Metropolitan Water Board.

THE WATER SUPPLY OF LONDON

Some historical notes together with a brief description of the engineering features of the Board's undertaking.

PREPARED IN 1937.

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By George Bickham (1772).

"SIR HUGH MYDDELTON'S GLORY"

Showing the first issuing of the water into the New River Head on September 29, 1613, in the presence of the Lord Mayor and other notables.

THE WATER SUPPLY OF LONDON

Some Historical Notes

By G. F. Stringer, O.B.E., of the Middle Temple, Barrister-at-Law; Clerk and Parliamentary Officer to the Metropolitan Water Board.

THE history of the supply of water, one of the first necessities of life to this great City, is one full of interest and romantic episodes.

The supply to the City of London presented no grave difficulties down to the end of the thirteenth century. The situation of London on a broad and noble river, on a healthy soil, in a valley from whose hills descended many a hidden if not forgotten stream, possessed many advantages. Much of the locality consisted of gravel resting on the clay so that "sweet water" was always accessible at a small depth, whilst springs and wells were numerous.

The Thames water was abundant and excellent. We learn from William Fitzstephen that the river was swarming with fish, and that it was for long a grievance with the "prentices of London that too much salmon entered into their diet"—it was so cheap.

John Stow wrote: "In the thirteenth century they had in every street and lane of the City divers fair wells and springs; and after this manner was this City then served with sweet and fresh waters, which being since decayed, other means have been started to supply the want."

Down to the thirteenth century Londoners with pail and pitcher were wont to resort to the springs and wells and to the shores of the Thames for their water.

Centuries elapsed before any attempt was made to convey the water to the dwellings otherwise than by manual carriage, and for a great part of this time those who desired to use the water of the Thames fetched it themselves or by their servants through the many lanes that led down to the riverside.

The water was also brought to the houses by water carriers who gained a living by selling the precious liquid. They were commonly called "Cobs," perhaps because many of them dwelt in a lane known as Cob's-court leading down to the river at Blackfriars.

The water-carrier was a well-known character to the Londoner, even in later times than these, when the means and distribution of the water supply were imperfect.

As London spread, and its population and commerce increased, the intramural supplies did not suffice for the wants of the inhabitants. Moreover, they became tainted, and slowly but surely the River Thames was converted from a sparkling salmon stream into a glorified sewer. We are told that the gutters of the City were black lines of stagnant filth, and refuse lay rotting even before the dwellings of noblemen and prelates, all of which was washed ultimately into the Thames.

At the beginning of last century water was drawn from the Thames for domestic use as low down as London Bridge and was delivered to consumers without filtration of any kind. The Thames became the common sewer of London and at numerous points sewage was discharged into the River above the intakes where water was drawn for the domestic purposes of the inhabitants of a considerable part of the City.

It was not until the year 1852 that, following successive outbreaks of cholera, Parliament ordained that the River Thames below Teddington should not be resorted to for the abstraction of water by the then Water Companies. Moreover, it was provided by the Metropolis Water Act of that year that all water for domestic use was to be filtered except such as was drawn from deep wells; that every reservoir for filtered water within five miles from St. Paul's was to be covered over; and that no water was to be conveyed except through pipes or covered aqueducts unless it was filtered before distribution.

Going back to the thirteenth century, it is found that greater attention began to be paid to the springs of the

suburbs. The practice grew up of conducting water from those springs to public cisterns and fountains placed in various parts of the City, which (like the pipes which supplied them) were called "conduits."

In 1236 Henry III granted to the citizens and their successors liberty to convey water from the village of Tybourne (the neighbourhood of Stratford-place, Oxford-street) by pipes of lead into the City. From this time, for several centuries, the City Corporation was regarded as the authority responsible for providing an adequate supply of water. During that period the supply from the river and wells was supplemented by the construction of twelve conduits bringing water from sources in the suburbs. Though the Corporation was responsible for the water supply, citizens considered the provision of water and the erection of conduit houses to be proper objects of charity.

Conduit houses were erected at Cornhill and elsewhere from the Tybourne source. There were also conduit houses at Cheapside, Bayswater and other places.

THE CONDUIT NEAR BAYSWATER.

The first cistern was called the Great Conduit in Westcheap and was made of lead and was castellated with stone. Its construction was expensive and tedious, occupying many years. In 1568 there was a conduit of Thames water within the City at Dowgate.

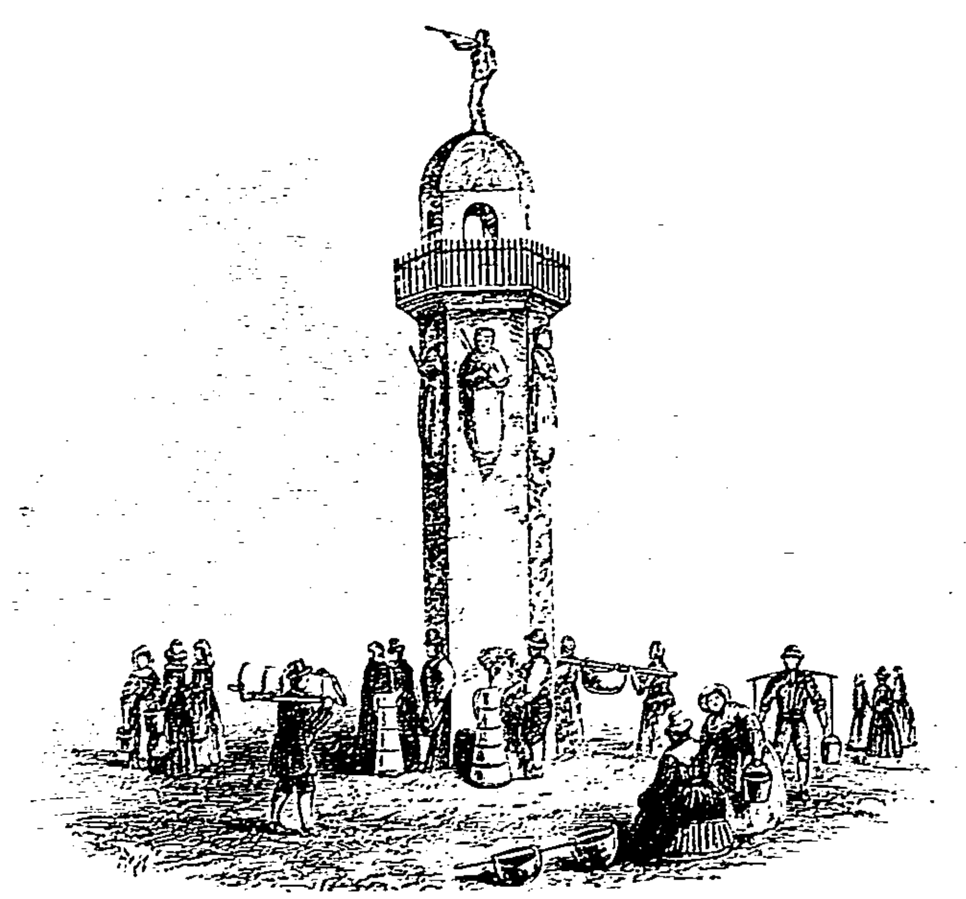
The inhabitants obtained the water from the conduits either by fetching it or by sending servants to fetch it and carry it to their houses. Or they could buy it from the water carriers, who made a business of selling it.

Instead of going to the conduits for their water, sometimes wealthy persons, having houses near the routes of these conduits, obtained permission to take a private supply by a pipe or "quill" connecting their houses with the conduits. Many instances of such grants are to be found among the City records.

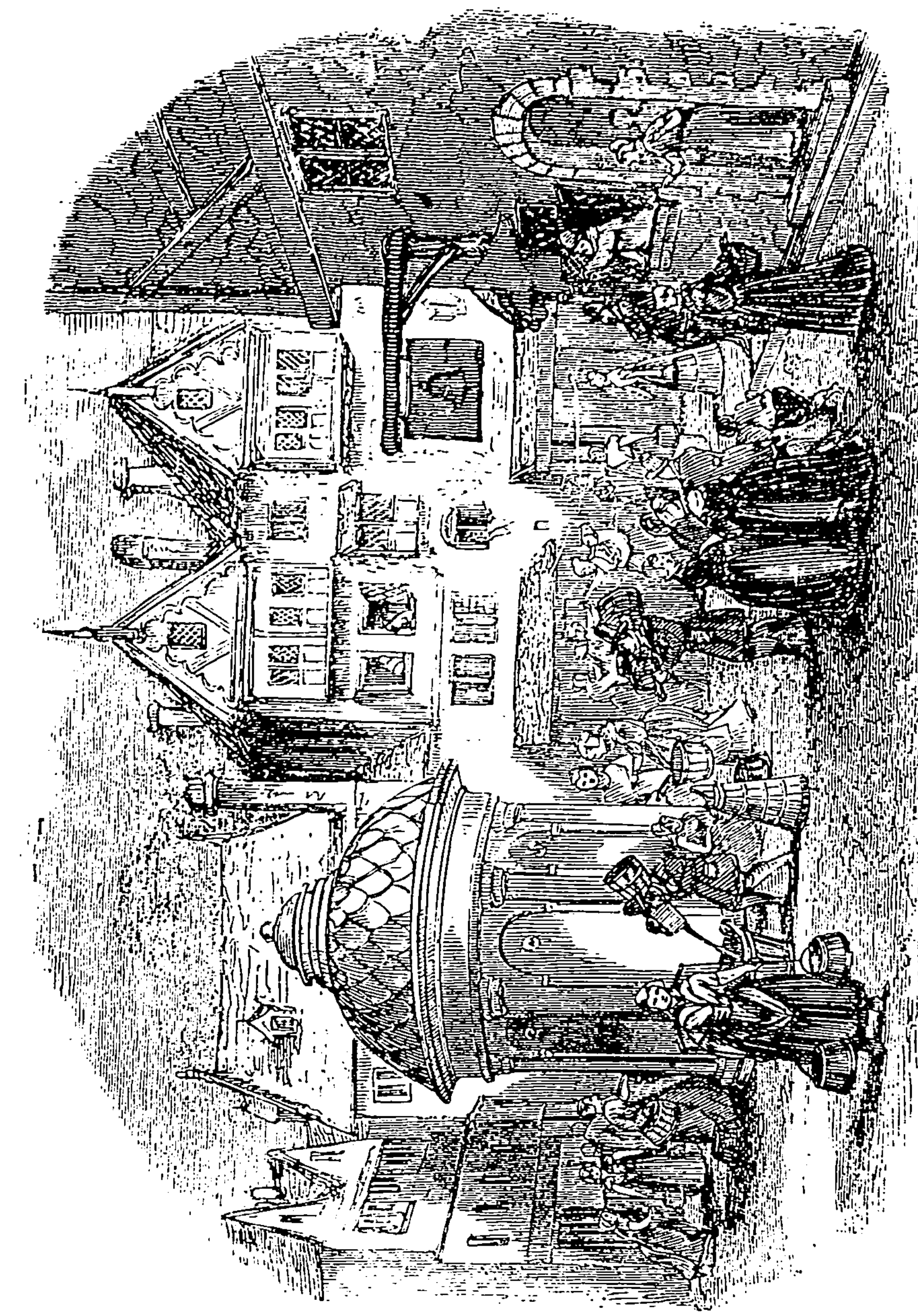
The City records also show that in the fourteenth century water was allowed to be taken from the conduits for domestic purposes without payment; but that a charge was made to those who required it for trade purposes, the proceeds being devoted to the upkeep of the conduits.

