Eynsford, Farnborough, Farningham, Hayes, Keston, Orpington, Stone, Sutton-at-Hone, Swanscombe, West Wickham, and Wilmington.

The Act of 1888 authorizes the supply of the following places, some of which are entirely supplied, one is partially supplied, and some are not supplied at all :

Supplied.—Cudham, Downe, Halstead, Horton Kirby, Knockholt, Southfleet, and Westerham.

Partly Supplied.—Brasted, Chevening, Shoreham, and Sundridge.

Not Supplied.—Lullingstaine or Lullingstone (private residence), and Sundridge (part of).

Subject to Request by the Sevenoaks Rural Sanitary Authority.—Brasted (part of), Chevening, Otford, Shoreham, and Sundridge.

WORKS RECENTLY COMPLETED.

Wells.—New wells have been sunk at Southfleet, near Gravesend (Fig. 33, u), and at West Wickham, in the valley about half a mile from West Wickham Court (Fig. 33, v). Works Recently Completed.

During the summer of 1898 the mains of the Kent Waterworks Company were connected with those of the East London Waterworks Company. Water was first supplied by the Kent Company to the East London Company on August 25, 1898, and the average amount supplied for many weeks was 200,000 gallons per day. Connection with East London Company's Mains.

THE SOUTHWARK AND VAUXHALL WATERWORKS COMPANY.

HISTORY.

FOR a long time the supply of water to the district south of the Thames was even more unsatisfactory than that to the north of the river. The district is a low-lying one, with surface-water which is not good, and the inhabitants were, comparatively speaking, poor. In the year 1767 a lease of the fifth arch (from the north and the second from the south) of London Bridge was granted by the Lord Mayor and Corporation of the City that water-wheels might be put up for the supply of South London, and the work was carried out by the London Bridge Waterworks Company. Southwark was also partly supplied by works from a pond in St. Mary Overie. Neither of these businesses, however, was in a flourishing state at the time of the destruction of London Bridge. They were carried on in rivalry; pipes from both had been laid in the same streets, and a considerable capital outlay had been necessary to carry out the work.

A private individual named Edwards bought the Borough works at St. Mary Overie in 1820, and in 1822 he purchased the Surrey side business of the London Bridge works from the New River Company. He united them in one concern called the Southwark Waterworks, erected steam-engines, and gradually substituted iron pipes for the wooden ones that had been previously used. A change was also made in the method of taking water. Up to that time it had been obtained from a point near the shore; a large iron main was now carried to the middle of the river, and the mouth of the conduit which conveyed it to the wells was covered with a perforated semi-spherical iron cap. The intake was 8 feet below low-water mark, and an iron grating was put at the end of the conduit next the engine well. Before being distributed the water passed through another wire interceptor, but no other method of purification was adopted, and there was no reservoir. To obtain the necessary pressure for the delivery of the water, it was pumped to a cistern which was raised about 60 feet from the ground, and was capable of holding 300 or 400 barrels of water. The engine power was sufficient to raise 4,000,000 gallons a day. The amount of water supplied was only about 1,500,000 gallons, and the number of houses supplied was about 7,000, and amongst the customers were the great hospitals of the Borough—Guy's and St. Thomas'. The mains extended for a distance of about two miles from the works.

Up to the year 1804 South London was supplied by the Southwark Company,

of which an account has just been given, and by the Lambeth Company, and the water was sent directly from the Thames to the houses without being kept in a reservoir or undergoing any purification except that of passing through a wire screen. In the year 1805 a number of persons united to form a new company, and an Act of Parliament was obtained in July, 1805. The amount of money originally raised was insufficient to carry out the work required, and another Act was obtained in 1813 to authorize an increase of capital; but the Company had to borrow Exchequer bills in 1823. At the early part of its career the Company lost a good deal of money by adopting wooden pipes for the distribution of water, for it was soon found that it was necessary to substitute iron pipes for those which had been laid. The principal station of the Company was near Vauxhall, at the south side of Kennington Common. The Company were unfortunate in the selection of their steam-engines. Those first supplied were too small. In 1822 one of 45 horse-power was erected, and this was capable of pumping the water to a height of 65 feet above the level of the reservoirs. A little later another engine was put up at Cumberland Gardens, near Vauxhall Bridge, to pump the water to Kennington Lane. The water flowed from the river through an iron tunnel 42 inches in diameter. The intake was placed in the stream as far as the third arch of Vauxhall Bridge, and at a level of 6 feet below low-water mark. The station at Kennington Common had an area of about five acres, and two reservoirs were erected there. Both were lined with brick, and had sloping sides. During spring tides the water flowed from the Thames to the reservoirs, and filled them to a level of 6 feet, but they could only be completely filled by pumping. When full one of the reservoirs was capable of holding 2,000,000 gallons of water, and the other rather less. A few years later a third reservoir was erected to receive water from the Thames through an iron tunnel 4 feet in diameter, which had already been put down. From the new reservoir water percolated through a filtering bank made of gravel and sand, and passed into another reservoir, where it remained for some time before going to the engine well. The second reservoir was several feet lower than the first, and was used for keeping the mains full during the night in case of fires. The total capacity of the reservoirs in 1835 amounted to 6,000,000 gallons. The Company were able to supply water to a height of 70 feet above the level of their reservoirs. At that date they supplied about 10,000 houses, and their Act allowed them to supply parts of Lambeth, Newington, Bermondsey, Rotherhithe, Deptford, Camberwell, and Clapham. They were, however, prevented by statutory provisions from laying down pipes to any houses within $1\frac{1}{2}$ miles of the Lambeth works. The Lambeth Company, however, were allowed to lay down pipes within 200 yards of the reservoirs of the South London Company. "Thus," as a contemporary writer points out, "restraints were imposed upon one concern and a privilege conferred upon another not in strict accordance with the primary object of legislation, which ought rather to aim at promotion to

benefit the security of the community." The restraints to which reference has been made were done away with by an Act passed in 1834. The new Act made it necessary also for both Companies to supply filtered water.

In the year 1845 the Vauxhall Company united with the Southwark, and became the Southwark and Vauxhall Water Company. Land was immediately bought at Battersea, so that all the work might be carried on at one station. Water was taken from the Thames at Battersea, subsiding reservoirs and filter-beds were constructed, and pumping engines and a stand-pipe were erected. In 1851 it was decided to change the source of the supply from Battersea to Hampton, and an Act was obtained for this purpose in 1852. Reservoirs were made at Hampton, and the necessary plant was put up to pump the water to Battersea. The pumping arrangements at Battersea were altered, and new filter-beds constructed there. In 1856 additional pumping power was arranged for at Battersea, and in 1862 another engine was put up at Hampton. In 1866 additional works were made at Hampton: a river wall was built, a subsiding reservoir and three filter-beds were constructed, and the pumping power was increased. A new main was made to Wandsworth. In 1871 four covered service reservoirs were commenced at Peckham. Of these reservoirs two were 168 feet and the other two 200 feet above Ordnance datum. Engines were also erected at Peckham. In 1881 a deep well was commenced at Streatham. In 1884 an arrangement was made for obtaining water from the gravel-beds at Hampton. In 1886 additional new engines were put up at Hampton, and an Act was passed to authorize the Company to construct a high-service reservoir at Forest Hill, and to lay a new main between Hampton and Nunhead. In 1891 the pumping-station at Wandsworth was erected for the supply of Forest Hill and the district around.

PRESENT STATE: GENERAL DESCRIPTION.

Present
State :
General
Description.

The Southwark and Vauxhall Company supplies Petersham and a district skirting the south bank of the Thames from Kew to Rotherhithe, including Mortlake, Barnes, Putney, Roehampton, part of Wimbledon, Wandsworth, Battersea, part of Clapham, Lambeth, Kennington, Newington, Walworth, Camberwell, Bermondsey, and part of Dulwich.

The sources of supply are: (1) the Thames at Hampton; (2) gravel-beds near the Thames at Hampton and Platt's Eyot; and (3) a deep well at Streatham.

The stations of the Company (indicated on Fig. 34) are six in number: A, Hampton and Sunbury, Middlesex, and Platt's Eyot, Surrey (intake, gravel water-collecting grounds, reservoir, filter-beds, and pumping-station). B, Wandsworth (pumping-station). C, Battersea (reservoirs, filter-beds, pumping-station). D, Streatham (deep well, pumping-station). E, Forest Hill (reservoir). F, Nunhead (reservoir, pumping-station).

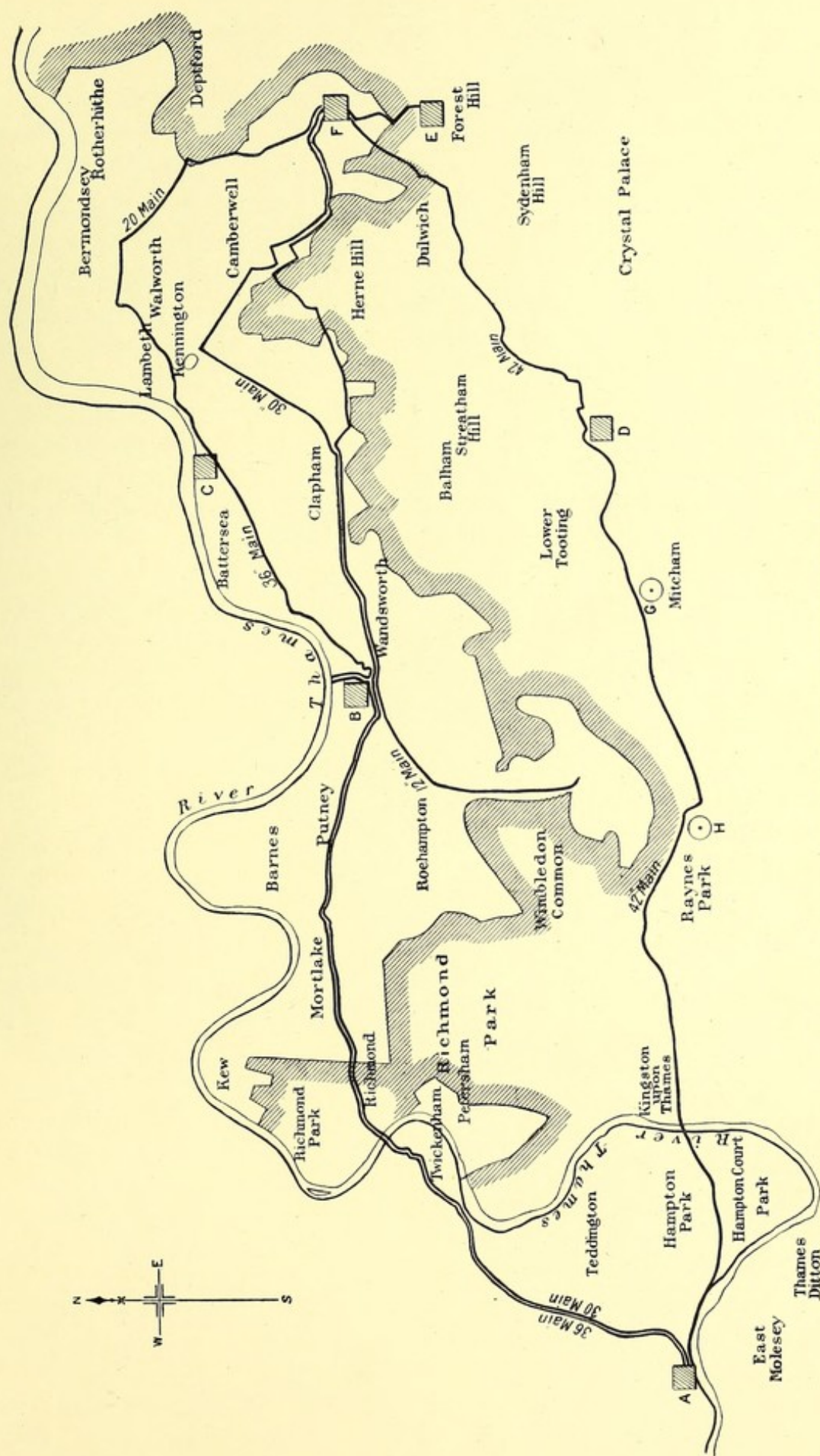


FIG. 14—THE SOUTHWARK AND VAUXHALL WATERWORKS COMPANY'S WORKS.

FIG. 34.—THE SOUTHWARK AND MERTON RIVERS. The shaded outline with the lower bank of the river define the area supplied by the Company. The six stations are marked with a shaded square. The construction works for two wells are indicated by small circles drawn round a central dot. A, Hampton and Sunbury (Middlesex) and Platt's Eyot (Surrey) intake, reservoir, filter-beds and pumping-station (for details see figures); B, Wandsworth pumping-station; C, Battersea reservoirs, filter-beds, and pumping-station; D, Streatham Deep Well and pumping-station; E, Forest Hill reservoir; F, Nunhead reservoir and pumping-station; G, deep well in course of construction at Merton Abbey; H, site of boring operations at Raynes Park.

A deep well is being sunk at Merton Abbey, and trial boring operations are in progress at Raynes Park. The sites of these operations are marked on Fig. 34, G and H respectively.

HAMPTON.—The station at Hampton is situated between the Upper Sunbury Road and the river Thames, almost entirely in the parish of Hampton. There is, however, a small piece at the east end of the property in the parish of Sunbury, and an island called Platt's Eyot in the river Thames, and this belongs to the county of Surrey. Extensive changes are now being made at this station, and it may be best to give first a general description of what is going on, which will be realized most easily by referring to the accompanying plan (Fig. 35).^{*} The parts which are not undergoing any changes are the engine-houses marked A A, and the filter-beds marked B B, some of which are situated to the north and some to the south of the Lower Sunbury Road. The land immediately to the west of the existing filter-beds belongs

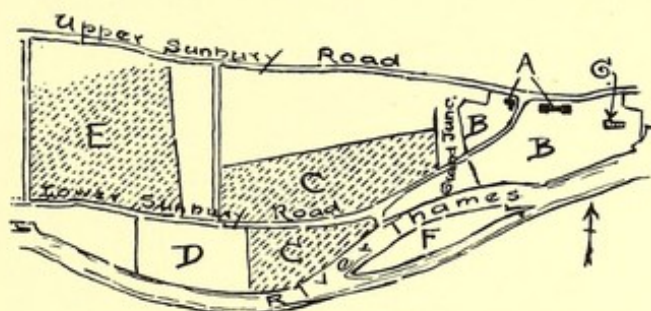


FIG. 35.—GENERAL PLAN OF THE STATION AT HAMPTON.

A, G, Engine-houses; B, filter-beds; C, land from which water is collected from the gravel-beds; D, E, reservoir; F, Platt's Eyot.

to the Grand Junction Company, and on going further in a westerly direction down the Lower Sunbury Road the next part belonging to the Company, marked c c, is land from which water is collected from the gravel-beds. The system adopted here will be described later. At present it is sufficient to point out that part of this collecting ground is situated to the north, and part to the south, of the Lower Sunbury Road, and that extensive changes are taking place in both these areas. The part to the north of the road is to be used for new filter-beds and a reservoir, the part to the south of the road for filter-beds. Going still to the west along the Lower Sunbury Road, it is seen that the Company have a reservoir to the south of the road, marked D; and farther on to the north of the road two extensive reservoirs, marked E, are in course of construction. Platt's Eyot, marked F, from which water is collected from the ballast, will not be affected by the changes now in progress. At the extreme east of the Company's property a new engine-house is in course of construction, and the site of this is marked G on the plan. The parts of the Hampton station in which

^{*} These alterations have been completed. See p. 149.

Hampton. work is now being carried on are marked with shading in the diagram, c, c, E, and this brief description and a glance at the map will show that active operations are being carried on at the present time.

Water from the Gravel-Beds.—The part of the station at Hampton which is devoted to collecting water from the gravel-beds occupies two fields, one to the north,

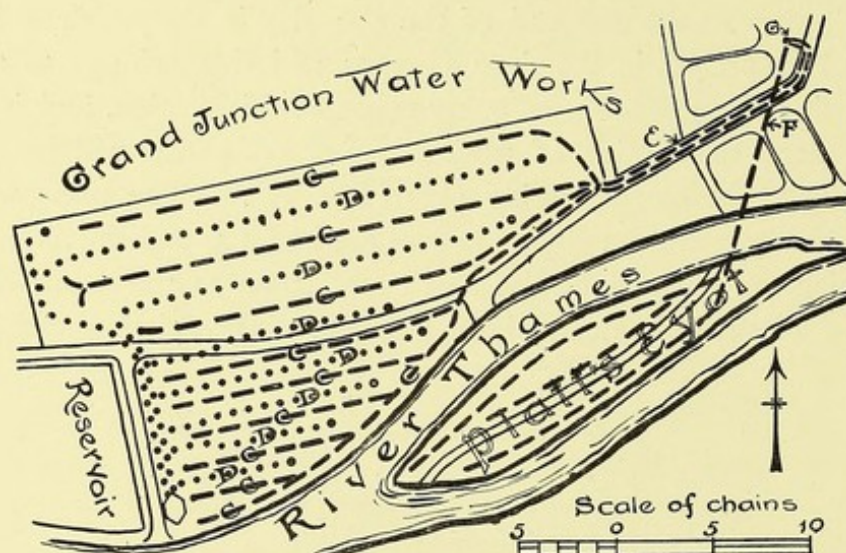


FIG. 36.—PLAN SHOWING ARRANGEMENT OF THE DISTRIBUTING AND COLLECTING PIPES IN THE HAMPTON GRAVEL-BEDS.

and one to the south of the Lower Sunbury Road, and the greater part of Platt's Eyot (see Fig. 36). The area of the two fields is about thirty-two acres, and that of the island rather over seven acres. Water was formerly admitted from the Thames

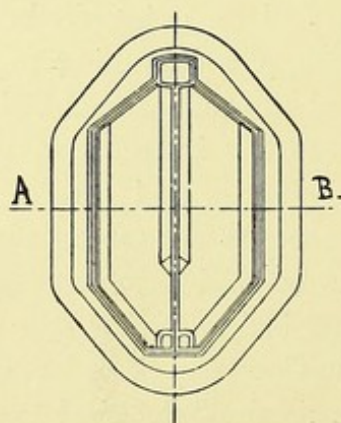


FIG. 37.—HORIZONTAL SECTION OF THE VERTICAL GRAVEL-FILTER THROUGH WHICH WATER WAS ADMITTED TO CHARGE THE BALLAST IN THE COLLECTING-GROUND.

to the fields through a vertical gravel-filter, sections of which are shown in the diagram (see Figs. 37 and 38). The ballast was thus filled with water by means of earthenware pipes, which are laid with open joints. The diagram (Fig. 39) shows

the way in which these pipes are arranged. Water thus artificially introduced into Hampton. the gravel-bed from the Thames, after passing through about 50 feet of gravel and sand, is collected by a system of 24-inch pipes, which are laid with open joints at a level of some feet lower than that of the distributing-pipes, and just on the surface of the London clay. The distribution of the collecting-pipes is shown in Fig. 36. It will be seen that they all converge to one point. Here there is a well. The water is conveyed thence through two 36-inch conduits to an engine-house, and then

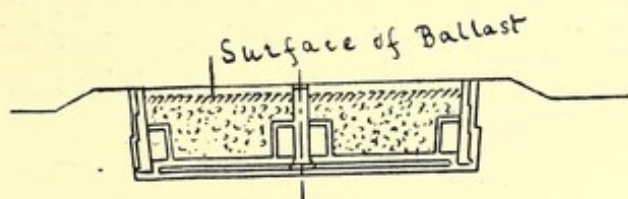


FIG. 38.—VERTICAL SECTION OF THE VERTICAL GRAVEL-FILTER SHOWN IN THE PREVIOUS FIGURE.

pumped up 14 feet to the filter-beds. The accompanying diagram shows in vertical section the arrangement of the distributing and collecting pipes (see Fig. 39). The upper pipes, marked D in the drawing, are the distributing-pipes; those marked c, which are on the surface of the clay, are the collecting-pipes. The arrangements for flooding the ballast are now in course of removal.