The Corporation protected its conduits most jealously and inflicted severe punishment on those who interfered with the flow of water.

A copious supply of water by these conduits was all the more necessary as London was, for the most part, built of timber and liable to frequent fires.



WESTCHEAP CONDUIT.

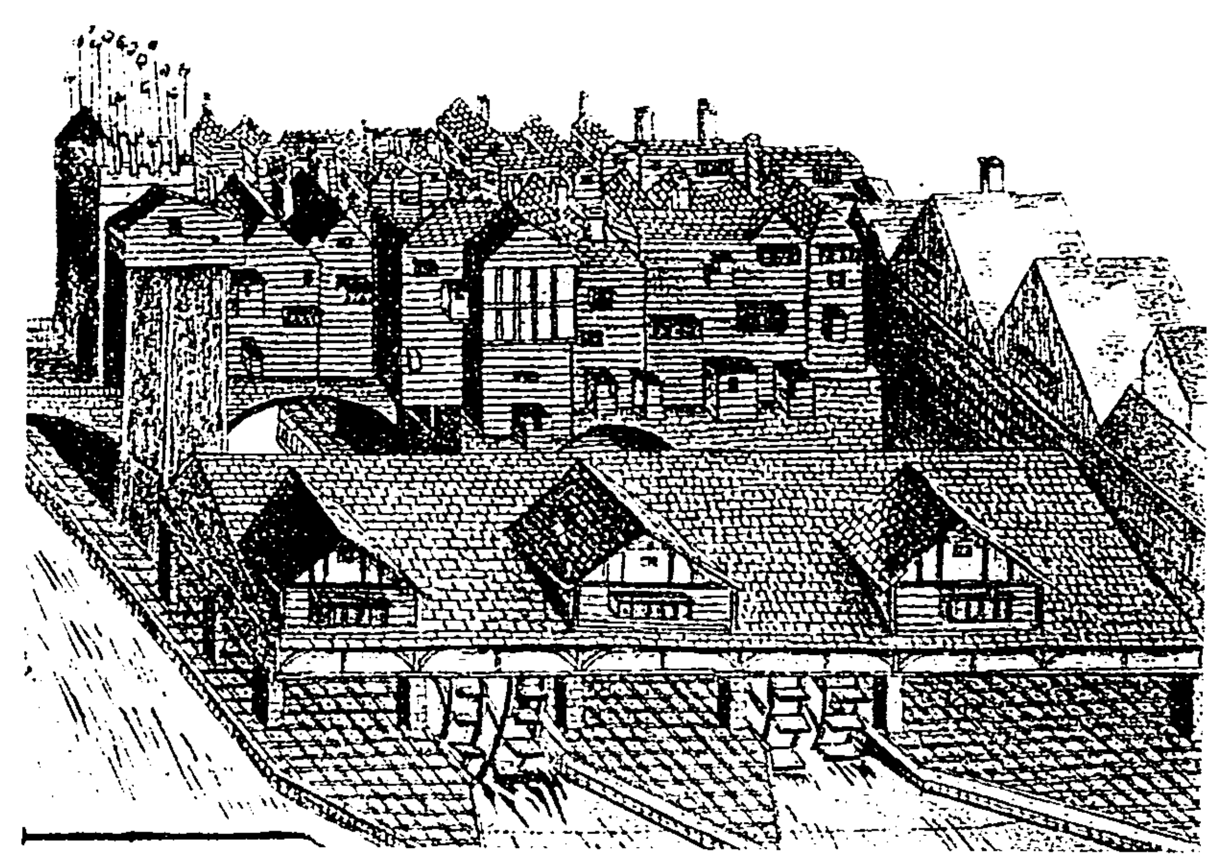


"TITTLE-TATTLE AT THE CONDUIT."

For more than three centuries the Lord Mayor and Commonalty, aided by the private gifts of many worthy citizens, continued to supply London with water; but so wretched was the supply and so neglected were the conduits and other means of supply that the City found itself face to face with a new system of supply which was introduced into London by a Dutchman called Peter Morrys, who, in 1582, established a pump, worked by a water wheel, in one of the arches of old London Bridge.

Before he obtained leave to supply the City, Morrys gave an exhibition of the power of his pump, and much astonished the City Fathers of those days, who came in state to witness the first water monopolist force a stream of water over the steeple of a neighbouring church, St. Magnus the Martyr. Morrys succeeded in getting a lease for 500 years from the City at a rental of 10s. a year, empowering him to take the Thames water and to use the arch.

In later years additional water wheels were added to augment the supply, two of which were situated on the Southwark side of the bridge and enabled the supply to be extended over a large portion of Southwark.



LONDON BRIDGE WATER WHEELS.

The lease of London Bridge continued in the Morrys family till 1701, when the Morrys of that period, finding that the adventure was suffering from competition with the New River Company, sold the concern to one Richard Soams, a member of the Goldsmiths' Company, who turned the business into a Company consisting of 300 shares of £500 each. The Company also took over the City conduits for a rental of £700 per annum. The water supply of the City of London was thus handed over by the Corporation to private enterprise.

The Company, however, was not the success it was anticipated and in 1822 it was bought up by its competitor, the New River Company. The works remained in existence until old London Bridge was destroyed in 1831.

It is of interest to note that the Metropolitan Water Board as successors to the New River Company is still under obligation to pay annuities in respect of the London Bridge Waterworks amounting to £3,750 per annum, which payments will continue until the year 2082.

The water supplied by Morrys was, however, limited in quantity for the growing needs of the City and was often turbid and foul. In 1603 the plague broke out and raged with such violence that in one week it carried off upwards of a thousand persons in the Metropolis; and London was roused to look for a better water supply.

During the reign of Elizabeth the question of an increased and better water supply for London seems to have been much considered. Queen Elizabeth granted to the citizens of London by Act of Parliament power to cut and convey a river from any part of Hertfordshire, through Middlesex, to the City of London, with a limitation of ten years for the performance thereof.

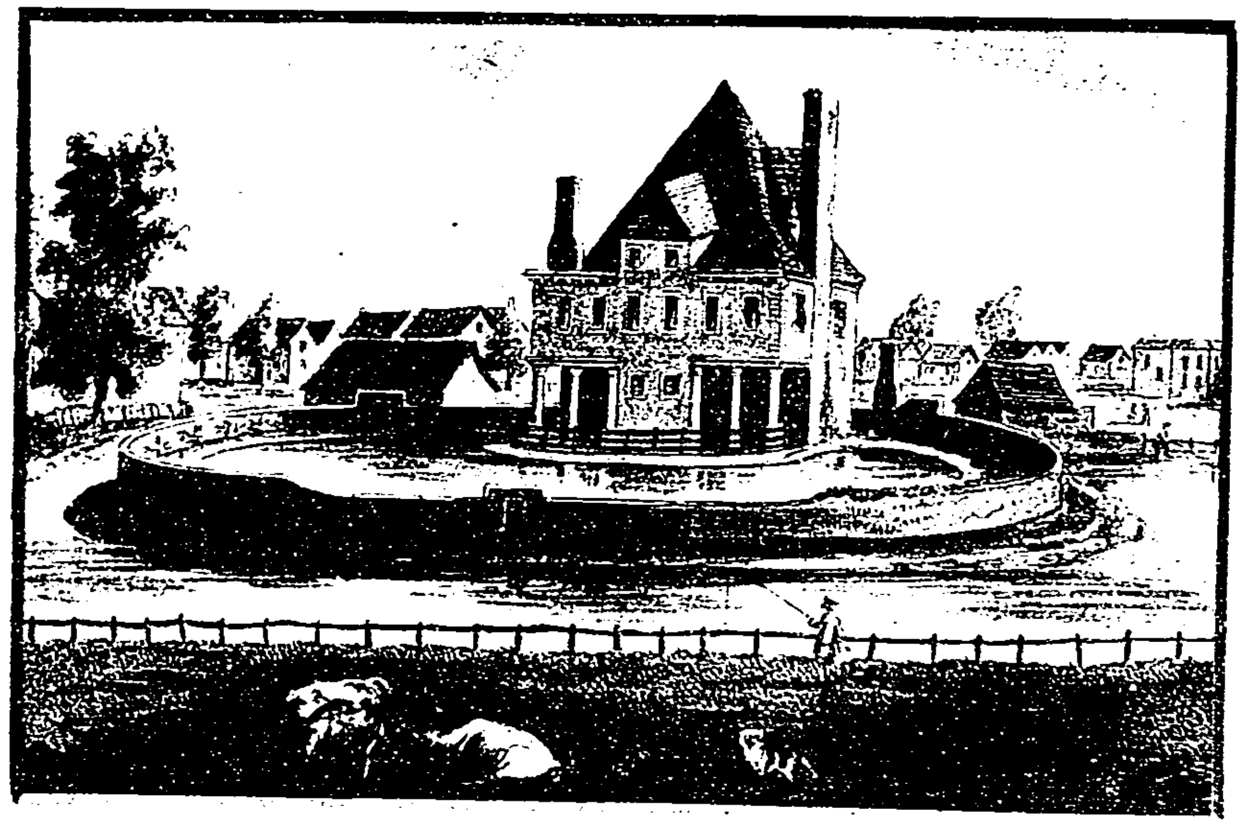
Nothing seems to have come of this; the citizens did not exercise the power, although very possibly this idea was the germ of the scheme which resulted in the formation of the New River Company. In the third year of James I an Act of Parliament was passed confirming what was afterwards the New River scheme, and the Mayor and citizens were empowered to bring water from the springs of Chadwell and Amwell, in the County of Hertfordshire, in an open cut or close trench.

But this was not the age of public enterprise; such an undertaking was thought to be beyond the power of what, even at that time, was no inconsiderable city. No doubt the difficulties in the way of such a scheme seemed impossible in

the then state of engineering knowledge. But what was considered no doubt for good reasons too great an undertaking for the City, was carried out by private enterprise, and the rights and privileges which were granted to the City by Parliament were handed over by a power of attorney to Mr.—afterwards Sir—Hugh Myddelton.

He was a member of King James' Parliament, and had sat on the Committee before which the scheme for providing London with a supply from the Hertfordshire springs had been discussed. The wealth he had accumulated as a London goldsmith and from his successful ventures at sea enabled him to support his faith in the scheme. The City Corporation was content to transfer to him its powers, and doubtless the fact that London had lost upwards of 33,000 citizens by plague in the last year of the reign of Queen Elizabeth caused the City Fathers grave anxiety.

Everyone who reads a description of the making of the New River cannot fail to admire the courage, energy, and vast perseverance of the remarkable man who carried out this wonderful scheme. Though it may be dwarfed by the larger undertakings of modern days, yet if we take into consideration the times when this work was accomplished, it must ever stand out as a monument of individual skill and industry.



"THE CISTERN," OR NEW RIVER HEAD, 5th AUGUST, 1730.

Perhaps it can best be described in the following simple but beautiful words which appear on the Memorial Stone at

Amwell: "An immortal work—since men cannot more imitate the Deity than in bestowing health."

Sir Hugh Myddelton obtained his power of attorney in 1606, but it was not till 20th February, 1608, that he began his work. This interval had been spent in overcoming the opposition of the landowners and others interested in opposing the scheme. When the work did commence, it was carried through as rapidly as possible; upwards of 600 labourers were employed, and the work was finished on Michaelmas Day, 1613.

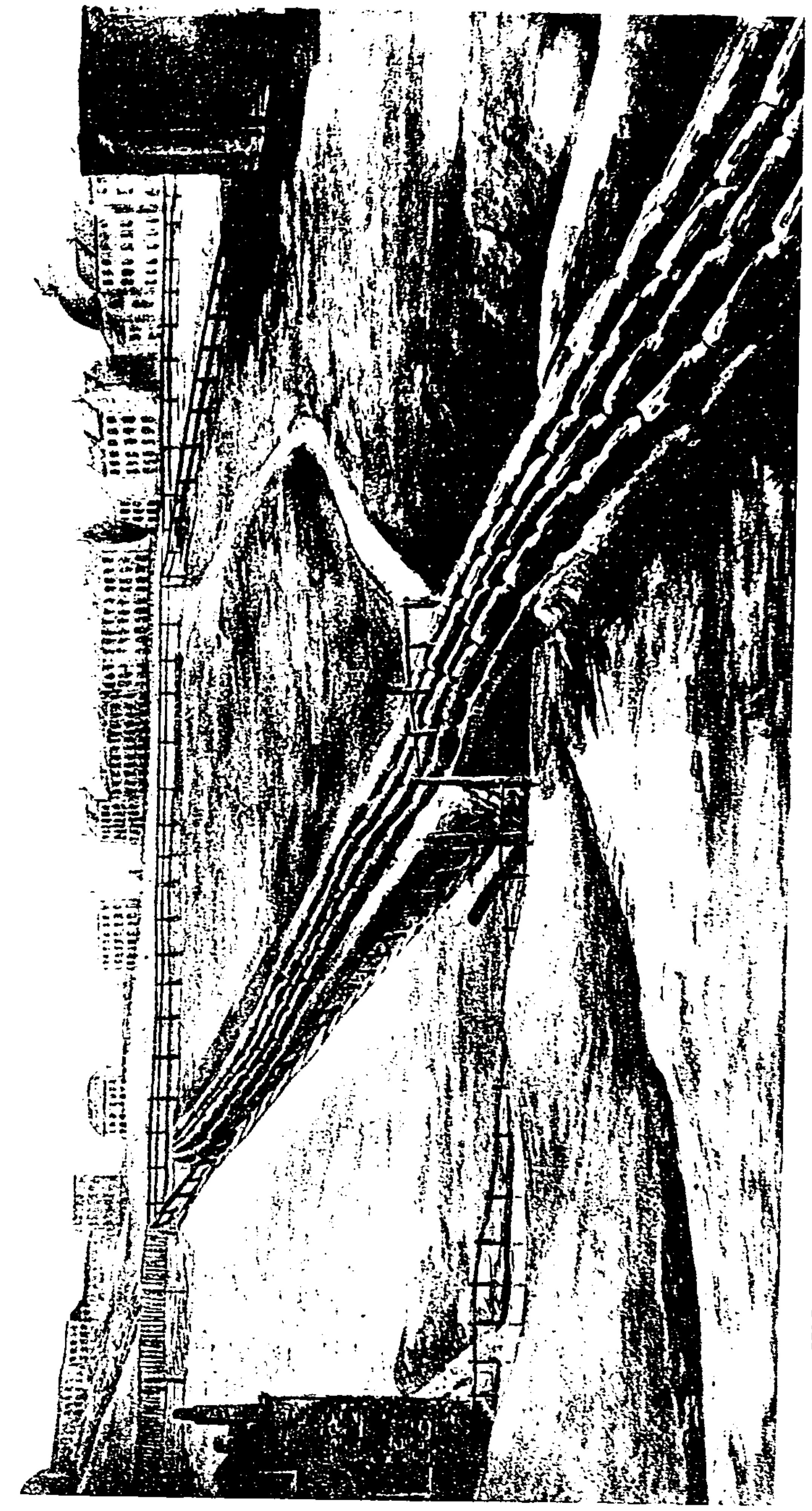
It was not, however, accomplished without much difficulty, both in the work itself and in providing the expense of carrying it out. When the work had been taken as far as Enfield Sir Hugh had spent the whole of his fortune, and had not King James come to the rescue the undertaking would in all probability have been stopped. Before, however, applying to the King, Myddelton endeavoured to obtain assistance from the Lord Mayor and Corporation of London, but it was still thought by them to be too hazardous an enterprise for them to take part in it and, moreover, they felt unable to assist on the ground that it might injure the "Cobs," or water carriers, of whom mention has already been made.

The completion of the work was a great day for the lovers of pomp and show when Royal and civic personages of high dignity assembled at Clerkenwell on Michaelmas Day, 1613, to see the flood-gates opened and the stream run gallantly into the cistern amidst the triumphal sounds of drums and trumpets. Among the distinguished personages present was Sir Thomas Myddelton (brother of Hugh), who had that morning been elected Lord Mayor of London.

The water from the Round Pond at Clerkenwell was conveyed to the City of London by means of hollow wooden pipes which were made usually of elm as that wood does not easily rot.

These wooden pipes were very unsatisfactory on account of local faults and as the bore was very small in order to allow for sufficient strength, they had very little carrying power. It was, therefore, not uncommon for six or more pipes to be laid side by side.

The birth of the New River Company was followed in due course by the creation of other Water Companies for supplying



WOODEN MAINS FROM THE NEW RIVER HEAD CROSSING THE RIVER FLEET other parts of London with water, and the order of their creation was as follows:

The East London Waterworks Company, dating from the Shadwell Waterworks of 1669.

The Kent Waterworks Company, dating from the Ravensbourne Waterworks of 1701.

The Chelsea Waterworks Company, dating from 1723.

The Southwark and Vauxhall Water Company, dating from 1771.

The Lambeth Waterworks Company, dating from 1785.

The Grand Junction Waterworks Company, dating from 1798.

The West Middlesex Waterworks Company, dating from 1806.

Space does not permit details being given of these private enterprises, which all possessed powers granted by Parliament for the purpose of supplying water, and in return for that service were endowed with a number of privileges.