PLATT'S EYOT.—There is a cutting from near one end of the island to the other, Platt's Eyot. and through this the water from the Thames flows. The flow of the water is regulated by gates situated at each end of the cutting. The island itself is formed

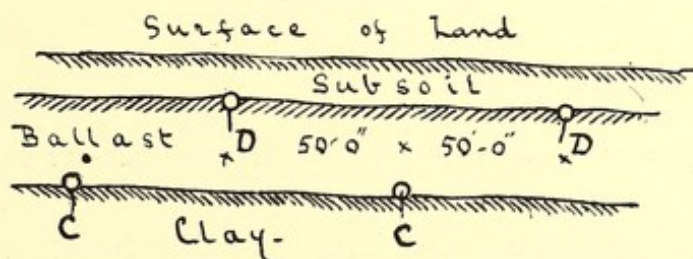


FIG. 39.—VERTICAL SECTION SHOWING THE ARRANGEMENT OF DISTRIBUTING PIPES (D) AND COLLECTING PIPES (C) IN THE HAMPTON GRAVEL-BEDS.

chiefly of gravel, and in the gravel-beds collecting-pipes similar to those which are used on the mainland are placed. These collecting-pipes are situated about 9 feet below the ordinary level of the Thames; the river water has therefore to pass through several feet of ballast before it gets into the collecting-pipe. From these pipes water is conducted through a tunnel 5 feet in diameter, which passes under the Thames to the engine well, from which it is pumped to the filter-beds. When the Thames is in high flood, water is not pumped from the island.

Hampton.

Intakes from the Thames.—There are three intakes from the Thames: (1) The new intake, used for the first time in 1896 to fill the new reservoir; (2) the middle intake; and (3) the old intake, situated near the filter-bed marked 7.

At the new intake there are three bays. The water passes through a screen which is formed of $\frac{3}{4}$ -inch bars, and through three sluices into an irregular octagonal reservoir. When visited on December 9, 1896, work was in progress here. A new engine-house was completed and one engine was erected, and a second was in process of being erected. The engine in working order is a triple-expansion high-speed engine, driving centrifugal pumps, the indicated horse-power being 160; the steam is generated by four water-tube high-pressure boilers. The new reservoir, which was

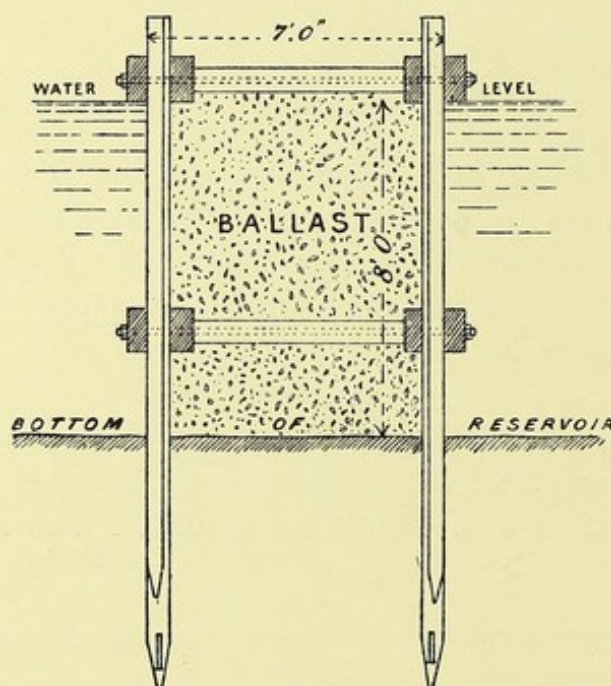


FIG. 40.—VERTICAL SECTION OF THE FILTERING SCREEN FORMERLY USED AT HAMPTON.

first filled during the summer of 1896, has a capacity of 90,000,000 gallons. It is faced with bricks and concrete.

From the second or middle intake the water is conveyed through a 36-inch conduit, and passes through a vertical iron screen similar to that at the new intake. The water is then admitted to the filter-beds. At the old intake there are six bays, and the water passes through a screen which is formed of $\frac{3}{4}$ -inch bars, and is then conducted through three 36-inch pipes to the filter-beds. A vertical filtering-screen (Fig. 40), of which a drawing is given, was formerly in use at Hampton. This system was found to be unsatisfactory, chiefly from the fact that the work of cleaning it involved much trouble, because it entailed moving and replacing the whole of the ballast.

Filter-Beds.—There are nine filter-beds at Hampton. Of these two are to the north and the others to the south-west of the Lower Sunbury Road and close to the Thames. The total area occupied by the filter-beds is nine acres. They were not all made at the same date, and are not constructed in exactly the same way. Their general form will be seen by looking at the accompanying diagram (Fig. 41). The earliest filters are those numbered 2, 3, 4; these were made in the years 1868-69. The sides of these beds are not vertical, but are built at a slope of $1\frac{1}{2} : 1$. The newer filter-beds have almost vertical sides. There is one other point of difference: in the older beds the filtered water-channels have central upright ventilators; in the case of the newer beds the ventilation is carried out by means of shafts situated at the sides of the beds. All the filters have central channels for the collection of the

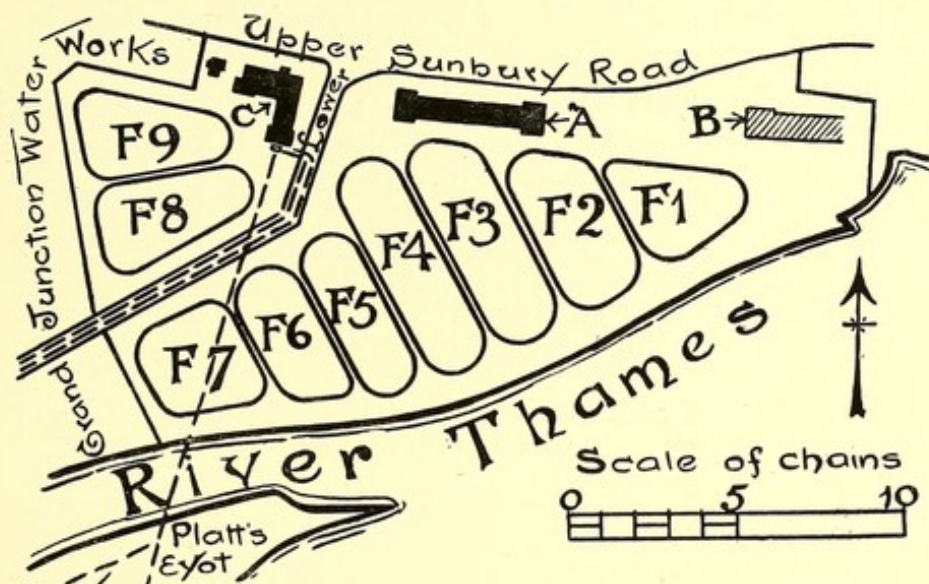


FIG. 41.—HAMPTON STATION.

A, B, C, Engine-houses; F 1 to F 9, filter-beds.

filtered water, which passes into them through agricultural tiles. The sand is cleansed by washing under high pressure.

Pumping Arrangements.—The work to be done is: (1) Raising water derived from the natural filtration system and from the river to filters 8 and 9; (2) pumping unfiltered water to Battersea; and (3) pumping filtered water to Nunhead and to the districts supplied. The water is raised to the filter-beds by a pair of inverted compound-gear engines and a set of tri-compound-gear engines. The head of water worked against is 16 feet. Three inverted direct-acting Cornish engines of the Bull type are used for pumping to Battersea. The head of water worked against is 135 feet. Two single-acting beam engines with double-acting pumps and two pairs of direct-acting compound inverted rotative engines are used for pumping to Nunhead.

Distribution of Water from Hampton.—From Hampton the water is distributed in two different directions.

Course of
the mains
from
Hampton.

The filtered water passes in a 42-inch main in an easterly direction along the high-road which passes just to the north of Hampton Court Palace to Hampton Wick. At this point the main goes in a tunnel under the Thames to Kingston. The tunnel under the Thames is in the London clay. It can be inspected from either end, and ladders pass down to the bottom of the tunnel. The tunnel itself is kept dry by a small water-pressure engine worked by the pressure in the main. From Kingston the main passes in a direction nearly due west close to Coombe House, and by Raynes Park to Merton and Streatham, then in a north-westerly direction to the north of Lower Norwood and Dulwich College to Nunhead.

The unfiltered water passed from Hampton in a 36-inch main. There is another main, 30 inches in diameter, which conveys filtered water from Hampton for the supply of the western portion of the Company's district. This is laid parallel with the 36-inch main just mentioned. The two mains pass in a north-easterly direction to Twickenham, then under the Thames just below Richmond Bridge, and then in an easterly direction to Wandsworth. From Wandsworth the 30-inch main passes through Clapham, Kennington, and Camberwell to the service reservoirs at Nunhead. The 36-inch main from Wandsworth takes a more northerly course, and conveys the water to Battersea, where it is filtered.

Wands-
worth.

WANDSWORTH.—The station at Wandsworth is situated on the banks of the Thames and of the Wandle, where that stream joins the river. The water is brought from Hampton in the 30-inch main just described, and reaches Wandsworth at a pressure of about 100 feet. At Wandsworth the pressure is raised to 200 feet or 220 feet, and the water goes to supply the higher parts of Wimbledon and the high service reservoir at Nunhead. The water is pumped by two direct-acting, inverted, quadruple expansion, rotative engines, for which the steam is generated by four Badcock and Wilcox tubular boilers, which are usually worked at a pressure of 120 pounds. The engine-house is built of white bricks with terra-cotta facings, and the inside is lined with shiny, white tiles, and is very well lighted. There is at this station an engineer's work-room, a blacksmith's shop, and a good lodge.

Battersea.

BATTERSEA.—The water is delivered from Hampton by a 36-inch main, and passes into three reservoirs, which have an area of twelve acres, and are capable of containing 46,000,000 gallons of water (Fig. 42, R_1 , R_2). From the reservoir the top-water passes through pipes which are chained to floating buoys, into the filters (Fig. 42, 1 to 9), which have an area of eleven and a quarter acres. From Battersea the water to the district is supplied by one 27-inch, one 24-inch, three 15-inch, and one 12-inch main. These are not all shown in the map. For the supply of the high-level districts the head of water worked against is 330 feet, and the water is pumped by two beam engines, which have cylinders of 55 inches, and work pumps of

which the diameters are $15\frac{3}{8}$ inches and 15 inches respectively, and have a stroke-length of 8 feet. Three other engines which supply the district work against a head

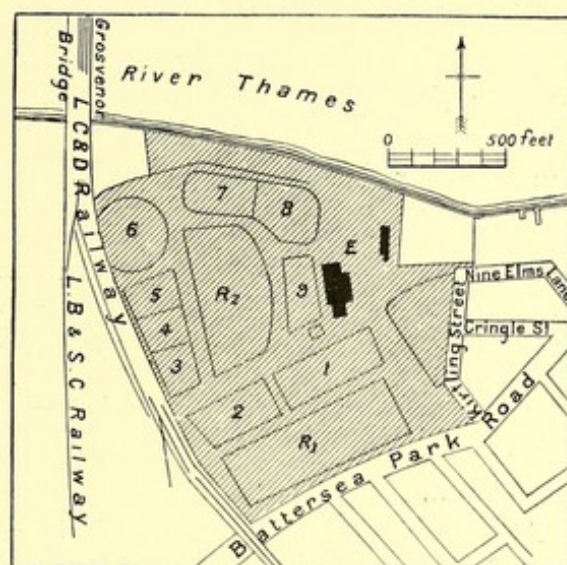


FIG. 42.—BATTERSEA STATION.

R_1 , R_2 , Reservoirs; 1 to 9, filter-beds; E, engine-house and stand-pipe.

of 170 feet, the water (or some of it) passing through a stand-pipe 170 feet in height. The description of these engines may be summarized thus :

	Diameter of Cylinder.	Diameter of Pump.	Length of Stroke.
No. 3	68 inches	33 inches	10 feet.
No. 4	64 "	33 "	9 feet 6 inches.
No. 5	112 "	50 "	10 feet.

The engine No. 5 is said to be the largest of this type in England, and to be capable of raising 12,000,000 gallons of water daily, working against a head of 170 feet. There is also a direct-acting engine of the Bull type capable of lifting 5,200,000 gallons of water, working against the same pressure. The Battersea station contains carpenters' and blacksmiths' shops, cottages, and a large yard which contains stores of pipes. The sanitary arrangements here are not strictly in accord with modern ideas. The station will not be used after the completion of the alterations which are now in progress at Hampton.

STREATHAM.—The station is situated in a field not far from Streatham Common Streatham. railway-station on the London, Brighton, and South Coast Railway. The top of the well is 110 feet above Ordnance datum. The depth of the well-shaft is 148 feet,

Streatham
Well.

and below this it is lined with cylinders to a depth of 242 feet. The water-level is about 45 feet from the surface. A careful record was made of the strata cut through. The results are given below :

					Thickness.				Depth.	
					Ft.	in.			Ft.	in.
Gravel and mud	...	...	...	...	10	0	...	...	10	0
London clay (153 feet ?):—										
Yellow clay	...	...	...	...	6	0	...	...	16	0
Blue clay	...	...	...	...	62	0	...	...	78	0
Blue clay and sand	...	...	...	...	25	0	...	...	103	0
Claystone	...	...	...	...	1	0	...	...	104	0
Blue clay	...	...	...	...	22	0	...	...	126	0
Blue clay and sand	...	...	...	...	33	0	...	...	159	0
Basement Bed (in part at least) :										
Pebbles (water)	...	...	...	...	1	0	...	...	160	0
Pebbles and shells	...	...	...	...	0	3?	...	...	160	3
Conglomerate	...	...	...	...	0	6?	...	...	160	9
Black clay and shells	...	...	...	...	0	9?	...	...	161	6
Conglomerate	...	...	...	...	0	6?	...	...	162	0
Hard conglomerate	...	...	...	...	1	0	...	...	163	0
Woolwich and Reading Beds (43½ feet ?) :										
Black clay and shells	...	...	...	...	1	0	...	...	164	0
Black clay and sand	...	...	...	...	0	4?	...	...	164	4
Black clay and shells	...	...	...	...	3?	0	...	...	167	4
Hard shells	...	...	...	...	0	6?	...	...	167	10
Black clay and shells	...	...	...	...	1	8?	...	...	169	6
Hard layer of shells	...	...	...	...	0	3	...	...	169	9
Oyster-shells	...	...	...	...	1	3	...	...	171	0
Green sand	...	...	...	...	2	6?	...	...	173	6
Mottled clay	...	...	...	...	2	6?	...	...	176	0
Conglomerate, shells, and quartz	...	...	...	...	0	3?	...	...	176	3
Clay, shells, and grey sand	...	...	...	...	5	6	...	...	181	9
Sandy clay	...	...	...	...	1	3	...	...	183	0
Black clay and shells	...	...	...	...	1	7?	...	...	184	7
Mottled clay	...	...	...	...	19	5	...	...	204	0
Hard, peaty clay, and pebbles	...	...	...	...	0	6	...	...	204	6
Clay, stones, and green sand	...	...	...	...	2	0	...	...	206	6
Thanet Beds (35 feet) :										
Hard green sand	...	...	...	...	4	6	...	...	211	0
Very hard sandstone	...	...	...	...	0	6	...	...	211	6
Dark sand, tinged with grey (water)	...	...	...	...	0	6	...	...	212	0
Grey sand	...	...	...	...	12	9	...	...	224	9
Black sand	...	...	...	...	2	8?	...	...	227	5
Grey sand	...	...	...	...	13	1?	...	...	240	6
Flints	...	...	...	...	1	0	...	...	241	6
Upper Chalk (198½ feet) :										
Flints, with little chalk (specimen, with one flint slightly green-coated). ? Some doubt about this part	...	...	...	...	8	6?	...	...	250	0

<i>Upper Chalk</i> —continued.				Thickness. Ft. in.	Depth. Ft. in.	Streatham Well.
Soft white chalk without flints	...	...		11 0 ...	261 0	
Soft white chalk, with flints every 2 or 3 feet (some specimens compact)	...	...		32 0 ...	293 0	
Large flints, with but little chalk (white)	...			13 0 ...	306 0	
Chalk (specimens white and some hard), with beds of flints every 2 or 3 feet	...	...		32 0 ...	338 0	
Very hard, grey chalk (specimens white) flints				8 0 ...	346 0	
Very hard, grey chalk, with hard stone or boulders (specimens white, and some very hard)	...	...	...	23 0 ...	369 0	
Very hard chalk, with stone like limestone (specimens white, one hard)	...	...		15 0 ...	384 0	
Very hard, grey chalk, with dark, dirty (clayey in specimen) partings (specimens white, with flints)	...	...	...	25 0 ...	409 0	
Very hard (firm), grey chalk, with stone or chert				31 0 ...	440 0	
<i>Passage Beds and Chalk Rock.</i> (Specimen of chalk and flints)				23 0 ...	463 0	
<i>Middle Chalk</i> (219 feet):						
Hard, grey chalk, with dark (grey) partings, mixed with stone or chert (many specimens, one, from 525 feet, bedded)	...	...		69 0 ...	532 0	
White chalk, much softer (specimens firm)	...			19 0 ...	551 0	
Hard chalk	...	...	...	19 3 ...	570 3	
Hard grey chalk with dark partings	...			48 9 ...	619 0	
Hard chalk with dark partings and fossils	...			27 0 ...	646 0	
Very hard, stony chalk	...	...	...	22 6 ...	668 6	
Very hard, stony chalk, with fossils...	...			2 0 ...	670 6	
Hard and rather green chalk, with few fossils (specimens with irregular greenish clayey partings). ? Melbourn rock	...	...		11 6 ...	682 0	
<i>Lower Chalk</i> (182½ feet):						
Very hard chalk, with green partings	...			10 6 ...	692 6	
Chalk, softer, working up into pipeclay	...			35 9 ...	728 3	
Hard grey chalk, working up into stiff pipeclay				57 6 ...	785 9	
Dark grey chalk, very hard, working up into pipeclay	...	...	...	21 3 ...	807 0	
Dark, marly chalk, working into a stiff putty. (Specimens from 786 feet to 840 feet were greyish and some with curved, marly fracture)	...	...	...	3 0 ...	840 0	
Chalk marl, or gault clay, with shells (specimens marly chalk or grey chalk marl)	...			14 0 ...	854 0	
Very hard marl rock band (specimen hard grey chalk)	...	...	...	1 0 ...	855 0	
Chalk marl or gault clay (specimen hard grey chalk marl, more sandy than that above)...				9 6 ...	864 6	
					22	

Streatham
Well.*Upper Greensand* (28½ feet):

Specimens of light-grey (rather greenish) calcareous sandstone, with glauconite grains: sometimes grains of mica; varying slightly

Thickness.
Ft. in.Depth.
Ft. in.

24 6 889 0

Specimens much the same as the above; grey calcareous sandstone, with small, blackish glauconite grains and small grains of mica

4 0 893 0

Gault (188½ feet):

Clay; specimen from top, hard, with green grains and a phosphatic nodule... ..

8 0 901 0

Greensand; probably only a thin layer, as specimen from 903 feet is hard clay

6 6 907 6

Hard clay (specimen firm)... ..

29 9 927 3

Clay (specimens at 940, 960, 980, 1,000, 1,020, 1,040, and 1,050 feet, and below, all firm; with phosphatic nodules at 1,068 feet, a layer at 1,070 feet, and at the base)

154 3 1,081 6

Lower Jurassic Beds (? forest marble) flat bedded (38½ feet):Hard grey and cream-coloured limestone, mostly crowded with oolitic grains of fair size, with bits of shells. Signs of plant in a trace of clay. At 1,083 feet softer, with oolitic grains dissolved out. *Ostrea acuminata*(?) at 1,086½ feet

8 6? 1,090 0

Greenish-grey, sandy rock, softest at the base

1 0 1,091 0

Hard grey, calcareous sandstone

1 6 1,092 6

? Clayey layers lost. Limestone, with oyster-shells, at 1,094 feet

2 6 1,095 0

Greenish-grey, sandy clay, with *Ostrea acuminata* and a small Crustacean claw

2 0 1,097 0

Harder specimen at 1,098 feet; but apparently softer rocks missing. Clay at the bottom

10 0 1,107 0

Clay, with hard bands

Clay, with oolitic grains; more numerous in the lower part

More like limestone, less granular

6 0 1,113 0

Impure limestone, with fragments of shells

Clay, with oolitic grains

Clay

Clay, with *astarte*

Clay, with fossils (two specimens)

Clay, with shells

More sandy clay

Clay (two specimens)

Sandy clay

7 0 1,120 0

Clay, with small (phosphatic?) nodules (two specimens)

Clay, much harder; calcareous

Clay, with hard beds; harder at the base

Oolitic limestone

Lower Jurassic Beds—continued.