Although the supply of water to London was originally municipal, as will have been seen from its earlier history, this principle was departed from and the policy of Parliament was to grant powers to private adventurers to form themselves into companies who undertook to make works, lay mains and to supply water to the inhabitants.

With the best of intentions, Parliament left the boundaries of these companies in an ill-defined state and in some cases purposely vague and indefinite, the object being to promote healthy competition.

For a time this policy was successful and fierce contention raged. It was no novel thing for two or three companies to be in the same street touting for customers just in about the same way as the milkman does to-day. This naturally meant that the streets were constantly being dug up and the navvies themselves would engage in battles royal with their pickaxes and shovels from opposing entrenchments.

But this state of things did not last long. Companies gradually amalgamated or agreed upon self-contained areas, so that districts which were legally in the limits of two or more companies were mutually divided by the companies between themselves. Thus the intention of Parliament was thwarted and the supply of water to London practically became a lucrative and, in the eyes of many, a dangerous monopoly.

Consequently a long agitation was begun on the part of consumers and local authorities against the Metropolitan Water Companies. This agitation lasted for best part of a century and during that period there were numerous Royal Commissions, Parliamentary Inquiries, Water Bills and Schemes involving the abolition of the companies, but the companies held their own.

To relate the detailed history of this long-drawn-out battle would take very much space and, therefore, it is proposed to pass it over by remarking that the controversy culminated in the introduction by the Local Government Board in the year 1902 of the Metropolis Water Bill which found its way to the Statute Book during that Session. Under this Act the Metropolitan Water Board was created, and entrusted with the obligation of acquiring by purchase and of managing the undertakings of the eight Metropolitan Water Companies.

Thus was the Metropolitan Water Board born and the control of London's water supply once again became municipal.

The compensation claimed by the companies for the loss of their undertakings amounted to no less than 51 million pounds, and the compensation awarded exceeded 30 million pounds in addition to which the Board took over the Debenture Stocks of the companies amounting in all to approximately 12 million pounds. The taxed costs of the companies were nearly £89,000, and the directors' compensation and taxed costs £221,000.

With this millstone around its neck the Metropolitan Water Board started its life.

The Board may be said to be the largest undertaking of its kind in the world, supplying as it does with water nearly eight million people distributed over an area exceeding 537 square miles.

The Board's area is 42½ miles from north to south and extends from Hertford in the north to about three miles south of Westerham in the south. From east to west it measures

34 miles, being bounded by Southfleet on the east and Sunbury on the west.

The population supplied by the Board is within 350,000 of the combined population of Australia and New Zealand. It represents 17 per cent. of the population of Great Britain. So that one out of every six persons living in Great Britain is dependent for water supply on the Metropolitan Water Board.

During last year the population supplied by the Board increased by 154,000, or 6,000 more than a town as large as Brighton.

The number of services in the Board's direct area is 1,438,600. If these could be placed right round the world at the equator, a supply would be available at every 30 yards.

The average daily supply for the year ended 31st March, 1937, was 290 million gallons. This vast quantity can best be appreciated by stating that it represents two full tanks each of the size of Trafalgar Square (2½ acres) and the height of Nelson's Column (170 feet high) and another full tank over a half that size.

The average supply per head per day during that year was 37·04 gallons, or more than a barrel of good water every day for every man, woman and child in the area. The supply of each house every day would weigh nearly a ton. In one way or another it may be said that every Londoner consumes or uses in a day about twice his weight in water.

Upon the transfer to the Board in 1904 of the undertakings of the Water Companies the Board was faced with the necessity of spending large capital sums for the purpose of extending and improving such undertakings and in converting them into one interconnected unit capable of meeting the ever growing needs of Water London.

How this has been achieved is dealt with in the notes by the Chief Engineer, but it will perhaps be of interest to observe from the following table the increases which have taken place in the equipment of the waterworks for the supply of London since they have been under the control of the Board :

	Before June, 1904.	At 31st March, 1937.
Storage reservoirs for unfiltered water ...	44	49
Acreage	843	2,702
Capacity in million gallons	4,115·7	19,657
Service reservoirs for filtered water ...	75	95
Capacity in million gallons	244·5	341·6
Filter beds (slow sand)	137	175
Acreage	139	172·9
Primary filters	—	63
Area in square feet	—	30,864
Mechanical filters	—	12
Area in square feet	—	640
Engines	235	296
Horse power	32,177	58,144
Miles of water pipes	5,759	8,054

The Board, which is elected every third year, is constituted on the principle of indirect election, *viz.*, of representatives, sixty-six in all, who are appointed by the County Councils of London, Essex, Hertfordshire, Kent, Middlesex and Surrey, the City Corporation, the Metropolitan boroughs, and other boroughs and urban districts within the statutory area of the Board, and by the Thames Conservancy and Lee Conservancy Boards. Some of the boroughs and urban districts are grouped for the purposes of representation.

The present Board is the eleventh; it came into office on 1st June, 1937.

Actual administration of the Board stands referred to a number of Standing Committees which are reconstituted annually.

The Board holds ordinary meetings each fourth Friday. At these meetings, which are open to the public, the committees report their proceedings to the Board and present recommendations. Generally speaking, except in matters of urgency, no committee has power to act until its recommendation has been approved by the Board.

The Board's business is divided into six departments, each under a chief officer and controlled by a Standing Committee.

The salaried staff of the Board, including temporary assistants, numbers 1,208, and the number of workmen on weekly wages, including the established and unestablished staff and the service staff, is about 4,600.

The Board is required under the provisions of Section 28 of the Metropolis Water Act, 1902, to make an annual report

of its proceedings to the Minister of Health, which report must be laid before Parliament.

The importance of the water supply to a great city cannot be exaggerated. It concerns the physical and moral well-being of every inhabitant. No one is independent of it.

No hygienic truth has been more firmly substantiated than that the water supply of a community is the main circumstance upon which depends its wealth and physical well-being.

Throughout the 34 years of its existence the Metropolitan Water Board has had a stupendous task. By close attention to the many difficult problems which have confronted it the Board has endeavoured to ensure that every person in its area should receive a supply of water copious in quantity and irreproachable in quality. As a result Londoners are in possession of a system of supply of which they have some reason to be proud.

A brief description of the Engineering Features of the Board's Undertaking

By J. R. Davidson, M.Inst.C.E., Chief Engineer.

AREA, POPULATION AND SUPPLY.

THE statutory area of the Board extends over 573 square miles and includes the County of London, together with parts of the Counties of Essex, Middlesex, Kent, Surrey and Hertfordshire. It extends from Ware in Hertfordshire on the north, to near Sevenoaks on the south, and from Sunbury on the west, to Southfleet by Gravesend on the east. The estimated population directly supplied on 31st March, 1937, was 7,812,900 living within an area of 537 square miles, and the Board also afford relatively small bulk supplies to a number of neighbouring authorities.

The average daily quantity supplied, including bulk, during the last five years has been 281·51 million gallons, of which 279·48 million gallons have been supplied direct to the Board's consumers. The average daily rate of consumption for all purposes within the Board's area during the year 1936–37 was 37·04 gallons per head. Of this figure 25·69 gallons are due to unmetered and 11·35 gallons to metered supplies.

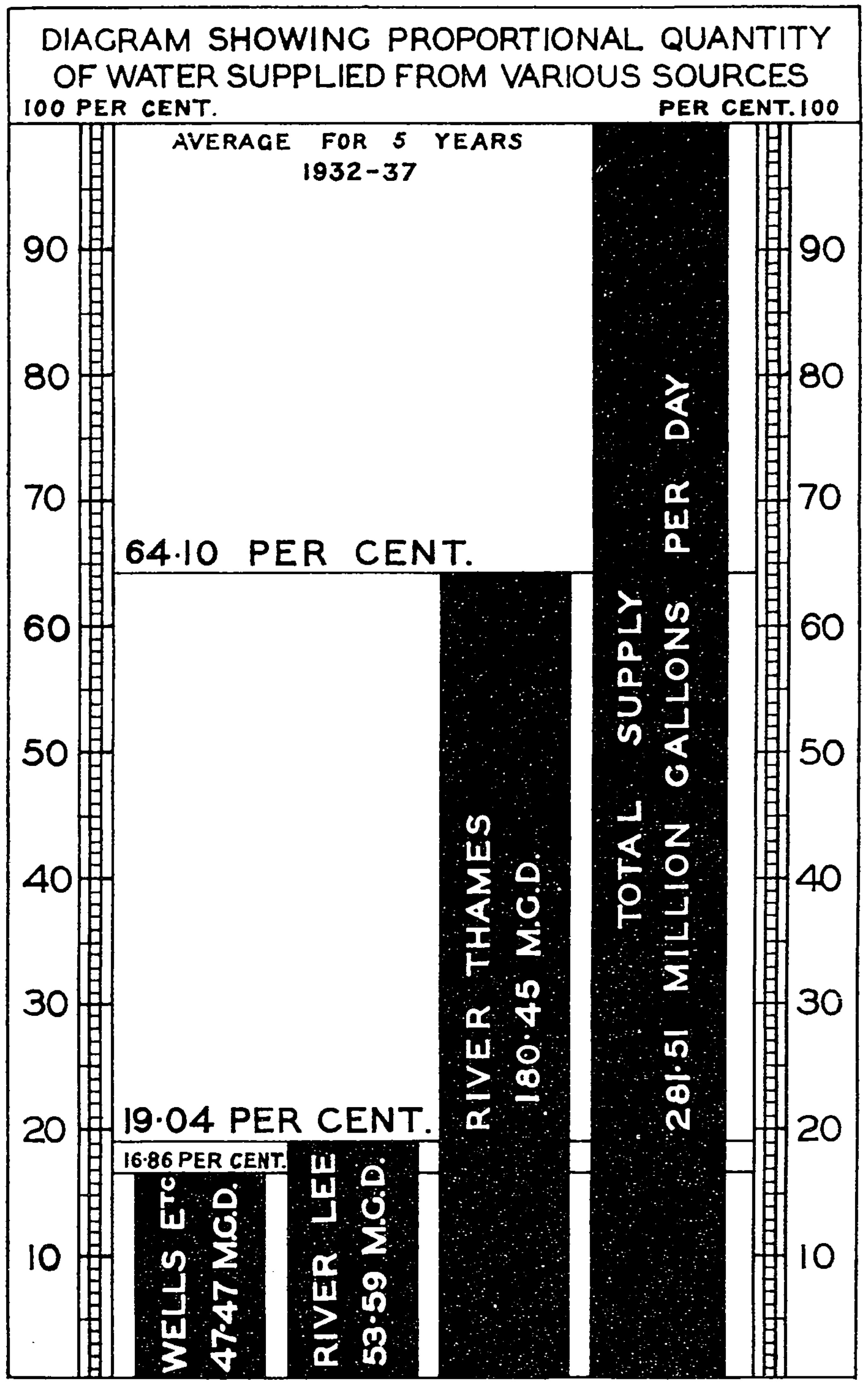
The highest rates of consumption occurred during the year 1933–34, when the average daily supply (direct and bulk) was 293·74 million gallons and exceeded 300 million gallons on 144 occasions. A maximum daily figure of 375 million gallons was reached on 8th June, 1933.

SOURCES OF SUPPLY.

The sources from which the Board derive their supplies are :

River Thames,
River Lee,
Wells, etc.

The average daily quantities obtained from each of these sources during the last five years are compared in the accompanying diagram, which indicates very clearly the preponderance of the Thames supply, this source yielding nearly twice as much as the other two.



The River Thames.

The Thames rises at Tewkesbury Mead in Gloucestershire, three miles south-west of Cirencester, at an elevation of between 360 and 370 feet above Ordnance Datum. It follows a winding course eastward and discharges into the sea at The Nore, 120 miles distant as the crow flies, but 210 miles along the course of the river.

The river is fed by numerous tributaries and springs from the jurassic and cretaceous formations and owing to the ability of these rocks, as well as of the gravel beds which occur all along the river valley, to store large quantities of water, the flow is well maintained during periods of dry weather.

The catchment area above Teddington Weir is 3,855 square miles over which the standard average rainfall for the 35 years 1881 to 1915 is 28·21 inches per annum. The percentage run-off varies from 20 to 46.

The Conservators of the River Thames are responsible for the river above Teddington Weir; below that point it is under the jurisdiction of the Port of London Authority.

Systematic gaugings have been taken since 1883 at Teddington Weir and the average daily natural flow over the period of fifty years from 1885 to 1935 was 1,426 million gallons. The highest recorded natural flow is 20,236 million gallons on 18th November, 1894, and the lowest 141 million gallons on 9th July, 1934.

The following table gives a comparison between the average flow in the river and that during periods of drought.

Natural flow at Teddington in million gallons per day.*

	Average for Month.		
Month.	Over 35 years (1883–1917).	1921	1934
May	1,096	482	444
June	819	328	276
July	596	205	241
August	549	228	251
September	529	280	265
October	900	289	288
November	1,487	338	412

* The natural flow is the gauged flow plus the quantity abstracted by the Board and the neighbouring water companies.

By the Metropolis Water Act of 1852, the Board, as successors to the late Water Companies, are prohibited from abstracting water below Teddington Weir.

The quantity of water which may be abstracted is governed by the Thames Conservancy Act of 1932, the most important condition being that the Board shall not abstract water when the actual flow at Teddington Weir is less than 170 million gallons per day, or reduce the actual flow to less than that quantity. The Act, however, provides for the reduction of this minimum in an emergency with the joint consent of the Ministers of Transport and Health.

Since the Board and the neighbouring Water Companies require about 205 million gallons per day of Thames-derived water during the summer, it is evident that when the natural flow falls below 375 million gallons per day the storage reservoirs have to be drawn upon. A reference to the foregoing table of natural flows at Teddington shows the period and the extent to which this is necessary in dry years such as 1921 and 1934, if a full supply is to be maintained.

The River Lee.

The Lee rises near Luton in Bedfordshire and flows in an easterly direction to Ware, at which point it turns south and enters the River Thames at Bow Creek, 56 miles from its source.

The basin of the river is wholly within the cretaceous and tertiary formations. The flow is gauged at Feilde's Weir, 32 miles from its source, below which point it is not joined by any important tributaries. The catchment area above Feilde's Weir is 414 square miles; the standard average rainfall is 25·65 inches; while the run-off during the last 30 years has varied from 12 to 41 per cent.

The daily average natural flow of the Lee at Feilde's Weir during the period of 35 years from 1883 to 1917 was ~~87.8~~ 107.5 million gallons. It has varied from 1,615 million gallons on 30th April, 1919, to 14 million gallons on 24th August, 1934, and in the table below are given comparative figures between the average flow and that in years of drought.

Natural flow at Feilde's Weir in million gallons per day.*

Month.	Average for Month.			
	Over 35 years (1883–1917).	1902	1921	1934
May	99·5	39	56	31
June	76·6	60	44	24
July	65·4	30	34	20
August	61·5	28	32	19
September	56.4	30	37	22
October	80·9	27	36	21
November	110.9	28	40	26
December	153·8	35	37	59

* The natural flow is the gauged flow plus the quantity abstracted by the Board.

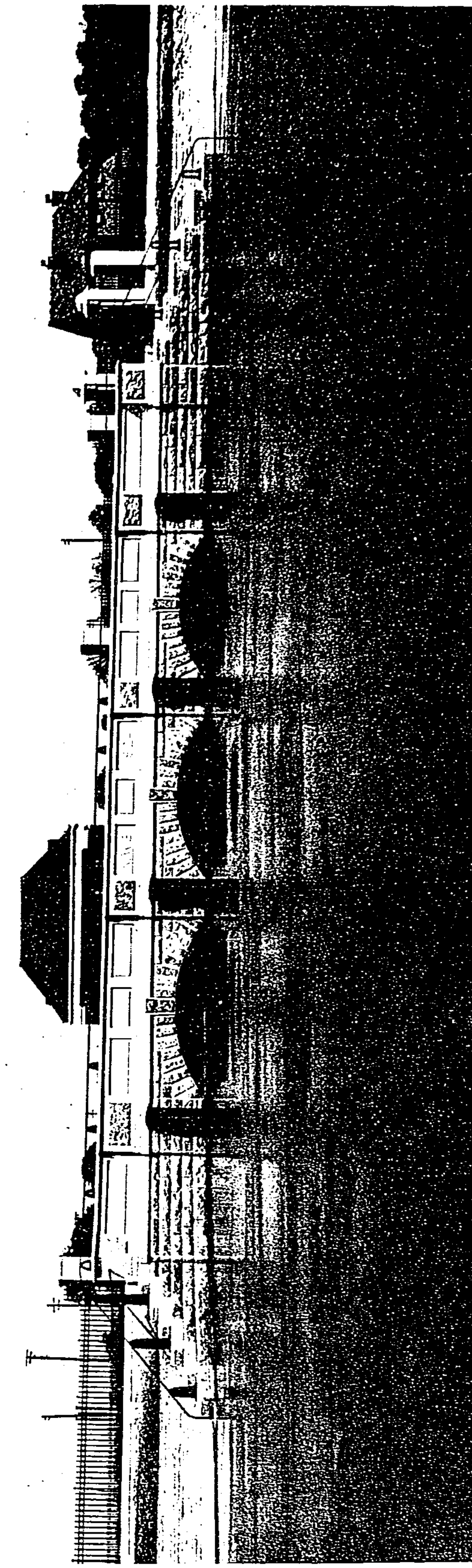
The periods of low flow in the Lee are more prolonged than those in the Thames, as it is not replenished to the same extent by water from underground sources, and during dry years it is necessary to transfer large quantities of Thames water to the areas normally supplied from the Lee.

The authority for the river is the Lee Conservancy Board and, under the River Lee Water Act of 1855, the Water Board, as the successors of the New River Company and East London Water Works Company, are entitled to abstract the whole of the flow with the exception of a quantity of 5·4 million gallons per day required for navigation.

The river has been canalised from Ware southwards and in the lower part of the valley its channel has been frequently diverted.

Wells.

London is situated in a chalk basin which is covered by a thick blanket of London clay. The chalk outcrops in the Chiltern Hills and North Downs and these provide a large gathering ground for underground water. At one time a true artesian flow was obtained from borings sunk through the clay to the chalk but, owing to excessive pumping from public and private wells, the water is now about 220 feet below the surface of the ground under London and is falling at the rate of about 2 feet per annum. The ground water level on the outskirts of London is, however, not so seriously affected. Below the chalk are the upper and lower greensands. These are prolific water-bearing strata, but their existence has not been proved under the greater part of the London basin.



LALEHAM INTAKE FROM RIVER THAMES.

The Board have forty-two well stations at which pumping machinery is installed in forty-seven wells and six boreholes.

With the exception of two wells in the upper greensand and two boreholes in the lower greensand, all the wells and boreholes are in the chalk.

The depth of the wells varies from 26 feet to 313 feet and the lifts from 11 feet to 277 feet. In the floors of three wells deep boreholes have been sunk to 831 feet, 1,001 feet and 1,271 feet from the surface to the silurian, devonian and lower jurassic formations respectively.

The well stations with the greatest yields are Deptford, Shortlands and Wilmington in Kent, and Amwell Marsh, Rye Common and Turnford in Hertfordshire, from which quantities ranging from 5·6 million gallons to 3·0 million gallons per day can be obtained.