	Thickness. Ft. in.	Depth. Ft. in.	Streatham Well.
Beds of doubtful age. Grey, reddish, and purplish beds, 100 feet; mostly with a tendency to break along planes at 20° to 30° dip.			
Pale greenish-gray, compact, calcareous sandstone; mottled reddish and purplish lower down; then with purplish bands, showing a dip of 20°. Probably about 8 feet missing (? clays)	10 0	1,130 0	
Greenish-grey sandstone, mottled purplish then reddish. Probably about 10 feet missing	17 0	1,147 0	
Dull, reddish-purple, hard, sandy clay ...			
Grey sandstone, mostly calcareous, with thin veins of calcite			
Greenish-grey sandstone, with some purplish mottling and veins of calcite	6 0	1,153 0	
Greenish-grey and red-mottled sandstone ...			
Greenish-grey bedded sandstone, with iron pyrites in the upper part, and with purplish bands in the lower (dip 35°)			
All these more or less micaceous			
(?) 2 feet missing			
Hard, purplish, clayey rock			
Many feet missing	7 0	1,160 0	
Greenish-grey, calcareous sandstone ...			
Greenish-grey sandstone, mostly calcareous, clayey at the base. Only 14 inches of core (?)	15 0	1,175 0	
Dark, dull, reddish, clayey and sandy rock. Then somewhat mottled with dark grey, and breaking unevenly			
A little pyrites. Small calcareous nodules at about 1,180 feet (?)			
Dull, reddish, fine-grained sandstone, mottled with pale grey. Then more of the grey. Small calcareous concretions. Then a reddish mass. Then grey, with reddish bands in bedding planes. About half missing	15 0	1,190 0	
Reddish, clayey rock, with about 6 inches of a nodular character (?) at bottom, and greenish-grey rock. About 5 feet of core	14 0	1,204 0	
Hard, greenish-grey micaceous sandstone, partly calcareous, and reddish, clayey, micaceous rock. About 5 feet of core ...	8 0	1,212 0	
No specimens seen	12 0	1,224 0	
Red, clayey rock, with greenish-grey in the midst, partly nodular below. 4 feet of core	14 0	1,238 0	
No specimens seen	12 0	1,250 0	

Streatham
Well.*Lower Jurassic Beds—continued.*

Grey, micaceous sandstone, here and there
with reddish bands
About 1,255 feet, with fish remains (?) ...
Grey and red rock as above; a few inches ...
Light-grey, coarse, very micaceous sandstone,
with black carbonaceous patches; about
20 inches

Thickness.
Ft. In.Depth.
Ft. In.

8 0 1,258 0

The boring was continued to the depth of 1,271 feet; but the last 13 feet of core were not brought up. The amount of water which it is estimated can be obtained from the well daily is 2,000,000 gallons. The water is bright and clear, and has a slightly ferruginous taste. It is pumped by two double-acting lift-pumps driven by two sets of triple-expansion engines, and the steam is generated by three Badcock and Wilcox boilers. In a building adjoining the engine- and pump-houses there is an arrangement for filtering the well-water through calico, but this operation is not considered to be necessary by the Company.

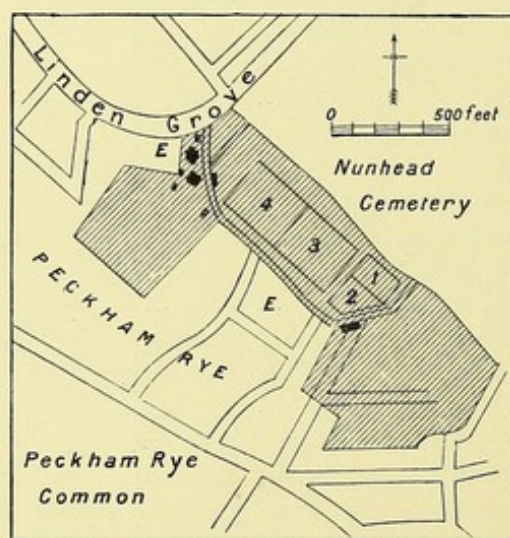


FIG. 43.—NUNHEAD STATION, PECKHAM.

1, 2, High-service reservoirs; 3, 4, low-service reservoirs; E, E, engine-house and offices.

Forest
Hill.

FOREST HILL.—This station is situated on the summit of Forest Hill, 345 feet above Ordnance datum. The reservoir is built with arches, completely covered in and turfed at the top. It is capable of storing 1,000,000 gallons of water.

The residence of the assistant-engineer and a cottage for a caretaker are situated here.

Nunhead.

NUNHEAD.—The station at Nunhead (see Fig. 43) contains reservoirs, pumping arrangements, an office, a valve house, workshops, and the residence of the engineer. The high-service reservoirs (Fig. 43, 1 and 2) are situated at the top of the hill

200 feet above Ordnance datum, and they are capable of storing 6,000,000 gallons of water. The low-service reservoirs (Fig. 43, 3 and 4) are situated on the slope of the hill 168 feet above Ordnance datum, and have a capacity of 12,000,000 gallons. The reservoirs are arched over and covered with turf. The engine-house contains two Bull engines, which are worked by four Cornish boilers. The engines are used to pump the water to the high-service reservoirs. A fire-engine is kept at this station. It is occasionally used to empty service-pipes rapidly when a pipe has burst. In such a case the fire-engine is at once despatched to the place at which the accident has happened. The brasswork here, it may be noted, is kept in a way which would be no discredit to a smart man-of-war, and the engine-house, like all the newer ones put up by the Company, is extremely well lighted and airy. The valve house, which is situated near the entrance gate, contains the arrangements for regulating the direction of the water-supply; the distributing mains all pass through the house. The office is in telephonic communication with the district inspectors, with the office in Southwark Bridge Road, Streatham, Wandsworth, Forest Hill, and the Metropolitan Fire Brigade at New Cross and at Kennington, and there is a private telegraph wire to Battersea and to Hampton.

Communications with other Companies' Mains.—There are two communications with other companies' unfiltered water mains: (1) With the Grand Junction Company at Hampton—a 15-inch connection; and (2) with the West Middlesex Company at Marsh Gate, near Richmond—a 36-inch connection. There is a communication between the filtered water mains of the Company and those of the East London Waterworks Company.*

Communica-
tions with
other
Companies'
Mains.

Length of New Pipes.—The length of new pipes, ranging from 3 inches to 20 inches, laid in 1895 was ten miles, in 1896 six miles, and in 1897 six miles. Statistics.

Hydrants.—The number of hydrants in use during the year 1895 was 3,829, in 1896 it was 4,137, and in 1897 it was 4,263.

Houses under Constant Supply.—The number of houses under constant supply on December 31, 1894, was 106,604; on December 31, 1895, 109,670; on December 31, 1896, 112,455; on December 31, 1897, 113,489; and on September 30, 1898, 114,177.

Percentage of Houses under Constant Supply.—On December 31, 1896, the percentage of houses under constant supply was 93·75; on December 31, 1897, 94; and on September 30, 1898, 94.

Average Daily Supply per Head.—The average daily supply per head for the year 1896 was 38·39 gallons, and for the year 1897 it was 41·72 gallons. For the month of September, 1898, it was 44·38 gallons.

Dates of Maximum and Minimum Supply.—The following table gives the date of the maximum and minimum supplies and the average daily quantities supplied:

* See p. 149.

THE LONDON WATER SUPPLY

YEAR 1895.			YEAR 1896.		YEAR 1897.
	Month.	Quantity in Gallons.	Month.	Quantity in Gallons.	Month.
Maximum	September	39,148,588	July	37,591,943 daily average	July.
Minimum	February	26,630,684	November	31,657,101 „ „	December.

TABLE OF STATISTICAL DETAILS GIVEN BY THE SOUTHWARK AND VAUXHALL
WATERWORKS COMPANY.

		FOR THE YEAR 1896.	SEPTEMBER, 1898.
SUPPLY.	Average daily supply in gallons ...	31,996,895	36,331,552
	Percentage delivered for other than domestic purposes, exclusive of waste	15 to 20	15 to 20
	Number of houses supplied ...	119,948	121,991
	Number of houses on constant supply ...	112,455	114,177
	Estimated population supplied... ..	891,213	
RESERVOIRS. Subsiding and storage unfiltered water. Storage filtered-water reservoirs	Number	4	5
	Area in acres	26	49
	Available capacity in gallons	136,000,000	276,000,000
	Number	4	5
ENGINES.	Capacity in gallons	18,000,000	19,000,000
	Number	16	16
	Horse-power	3,200	3,200
	Greatest lift	360 feet.	
WATER-PIPES.	Head of pressure in the district supplied	Highest, 170 feet ; lowest, 20 feet.	Highest, 170 feet ; lowest, 20 feet.
	Total number of miles of water-pipes ...	827	839
	Number of miles of water-pipes in the metropolis	627	636
	Number of miles of streets with water-pipes constantly charged in the metropolis	160	160
	Number of hydrants erected within the metropolis	4,137	4,263
FILTERS.	Number of beds	18	18
	Area in acres	20½	20½
	Depth of sand and other materials ...	5 feet 6 inches.	5 feet 6 inches.

AREA OF SUPPLY.

Area of
Supply.

The Act of 1852 authorizes the Southwark and Vauxhall Company to supply the following places, some of which are entirely supplied, some partly supplied, some not supplied :

Supplied.—St. Thomas, Southwark; St. John, Southwark; and St. Olave, Southwark.

Partly Supplied.—Battersea, Bermondsey, Brixton (Lambeth), Camberwell, Clapham, Christchurch (Surrey), Deptford (St. Paul), Dulwich, Kennington, Lambeth, Peckham and Peckham Rye, Newington (St. Mary), Rotherhithe (St. Mary), St. George the Martyr (Southwark), St. Saviour (Southwark), Stockwell, Walworth, and Wandsworth.

Not Supplied.—Deptford (St. Nicholas), and Streatham (St. Leonards).

The Act of 1884 authorizes the Company to supply the following places, all of which are entirely supplied with the exception of one place, which is partly supplied:

Supplied.—Barnes, East Sheen, Ham, Kew, Mortlake, Petersham, Roehampton, Sheen and Wimbledon (parts above the 100 feet Ordnance contour line).

Partly Supplied.—Putney.

The Company also supplies water by bulk to the Corporation of Richmond.

NEW WORKS IN PROGRESS AND RECENTLY COMPLETED.

HAMPTON.—In the description of the present state of the Company's station at Hampton, it was said that the work was in active progress there, and a plan was given showing the site of the operations. The works are as follows: (1) Two storage reservoirs, which will have a total capacity of 300,000,000 gallons; (2) a subsiding reservoir, which will have a capacity of 40,000,000 gallons; (3) seven new filters, which will have a total area of seven acres, and which it is hoped will be in use in April, 1899; and (4) a new engine and boiler house, which is to be supplied with engines of 1,500 indicated horse-power. Some of this work has now been completed, and a new reservoir was first filled on December 22, 1898.

NEW WELLS.—A new well is being dug at Merton Abbey; the depth reached is 175 feet. Trial borings have been made at Raynes Park, Nunhead, and Honour Oak, and a well has been commenced at the latter place.

WEST MOLESEY.—One hundred and forty-six acres of land have been acquired at West Molesey, and it is proposed to construct a storage reservoir having a capacity of 1,076,000,000 gallons.

CONNECTION WITH THE EAST LONDON WATER COMPANY'S MAINS. — In the autumn of 1898 a connection was made between the mains of the Company and those of the East London Waterworks Company by means of a 20-inch main which passes through the Tower Subway. The new connection was first used on September 18, 1898, and between that date and the end of the month 62,500,000 gallons of filtered water were supplied by the Southwark to the East London Company. During the month of October the average amount supplied was 4,811,408, during November 4,483,820, and during December 4,245,583 gallons daily.

THE LAMBETH WATERWORKS COMPANY.

HISTORY.

THE early history of the Lambeth Waterworks Company shows how very rapidly an excellent business was built up by a number of men who gave their time and energy to a work which supplied a very obvious want.

The first meeting of the original founders of the Company was held in April, 1785. A list had been prepared of the owners of over 600 houses who wished to be immediately supplied with water. Another list was handed in of the occupiers of another 600 houses, who, it was believed, would be glad to have water as soon as they saw what a convenience it was to their neighbours. At the same meeting an estimate as to the probable cost of the undertaking was submitted, and it was calculated that a profit of 12 per cent. and upwards could easily be paid; but it was decided that the projectors should not flatter themselves with an immediate advantage from the work to the extent that their own calculations seemed to hold out. It was resolved that this was not a visionary scheme, but a "business suggested and taken into consideration on substantial grounds by men capable of judging both of the expense and effect." A subscription list was opened, and it was decided at once to apply for an Act of Parliament. Mr. White, a clerk to the House of Commons, seems to have been the Company's Parliamentary agent. Sir Joseph Mawbey, one of the Members for Surrey, and the Rector of Lambeth helped to draw up the petition, which was signed by those of the inhabitants who wished to be supplied with water. An Act incorporating the Company was obtained, and received the Royal Assent on July 9, 1785, on which day the proprietors appointed to meet at two o'clock at the New Inn near Westminster Bridge, to comply with the statutory directions of the Act of Parliament.

The work was rapidly taken in hand. Premises were obtained in Belvedere Road, near the site of the present Waterloo Bridge, which was not then built, and nearly opposite to Hungerford Market. A steam-engine was put up, but it was not at first capable of supplying a higher service than 42 feet above the Thames high-water mark. Wooden pipes were used for conveying the water. The proprietors showed great attention to the details of their business, and printed and distributed handbills among the inhabitants of Lambeth to say that after the following Christmas they would be glad to supply anyone who lived within reasonable distance of their

mains. Letters were also written to certain fire assurance companies asking them if History. they would care to bear part of the expense necessary for keeping a fire-engine ready to work. In this application the Company were not successful, but the request shows, it must be admitted, excellent business instincts.

At the end of the last century there is no doubt that a water-supply was urgently needed in Lambeth, and requests were sent to the Company asking them to extend their area of supply as quickly as possible. In 1790 some of the inhabitants of St. George's Fields wrote to say that unless they were speedily supplied with water they would have to leave their houses, as no lodgers would remain with them if they could not get a supply. The work of development proceeded so rapidly that in 1791 the clerk reported that they could not obtain small pipes as quickly as they wanted them. In 1800 some of Watt's improvements were adopted for working the engine which was then in use.

The early records of the Company contain instances of people who clandestinely laid on the water to their houses from the Company's mains. In such cases the Company acted with great vigour. Thus, in the case of one Mr. Green, who supplied his neighbours from his own tub, it was decided "that the ferril that serves the house be drawn, and that the water be not laid on again until the several houses reported to have been supplied laid down separate pipes." The Company's Act enabled them to impose a penalty of £50 to £1 a day for stealing their water. One man who was caught doing this was called to a meeting of the Board, and informed of the penalty to which he had rendered himself liable. He pleaded that if it were imposed it would "materially injure his circumstances, and that he had a family of six children." The matter was settled by the culprit paying the arrears of water rent, and giving £5 to a charity. In another case the directors agreed to give an informer half of any sum which might be obtained from an individual who had taken the water without paying for it.

The Company gradually extended their area, and in 1802 it was decided to go as far as The Horns, Kennington, that an ample supply might be given to "that respectable and populous neighbourhood." In the same year it was decided that a certain number of 10-inch iron pipes should be laid every year, provided that the outlay did not interfere with the dividends; and in 1816 it was decided to use only iron mains from that date. In the year 1805 a new 24 horse-power engine was erected, and a fixed instrument, called a "dolphin," was put over the mouth of the suction-pipe which conveyed water from the river. The dolphin took the place of a floating rhomboidal fender which had previously been used. The Company did not remain entirely without rivals. In 1805 the South London Waterworks were established. At first the relations between the companies were friendly, and two years after their formation the Lambeth Company offered to supply some water which their rivals were unable to do in consequence of the destruction of their engine by fire. A few years

History.

later, however, there was a fierce competition between the companies, and this raged for some years.

After the building of Waterloo Bridge, many new streets were made in a southerly direction, and the Company at once put an iron main in the direction of the Obelisk, St. George's Fields. From the first the financial arrangements of the Company seem to have been made with a view to the development of a big business, and money which might have been paid in dividends was used for paying the expenses incurred in extending the area of supply. In 1819 a resolution was passed by a committee of the proprietors that it would be disastrous if it should happen from the "impatience of some proprietors" that they should be induced to break through their rule of extending the business and draw money out of the concern; it would either "shackle" their proceedings or compel them to get into debt. In that case the committee thought that the sun of their prosperity would very soon set.

The proprietors took a keen interest in the reputation of the water they supplied, and in 1824 their solicitors threatened one Mr. Keys, a plumber, for his interfering with their business "by defaming their commodity." On the other hand, Mr. Mathews, who wrote in praise of Thames water, was rewarded by receiving the sum of five guineas.

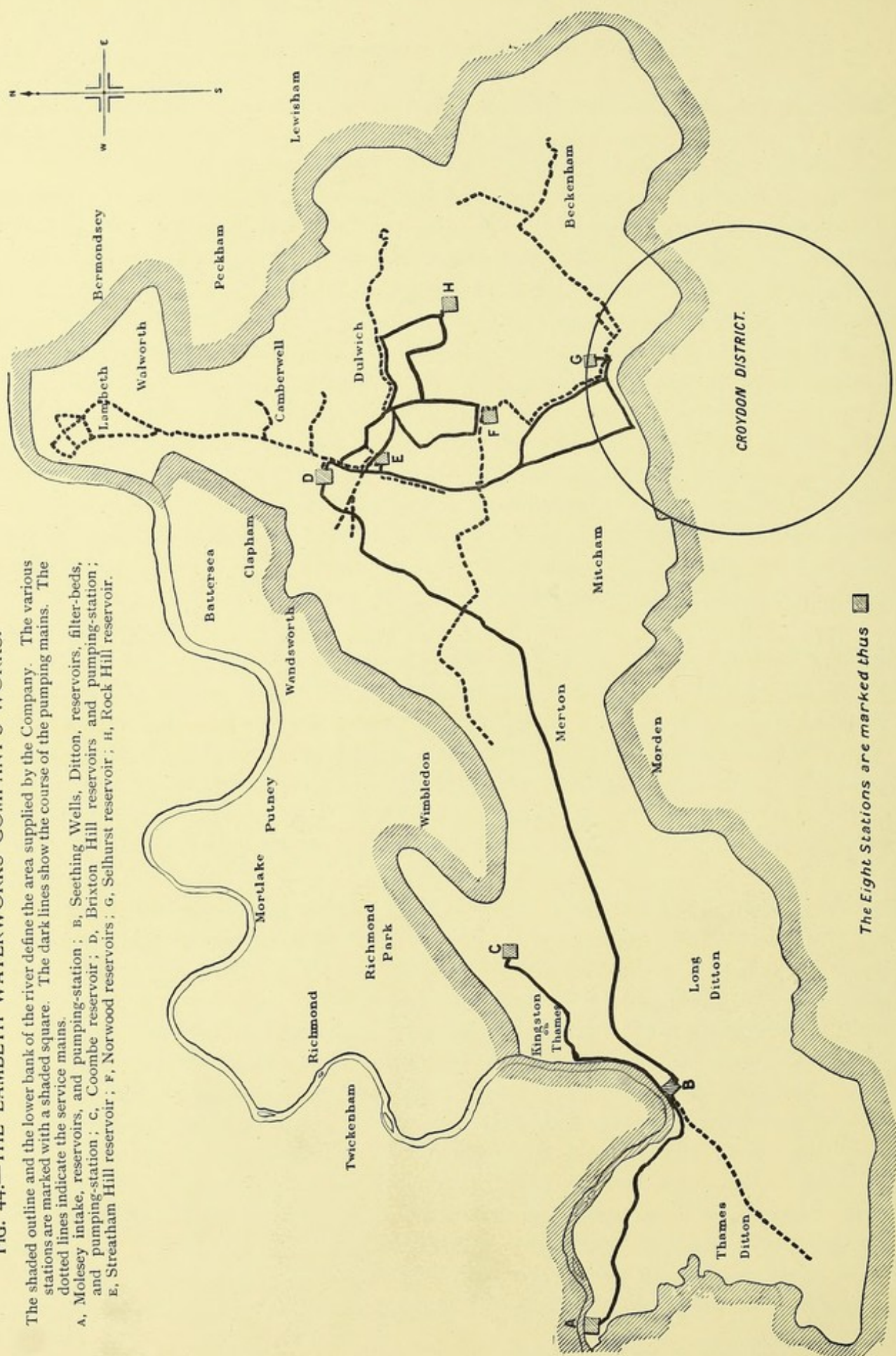
In the year 1831 it was decided to buy some land on high ground, and to make a "filtering apparatus," and some land was bought on Streatham Hill, the site of the present reservoir. Two years later the ground on which the present Brixton pumping-station is situated was bought, and it was decided to lay down an iron main from the works to the new reservoir which had been made at Brixton. An Act of Parliament was obtained in 1834, and the share capital of the Company was increased to £143,800. Up to that time the proprietors' capital had been limited to thirty-two shares of £150 each.