It is interesting to note that the average daily quantity obtained from the Board's wells during the past five years amounted to 46·76 million gallons, or more than sufficient to satisfy the requirements for all purposes of a city with a population of 1,250,000.

In general the water raised from the wells is so pure that it can be pumped direct into supply, but in the case of eleven well stations the water is at present filtered.

INTAKES.

There are fifteen intakes on the River Thames or its tributaries, of which only three are in regular use, *viz.*:—

Staines, 18 miles above Teddington Weir.
Laleham, for the "Queen Mary" reservoir, 15 miles above Teddington Weir.
Walton, 7 miles above Teddington Weir.

Of the others, five at Hampton are used occasionally, but the remainder are only opened in an emergency.

Water is abstracted from the River Lee at the following places :—

The New River intake between Ware and Hertford.
At Enfield for "King George's" reservoir.
At Chingford Mill for the Walthamstow reservoirs.

The design of the intakes varies considerably, the largest being that at Laleham, of which a photograph is reproduced facing page 18. Here the water is controlled by Stoney sluices and measured by three 100 million gallons per day Venturi meters, but some of the older intakes at Hampton merely consist of a 48-inch pipe built into the river wall. At the New River intake in Hertford there is a floating regulating gauge which normally permits a maximum of 22½ million gallons per day to pass into the New River. Most of the intakes are equipped with screens for arresting leaves and floating debris.

STORAGE.

The Water Companies originally constructed small reservoirs to allow suspended matter in the river water to settle, but, as the supply increased, storage capacity became necessary to supplement the abstraction in times of low flow in the rivers. At an early stage in the development of storage reservoirs it was found that they served an important secondary purpose owing to the great improvement in the purity of the water effected by storage for a period of thirty days, and, for this reason, all river water is now normally passed through storage reservoirs although this involves additional pumping in nearly every case.

When considering the relatively small total storage capacity (19,657 million gallons) of the Board's reservoirs it must be remembered that the flow in the Rivers Thames and Lee provides the bulk of the supply, the reservoirs being mainly auxiliary, and in normal summers they are not drawn down to any great extent.

Particulars of the most important storage reservoirs in the Thames Valley are given in the following table :—

Reservoir.	Capacity.	Water Area.	Top Water Level.	Depth.
	M.G.	Acres.	O.D.	Feet.
"Queen Mary" ...	6,750	723	75·00	38·0
Staines, No. 1	1,584	178	87·00	39·0
,, No. 1A ...	1,754	246	77·00	29·5
Walton, Knight ...	480	52	65·00	42·0
,, Bessborough ...	718	74	65·00	42·0
Island Barn	922	121	59·20	30·0

The capacity of these six reservoirs is 12,208 million gallons and that of the remaining twenty-six 1,810 million gallons, making a total of 14,018 million gallons.

"QUEEN MARY" RESERVOIR, LITTLETON.
(Staines Reservoirs in the background.)

In the Lee Valley the principal storage reservoirs are :—

Reservoir.	Capacity.	Water Area.	Top Water Level.	Depth.
	M.G.	Acres.	O.D.	Feet.
"King George's" ...	3,073	426	71·00	28·0 to 32·0
Banbury	650	91	50·00	28·0
Lockwood	548	74	50·00	34·0

There are also fourteen other reservoirs having a joint capacity of 1,368 million gallons, making a total of 5,639 million gallons.

With the exception of these fourteen reservoirs in the Lee Valley all the storage reservoirs have to be filled by pumping.

Plans showing the major works in the Thames and Lee Valleys are inserted at the end of this brochure.

An aerial photograph of the "Queen Mary" reservoir at Littleton is reproduced facing page 20. The pumping station can be seen at the left-hand side of the reservoir and the outlet is almost diagonally opposite in the top right-hand corner.

The baffle bank extending into the reservoir was constructed to limit wave action. The bank of this reservoir, like those of all the Board's reservoirs, is entirely artifical, being formed of material excavated from inside the site. It is rendered watertight by a central wall of puddled clay which is carried down and tied into the underlying London clay.

The bank of the "Queen Mary" reservoir measures nearly 4 miles round, while the water area of 723 acres is only slightly less than the combined areas of Hyde Park, Kensington Gardens and St. James's Park. When full the reservoir contains 6,750 million gallons, or sufficient to supply the whole of the requirements of a community of 10,000 persons for 50 years. The cost of the reservoir, including land and the pumping station, was nearly £2,000,000. It was completed in 1925, when it was opened by His late Majesty King George V, accompanied by Her Majesty Queen Mary.

In the background of the photograph can be seen the two reservoirs at Staines.

FILTRATION.

The whole of the river-derived water and the output of eleven well stations is passed through open slow sand filter beds similar to those constructed in Pimlico in 1829 by James Simpson, then Engineer to the Chelsea Water Works Company.

Whilst filtration through slow sand beds alone is a reliable and effective means of purification when properly carried out, this type of filter has of necessity to be operated at a slow rate, thus requiring a considerable area when large quantities have to be dealt with, and their output is liable to be seriously reduced by the algal growths prevalent in the river-derived water at certain periods of the year.

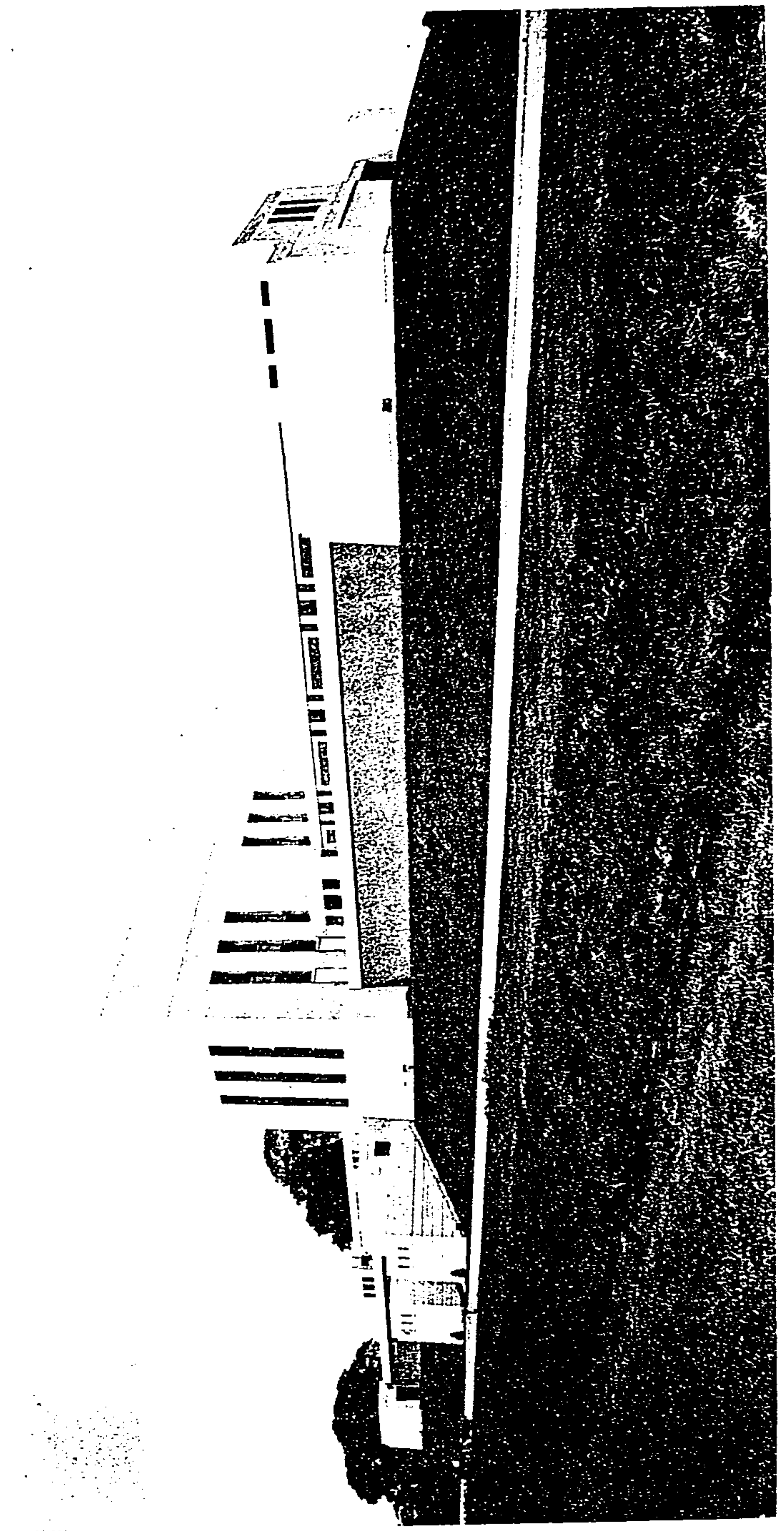
To overcome these disadvantages and still to retain the merits of the slow sand filter, the Board have adopted a system of double filtration.

At the Barn Elms, Walton, Kempton Park and Stoke Newington works the raw water is passed through primary or rapid filters before admission to the slow sand beds. These rapid filters are all of the open gravity type operating without a coagulant and are cleaned by an air scour followed by an up-wash of filtered water. The aggregate capacity of these installations is 95 million gallons per day.

This system has entirely justified expectations. By supplying partly filtered water to the slow sand filter beds their output has been more than doubled, the troubles from algal growths greatly reduced and the costs of operation lessened, while at the same time the standard of purity has actually been improved. An installation of primary filters having a normal output of 120 million gallons per day is about to be constructed at Hampton.