The outlying districts south of the Thames which were not supplied by the Company obtained their water with difficulty. The poorest people were supplied from water-carts, and had to pay from $\frac{3}{4}$ d. to 2d. a pail for it. A great many petitions were sent to the Company to ask them to extend their area of supply. Complaints as to the insufficiency of the water-supply came from districts as far apart as Kingston and Beckenham, and the Company resolved to extend their business, to abandon their original works, and to remove their intake higher up the river. This decision was come to in 1847, and the Company were re-incorporated in 1848, and the Act authorized the construction of works at Seething Wells, Ditton, and gave them power to extend the area of their supply. The works at Ditton were opened in 1852, and the directors justly prided themselves on being the first Company which resolved to obtain their supply from a less impure source by going higher up the river. In 1852 the other Metropolitan Water Companies which took their water from the Thames were compelled by an Act of Parliament to move their intakes to

FIG. 44.—THE LAMBETH WATERWORKS COMPANY'S WORKS.

The shaded outline and the lower bank of the river define the area supplied by the Company. The various stations are marked with a shaded square. The dark lines show the course of the pumping mains. The dotted lines indicate the service mains.

A, Molesey intake, reservoirs, and pumping-station; B, Seething Wells, Ditton, reservoirs, filter-beds, and pumping-station; C, Coombe reservoir; D, Brixton Hill reservoirs and pumping-station; E, Streatham Hill reservoir; F, Norwood reservoirs; G, Selhurst reservoir; H, Rock Hill reservoir.



The Eight Stations are marked thus 

some point above the tidal portion of the Thames. At this time the Lambeth Company had already done this, a fact which must always be remembered to their credit.

In 1871 the Company decided to remove their intake from Seething Wells still higher, because the water at Seething Wells was discoloured and turbid whenever the rivers Mole and Emmett were in flood. An Act to enable the Company to move to West Molesey was obtained, and subsiding reservoirs and pumps were erected there, and the works completed in 1874. During the progress of the excavations at West Molesey it was discovered that there was a quantity of water in the gravel, and this was used as an additional source of supply. The dates of the Lambeth Water Company's Acts, besides those above mentioned, are 1848, 1856, 1869, 1871, 1883, 1886 and 1896.

PRESENT STATE: GENERAL DESCRIPTION.

The Lambeth Waterworks Company supply Molesey, Ditton, part of Wimbledon, Balham, Brixton, Streatham, Lambeth, Walworth, Dulwich, and Sydenham.

Present
State:
General
Description.

The sources of supply are: (1) the Thames at West Molesey; (2) gravel-beds near the Thames at Molesey; and (3) the Thames at Ditton (in cases of emergency).

The stations of the Company indicated upon the map are eight in number: A, Molesey (intake, reservoirs, pumping-station); B, Ditton (reservoirs, filter-beds, pumping-station); C, Coombe (reservoir); D, Brixton Hill (reservoirs, pumping-station—see Fig. 45); E, Streatham (reservoir—see Fig. 46); F, Norwood (reservoir); G, Selhurst (reservoir—see Fig. 47); and H, Rock Hill, Sydenham (reservoir—see Fig. 48).

MOLESEY.—The chief intake of the Company is from the Thames at West Molesey, on the south bank of the river. The area of the property here is rather over 36 acres, and the works consist of the intake, a pumping-station, an arrangement for obtaining water from the gravel-beds, two reservoirs, and three cottages, one containing a small Board-room.

Intake.—There are five inlets from the Thames, and they are placed close together. They are guarded by an outside grating composed of bars an inch in width, with spaces of one inch between each bar. A screen with smaller meshes is situated inside. There are grooves for two sets of screens, but only one set is used at a time. The inner screens are of galvanized iron, with $\frac{3}{8}$ -inch meshes. The inlets allow the water to pass into a brick culvert, which passes under the towing-path to the engine-house well through a sluice-house.

Pumping Arrangements.—The river-water is pumped up a height of about 14 feet to the reservoir. This is done by a pair of centrifugal pumps, worked by two horizontal engines, and capable of raising 25,000,000 gallons of water daily. There

Molesey. are also two vertical engines of 50 horse-power each, which are capable of pumping 17,625,600 gallons of water daily. These engines are used for pumping into the subsiding reservoirs and culvert, and for pumping water from the gravel-beds.

Water from the Gravel-Beds.—A considerable quantity of water is obtained from the gravel-beds situated on the property at Molesey. This water is collected by perforated pipes, which are laid in the ballast above the clay at a level of about 7 feet below the summer water-level of the Thames. Perforated earthenware pipes are arranged in a double line all along the northern side of the property near the towing-path, parallel with the river, and for some little distance near the eastern boundary of the property, at right angles to the line just described. The pipes vary in size from 12 to 24 inches. There is a line of 12-inch pipes, 771 feet in length, a line the same length of 18-inch pipes, a line of 200 feet of 24-inch pipes, and a line of 459 feet in length of 18-inch pipes. The water collected by these pipes passes into a tank 12 feet in depth and 5 feet in diameter; from this tank it flows into an engine-house well, from which it is pumped into the reservoirs. The amount of water which can be obtained from the gravel-beds is stated to be 6,000,000 or 7,000,000 gallons daily.

Reservoirs.—There are two reservoirs situated on the side of the engine-house remote from the Thames. The reservoirs occupy an area of thirty acres, and are capable of storing 128,000,000 gallons of water. The lower part of the sides of the reservoirs is concreted, and the upper part is paved with bricks. For the supply of Ditton the upper part of the water is drawn off. The arrangement for conveying water to the filtration works at Ditton is that the iron pipes which take the water to the culvert from the reservoirs are fixed to floating buoys, thus insuring that the "top-water" only is drawn off. No water is filtered at Molesey; it all flows by gravitation to the station at Ditton.

The water is conveyed to Ditton in two separate channels, (1) an iron main 36 inches in diameter, and (2) a culvert. The greater part of the culvert is built of brick, and is oval in form. Its dimensions are 5 feet 9 inches by 4 feet 9 inches. In two places the brick conduit is replaced by a 54-inch iron pipe. The two places in which iron pipes are used are (1) near and under the rivers Mole and Ember for a distance of 800 yards; (2) through the village of Thames Ditton for a distance of 550 yards. The culvert is of older date than the 36-inch iron main.

**Seething
Wells,
Ditton.**

SEETHING WELLS, DITTON.—At Seething Wells the whole of the water-supply of the Company was formerly taken from the Thames. Water can, in cases of emergency, be taken at this point, and the old intake arrangements remain. It is not often necessary to use them, and when they are used the Company are under a statutory obligation to notify the fact to the Water Examiner of the Local Government Board. The station consists of two parts, divided by the Portsmouth Road.

The older part, that next the river, contains four filter-beds and a small reservoir. The total area of these filter-beds is between three and four acres. On January 6, 1897, it chanced that one of the filter-beds was being re-made. As the construction of this filter differs from that of those usually made at the present time, it may be worth while to describe it briefly. The bed of the filter is formed by thick, open-jointed slates supported on brick walls. The chamber below the slates is about 4 feet in depth. Above the slates a layer of large gravel is placed, then a layer of shells, and then at the top the usual layer of fine sand. The newer part of the station is situated to the south of the Portsmouth Road, and consists of the pumping-station, reservoir, and filter-beds. There are eight filter-beds, and these are placed 30 feet higher than the four older ones next the river. More than half the water, therefore, has to be pumped up to them, and this is done by means of two compound beam-engines of 100 horse-power each.

Filter-Beds.—The eight newer filter-beds have a total area of about nine acres. The filtered water is collected into tanks. Each filter has a separate tank of its own, so that the water from any filter-bed can be examined separately. All these tanks are connected with one main.

Engines.—From Seething Wells the filtered water is pumped to Coombe and Brixton. The engines used for pumping to Brixton are four compound beam-engines of 180 horse-power each, three compound beam-engines of 150 horse-power each, one compound beam-engine of 150 horse-power (all of the Woolf type), and one Worthington triple expansion engine of 420 horse-power. For the supply of Coombe reservoir a compound beam-engine of the Woolf type, 150 horse-power, is used to work a double-acting solid plunger-pump. Steam for working the engines is generated by Cornish and Lancashire boilers, which supply two steam mains. All the boilers of 100 pounds pressure can thus be connected through one main, and those of 50 pounds pressure through the other. The coal supply is landed from the Thames at the old part of the station, and goes in trucks through a tunnel under the Portsmouth Road to the coal stores in the new part of the station.

COOMBE RESERVOIR.—The reservoir at Coombe Warren is built on land belonging to the Duke of Cambridge, 180 feet above Ordnance datum. It is situated not very far from the shooting-range just off the highroad from Portsmouth to London. The reservoir is built on brick arches, and is capable of holding 1,150,000 gallons of water. At Coombe there is a stand-pipe 50 feet in height and 220 feet above Ordnance datum. The water for the supply of Surbiton, Kingston, Esher, Ditton, and East and West Molesey comes from this reservoir. Coombe Reservoir.

BRIXTON HILL.—This station is situated at Brixton Hill (see Fig. 45), and to the west of the thoroughfare of that name. The area of the works is about twelve acres, and the height above Ordnance datum is 115 feet. The office of the Company, two Brixton Hill.

Brixton Hill. reservoirs (Fig. 45, A, A), a pumping-station (Fig. 45, B), workshops (Fig. 45, c), and four cottages are situated here.

Reservoirs.—There are two reservoirs built on brick arches, and each is capable of holding 6,000,000 gallons of water. The mains which bring the water from Ditton come into the space between them.

Distribution of Water.—From Brixton Hill the town district is supplied by gravitation, the water being distributed by four main trunks, 24, 20, 18, and 12 inches in diameter respectively. For the supply of the country districts the water is pumped from Brixton to Streatham, Selhurst, Norwood, and Rock Hill reservoirs.



FIG. 45.—BRIXTON HILL STATION.

A A, Reservoirs; B, engine-houses; c, workshops.

Engines.—There is a compound Worthington pump of 125 horse-power, which is used for pumping water to Streatham. This engine is worked by three Cornish boilers. A compound beam-engine, 120 horse-power, working two bucket and plunger pumps, is used for pumping to Rock Hill reservoir, and works under 320 feet head of water. Three compound beam-engines of the Woolf type, each 60 horse-power, work bucket and plunger pumps, and are used for pumping water to Streatham and Selhurst. The steam is generated by eight Cornish boilers. A compound beam-engine of 130 horse-power, working a bucket and plunger pump, and another engine of 160 horse-power pump water to Norwood. There is a 120 horse-power compound beam-engine of the Macnaught type working a bucket and plunger pump, and another of 140 horse-power of the same type. The former of these is used when occasion requires for pumping to Rock Hill, Norwood, Selhurst, and Streatham. The latter is used for pumping to Norwood, Selhurst, and Streatham. There is also a small compound beam-engine of 30 horse-power, which can be used for pumping to Rock Hill.

STREATHAM HILL.—Streatham Hill station (see Fig. 46) has an area of four acres. It contains two covered reservoirs built on brick arches. They are situated at the Streatham Hill.

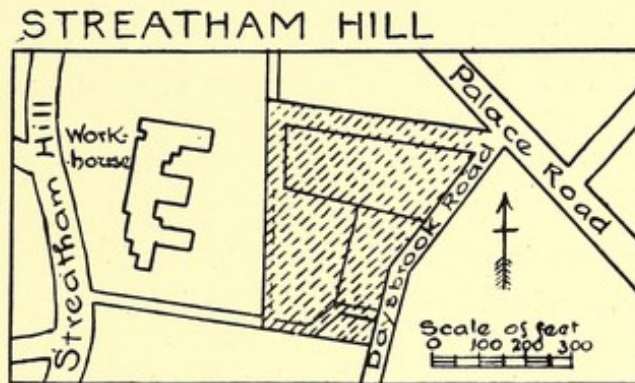


FIG. 46.—STREATHAM HILL RESERVOIRS.

level of 198 feet above Ordnance datum. Each reservoir is capable of holding 3,750,000 gallons of water. The reservoirs are covered with earth and turfed over at the top.

NORWOOD RESERVOIR.—This station is situated in Crown Lane, Streatham (see Norwood Reservoir. Fig. 47). The reservoir, like all the others, is built on brick arches, and occupies an

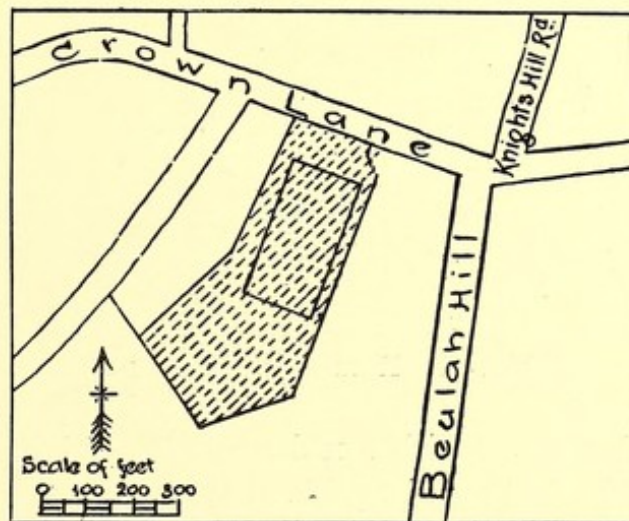


FIG. 47.—NORWOOD RESERVOIR.

area of about one acre. It has a capacity of 5,000,000 gallons. The reservoir is covered with earth and turfed over. There is at this station a sufficient area of spare ground to build another reservoir of the same size.

A caretaker's cottage is situated here.

SELHURST RESERVOIR.—The Selhurst station is situated near Thornton Heath. Selhurst Reservoir. The reservoir is 218 feet above Ordnance datum. It is built on brick arches, and has

a capacity of 2,500,000 gallons. The reservoir is covered by about 3 feet of earth and turfed over. In the description of this station that was given to the last Royal Commission on the Metropolitan Water Supply, it was said that there was a stand-pipe. Now, a stand-pipe is said to be "a curved vertical pipe arranged as a part of the main in waterworks to give the necessary head to supply elevated points," etc. There is no such "curved vertical pipe" at Selhurst, but there is an arrangement which acts as a stand-pipe. An 18-inch pipe is laid in the public road up the hill at a level of 42 feet above that of the reservoir. When the water is pumped into this pipe an increased pressure is put on the water in the district main. So the effect is the same as if there were a stand-pipe 42 feet in height.

**Rock Hill
Reservoir.**

ROCK HILL RESERVOIR is on the brow of Sydenham Hill, and is close to the Crystal Palace (see Fig. 48). The area here occupied is one and a half acres. The reservoir is built on brick arches, and is capable of holding 500,000 gallons of water,

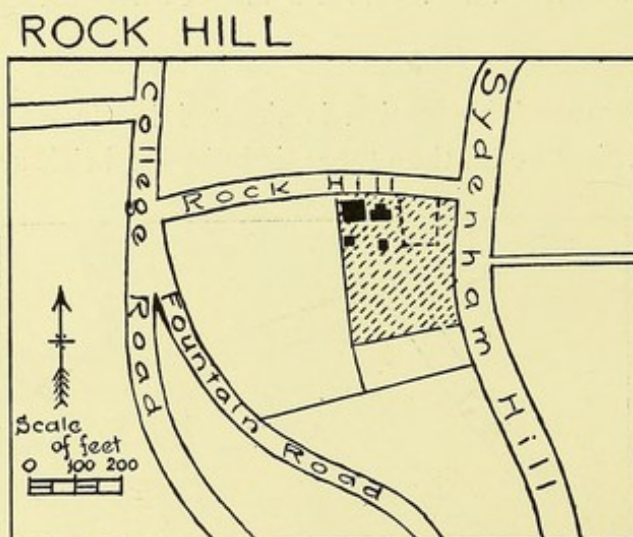


FIG. 48.—ROCK HILL RESERVOIR.

and is situated 372 feet above Ordnance datum. There is also a high-service tank 387 feet above Ordnance datum, and capable of holding 115,000 gallons of water, and a stand-pipe 60 feet in height. The top of the stand-pipe is 412 feet above Ordnance datum. During the day the water is pumped over the stand-pipe for high service and distributed in the neighbourhood. At night the water is pumped to fill the reservoir. The main is charged from the high-service tank.

AREA OF SUPPLY.

The Act of 1848 authorizes the Lambeth Waterworks Company to supply the places given in the following lists. Of these places some are entirely supplied, some partly supplied, some not supplied. Area of Supply.

Supplied.—Beckenham (the part of the parish lying on the western side of the River Ravensbourne), Esher, Kingston-upon-Thames, Long Ditton, Malden, Merton, Mitcham, Streatham, Thames Ditton, and Tooting Graveney.

Partly Supplied.—Battersea, Bermondsey, Camberwell, Christchurch, Clapham, Croydon, Lambeth, Lewisham (the part of the parish lying on the western side of the river Ravensbourne), Morden, St. Mary Newington, Newington Butts, Putney, St. George the Martyr, St. Saviour, the Clink Liberty, Wandsworth, and Wimbledon.

Not Supplied.—Horselydown, Rotherhithe, St. Olave, and St. Thomas.

The Act of 1871 authorizes the supply of East Molesey and West Molesey, and these places are supplied by the Company.

The Lambeth Company supply about 150 houses in the parishes of Ham and Hook, hamlets of Kingston civil parish, and about 200 houses in the parishes of Cheam, Chessington, Cuddington, and Ewell.

TABLE OF STATISTICAL DETAILS GIVEN BY THE LAMBETH WATERWORKS COMPANY.

Statistics.

		FOR THE YEAR 1896.	1897.
SUPPLY.	Average daily supply in gallons ...	22,855,836	23,688,312
	Percentage delivered for other than domestic purposes, exclusive of waste ...	25	25
	Number of houses supplied ...	105,448	108,086
	Number of houses on constant supply ...	67,215	70,260
	Estimated population supplied ...	738,136	756,602
RESERVOIRS. Subsiding and storage unfiltered water ... Storage filtered-water reservoirs	Number ...	5	5
	Area in acres ...	31	31
	Available capacity in gallons ...	128,000,000	128,000,000*
	Number ...	8	8
	Capacity in gallons ...	28,765,000	28,765,000

* Work is in progress to bring up the available capacity to 340,500,000 gallons.

THE LONDON WATER SUPPLY

TABLE OF STATISTICAL DETAILS (*continued*).

		FOR THE YEAR 1896.	1897.
ENGINES.	Number Horse-power Greatest lift Head of pressure in the district supplied	28 3,665 380 feet. Greatest, 380 feet ; least, 30 feet.	
WATER-PIPES.	Total number of miles of water-pipes Number of miles of water-pipes in the metropolis Number of miles of streets with water- pipes constantly charged in the me- tropolis Number of hydrants erected within the metropolis	738, of which 544 are con- stantly charged. 442, of which 386 are con- stantly charged. 242 $\frac{3}{4}$; many streets with two and three, and some with six, lines of pipes. 3,733 public hydrants, 471 hydrants for street water- ing, 182 private hydrants, and about 10,000 fire- plugs.	748 $\frac{3}{4}$, of which 556 $\frac{1}{4}$ are constantly charged. 448 $\frac{1}{2}$, of which 396 are constantly charged. 249 3,907 public hydrants, 471 hydrants for street water- ing, 182 private hydrants, and about 10,000 fire- plugs.
FILTERS.	Number of beds Area in acres Depth of sand and other materials	12 12 $\frac{1}{4}$ 7 feet.	

APPENDIX A.

NEW RIVER COMPANY'S ROYAL LETTERS PATENT. GRANTED BY JAMES I.

(PATENT ROLL 17 JAC. I. NO. 2214.) (67)

JAMES by the Ordre of God Kinge of England Scotland ffraunce and Ireland Defender of the ffaith etc To All to whome theise presents shall come Greeinge Whereas the severall Actes of Parliament were made the one in the third yeare of our Raigne of England ffraunce and Ireland and of Scotland the nyne and thirtieth Intituled An Acte for the bringinge in of a freshe Streame of runninge Water from the Springs of Chadwell and Amwell in the County of Hertford to the north partes of the Citty of London : and another in the fourth yeare of our Raigne of England ffraunce and Ireland and of Scotland the fortieth intituled an Acte for the explanation of the former Statute touchinge the bringinge in of the said Streame By virtue and Authority of which Act and Acts the Mayor Cominaltie and Cittizens of our Cittie of London and their successors have libertie given them and are thereby enabled to bringe a freshe Streame of runninge Water to the north partes of our said Cittie of London from the springs of Chadwell and Amwell and other springs in the Countie of Hertf not farr distant from the said Springs either in an open cutt or in close Truncke vaulte of bricke or stone which worke upon view was found verie fezible and was like to be profitable to manie As by the said Actes more at large appeareth ; nevertheless the said Mayor Cominaltie and Cittizens weighinge the great charge and expence the said Worke would require and doubtinge what damage and losse might fall upon the Chamber of the said Cittie in Case the Work should not fall out to be both beneficiall and gainfull did thereupon forbear at their comon charge to undertake that Worke so as the same lay longe neglected and unlike by them to be performed : And whereas Hugh Middleton Cittizen and Gouldsmith of London well affectinge the good of our said Cittie of London and being moved with a desire and zeale to performe soe publique necessary and worthie a Worke to that Cittie whereof he is a member was willing to adventure and upon his own private charge to undertake the said Worke and did out of a pyous and comendable purpose make offer to the Lord Mayor Aldermen and Comons of our Cittie of London assembled in a comon Councell houlden within the said Cittie the eight and twentieth daie of March in the seaventh yeare of our Raigne of England ffraunce and Ireland to undertake the said Worke and fully and perfectly to do execute and performe at the proper coste and charges of him his heires and Assignes whatsoever on the parte and behalfe of the said Mayor Cominaltie and Cittizens by and accordinge to the Acts of Parliament on the true Intent and meaninge of the same Acts or

De con' cart'
pro
Gubernator'
et Societat'
de le New
River.

either of them was or should be necessary and convenient to be done and performed and withall to save and keep harmles the said Mayor Cominaltie and Cittizens and their successors for ever of and from all charges and damages losses hinderances and expences that should or might anie wise arise or growe by omission or meanes of the foresaid Worke or anie thing thereto belonging or thereupon followinge and to make such Agreements with every partie interested in any soile through which the said river or streame should be brought and to give such recompence satisfacōn and amends to any partie which should be dampnified putt to a losse or hindred by the said Worke as the said Mayor Cominaltie and Cittizens might anie ways be charged withall either by reason of the said Actes of Parliament or either of them or anie thinge done in the pformance thereof or whosoever should arise by meanes or omission of the said Workes so alwaies as he the said Hugh Middleton his heires and Assignes might be constituted and appointed and severally the lawfull Deputy or Deputies Attorney or Attornies Agents or Assignes to and for the said Mayor Cominaltie and Cittizens to doe execute and performe whatsoever by vertue of the said Acts or either of them the said Mayor Cominaltie and Cittizens had power libertie or Authoritie to doe by them or their Deputies or workmen; and so as the said Mayor Cominaltie and Cittizens would condescend and agree to graunt convey and assure to the said Hugh Middleton his heires and Assignes for ever the whole and entire profitf benefitt and comoditie that should or might arise come or growe by the said River or Water and the disposiōn or distribuōn thereof and of every or anie part or parts thereof into the severall partes and places of the said Cittie and Suburbes thereof and that he the said Hugh Middleton his heires and Assignes should and might have libertie for layinge of pipes for conveyance of Water in by and through all partes and places where the said Mayor and Cominaltie and Cittizens had power and Authoritie to doe and license the same to be done; and that all Contracts Bargaines and Agreements to be made for the said Water or any part thereof and the whole benefitt profitf and comoditie thereby coming growinge or arising from tyme to tyme should and might be to and for the sole use and behoofe of the said Hugh Middleton his heires and Assignes for ever; Whereupon the said Lord Mayor Aldermen and Comons in the said comon Councell assembled well weighing and consideringe the offer made by the said Hugh Middleton as afores^d after longe and deliberate consultaōn and advisement had and taken among themselves in the said cause declared their verie good likinge thereof and willingly accepted and embraced the said offer as a thinge of great consequence and worthie of acceptaōn for the good of the said Cittie, as by the said Acte of Comon Councell more fully may appeare; And thereupon the said Mayor Cominaltie and Cittizens by their Indenture under their comon Seale bearinge date the eight and twentieth day of March in the nynth yeare of our raigne of England ffraunce and Ireland made betweene them the said Mayor Cominaltie and Citizens on the one parte and the said Hugh Middleton on the other parte, have made constituted and appointed the said Hugh Middleton his heires and Assignes joyntly and severally their true and lawfull Attorneys Deputies and Agents in their names but to the only benefitt and behoofe of the said Hugh Middleton his heires and Assignes for ever to doe execute and performe whatsoever by the said Actes of Parliament or either of them the said Mayor Cominaltie and Cittizens were authorized to doe or lawfully might doe; And the said Mayor Cominaltie and Cittizens did by their said Indenture for them and their successors fully freely and absolutely Graunt convey assigne and confirme unto the said Hugh Middleton his heires and Assignes for ever the whole entire and sole profitf benefitt comoditie and advantage whatsoever that should or might be raised gained or gotten by the said River new cutt and Streame and the Water and benefitt of the Water that might come or be conveyed thereby together with the free liberty of layinge and conveying the pipes for the Currency and passage of Water in by and through all partes and places convenient where the said Mayor Cominaltie and

Cittizens have power Interest or Authority so to doe or to license or graunt it soe to be done ; whereupon the said Hugh Midleton in and by the said Indenture did undertake to performe the said worke and to save harmeles the said Mayor Cōminaltie and Cittizens and their successors from all damages and losses that might thereby come or happen to the said Mayor Cōminaltie and Cittizens or their successors As by the said Indenture amongst divers other Covenants Articles and Agreements therein contained more at lardge may appeare and whereas the said Hugh Midleton by vertue of the said Acts of Parliament and of the power and Authoritie graunted to him by the said Mayor Cōminaltie and cittizens had begun to convey the said Springs in a new Channell and River towards the said Cittie of London and soe farr proceeded therein as he had brought the same Waters divers Myles towards the said Cittie yet findinge the charge of the said Worke greater and heavier then at first was expected the Successe thereof doubtfull and the Opposiçons made against it very stronge besides many other difficulties thought fitt to joyne unto him for helpe therein some other ffriends such as were well affected to the Work and willinge to adventure and joyn in contribuçon towards the charge thereof whereupon divers our lovinge Subjects hereafter named well affectinge the said Worke made severall Agreements with the said Hugh Middleton to pay disburse and contribute towards the charge of the said Worke both past and to come for such ratable partes and porçons in the said Worke as was agreed between them and in regard thereof it was likewise agreed That the said Adventurers should have and receave severallie to them and their heires ratable shares and parts out of the proffitts to growe and arise out of the same accordinge to the proporçon of their severall Disbursements and Adventures ; after which time the said Hugh Midleton and the said Adventurers at their great Charge proceeded soe farr in bringinge the said River towards the said Cittie of London that it not only appeared to be feazible but likewise also to be a Worke of great use benefit and Comfort to the cōmon wealth and especially to our said Cittie of London which Wee considering out of our Royall and gracious Inclination being willinge to give our Ayde and ffurtherance to soe good publike and cōmodious a Worke by Indenture under our great Seale of England bearinge date the second day of May in the tenth yeare of our Raigne of England ffrance and Ireland made betweene us on the one parte and the said Hugh Midleton on the other parte with consent of the said Adventurers did agree to beare and paye the one halfe and moietie of all the charges disbursed and expended and to be disbursed and expended in and about the bringinge and perfectinge of the same Worke ; And the said Hugh Midleton for and in consideraçon of the powers liberties priviledges Authorities payments and other things to him the said Hugh Midleton his heires Executors and Administrators in and by the said last mentioned Indenture graunted and to be paid and performed did by the said Indenture for him his heires and Assignes covenaut promise and graunt to and with us our heires and successors that Wee our heires and successors well and truly payinge such sōmes of money disbursed verified or proved As in the said Indenture is mençoned and at the tymes therein lymited or within one and twentie daies respectively ensueinge should have and receive for ever the one halfe of the benefitt proffitt and cōmoditie of the said Water and of the conveyinge of the same to and from all places. And that the said Mayor Cōminaltie and Cittizens of the said Cittie of London and their Successors and the said Hugh Midleton his heires Executors and Administrators and Assignes should and would from tyme to tyme doe and suffer to be done all Acts and thinges for the assuring and sure makinge of the same to some such person or persons and in such manner and fforme as We our heires and Successors should nominate and appointe and that the same assurances should be from tyme to tyme renewed altered or amended as should be appointed by us our heires or successors or anie of them or by our Councell learned in the lawe, soe as the Interest should and might be still settled and kept in a subject and not in us our heires or successors accordinge to the purporte effecte and true

meaninge of the Covenants and Agreements of the said Mayor Cominalte and Cittizens in the aforesaid Indenture contained betweene them on th one parte and the said Hugh Middleton of the other parte bearing date the aforesaid eight and twentieth day of March as by the same more fullie and at large it doth and may appeare And whereas the said Hugh Middleton and the said Adventurers with great Expences and Charge both of us and of themselves in particular have proceeded in the said Worke and after many Difficulties and Opposiçons undergon therein have by our aid and ffurtherance and with the speciall Labor Care and Industrie of the said Hugh Middleton longe since brought the said ffreshe streame into our said Cittie of London and into the Suburbes thereof And also into our Cittie of Westminster and distributed the same by pipes through manie partes thereof all which notwithstandinge the said worke hath not hitherto yeilded such profit as was hoped for partly by reason of the Expences dailie arisinge farr greater and heavier then by the said Adventurers was expected and partly for want of power in them to settle the carriage and Government thereof in such order and forme as is fitt and convenient; Know yee therefore that Wee for the settling and establishinge of the said Worke and the profitts and comodities thereof in tyme to come to such intents uses and purposes as are herein mençoned (that is to say) for and concerninge the one moietie thereof (all necessarie Charges and Expences deducted) to the use of us our heires and Successors and for the other moietie to the use of the said Hugh Middleton and the said Adventurers their heires and Assignes ratablie and respectivelie accordinge to the proporçons of their severall Disbursements Adventures and parts therein, And to the end they maie be the better encouraged to take paines hereafter in perfectinge and preservinge the said Worke and enabled to make and execute good Orders for the maintayninge and continueinge of the same and receive assureture of their severall partes and shares of the cleere benefitt and profit of the said Worke to them their heires and Assignes for ever: And upon the humble Petiçon of the said Hugh Middleton and the rest of the said Adventurers of our especiall grace certaine knowledge and meer moçon have willed graunted ordained created and appointed and by theis presents for us our heires and Successors doe will graunt ordaine create and appoint. That our welbeloved Subjects Hugh Middleton Cittizen and Gouldsmith of London Sir Henry Mountague Knight Lord Chiefe Justice of our Court of Kings Bench Sir Robert Killigrew Knight Sir William Burlacie the elder Knight Sir Thomas Middleton Knight Cittizen and Alderman of London Sir Lawrence Hide Knight Sir William Burlacie the younger Knight Sir Henry Nevill Knight Nicholas Hide of the Middle Temple London Esquier John Parker Esquier Samuel Backhowse Esquier John Backhowse his Sonne and heire Esquier Robert Bateman of London Skynner Henry Middleton sonne and heire of David Middleton late of London Gent deceased Humfrey Hall of London Girdler Peter Vauloze Merchant stranger Rowland Backhowse of London Mercer Timothie Middleton of London Esquier Hugh Middleton sonne and heir of Hugh Middleton Gouldsmith William Middleton of London Draper Richard Middleton of London Grocer William Middleton of London Gouldsmith Marmaduke Rawden of London Clothworker Henry Vincent of London Letherseller William Bateman of London Grocer John ffarror of London Skinner Edward Prichard of London Skinner James Bearblocke of London Gent and Gabriell Newman of London Gouldsmith and all and every person and persons which hereafter accordinge to the true Intent of theise presents shall be elected and chosen into the roome or place of them or anie of them which shall dye or be removed for ever hereafter be and shalbee by force of these presents one body corporate and politique in Deed fact and name and by the name of the Governor and Company of the new River brought from Chadwell and Amwell to London, and them by the name of the Governor and Companie of the new River brought from Chadwell and Amwell to London one body corporate and politique really and fully for us our heires and Successors We doe erect make ordaine create constitute and declare by these presents and that

by the same name they shall have perpetuall Succession and that they and their Successors for ever by the name of the Governor and Companie of the new River brought from Chadwell and Amwell to London be and shalbee for ever able and capable in lawe to have receive take purchase and possesse to them and their Successors Mannors Landes Tenements Rents Revenues possessions liberties priviledges Rights Jurisdicōns franchises and hereditaments and also goodes and Chattles whatsoever of what kinde nature or Qualitie soever they be in fee and perpetuitie or otherwise howsoever And alsoe to demise lease assigne lett give graunt sell or dispose of the said Mannors Landes Tenements rents revenues possessions liberties priviledges rights Jurisdicōns franchises hereditaments goodes and Chattles or anie of them and that they and their Successors for ever by the name of the Governor and Company of the new River brought from Chadwell and Amwell to London may pleade and be impleaded answeare and be answeared unto defend and be defended in all manner of Courts and places that now are or hereafter shalbe within our Realme or elsewhere as well spirituall as Temporall in all manner of Accōns Suits pleas matters or causes whatsoever of what kinde sorte or qualitie soever they be or shalbe called or knowne in the same and in as large and ample manner and forme to all Intents construccōns and purposes as anie other person or persons bodies politique or corporate of this our Realme of England beinge able and capable persons in lawe may doe; And further of our more especiall grace certaine knowledge and meere moōn Wee doe by these presents for us our heires and Successors give and graunt unto the said Governor and Company of the new River brought from Chadwell and Amwell to London and their Successors That they and their Successors shall for ever hereafter have and enjoy a coñon Seale to seale any manner of Instruments Deedes or Writings and for doeing of anie other business the said Company or Societie anie waie touchinge or concerninge, And that it shall and may be lawfull for them and their Successors the same Seale from tyme to tyme to breake change alter and new make as to them shall seem most expedient and further of our more especiall grace certaine knowledge and meere moōn Wee doe hereby for us our heires and Successors will and graunt That there shalbe for ever hereafter one of the most sufficient and discreete persons of the said Companie in manner and forme hereafter in these presents expressed from tyme to tyme elected and chosen which shalbe and shalbe called the Governor of the said Companie for the callinge of Courts Assemblies Councells and Consultaōns and for the better direcōn and necessary dispatch of the affaires and busineses concerninge the same Companie And that there shalbe also one other sufficient person of the said Company in manner hereafter in these presents expressed elected and chosen which shalbe and shalbe called the Deputy Governor of the said Company who shalbe usually resident within our said Cittie of London or the Suburbs thereof and shall in the absence of the Governor supplie his place and roome and have the like and the same Authoritie as the Governor hath, and that there shalbe also one other person of the same Companie in manner and forme also in these presents expressed to be elected and chosen which shalbe and shalbe called the Treasurer of the said Company who shall from tyme to tyme have the receipts of all the rents and profitts arisinge and cominge of and by the aforesaid Worke and the things thereunto belonginge as also the disbursinge and layinge forth of the same or so much thereof as shalbe necessary for the charges and Occasions touchinge and concerninge the said Worke by direcōn of the said Companie accordinge to the Intent of theis presents and the Distribuōn and payment of the residue of the cleare gaine and profitt thereby arisinge (all necessary charges and Expences and the Officers ffees and Allowances first deducted) That is to The one moietie thereof to us our heires and Successors and the other moietie thereof to the severall parties Interested in the said Worke accordinge to their severall partes shares proporōns and Interests and accordinge to the true meaninge of these presents And further Wee doe by these presents for us our heires and Successors graunt unto the said Governor and Company and

their Successors, That it shall and may be lawfull to and for the persons before in these presents named and appointed to be of the said Company together with the Deputy Governor for the time being and all others hereafter accordinge to the true meaninge of these presents which shalbe of the said Companie and their Successors or anie five or more of them (whereof the Governor of the said Companie or his Deputie for the tyme beinge to be one from tyme to tyme to meete and assemble themselves together in some such meete and convenient place within our said Cittie of London or the Suburbes thereof as to them shall seem best and as often as they shall thinke convenient and there beinge so well mett together to hould Courts Councells and Consultaçons and in them from tyme to tyme conclude and agree upon and to make demises and leases of anie parte or partes of the Water cominge from the foresaid new River or streame or anie profit or advantage of or by reason of the said river or streame to anie person or persons either to be derived or conveyed out of the pipes of the said Worke or otherwise for anie Terme or Estate not exceedinge the terme of one and twentie yeares or three lives or anie number of yeares determinable upon one two or three lives and for such fines and rents uppon such covenants and condiçons as they shall from tyme to tyme thinke fitt and also to heare and handle and determine all and all manner of businesses matters and things concerninge the well preservinge orderinge and maintayning of the foresaid Workes streame and Water and the collectinge and receivinge of the whole profit gaine and benefitt arisinge or cominge thereof and thereby ; And as touchinge the charges expenses disbursements payments and allowances to be made or given as well for the needfull Occasions and businesses touchinge the foresaid Worke streame and Water or anie thinge thereto belonginge as for the Officers to be used or employed in or about the said Worke streame and water or for the Affaires concerninge the same and ffees and wages to be to them paid and allowed for the same, And also in the same Courts Assemblies Councells and Consultaçons in forme aforesaid to be houlden from tyme to tyme to name make and constitute Stewards Clarkes and such and soe manie other Officers and Ministers for the said Company as well for the writinge and registringe of their Graunts Acts and Constituçons and for the Oversight repayinge mayntaininge and preservinge of the said Worke streame and Water as for the dispatch of other the businesses concerninge the said Companie and Worke Streame and Water as they shall thinke fitt and to give and minister unto every of the said Officers so to be nominated and appointed his Oath for the true due honest and faithfull execuçon and discharge of his or their place or Office appointed to him or them so long as hee or they shall continue in the same for the most profit benefitt and advantage of the said Worke streame and Water and of the Owners thereof and the affaires and businesses of the same and for makinge true Accompts of all matters and things within their severall Offices and ymployments and further Wee doe hereby for us our heires and Successors give and graunt unto the said Governor and Company of the new River brought from Chadwell and Amwell to London and their Successors That it shall and maie be lawfull to and for the said Governor and Companie for the tyme beinge or anie five or more of them beinge assembled and mett together as is aforesaid (whereof the Governor or his Deputy for the time beinge to be one) to make ordaine and sett downe orders Ordinances Acts of comon Councill lawes and Constituçons whatsoever reasonable and convenient in writinge which accordinge to their discreçons shall seeme to be good wholesome profitable necessary and requisite as well for the good rule order and government of the said Companie and every member of the same as also for the well orderinge preservinge and governinge of the said Worke streame and Water or anie matters or things concerninge the same : and that the same Orders Constituçons Acts of comon Councill lawes and Ordinances so by them or anie five or more of them as is aforesaid to be made sett downe and prescribed shalbe and shall stand in full force and strength in lawe to all Construçõs Intents and purposes untill such