A photograph showing the exterior of the Kempton Park primary filters is reproduced opposite.

The Board have fourteen filtration stations, having an aggregate reliable output of 311 million gallons per day. At four of these there are primary filtration plants, having a total of 63 beds and an aggregate area of 30,864 square feet. There are in all 173 acres of slow sand filters, the total number of beds being 175. Particulars of these works are given in the accompanying table :—



KEMPTON PARK WORKS.
Primary Filters.

Name.	Primary Filters.		Slow Sand Filters.		Normal Capacity of installation
	Number.	Area	Number.	Area	
		sq. ft.		Acres.	m.g.d.
Hampton ...	—	—	45	48·73	63*
Kempton Park ...	24	9,984	12	9·00	32
Walton	18	7,488	6	5·00	24
Surbiton	—	—	28	29·96	45
Barnes and Barn Elms.†	9	2,592	20	24·25	34
Lee Bridge ...	—	—	25	24·75	45
Stoke Newington	12	10,800	9	9·00	32
Other works ...	—	—	30	22·22	36
Totals ...	63	30,864	175	172·91	311

* The output prior to the commencement of reconstruction was 65 million gallons per day.

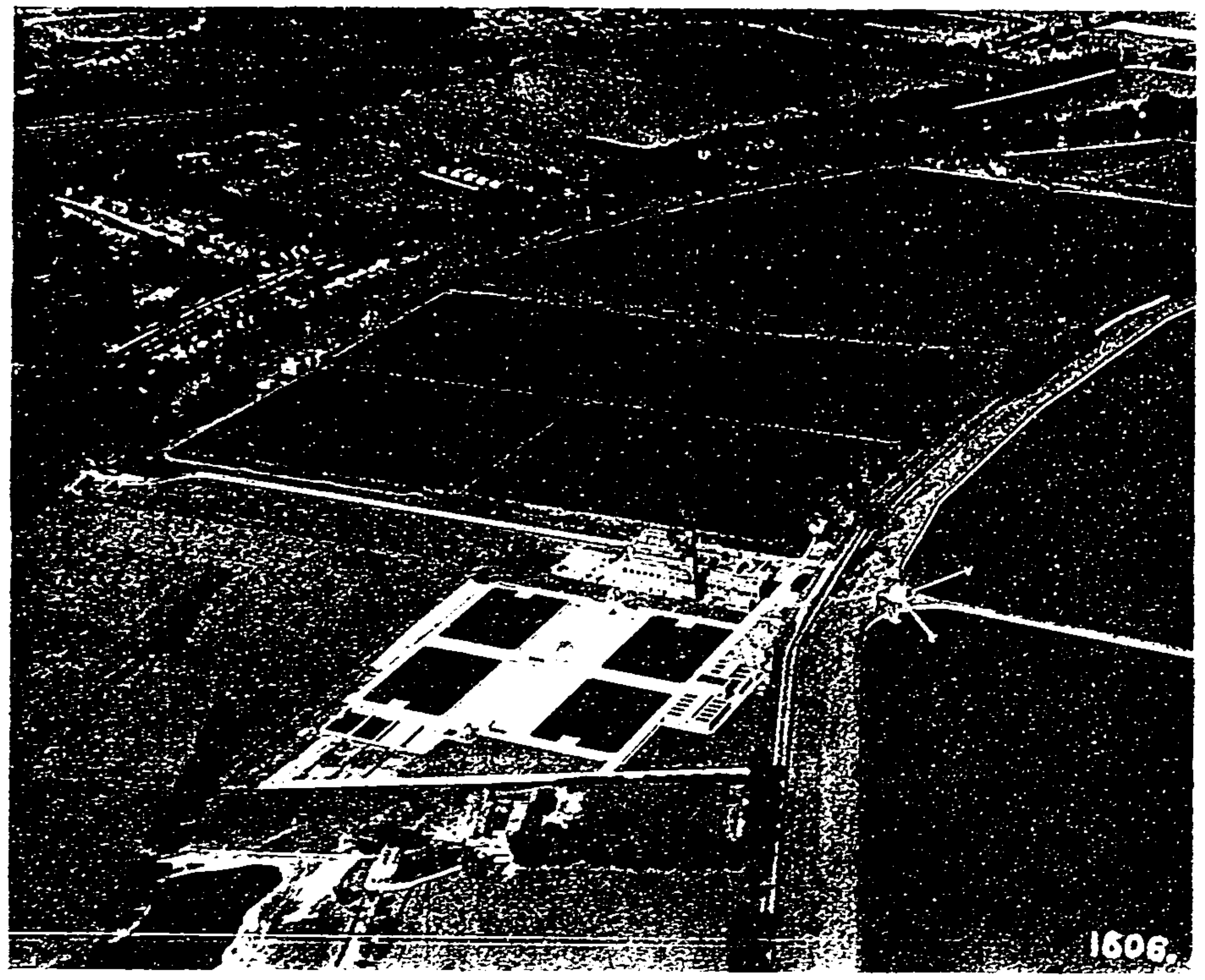
† Only a portion of the water passes through the primary filters.

By reason of the fact that seven of the eight Water Companies constructed filtration plants over a period of more than half a century the individual filters present a variety of designs, shapes and sizes. It is intended as opportunity offers to reconstruct the beds at the more important stations to a standard pattern of rectangular shape having an area of about an acre and equipped with loss of head recorders and filtered water meters. The thickness of sand and gravel will be 2 feet 6 inches and 1 foot respectively. A photograph of the first reconstructed filter bed at Surbiton is shown facing page 24, the dimensions being as follows :—

Area	0·92 acres.
Depth of water	4 feet.
Depth of sand	2 feet 6 inches.
Depth of graded gravel	1 foot.

The walls are constructed of concrete faced by blue brindle brick with asphalt expansion joints every 25 feet, while the concrete slabs forming the floor are 10 feet by 10 feet resting on breeze concrete. The under drains and perforated slabs over the collecting channel will be noticed. A Venturi meter and loss of head recorder have also been fitted at the outlet.

A typical illustration of one of the Board's modern filtration plants is provided by the aerial view of the Walton works on page 24. The intake from the river is seen on the left, the raw water being conducted to the pumping station by an open channel whence it is lifted by low lift pumps into the storage reservoirs. After circulation it passes to the primary filters which are situated on the right hand side of

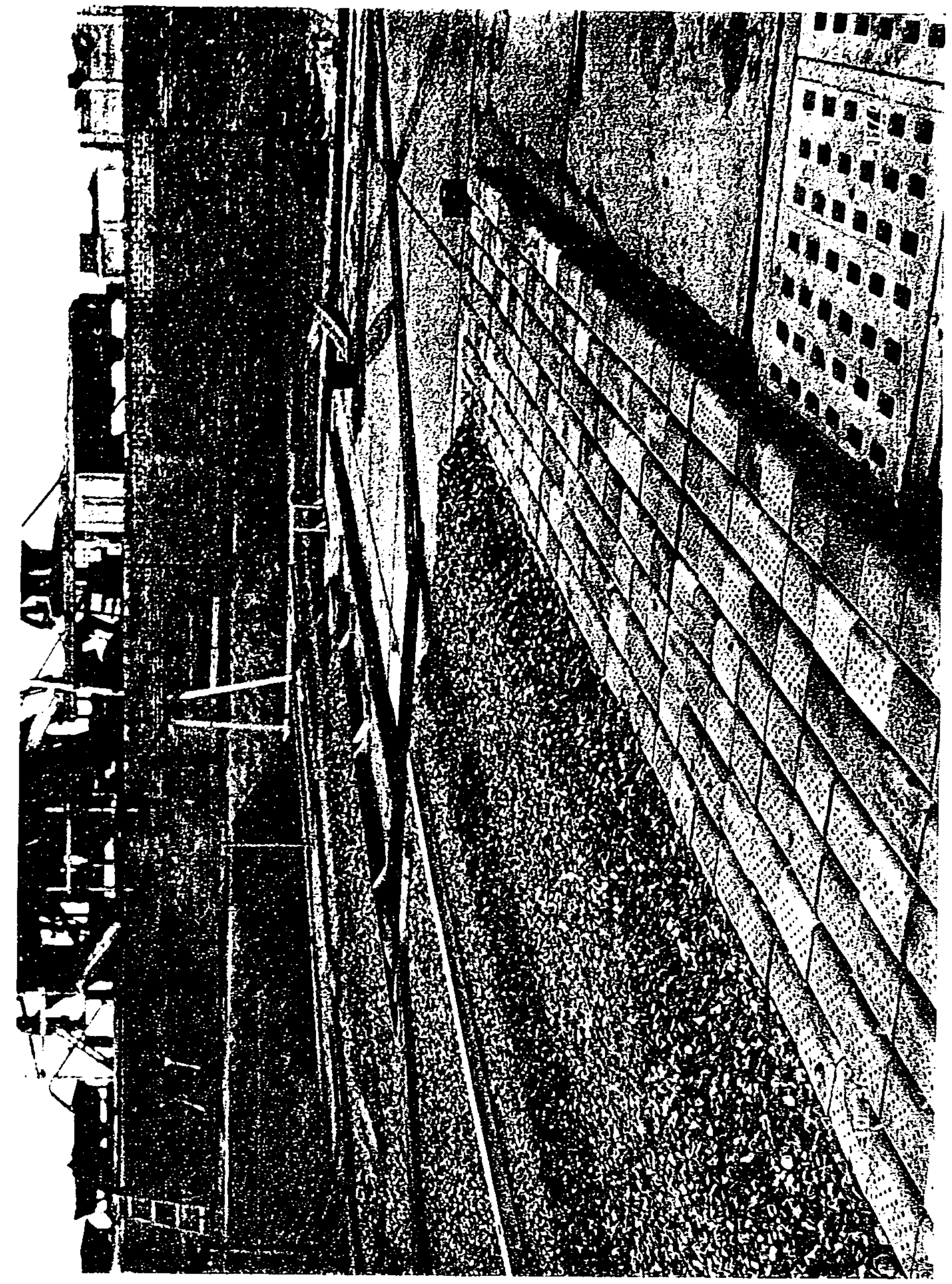


WALTON WORKS.

the six slow sand beds. When the secondary filtration is complete the water receives a small dose of chloramine and flows to the pumping station, where the high lift engines force it through a 48-inch main to consumers in South London. When the photograph was taken the two centre slow sand filter beds were empty.