tyme as by other ordinances orders and Constitucōns to be made by the said Company the same shalbe altered revoaked or repealed, so as the same Orders Constitucōns Acts of cōmon Councell Lawes and Ordinances be not repugnant to the lawes and statuts of the Realme nor to our Prerogative Royall; And for the better execucon of our will and pleasure herein Wee have nominated appointed created constituted and made and by theis presents for us our heires and Successors doe nōiate appointe create constitute and make the said Hugh Middleton to be the first and present Governor of the said Companie and our welbeloved Subject Robert Bateman to be the first and present Deputy Governor of the said Company and our welbeloved Subject Rowland Backhowse to be the first and present Treasurer of the said Companie to remaine and continue in the said Offices severally and respectively untill the Tuesday next after the ffeast of All Saints which shalbe in the yeare of our Lord God one thousand sixe hundred and twentie and from thence untill some other sufficient and discreet persons shalbe chosen in their roomes and places accordinge to the true meaninge of these presents; The said present Governor takinge first his corporall Oath for the due Execucon of his Office and place in all things concerninge the same before the cheife Baron of our Court of Exchequer for the time being or any other of the Barons of the same Courte for the tyme beinge, unto which said cheife Baron or other of the Barons Wee doe hereby give and graunt full power and Authoritie to Minister an Oath to the said first Governor for the due and true execucon of his Office without anie further or other Warrant from us our heires and Successors in that behalfe to be had procured or obtained And likewise our will and pleasure is that the persons before named to be the present Deputy Governor and Treasurer and every of them before they or anie of them enter into the Execucon of the said Office or Offices shall take their and every of their Oaths for the due Execucon of their said severall places and Offices before the present Governor of the said Companie; and Wee doe therefore hereby for us our heires and Successors give full power and Authoritie unto the said Governor of the said Company (haveing first taken his Oath for the true execucon of his Office of Governor of the said Companie) to administer severall Oathes unto the said Deputy Governor and Treasurer aforesaid for the due and faithfull execucon of their severall Offices and places respectively accordinge to the true meaninge of these presents without any further or other warrant from us our heires or Successors in that behalfe to be had procured or obtained; And further our will and pleasure is, And Wee doe hereby for us our heires and Successors graunt unto the said Governor and Companie and their Successors that it shall and maie be lawfull to and for all and every person and persons now beinge or hereafter to be of the said Companie accordinge to the true meaninge of these presents or anie seaven or more of them (whereof the Governor or his Deputy for the tyme beinge to be one) to assemble and meete together within our said Cittie of London or the Suburbes of the same as is aforesaid yearelie and every yeare on the Tuesday next after the feast of All Saints as aforesaid or within tenn daies after, and there to elect nominate choose and appoint one fitt sufficient and discreete person of the said Company to be Governor of the said Company and one other person of the said Companie to be Deputy Governor of the said Company and one other like person of the said Company to be Treasurer of the said Company which said severall persons soe to be elected nominated and chosen shall severally take their and everie of their Corporall Oathes for the true and faithfull execucon of the said places respectively unto which they shall be so nominated and chosen before the Governor of the said Company or his Deputy for the tyme beinge and before such of the same Company as will then be present And the same severall psons havinge so taken their and every of their Corporall Oathes shall and may lawfully have use and execute the same their severall Offices roomes and places for one whole yeare from thence next ensueinge and untill some other fitt psons shalbe unto the said Offices respectivelie nominated elected chosen and sworne to the due

execucon thereof accordinge to the true meaninge of these presents, And Wee doe hereby for us our heires and Successors give and graunt full power and Authority unto the Governor or Deputy Governor of the said Company for the tyme beinge as well to minister reasonable Oathes unto such Governor Deputy Governor and Treasurer so from tyme to tyme to be elected and chosen as to all Stewardest Clerks and other Officers or ministers in manner and forme aforesaid to be elected and chosen severally and respectively for the true and faithfull execucon of their severall Offices and places duringe the tyme they shall contynue in the same without any other Coṁmission or further warrant from us our heires or Successors in that behalfe to be had procured or obteyned And if it should happen at anie tyme or tymes hereafter the Governor Deputy Governor or Treasurer or anie other Officer or minister of the said Company to dye departe or be removed from the execucon of anie their places respectively (whom for cause reasonable Wee will shalbe from tyme to tyme removeable at the will and pleasure of the said Company or anie twelve or more of them) That then and so often it shall and may be lawfull to and for anie twelve or more of the said Company then remayninge with as convenient speede as they may after such death departure or removinge to nominate elect and choose one or more other person or persons unto the roome or roomes place or places of the Governor Deputy Governor Treasurer or other Officer or minister of the said Company so deceased deptyed or removed for the residue of the yeare then to come and forthwith to yield and give an Oath to every such pson so nominated elected and chosen faithfully to performe his Office and place as aforesaid without anie further coṁmission or warrant in that behalfe and so often as the case shall soe require And further of our especiall grace certaine knowledge and meere mocon Wee have given and graunted And by these presents for us our heires and Successors (for the consideracons aforesaid) as much as in us is Wee doe give and graunt unto the said Governor and Company of the new River brought from Chadwell and Amwell to London and their Successors the said new River cutt and streame soe as aforesaid brought from Chadwell and Amwell to London with the Appurtenaunce and all manner of profitts Advantages and Coṁmodities thereof or by reason thereof in any sorte to be made raised or gotten To have hould and enjoye the said new River Cutt or Streame and premisses with the appurtenaunce to the said Governor and Company of the new River brought from Chadwell and Amwell to London and their Successors for ever accordinge to the true meaninge of these presents; To be holden of us our heires and Successors as of our Mannor of Eastgreenwich in our Countie of Kent in free and comon Socage by fealtie onely and not in chiefe nor by knights service And further Wee will and by these presents for us our heires and Successors doe ordaine that the said Governor and Company of new River brought from Chadwell and Amwell to London and their Successors at all and every tyme and tymes hereafter shall well and sufficiently maintaine repayre preserve and scoure the said new River and Streame and all the Bancks and Bridges of and belonginge to the same as now it is, And that the said Governor and Company and their Successors shall and may lawfully alter and change the said new River or cutt in by and through anie of the Groundes or soyle of us our heires or Successors without anie ympeachment or Impediment or further or other warrant in that behalfe; And further that it shall and may be lawfull for the said Governor and Company of the new River brought from Chadwell and Amwell to London and their Successors and to their Officers and Workemen and Servants to take and use the earth digged and cast up out of the said new River or Trench already made or hereafter to be made and to carry the same to anie place or places for the good of the said worke streame or water or for the benefitt of the said Companie of and from the Ground or Soile of us our heires or Successors; And further of our more especiall Grace certaine knowledge and meere mocon Wee doe for us our heires and Successors, hereby give and graunt unto the said Governor and Company of the new River brought from Chadwell and Amwell to London and their Successors

full power license and Authoritie to purchase have receive take and enjoy to the use of the said Governor and Company of the new River brought from Chadwell and Amwell to London and their Successors for ever aswell of the Mayor and Cominalty and Cittizens of the said Cittie of London as from the said Hugh Midleton his heires and Assignes and of and from all and every other pson and psons havinge or clayminge anie thinge into or concerninge the said new River Streame Water and premisses such Estate Right Title and Interest liberties and priviledge whatsoever as they or anie of them have or ought to have and which may be lawfully passed conveyed graunted or anie waie transferred to the said Governor and Company and their Successors ; And likewise Wee doe hereby for our heires and Successors give and graunt unto the said Governor and Company of the new River brought from Chadwell and Amwell to London and their Successors full and free licence libertie power and Authority to purchase have receive take enjoy and possesse from or of us our heires or Successors or of and from anie other pson or psons whatsoever one convenient Messuage Tenement or howse with the Appurtenauncs within our Cittie of London or Suburbes of the same for hall or meetinge place To hold their Councells Courts and Consultacons in for and touchinge the Affaires matters and businesses of the said Company, so as the same be not holden of us our heires or Successors by knights service in Capite ; The Statute of Mortmaine or anie other Act or Statute to the contrary notwithstanding ; And to the end that the said Company may have perpetuall Continuance and the psons unto whome anie partes or porcons in the moiety of the benefitt arisinge by the said Water Worke shall come or fall by purchase discent or otherwise maie in equall and respective measure for every parte and share accordinge to their severall parts and shares in the said Worke have a severall voice and dealing in the said Company and worke ; Wee doe hereby for us our heires and Successors will ordaine appoint That whensoever and so often as it shall happen anie of the said psons before menconed to have anie share or shares out of the moiety of the said new River and of the cleare profitt from thence arisinge accordinge to the true meaninge of these presents to departe withall or so much of the said share or part as that hee shall not still retayne a full thirtie sixe part or share of the moiety of the benefitt or profitt of the said Worke Then and soe often it shall and may be lawfull to and for the same Governor and Company to remove such pson from being of the said Companie and to elect such pson or psons to whom such share or part shalbe transferred or some other pson or psons to whom a thirtie sixe parte or share of the benefitt or proffitt of the said worke shall apptaine into the roome or place of him that is or shalbe so removed and also that upon death or avoydance of the place of any of the said Company that then such heire or person unto whom the Inheritance of such part porcon or share shall come or some other pson or psons beinge lawfully Intituled to a full thirtieth sixte parte of the benefitt of the said Worke shalbe by the said Governor and Company for the tyme beinge elected and taken into the said Company and be a Member thereof in the roome of him so deceasinge or whose place shalbe voyde, And further Wee doe by these presents for us our heires and Successors straightly charge and comaund all pson and psons whatsoever that they or anie of them doe not hereafter cast or putt into the said new River anie Earth rubbish soyle gravell stones dogges Catts or anie Cattle Carrion or anie unwholesome or uncleane thinge nor shall washe nor clense anie Clothes wooll or other thinge in the said River nor hurt abate breake pull downe take or carrie away anie the howses pipes pondes banckes or bridges of or belonging to the said new River made or to be made or anie parte of them nor shall doe anie Act or thinge that shall or may hinder lett stopp or annoy the said water or the current or passage thereof nor shall make or convey anie sincke sewer ditch Tanhowse dying howse or seege into the said River or to have anie fall into the same ; And further that they or anie of them doe not hereafter presume to lay or place anie pipe or pipes or make anie devise to drawe or convey or otherwise to fetch or carry away turne

or divert anie the water out of the said River nor out of anie pipe or quill graunted or to be graunted to anie pson or psons by the said Companie without the lycense and consent of the said Governor and Companie for the tyme beinge or of their lawfull Officers and Ministers thereunto to be authorized first had and obtayned in writinge nor do hereafter make or digge any new ditch pond pitt or trench neere the said new River whereby the water of the same may fall or drayne away nor doe hereafter plant or sett anie Sallowes Willowes or Elme within five yardes of the said River at the least nor doe anie other Nusance or Annoyance whatsoever to the said river or attempt nor goe about to bring to the said Citties of London and Westminster and to the borough of Southwarke or to either of them anie other river or pipe for conveyinge or bringinge of water from anie place whatsoever without the lycense and Assent of the said Governor and Company of the new River brought from Chadwell and Amwell to London or their Successors upon payne that every pson and psons offendinge in all or anie of the premisses shall Incurr our high displeasure and such paines penalties and punishments as by the lawes or statuts of this our Realme of England or by our Prerogative royall can or maie be Inflicted and Imposed upon such Offenders as Breakers and Contemners of our royall Comaundement given for the preservacon and Continuance of this soe great and necessary a worke tendinge so much to the publique good of our said Cittie of London: And further Wee will and Ordaine by these presents for us our heires and Successors That such pson or psons as Wee our heires or Successors shall hereafter name and appoint to take and receive to our use of and from the said Governor and Company and their Successors such soimes of money and profitts as shall accrue and belonge to us our heires and Successors for or by meanes of the said Water Worke shall have full power and Authoritie and him and them Wee doe hereby authorize upon receipt of the same monies and profitts to make and deliver to the said Governor and Company and their Successors from tyme to tyme such Acquittances and Releases in writinge under his and their hand and seale of and for the same monies and profitts soe received as aforesaid which said Acquittances and releases Wee will shalbe from tyme to tyme good and sufficient exoneracons and Dischargs to and for the said Governor and Company and their Successors against us our heires and Successors of and for the same moneys and profitts so paid as aforesaid without other or further warrant to be had or obtained from us our heires or Successors in that behalfe; And likewise Wee will and by these presents for us our heires and Successors doe graunt unto the said Governor and Company and their Successors That theis our lres patents or the Inrollment of them and all and every thinge and things in the same contayned shalbe in and by all things firme stronge effectuall and avayleable in the law against us our heires and Successors aswell in all our Courts as elsewhere; Notwithstandinge the not recitinge or misrecitinge of the foresaid Acts of Parliament or of the foresaid Acts of Comon Councell or of the said Indenture made betweene the said Mayor Cominaltie and Citizens of the Cittie of London and the said Hugh Midleton or of the said Indenture made betweene us and the said Hugh Midleton or misrecitinge of the dates or tymes of them or any of them And notwithstandinge the statute concerninge landes and tenements not to be putt to Mortmaine and notwithstandinge anie other defect Impfeccon matter cause or thinge whatsoever; and further Wee doe for us our heires and Successors (In consideracon of the long travell and Attendance of our welbeloved subject William Lewyn Gentleman in and about the said Water Worke) appoint name constitute and make him the said William Lewyn to be the first Clarke of the said Companie; to have hould execute and enjoye the said Office by himselfe or his sufficient Deputy for and duringe the naturall life of the said William Lewyn (hee behavinge himselfe well and honestly in the execucon of the same) And after the decease of the said William Lewyn Wee will and appoint That it shall and may be lawfull to and for the said Governor and Company and their

Successors or anie seaven or more of them (whereof the Governor or his Deputy for the tyme being to be one) to name elect and choose some other meete pson to the said Office of Clarke of the said Company who shalbe and continue in the same place for and during the pleasure of the Governor and Company and their Successors or the greater parte of them The said William Lewyn and all other persons hereafter to be chosen to the said place of Clarke of the said Companie first taking his and their Oath before the Governor or Deputy Governor of the said Company as aforesaid for the execucon of his and their place of Clarke of the said Company ; although expresse mencon of the true yearely value or certenty of the premisses or anie of them or of anie other Guifts or Graunts by us or anie of our Progenitors or Predecessors to the foresaid Governor and Company of the New River brought from Chadwell and Amwell to London before theis tymes made in theis presents is not made or any Statute Acte Ordinance provision proclamacon or restraint heretofore had made sett forth ordained or provided or anie other matter cause or thinge whatsoever to the contrary in anie wise notwithstandinge ; In witnes whereof Wee have caused these our lres to be made patents Witnes ourselfe at Westminster the one and twentieth daie of June in the seaventeenth yeare of our Raigne of England ffrance and Ireland and of Scotland the two and fiftieth.

per Breve de privato Sigillo.

The Charter contains the following endorsement on sheet eleven :

To the Right Honourable the Master
of the Rolls.

The humble Petition of the Governor and Company
of the New River

Sheweth

That by letters Patent under the Great Seal of England bearing date the one and twentieth day of June in the seventeenth year of the raign of King James the first Sir Hugh Middleton Knight and severall other persons in the said letters Patent named were incorporated and made a Body Corporate and politick by the name of the Governour and Company of the New River brought from Chadwell and Amwell to London. That the said King by the said letters Patent made and constituted the said Sir Hugh Middleton to be the first and then present Governour and also constituted the Deputy Governour and other Officers of the said Company therein particularly named.

That the said then Governour and the other persons so by the said letters incorporated did accordingly forthwith proceed in the Execution of the severall powers and Authorities therein and thereby granted to them ; And that they and all their successors ever since have acted under the said letters Patent or Charter. And your Petitioners the present Governour and Company by right of succession do act under the same, And by no other Charters or letters Patent of Incorporation whatsoever.

That your Petitioners have lately discovered, that by some omission or neglect, the said letters Patent and Charter so granted as aforesaid were never to this time Recorded or Inrolled.

28 March 1737

Be it so

J. Jekyll.

Your Petitioners therefore to prevent any damage, that by any accident, may attend the loss of the said letters Patent, upon which the Properties of many persons depend, And the Inconveniencies that by any such loss may ensue to the Inhabitants of London Westminster and other places, who are supplied with water in their houses from the said New River, humbly pray Your Honour will be pleased to order that an Inrollment may be forthwith made of the said letters Patent under the Great seal and affixed to the Patent Rolls of the same year wherein they bear date.

And your Petitioners shall ever pray &c.

APPENDIX B.

A PETITION BY A PLUMBER TO THE LORDS OF THE TREASURY IN THE REIGN OF QUEEN ANNE, AND A REPORT BY SIR CHRISTOPHER WREN.

[*Treasury Papers*, 1693. Vol. xxv., No. 17.]

To the Right Hon^{ble} the
Lords of the Treasury.

The Humble Petition of John Cocke, Plummer.

Sheweth

That yo^r Pet^r hath done (for these four years past) Plummers work about the Pipes of St. James's House whereby there is Due to your Pet^r Twenty two Pounds six shillings and ten pence, That formerly your Pet^r has been pay'd by the privie Purse. But makeing Application that way for his said Debt and afterwards by Petition to the Queen, Her Maj^{ty} was pleased to direct your Petitioner to Apply to your Lordships for the same. And in as much that the said debt hath been a long time due to your Pet^r whose necessities at this time are very great

Therefore your Pet^r most humbly pray's your Lordships to order him the Payment of the said Twenty two pounds six shillings and ten pence.

And yo^r Pet^r shall ever pray &c.

Whitehall Treäry Chambers.

6th March 169³.

The Lords Comm^{rs} of their Ma^{ts} Treäry are Pleas'd to Referr this Petition to S^r Christopher Wren Surveyour Gen^l of their Ma^{ts} Works who is desired to consider y^e same and certifie their Lopps a new State of the matter therein contain'd together wth his opinion w^t is fitt to be don therein.

Hon. Grey.

Jno. Cock to S^r Xtop^r Wren.

Sir Christopher Wren's Reply.

May it please yo^r Lp^s

In pursuance of your Lp^s Reference upon y^e petition of John Cock one of y^e Plumbers to y^e New River Company, I have examined the Bills annexed, which are for plumber's worke in mending the pipes that were lay'd in by the said Company into St. James' Pallace during the time for which the Said Company lately petitioned your Lp^s for their arreares of Rent for w^{ch} reason I respited the answer to this reference till now your Lp^s had adjusted the matter of the Rent; and I suppose these bills are to be pay'd upon y^e same account by the Greencloth. I find the Bills vouched by credible persons, and though they amount to £24 12s. 8d. by reason some worke hath been since added, yet I judge the summe mentioned in the petition viz. £22 6. 10½. may satisfie for the whole worke mentioned in both Bills annexed. All which is humbly submitted.

Chr Wren

Dec. 21

1693.

APPENDIX C.

THE CHARTER GRANTED BY GEORGE I. TO THE GOVERNOR, AND COMPANY OF CHELSEA WATER-WORKS. (1723).

GEORGE by the Grace of God, of Great Britain, &c. To all to whom these Presents shall come Greeting: WHEREAS, by an Act passed in the last Sessions of Parliament, Entitled an Act for the better supplying the City, and Liberties of Westminster, and parts adjacent with Water, Reciting, that by reason of the great Increase of Buildings, and Inhabitants, in and about our City of Westminster, and the Liberties thereof, and divers other Places in our County of Middlesex, there are greater Occasions for Water, for the Safety and necessary Uses of the said Inhabitants, than are supplied by the Water Works now in being; and for the want thereof, many great and dangerous Inconveniences do happen, which would be remedied, and great advantages accrue, if new Water Works were erected, in convenient places for providing, and supplying the said Inhabitants with good, and wholesome Water, from our River Thames, by one or more Cutt, or Cutts, to be made at any convenient place, or places, between the Grounds belonging to our Royal Hospital at Chelsea, and the Houses, and Grounds commonly called the Neat Houses, in our said County of Middlesex, into Canals, and Ponds proper for receiving the same; and from thence to convey, and raise such Water into convenient Reservoirs, to be erected, or made, at any place, or places between the place called Oliver's Mount, and our Park called Hyde Park. For the Purposes of the said Act it was Enacted, That the Honourable *John Fane*, Colonel *Richard Molesworth*, Colonel *James Otway*, Colonel *Robert Gardner*, Sir *Andrew Chadwick*, Knt. *Henry Foubert*, *William Lewis Le Grand*, *William Churchill*, *Thomas King*, *William Green*, *Thomas Beake*, *John Eckersall*, *James Scanlan*, *William Looker*, *Joseph Watts*, and *John Briscoe*, Esqrs. should be, and are thereby constituted, and appointed Commissioners, Undertakers, and Trustees, for designing, carrying on, and effecting the Purposes aforesaid; and for directing, ordering, appointing, and making such Water Works, and for maintaining, preserving, and supporting the same; and that the Property thereof should be, and was thereby vested in the said Commissioners, Undertakers, and Trustees, and their Successors.

1st.
Act of
Parliament
recited as to
the Intent of
the Under-
taking.

AND it is in and by the said Act of Parliament Enacted, That it should, and might be lawful to, and for us, our Heirs, and Successors, by Letters Patent under our Great Seal of Great Britain, to incorporate all, and every the Commissioners, Undertakers, and Trustees, or such of them as should be living at the time of granting such Letters Patent, and such others as We, our Heirs, and Successors should think fit to be one Body Politick, and Corporate in

2nd.
Act of
Parliament
recited
Empowering
the Incor-

poration of
the Under-
takers.

Deed and in Name, by the Name and Title of *The Governor and Company of Chelsea Water Works*, with such Powers, Immunities, and Privileges as in, and by the same Act, are mentioned, and intended; and to be under such Rules, Qualifications, and Appointments as We, our Heirs, and Successors should think necessary, or reasonable to be inserted in such Letters Patent.

3rd.
The Under-
takers'
Petition for
a Charter of
Incorporation.

AND WHEREAS, the said Colonel *John Fane*, and Colonel *Richard Molesworth*, by their humble Petition, on behalf of themselves, and the rest of the Commissioners, Undertakers, and Trustees, have humbly besought Us, that our Royal Charter of Incorporation may be granted to them the said Petitioners, with the rest of the said Commissioners, Undertakers, and Trustees, and such others as We shall think fit, for the designing, carrying on, and effecting the Purposes aforesaid; and directing, ordering, appointing, and making such Water Works, and for maintaining, preserving, and supporting the same; with such Powers, Liberties, and Privileges as in the aforesaid Act are mentioned; and under such further Powers, Rules, Qualifications, and Appointments as We shall think convenient.

4th.
The Under-
takers incor-
porated.

NOW KNOW YE, That We being desirous to promote, and encourage so commendable, and useful an Undertaking, in Pursuance of the said Act, and also of our especial Grace, certain Knowledge, and mere Motion, have given, granted, constituted, declared, and appointed, and by these Presents, for Us, our Heirs, and Successors, do give, grant, constitute, declare, and appoint, that the said Colonel *John Fane*, Colonel *Richard Molesworth*, Colonel *James Otway*, Colonel *Robert Gardner*, Sir *Andrew Chadwick*, *Henry Foubert*, *William Lewis le Grand*, *William Churchill*, *Thomas King*, *William Green*, *Thomas Beake*, *John Eckersall*, *James Scanlan*, *William Looker*, *Joseph Watts*, and *John Briscoe*, and such others as shall be admitted into the said Company, according to the Directions, and Regulations herein after mentioned, from henceforth shall be one Body Corporate, and Politick, in Deed, and in Name, by the Name, and Title of *The Governor, and Company of Chelsea Water Works*; and them, by the Name of *The Governor, and Company of Chelsea Waterworks*, we do, really, and fully, for Us, our Heirs, and Successors, make, create, erect, ordain, constitute, and establish, by these Presents, to be one Body Corporate, and Politick, in Deed, and in Name, for ever, and that by the same Name, of *The Governor, and Company of Chelsea Water Works*, they shall have perpetual Succession; and that they, and their successors by the same Name be, and at all times hereafter shall be able, and capable in Law to have, purchase, receive, possess, enjoy, and retain to them and their Successors, Manors, Lands, Tenements, Rents, Privileges, Liberties, Franchises, and Hereditaments, of what Kind, Nature, and Quality soever they be, not exceeding One Thousand Pounds per Annum in the whole; and also to give, grant, demise, alien, assign, and dispose of such Manors, Lands, Tenements, Rents, Privileges, Liberties, Franchises, and Hereditaments, according to the Limitations, and Restrictions herein after mentioned; and to do, and execute, all and singular, other Matters, and Things touching the Premises, by the same name, that to them shall, or may appertain to do, and that they, and their Successors, by the name aforesaid, may sue, and be sued, plead, and be impleaded, answer, and be answered unto, defend, and be defended, in whatsoever Court, and place, and before any Judges, Justices, or Officers of Us, our Heirs, and Successors, in all and singular Actions, Pleas, Suits, Complaints, Matters, and Demands, of what kind, or quality soever they shall be, in the same manner, and form, and as fully, and amply as any of our Subjects of this our Realm of Great Britain, may or can do, sue, or be sued, plead, or be impleaded, answer, and be answered unto, defend, and be defended; and that the said Body Politick, and their Successors may have a common seal for the business, and affairs of the said Company, and that it shall, and may be lawful to, and for the said

Governor, and Company and their Successors, the same seal from time to time, at their will and pleasure, to break, change, alter, or make anew as often as to them shall seem expedient.

AND FURTHER WE WILL and by these Presents for Us, our Heirs, and Successors, do ordain, that there shall be from henceforth one of the same Company to be elected, and appointed in such form, and manner as hereafter in these Presents is expressed, who shall be, and be called the Governor of the said Company; and that there shall be from henceforth a Deputy Governor, and Thirteen Directors of the said Company, to be elected, and appointed in such manner, and form as hereafter in these Presents is directed, mentioned, and expressed, for the managing, and carrying on the business, and affairs belonging to the said Company.

5th.

A Governor,
Deputy-
Governor,
and Thirteen
Directors
established.

AND WE DO HEREBY make, nominate, ordain and constitute *Sir Thomas Hewett*, Knt., to be the first, and present Governor of the said Company; and *Colonel Robert Gardner*, to be the first, and present Deputy Governor of the said Company; and *Colonel John Fane*, *Colonel Richard Molesworth*, *Sir Andrew Chadwick*, Knt., *Henry Foubert*, *Thomas King*, *William Green*, *Thomas Beake*, *John Eckersall*, *James Scanlan*, *Francis Negus*, *Joseph Watts*, *Andrew Doyle*, and *Anthony La Meloniere*, Esqrs., to be the first, and present Directors of the said Company, and to continue in their respective offices, until the expiration of one year next after such time, as the said Water shall be conveyed, and raised into the grand Reservoir, or Reservoirs intended to be made, at or near the said place called *Oliver's Mount*, and from, and after that time, until some other fit Persons shall be duely elected, and sworn into the said offices of Governor, Deputy Governor, and Directors of the said Company, if they shall so long live.

6th.

The first
Governor,
Deputy-
Governor,
and
Directors
nominated,
and time of
continuance.

AND WE DO HEREBY for Us, our Heirs and Successors, give, and grant unto the said Governor and Company, and their Successors for ever, full power and authority to hold a general Court, in some convenient place, within, or near our Cities of London, and Westminster, or one of them, and there to assemble, and meet together so often as the Governor, Deputy Governor, and Directors for the time being, or any five, or more of them shall see Cause, or as Ten other Persons, who shall have, in their own Right, Ten whole Shares a-piece, in the joint stock of the said Company, in Writing under their hands, shall demand of the Governor, Deputy Governor, or any five, or more of the Directors. Such Court to be held, to treat, and consult, or make, and establish reasonable Laws, Orders, and Rules, concerning the affairs of the said Company, or for the good Government thereof. The time, and place of holding, and keeping all which Courts shall, Fourteen Days before the same are held, and kept, be published in the London Gazette, or such other publick manner, as the said Governor and Company, and their Successors shall from time to time hereafter order, and direct.

7th.

Power to
hold General
Courts.

AND WE DO HEREBY for Us, our Heirs, and Successors, grant, and declare, that the said Governor, Deputy Governor and Directors, or any five or more of them (whereof the Governor or Deputy Governor for the time being to be always one) shall make, and be called the Court of Directors of the said Company, and that it shall be lawful for the said Court of Directors, or the major part of them then present, from time to time to choose, and appoint one, or more Treasurer, or Treasurers of the said Company, and also from time to time hereafter, as they shall see cause, to choose, and appoint one, or more Secretary, or Secretaries, Book-keepers, Stewards, Clerks, Beadles, and other under Officers necessary for the service of the said Company, and to allow their respective Fees, or Salaries, and to encrease, or diminish, or otherwise alter the same, and to remove, and displace them, and every of them, when and so often as they, or the major part of them then present shall think fit, and to

8th.

Court of
Directors.

Officers and
Servants.

administer Oaths to all under Officers, and Ministers of the said Company, for the true, and faithful execution of their several Offices, and Places during the time they shall continue in the same, and for the observance of the Laws, Constitutions, Orders, and Ordinances of the said Company, which said Oath, and Oaths we do hereby for Us, our Heirs, and Successors, fully empower, and authorize such Court of Directors, or the major part of them then present, to administer to such under officers, or ministers, and also to contract for, and direct Demises, and Leases to be made under the seal of the said Company, of any part, or parts of the Water coming, or which shall come, from, or through any of the Pipes, Canals, or other Works, which shall belong to the said Company, to any person, or persons for any term, or estate not exceeding the term, or terms, which shall be limited by order of the general Court of the said

Let Water
by Leases.

Company; and for such Fines, and Rents, and upon such Covenants, and Conditions, as the said Court of Directors, or the major part of them then present shall from time to time think fit; and also to order, direct, manage, and transact all and every the affairs, and things of, or belonging to the said Company, (except such matters which ought to be ordered in and done by a general Court of the said Company,) and to constitute, ordain, and make such, and so many reasonable, and Bye Laws, Constitutions, Orders, and Ordinances, as to them, or the greater part of them, being then and there present, shall seem necessary, and convenient for the well-ordering, and governing of the said Company: and the said Bye Laws, Constitutions, Orders, and Ordinances, or any of them to alter, and annul, as the said Court of Directors of the said Company, or the major part of them present, shall see requisite, and in, and by such Bye Laws, Orders, and Ordinances to set, impose, and inflict reasonable Pains, and Penalties upon any Offender, or Offenders, who shall transgress, break, or violate the said Bye Laws, Constitutions, Orders, or Ordinances to be made as aforesaid, and to mitigate the same as they, or the major part of them then present, shall find Cause; which said Pains, and Penalties shall, and may be levied, sued for, taken, retained, and recovered by the said Governor, and

Orders
and Laws.

Company, and their Successors, or by their Officers, or Servants from time to time to be appointed for that purpose, by Distress or Action of Debt, or by any other lawful ways, or means to the use, and benefit of the said Governor, and Company, and their Successors, all and singular which Bye Laws, Constitutions, Orders, and Ordinances so as aforesaid to be made, We will, shall be duly observed and kept under the Pains, and Penalties therein to be contained. So, always as the said Bye Laws, Constitutions, Orders and Ordinances, Pains and Penalties, from time to time to be made, and imposed be reasonable, and not contrary, or repugnant to the Laws, or Statutes of this our Realm. And that such Bye Laws, Constitutions, Orders and Ordinances, Pains and Penalties, from time to time to be made, and imposed, be likewise agreed to, established, and confirmed by the general Court of the said Corporation, to be held, and kept next after the same shall be respectively made.

9th.
Manner of
Electing,
succeeding
Governors,
Deputy-
Governors,
and
Directors.

AND FURTHER WE have given, and granted, and by these presents for Us, our Heirs, and Successors, do give, and grant unto the said Governor and Company, and their Successors, from, and after the expiration of one year, next following such time, as the said Water shall be conveyed, and raised into the Grand Reservatory, or Reservatories intended to be made, at or near the said place called Oliver's Mount, full Power and Authority to elect yearly, *on the Twenty-fifth day of March, or within ten days afterwards*, a Governor, Deputy Governor, and seven Directors, out and from the Members of the said Company, and fix more Directors, from, and among the last preceding Directors of the said Company, by Plurality of Votes of all such, who have, or shall have in his, or their own Right, five whole Shares in the joint Stock of the said Company, and are then capable to vote, as hereafter mentioned, fourteen Days Notice being given in the London Gazette, or in such other publick manner, as the said Governor, and

Company, and their Successors, by Order of any general Court shall from time to time hereafter order, and appoint, by the Governor, or Deputy Governor for the time being, of the time, and place of such Election, which said Governor, Deputy Governor, and Directors, so chosen and elected, shall continue in their respective Offices, until the five and twentieth day of March next following his or their Election, or Elections, and from that time, until some other fit Person, or Persons shall be duly elected, and sworn in the Office of Governor, Deputy Governor and Directors of the said Company.

AND WE DO HEREBY for Us, our Heirs, and Successors, declare our Will, and Pleasure to be, that the Governor, or Deputy Governor of the said Company for the time being, do and shall yearly, and every Year, from and after the Expiration of one Year, next following such time, as the said Water shall be conveyed, and raised into the Grand Reservatory, or Reservatories, intended to be made, at or near the said place called Oliver's Mount, call and hold a general Court on the said *five and twentieth Day of March, or within ten Days after*, as aforesaid, for and in order to such Election, or Elections, and shall give fourteen Days Notice in the London Gazette, or in such other public manner, as the said Governor, and Company, and their Successors, by Order of any general Court, shall from time to time hereafter order, and direct, of the time, and place of such Election, or Elections, and from time to time, as often as there shall be Default of such Notice, that Ten, or more of the said Company, who shall be entitled, or qualified to vote at such general Court, shall, or may assemble themselves together, upon the fourteenth Day after the said five and twentieth Day of March, unless the same shall happen to be on a Sunday, and in such case such Ten, or more of the said Company shall, or may assemble themselves together, the next following such fourteenth Day after the said 25th Day of March, and such Ten, or more of the said Company, being so assembled, or the major part of them, (such major part not being fewer than Ten) may order, and direct a general Court of the said Company to be held within fourteen days after such Meeting, (Ten Days Notice at least of holding such general Court being first given in the London Gazette, or in such other public manner as aforesaid, of the hour, time, and place of holding such general Court,) and then, and there, by the Majority of Voices, shall, or may make such Election or Elections as aforesaid.

10th.
Obligations
to hold a
General
Court for
Electing a
Governor,
Deputy-
Governor,
and
Directors
annually.

AND WE DO HEREBY ALSO for Us, our Heirs, and Successors grant, and ordain, that each, and every *Twenty Pounds*, which will be part of the joint Stock, and *no less*, shall be, and accounted one Share therein, and that each Member, who hath, or shall have, in his, or her own Right, five whole Shares, in the said joint Stock, shall have, in every general Court of the said Company, one Vote for the same, and each Member, who hath, or shall have, in his, or her own Right, ten whole shares, in the said joint Stock, shall, in every such Court, have Two Votes for the same, and each Member, who hath, or shall have, in his, or her own right Twenty Shares, in the joint Stock aforesaid, shall have Three Votes, in every such Court, for the same, and no Member shall have, at any time or times, in any Court to be held, and kept, by the said Governor, and Company more than three Votes how great soever his, or her number of Shares, in the said Company, or Interest in the joint Stock thereof, shall or may be, nor shall any Member have a Vote, who shall have in his, or her own Right, any less number than Five whole Shares in the joint Stock as aforesaid.

11th.
Right of
Voting pro-
portioned to
Shares in
Stock.

PROVIDED ALWAYS that no Person shall have a Vote, in any such general Court, who shall be possessed, or interested in his own Name, or in the Name of any Person, or Persons in Trust for him, either solely, or jointly, of any Part, or Share of, or in the joint Stock of any other Company, or Undertaking for raising, or conveying of Water to our Cities of London,

12th.
Right of
Voting
further
explained.

and Westminster, or to either of them, or to the Liberties of, or Parts adjacent to the same, or to either of them.

13th.
Right of
Voting
further
explained.

PROVIDED ALSO that every Member, who shall Vote in such Election as aforesaid, or in any Court to be held by the Governor, and Company aforesaid, be personally present at the same, and do also take an Oath, before the Governor or Deputy Governor, or three or more of the Directors for the time being, and then present, that such number of Shares, in the said joint Stock, which shall entitle him, or them so to vote, are in his, or their own Name, and in his, or their own Right, and not in Trust for any Person, or Persons whatsoever, and that he, or they is, or are not then possessed, or interested in his, or their own Name, or in the Name, or Names of any other Person, or Persons in Trust for him, or them, either solely, or jointly of any Part, or Share of, or in the joint Stock of any other Company, or Undertaking, for raising or conveying of Water to our Cities of London, and Westminster, or to either of them, or to the Liberties of, or Parts adjacent to the same, or to either of them, to which Governor, Deputy Governor, and Directors for the time being, or any three, or more of such Directors respectively, We do hereby for Us, our Heirs, and Successors give full Power, and Authority to administer such Oaths accordingly.

14th.
Right of
Voting
further
explained.

AND WHENEVER there shall happen to be an Equality of Votes in the Election of any Officers, or Members of the said Company, the said Governor, or, in his absence, the Deputy Governor for the time being, shall have the casting Vote.

15th.
Oaths of
Qualification
ordained for
Governor,
Deputy-
Governor,
and
Directors.

AND that no Person shall be admitted to execute the Office of Governor, Deputy Governor, or Director of the said Company, until he, or they shall have taken, in open Court, before the preceding Governor, or Deputy Governor, or three, or more of the preceding Directors of the said Company, an Oath for the due Execution of his, or their respective Office, or Offices in the same Form, or to the Effect of the Oath hereinafter appointed to be taken by the first Governor, Deputy Governor, and Directors respectively, and also one other Oath importing, that he is entitled in his own Right, and not in Trust for any other Person, to such Quantity of Stock, in the joint Stock of the said Company, as is sufficient to qualify him for the Enjoyment of such Office of Governor, Deputy Governor, or Director respectively, according to the true Intent, and Meaning of these Presents, to which preceding Governor, Deputy Governor, and Directors for the time being, or any three of such Directors respectively, We do hereby for Us, our Heirs and Successors, give full Power, and Authority to administer such Oath, and Oaths accordingly.

16th.
Shares in
Stock pre-
scribed for
Qualification
of Governor,
Deputy-
Governor,
and
Directors.

PROVIDED ALSO, and We do, by these Presents, for Us, our Heirs, and Successors, will, ordain, and appoint, that no Person shall be capable of being elected, or chosen a Governor, of the said Corporation hereby established, who shall not, at the time of such Choice, or Election, have in his own Name, and his own Right, and for his own Use, and not in Trust for any other, Twenty, or more Shares in the joint Stock to be raised in pursuance of this our Charter, as is hereinafter mentioned, and that no Person shall be capable of being chosen a Deputy Governor, or Director of the said Corporation, hereby established, who shall not, at the time of such Choice, or Election, have in his own Name, and his own Right, and for his own Use, and not in Trust for any other, Ten or more Shares in such joint Stock of the said Corporation, and that no Governor, Deputy Governor, or Director of the said Corporation, hereby established, shall continue in such respective Office in Trust longer than the continuance of such his respective Shares, in the said joint Stock in his own Name, and Right, and to his own

Use as aforesaid. But upon parting with his said Shares in the said joint Stock, or reducing the same to any lesser Shares than the respective Shares before mentioned, the Office or Place of such Governor, Deputy Governor, or Director respectively, so parting with, reducing or diminishing his Shares in the said joint Stock, as aforesaid, shall become vacant, and another shall be elected in his Room by the Members of the said Corporation, according to the Rules, and Methods herein prescribed, or mentioned, any thing herein contained to the contrary notwithstanding.

AND FURTHER IT is our Will and Pleasure, that every Person, who, after his being duely elected into the Office of Governor, Deputy Governor, or Director of the said Company, shall, within fourteen Days after this Election, refuse to take upon him, or them, his, or their Office, or Place, Offices, or Places, whereunto he, or they shall be duely elected as aforesaid, or to be duely sworn into the Execution of his, or their Office, or Offices as aforesaid, or make, or render himself incapable by the Laws, Constitutions, Orders, and Ordinances of the said Company, or otherwise of holding the same, being at the time of such Election under no Impediment, or Incapacity from holding the same, shall forfeit, and pay to the said Governor, and Company, and their Successors, such Penalties as by the said Laws, and Ordinances, as aforesaid, shall be directed, limited, and appointed, and some other fit Person, or Persons, of the said Company, shall be chosen, and elected into his, or their Place, or Places.

17th.
Obligation
upon
Governor,
Deputy-
Governor,
and
Directors to
Act when
elected, and
Penalty.

AND FURTHER WE do for Us, our Heirs, and Successors, give, and grant unto the said Governor, and Company, and their Successors, or the major Part of them, in a general Court assembled, as aforesaid, full Power and Authority to remove, and displace any Governor, Deputy Governor, Director, or other Officer of the said Company, for Misdemeanor in his Office, or any reasonable Cause, and to elect others in the Place, or Places of the Person, or Persons so removed, and that as often as it shall happen that the Governor, Deputy Governor, or any of the Directors of the same Company, for the Time being, shall die, or be disqualified, by parting with, or reducing his Stock, or be permitted by the major Part of the Governor, Deputy Governor, and Directors of the said Company, in open Court, to surrender his, or their Office, or Offices, or shall be removed, and that there shall happen to be any Vacancy of a Governor, Deputy Governor, or Director of the said Company, that it shall, and may be lawful to, and for all Persons, having any Right to vote, fourteen Days Notice being given in the London Gazette, or in such other public Manner as the said Governor, and Company, and their Successors, by Order of any general Court, shall from time to time hereafter order, and direct, by the Governor, or Deputy Governor, of such Deaths, Disqualifications, or Vacancy, to choose, and elect into his, or their Place, or Places, some other fit Person, or Persons of the said Company, to the Office of Governor, Deputy Governor, or Director, by the Method, Manner, and Limitations herein before appointed, mentioned, and expressed, the said Governor, Deputy Governor, and Directors, so chosen, and elected, to continue in his, or their Office, or Offices, till the Twenty-fifth Day of March next following his, or their Election, or Elections, and till some other fit Person, or Persons shall be duly elected, and sworn into his, or their Office, or Offices, he, or they first taking, in open Court, the Oath, and Oaths herein appointed to be taken by the Governor, Deputy Governor, and Directors, before the Execution of their respective Offices, according to the Directions, and in the Manner in these, our Letters Patent, mentioned and expressed.

18th.
What may
be done upon
there being
Vacancies by
Death, etc.

PROVIDED NEVERTHELESS, and our Will and Pleasure is, that if the Governor, Deputy Governor, or any of the Directors of the said Company, for the Time being, shall die, or be

19th.
Proviso in
case of

Death, Surrender, or Removal of Governor, Deputy-Governor, or Directors.

permitted by the major Part of the Governor, Deputy Governor, or Directors as aforesaid, to surrender his, or their Office, or Offices, or shall be removed, and that there shall happen to be any Vacancy of a Governor, Deputy Governor, or Directors of the said Company, before the expiration of one Year next following such Time, as the said Water shall be conveyed, and raised into the Grand Reservoir, or Reservoirs, intended to be made, at, or near the said place called Oliver's Mount, that then, and in every such Case respectively, the Person, or Persons to be chosen, and elected into his, or their Place, or Places as aforesaid, shall continue in his, or their Office or Offices, till such Expiration of one Year, next following such time, as the said Water shall be conveyed, and raised into the Grand Reservoir, or Reservoirs, intended to be made, at, or near the said place called Oliver's Mount, and till some other fit Person, or Persons shall be duly elected, and sworn into his, or their Office, or Offices, he, or they first taking the Oath, and Oaths herein appointed to be taken by the Governor, Deputy Governor, and Directors as aforesaid.

20th.
The form of the Oath of Office, and Manner of taking it.

AND FURTHER our Will, and Pleasure is, and We do hereby ordain, that the said Sir Thomas Hewett, herein before named, to be present Governor of the said Company, shall take a Corporal Oath, before one of the Masters of our High Court of Chancery, in the words, or to the effects following, viz.: *I, A. B. do faithfully promise, that in the Office of Governor of the Corporation, called the Governor, and Company of Chelsea Water Works, I will give my best Advice, and Assistance, for the Support, and good Government of the said Corporation, and I will faithfully, and honestly demean myself, and execute the said Office, according to the best of my Skill, and Understanding, so help me God.* And the aforesaid several Persons, herein before named, to be the present Deputy Governor, and Directors of the said Company, shall take the like Oath, *Mutatis Mutandis*, before the said Sir Thomas Hewett, herein before nominated, and appointed to be the present Governor of the said Company, to whom severally, and respectively, We do hereby for Us, our Heirs, and Successors, give full Power, and Authority to administer the said Oath to the said Officers accordingly.

21st.
Power for the Company to purchase Lands, Goods and Chattels, to a Value limited, and to dispose of the same.

AND OF OUR FURTHER especial Grace, certain Knowledge, and mere Motion for the carrying on, and promoting the Interest of the Company aforesaid, We have given, and granted, and, by these presents for Us, our Heirs, and Successors, do give, and grant unto the said Governor, and Company and their Successors, that they the said Governor, and Company, and their Successors shall, and may have full, free, and lawful License, Power, and Authority to take, have, purchase, receive, enjoy, and possess to them, and their Successors for ever, any Manors, Lordships, Messuages, Mills, Waters, Streams, Conduits, Rents, Services, Reservoirs, Lands, Tenements, and other Hereditaments whatsoever, so as the same Manors, Lordships, Messuages, Mills, Waters, Streams, Conduits, Rents, Services, Reservoirs, Lands, Tenements, and other Hereditaments, do not exceed the yearly Value of *One Thousand Pounds* above all Charges and Repairs, and also Estates for Life, or Lives, and for Years, and for Goods, and Chattels, of what Value, Nature or Kind soever, for the better carrying on, and effecting the Purposes, in these our Letters Patent contained, not exceeding the Value of the Joint Stock of the Corporation herein after mentioned, and limited, and to be taken, and computed as part thereof, and also to give, grant, demise, alien, assign, and dispose of such Manors, Lordships, Messuages, Mills, Waters, Streams, Conduits, Rents, Services, Reservoirs, Lands, Tenements, Hereditaments, Estates for Life, or Lives, and for Years, Goods, and Chattels, and also to do, and execute all such other lawful Acts, and things whatsoever by the Name aforesaid, touching, and concerning the Powers, Liberties, Priviledges, and Purposes before mentioned.

AND FURTHER We have given, and granted, and by these Presents for Us, our Heirs, and Successors do give, and grant to all, and every Subject, and Subjects whatsoever of Us, our Heirs, and Successors, especial License, Power, and Authority, to give, grant, sell, and alien unto the said Governor, and Company, and their Successors, any Manors, Lordships, Messuages, Mills, Waters, Streams, Conduits, Rents, Services, Reservoirs, Lands, Tenements, and Hereditaments whatsoever, so as the same do not exceed the clear yearly Value of *One Thousand Pounds* above Charges, and Repairs whatsoever, and also Estates for Life, and Lives, and for Years, and Goods, and Chattels of what Nature, or Value soever, for the Intents, and Purposes aforesaid, not exceeding the Value, of the Joint Stock, of the said Corporation herein after mentioned, and limited, and to be taken, and computed as Part thereof.

22nd.

Powers to any person to give or sell to the Company a limited value.

AND WE DO HEREBY for Us, our Heirs, and Successors, give, and grant unto the said Governor, and Company, and their Successors full Power, and Authority, by Subscription, or Contribution of their Members, and others to make, and raise a Joint Stock, not exceeding the sum of *Forty Thousand Pounds* of Lawful Money of Great Britain, to be applied for the carrying on, and effecting the Purposes of this Charter, and the same Joint Stock to order, manage, and conduct from time to time, for the Purposes aforesaid, and to receive the Benefits, and Advantages of the same, to the use of them the said Governor, and Company, and their Successors according to such Shares, and Proportions, as they, or any of them have, or shall have therein, and all, and every Person, and Persons so subscribing, and contributing any sum, or sums of Money to such Joint Stock, shall, by virtue thereof, become members of the said Corporation, and shall be entitled to a Share, or Shares in such Joint Stock, equal to the sum, or sums of Money, so by him, or them actually contributed, and paid in, and no greater, and shall be, and are hereby enabled to sell, assign, and transfer the same, or any Part thereof to any Person, or Persons by Transfer in the Books of the said Company, in such Manner as shall be ordered, directed, appointed, and established in, and by a General Court of the said Company, or by his, or their last Will, and Testament, and the Person, or Persons to whom such Assignments, or Transfer, or Disposition, by last Will, and Testament shall be made, shall by Virtue thereof become Members of this Corporation.

23rd.

Power to raise a Joint Stock not exceeding £40,000, and to transfer the shares of that Stock.

PROVIDED NEVERTHELESS that no Person, or Persons who hath, or shall have any Shares, or Part of the said Joint Stock, shall assign, or Transfer the same before, or until such time as the said Water shall be brought into the Grand Reservatory, or Reservatories, intended to be made at, or near the said Place, called Oliver's Mount.

24th.

Power to Transfer, further explained.

PROVIDED ALSO that no Assignment, or Transfer be at any time made of any sum, or sums in the said Joint Stock less than one whole Share.

25th.

Transferring further explained.

AND of Our more abundant Grace, and Favour to the said Governor, and Company, we do hereby declare our Will, and Pleasure to be, that, if it should so happen, that any of the Persons, in these our Letters Patent, particularly named, or who shall hereafter become Members of the said Company, who have subscribed, and agreed, or shall subscribe, and agree in Writing under his, or their Hand, or Hands to adventure, or to pay in any sum, or sums of Money towards the Joint Stock of the said Company, and shall not, within the space of one Month, next after Notice, given for that purpose, in the London Gazette, by Order of the said Governor, or Deputy Governor, bring in, and pay to the Treasurer, and Treasurers to be appointed for the said Corporation such sum, or sums of Money as shall have been expressed, or set down in Writing, and subscribed by the said Person, or Persons, that then, and at all

26th.

Power to compel Payment of the Subscribed to the Joint Stock.

times after, it shall, and may be lawful to, and for the said Governor, and Company, and the major Part of them present, (whereof the Governor, or Deputy Governor to be one,) at any of their General Courts, or Assemblies, to remove, from, and out of the said Corporation, or Company, every such Person, and Persons so refusing, or neglecting to pay, or answer his, or their Subscription Money, and to admit any other Person, or Persons in his, and their Room, and, in every such case, the Person, and Persons so refusing, or neglecting, shall also forfeit to, and to the use of the said Governor, and Company, and their Successors, one fourth part of such sum, and sums of Money so subscribed by him, or them as aforesaid.

27th.
Pains and
Penalties on
Persons
destroying,
or damaging
Pipes,
Works, etc.

AND for the better preservation, and continuance of this so great, and necessary a Work, tending so much to the Publick good of Our said City, and Liberty of Westminster, and divers other Places in our County of Middlesex. We do, by these Presents, for Us, our Heirs, and Successors, require, and strictly command all, and every Person, and Persons, Bodies politick and corporate, and all other, the Subjects whatsoever of Us, our Heirs, and Successors within this our Kingdom of Great Britain, or Dominion of Wales, that they, or any of them at any time hereafter, do not commit, or cause to be committed any Act, matter, or thing whatsoever, which shall or may straiten, stop, lessen, or obstruct the current, or passage of the said Water, or any part thereof into, or out of the Mills, Engines, Ponds, Canals, Pipes, Reservoirs, or other the Works of the said Company, or presume to lay, or place Pipes, or make, or use any Device, to draw, convey, or otherwise to fetch, or carry away, or direct any of the Water of the said Mills, Engines, Ponds, Canals, Pipes, Reservoirs, or other the Works of the said Company, nor out of any Pipe, or Quill, granted, or to be granted to any Person, or Persons, or Body politick, or corporate by the said Governor, and Company, or their Successors without the License of the said Governor, and Company, or their lawful Officers, and Ministers thereunto to be authorized, first had, and obtained in Writing, nor do hereafter, make, or dig any Ditch, Pond, Pit, or Trench, or any other Device near any of the Ponds, or Canals, or other Works which shall belong to the said Governor, and Company, or their Successors, or do any other matter, or thing whatsoever, whereby the Water of the same may abate, diminish, fall, pass, or drain away without the License, and Assent of the said Governor, and Company, or their Successors first had, and obtained in Writing for that Purpose, upon such Pains, and Penalties as can, or may be inflicted upon such Offenders, for their Contempt of this our Royal Command, and further to be answerable to the said Governor, and Company, and their Successors according to Law, for their Damages thereby occasioned.

28th.
Company
not to use
the Banking
Trade, in
Bullion, or
Goods, or
Wares, or
Merchan-
dises.

PROVIDED always, and for the effectual preventing the Governor, and Company of Chelsea Water Works, hereby incorporated from intermeddling, or interfering with the Business, or Affairs of the Corporation of the Governor, and Company of the Bank of England, and dealing in any Trade, or Merchandise, Our Will, and pleasure is, and we do hereby direct, and command that the said Corporation hereby established, shall not at any time hereafter discount, or deal in Bills of Exchange, or in Land Bills, or Notes, nor shall receive Monies, or keep the Accounts, or Cash of any Person, or Persons, (other than their own proper Monies, Accounts, and Cash being the real Produce of their Joint Stock, or Fund, or such Monies as shall be paid to them for the Purposes herein mentioned,) nor shall deal in Banking, or any ways use the Banking Trade, or Business, nor shall upon their Common Seal, nor by their Cashiers, Officers, or Servants, or any other Person on their behalf give, or issue out any Bills, or Notes payable upon Demand for the Loan of Money, with, or without Interest, nor shall advance, or lend any Money at Interest upon any Account whatsoever, (except the Monies arising out of, or by the real Produce of their own Joint Stock, or Fund, or to be received by them, as herein

before is mentioned) nor shall by way of Trade, or Merchandise, directly, or indirectly buy, or sell, or deal in any Bullion, Gold, or Silver, or any Goods, Wares, or Merchandises. And in case the said Corporation hereby established do, or shall at any time, or times hereafter discount, or deal in Bills of Exchange, or in Land Bills, or Notes, or shall receive the Monies, or keep the Accounts of any Person, (other than their own proper Money, Accounts, and Cash being the real Produce of their own Joint Stock, or Fund, or such Monies as shall be paid to them as aforesaid,) or shall deal in Banking, or shall any ways use the Banking Trade, or Business, or shall either upon their common Seal, or by their Cashiers, Officers, or Servants, or any other Person on their behalf, give, or issue out any Bills, or Notes payable on Demand for the Loan of Money, with, or without Interest, or shall advance, or lend any Money at Interest upon any Account, or Pretence whatsoever, (except the Monies arising out of, and by the real Produce of their own Joint Stock, or Fund,) or shall by way of Trade, or Merchandise, directly, or indirectly, buy, or sell, or deal in any Bullion, Gold, or Silver, or any Goods, Wares, or Merchandises whatsoever, that then, and in any of the said Cases our Will, and Pleasure is, and We do hereby reserve to ourselves, our Heirs, and successors full Power, and absolute Authority by our, or their Order in our, or their Privy Council at any time, after three Months notice to the said Corporation, to determine this our present Charter, and the Corporation hereby made, created, or erected. And from three Months after such Order of Council, made in any of the said Cases, this our present Charter, and the Corporation hereby made, shall cease, determine, and be utterly null, and void to all Intents and Purposes whatsoever, and in case the said Corporation hereby established shall, contrary to the Restrictions before mentioned, offend in any Matter aforesaid, or in any Particular, or Particulars exceeding the Sum, or Value of £.500 within the Compass of any one Year to be reckoned from Lady Day yearly, that then the Attorney General of Us, our Heirs, and Successors, for the time being, shall, and is hereby authorized, and directed, by virtue of these presents, without any further Warrant, or Order from Us, our Heirs, and Successors, at the Request of the Governor, and Company of the Bank of England by *Scire Facias*, or Information, or otherwise, as the Law shall allow of, to prosecute the said Corporation hereby established for such Offence, and Breach of any of the Restrictions aforesaid, and to procure these our Letters Patent, and the Corporation hereby created, by Judgment thereon to be made void.

PROVIDED likewise nevertheless, and these our Letters Patent are, upon these express Conditions, that the said Corporation hereby established, or their Successors shall not by themselves, or their Agents, or Servants, commit, or do, or procure, or permit to be committed, or done any Act, Matter, or Thing whatsoever not authorised by these presents, which shall be contrary to the true Intent, and Meaning of a certain Act of Parliament, made in the Sixth Year of our Reign, entitled an Act for the better securing certain Powers, and Privileges, intended to be granted by His Majesty, by two Charters for Assurance of Ships, and Merchandises at Sea, and for lending Money upon Bottomry, and for restraining several extravagant, and unwarrantable Practices therein mentioned.

29th.
Company
not to do
anything to
the prejudice
of the two
Charters,
for the
Assurance
of Ships, etc.

PROVIDED also, and our Will, and Pleasure is, that nothing in these our Letters Patent contained, shall extend, or be construed to extend to hinder, or obstruct the Company called the Governor, and Company of the New River brought from Chadwell, and Amwell to London, or the Mayor, Citizens, or Commonalty of Our City of London, or their Lessees, or Assigns, or the Governor, and Company of Undertakers for raising Thames Water in York Buildings, or any other lawful Proprietors, or Undertakers of any Water Works whatsoever, or any, or either of them, or any claiming by, from, or under them, or any of them from holding, using,

30th.
Rights of
other Water
Works
secured to
them.

exercising, or enjoying all such lawful Rights, Titles, Estates, Interests, Privileges, Powers, and Advantages whatsoever, which they, or any of them now have, or ought to have, or be entitled to.

31st.
Injunction
upon other
Companies
of Water
Works not
to damage
this Com-
pany.

NEVERTHELESS, We do for Us, Our Heirs, and Successors, charge, and strictly command all, and every the Proprietors of Water Works, and Undertakers last mentioned, and their, and every of their Lessees, or Assigns, Workmen, Agents, and Servants, and every other Person, and Persons whatsoever, that they, or any of them do not disturb, obstruct, or hinder the digging, laying, making, conveying, repairing, or amending any of the Pipes, Branches, Aqueducts, or other the Water Works of the Governor, and Company hereby incorporated, or their Successors, or do, or cause to be done any wilful Prejudice, or Damage to the same, upon such Pains, and Penalties as can, or may be inflicted upon such Offenders for their Contempt, of this, our Royal Command, and to be further answerable to the Governor, and Company hereby incorporated, and their Successors according to Law for their Damages thereby occasioned.

32nd.
Right of the
City of
London in
the River
Thames
secured.

AND Our Will, and Pleasure further is, that nothing in these Our Letters Patent contained, shall extend, or be construed to extend to take away any Right, Property, or Jurisdiction of the Mayor, Commonalty, and Citizens of Our City of London, to, in, and upon Our said River of Thames.

33rd.
Injunctions
to the Civil
Magistrates
and Officers
to Assist in
favour of
this
Company.

AND We do further hereby for Us, Our Heirs, and Successors will, authorize, and command all, and singular Our Judges, Justices of the Peace, Mayors, Sheriffs, Bailiffs, Constables, Headboroughs, and all others, the Officers, and Ministers whatsoever, of Us, our Heirs, and Successors, for the time being, within this Our Kingdom of Great Britain, and Dominion of Wales, that they, and every of them respectively be from time to time in their several, and respective Offices, aiding, furthering, helping, and assisting unto the said Governor, and Company, and their Successors, their Agents, and Servants in all things according to Our Will, and Pleasure herein declared.

34th.
These
Letters
Patent to be
construed in
favour of the
Company
in the most
beneficial
sense.

And lastly, We do hereby for Us, Our Heirs, and Successors, grant, and declare, that these, Our Letters Patent, or the Inrollment thereof, shall be in, and by all things good, and valid, and effectual in Law, according to the true Intent, and Meaning of the same, and shall be taken, construed, and adjudged in the most favourable, and beneficial Sense for the best Advantage of the said Governor, and Company hereby incorporated, and their Successors, as well in all Our Courts of Record as elsewhere by all, and singular Judges, Justices, Officers, Ministers, and Subjects whatsoever of Us, Our Heirs, and Successors, the not reciting, or misreciting any Act of Parliament, or any other Nonrecital, Misrecital, Defect, Incertainty, Contrariety, or Imperfections in these, Our Letters Patent, or any other Matter, Cause, or Thing whatsoever to the contrary thereof in any wise notwithstanding. In Witness whereof, We have caused these, Our Letters to be made Patent, Witness Ourselves at Westminster, the eighth Day of March, in the ninth year of Our Reign.

INDEX.

THE following abbreviations are used, and the letters placed in brackets after the name of a place denote the Company to which it belongs :

C.	= Chelsea Waterworks Company.
E.L.	= East London Waterworks Company.
G.J.	= Grand Junction Waterworks Company.
K.	= Kent Waterworks Company.
L.	= Lambeth Waterworks Company.
N.R.	= New River Waterworks Company.
S.V.	= Southwark and Vauxhall Waterworks Company.
W.M.	= West Middlesex Waterworks Company.

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