The maximum monthly rates of filtration in gallons per square foot per hour, over the last five years at the different stations, varied from 4·86 to 6·15 in the case of slow sand filters working in conjunction with primary filters and from 1·2 to 2·42 where no primary filters are in operation. The maximum speeds through the primary filters varied from 145 to 200 gallons per square foot per hour.

The average area of slow sand filter beds cleaned per annum was 1,167 acres and the average quantity of water filtered per acre cleaned was 79·38 million gallons.



SURBITON WORKS.
Slow sand filter bed under reconstruction.

The average annual cost of filtration was £81,231 or 19s. 8d. per million gallons filtered, and the approximate number of men employed on this work was 532.

CHEMICAL TREATMENT.

As a final safeguard all the filtered water is chloraminated before being pumped into supply. The latest practice is to use ammonia and chlorine gas, but at some of the plants ammonium sulphate is still in use.

The average dose of ammonia varies from 0·05 to 0·075 parts per million in the case of deep well waters; 0·09 to 0·125 parts per million for New River filtered water, and 0·1 to 0·2 parts per million for Thames and Lee filtered waters, that of chlorine being 0·1 to 0·15; 0·175 to 0·25 and 0·2 to 0·4, respectively. Since the adoption of this process at all the filtration plants the results have shown a marked improvement, nearly 99 per cent. of the samples examined being free from B. coli in 100 ml. The Board use some 19 tons of ammonia gas, 405 tons of ammonium sulphate and 181 tons of chlorine per annum.

PUMPING.

Owing to the low levels at which water is obtained from the various sources the maintenance of the supply is entirely dependent upon continuous pumping.

The pumping machinery presents a great variety of types and sizes from the Cornish beam and Bull engines installed at Chelsea in 1820, and re-erected at Kew in 1840, using steam at 40 lbs. pressure, to the high-pressure compound turbines now being constructed for the Hampton works. The total number of units at present operated by the Board is 296, with a water horse power of 58,144. In round figures, 83 per cent. of the power is provided by steam, 12 per cent. by oil, and the remainder by electricity or suction gas. In the following table a comparison of the power developed by the various types of engines now in use is set out.

Type.	Average Age.	Total W.H.P.
Steam engines—	Years.	
Cornish Beam and Bull engines	76	3,266
Rotative Beam engines	62	5,169
Horizontal engines, including Worthington and Uniflow engines.	41	8,463
Vertical simple and compound engines ...	49	2,804
Vertical triple expansion engines	32	15,441
Turbines	11	10,576
Oil engines	9	7,291
Electrical and miscellaneous pumping machinery	13	5,134

It will be seen that the horse power of the vertical triple expansion engines is greater than that of any other type, while the steam turbine occupies second place, but when the new Hampton pumping station is completed the positions will be reversed and the total horse power of the steam turbines will be 25,692.

The duties performed by the pumping plant are threefold, *viz.*:—

Raising river water into storage reservoirs.
Pumping filtered water into supply.
Raising water from wells to the surface and forcing it into supply.

Raw Water Pumping Machinery.

This is required to pump large quantities against small heads. The total number of stations employed for this purpose is fifteen, the units having a total water horse power of 10,397 and a pumping capacity of 984 million gallons per day. These figures show in a striking manner the reserve of power provided in this class of machinery to enable large quantities of water to be pumped into the reservoirs when available in the rivers.

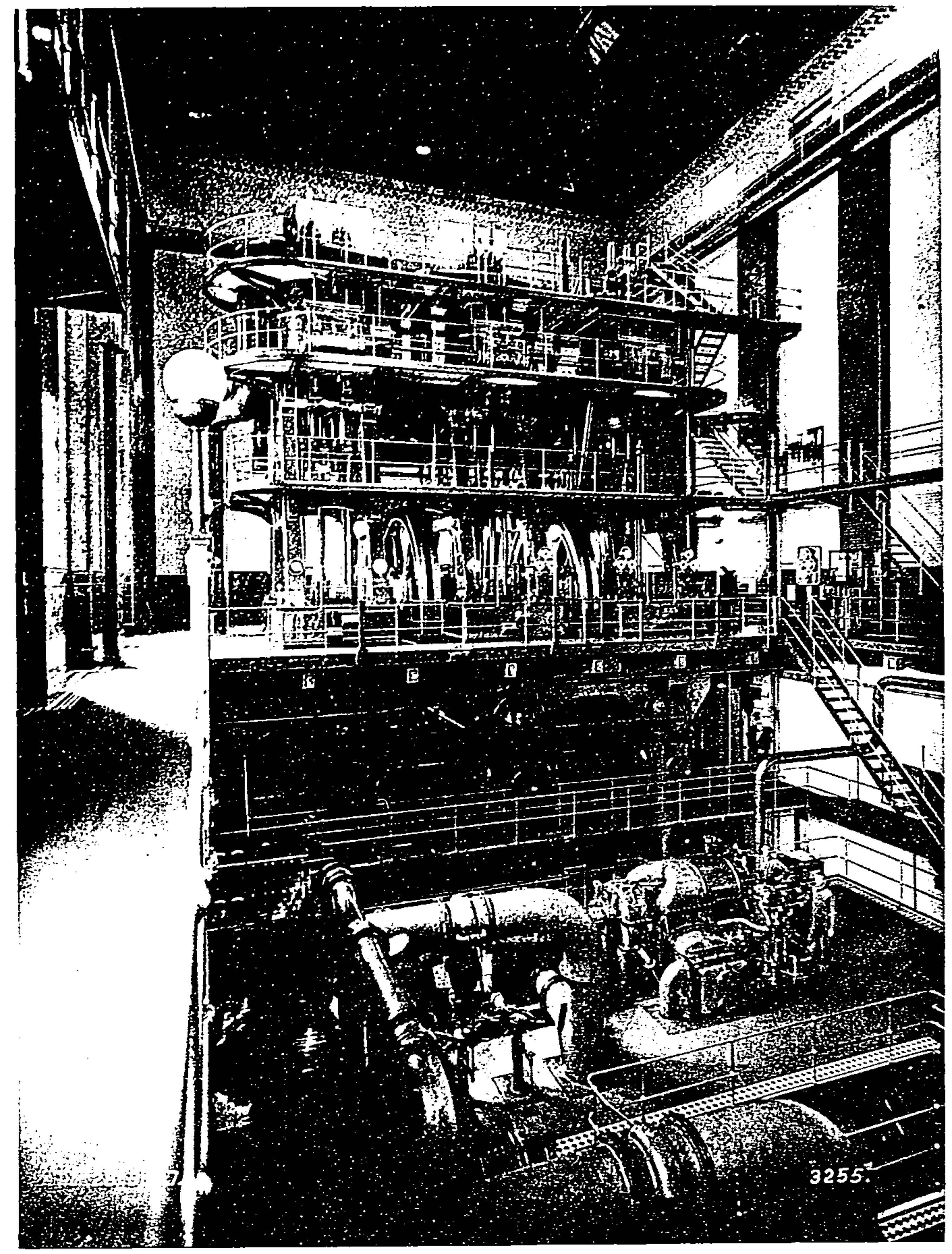
The machinery is of various types. At the "Queen Mary" reservoir there are four centrifugal pumps of a total capacity of 300 million gallons per day driven by single cylinder uniflow steam engines; Worthington pumps with an output of 82·5 million gallons per day are installed at Staines, while triple expansion marine type steam engines driving centrifugal pumps direct and capable of pumping 100 and 105 million gallons per day respectively, are in use at the Walton and Greaves pumping stations.

The "King George's" reservoir is filled by five Humphrey gas-driven pumps, four having a capacity of 40 million gallons per day and one a capacity of 20 million gallons per day.

The heads against which these installations work vary from 19 to 56 feet.

Filtered Water Pumping Machinery.

The greater part of the pumping machinery operated by the Board is employed to pump filtered water into supply. The individual units are of smaller capacity than the unfiltered water pumps but, since they operate against higher heads, they are generally of considerably greater power.



KEMPTON PARK PUMPING STATION.
"Sir William Prescott" Engine.
One of a pair constructed 1929 by
Worthington-Simpson & Co., Ltd., Newark-on-Trent.

Horse-power ...	1,008 W.H.P.
Cylinders ...	29 ins., 54 ins. and 86 ins. diameter.
Pumps	3 single acting, with compound plungers 25½ ins. and 30½ ins. diameter by 5 ft. 6 ins. stroke.
Capacity	12 m.g.d. against 400 ft. head. 19 m.g.d. against 200 ft. head.

In the foreground is one of a pair of steam turbines, each driving two centrifugal pumps, the water horse power and output of each unit being the same as that of the "Sir William Prescott" engine.

As it is not practicable to construct sufficiently large service reservoirs in London to balance fluctuations in the hourly rate of demand, the load on the pumping plant varies considerably between day and night, and this provides the greatest problem in determining the type and size of the individual engines. Reciprocating engines driving plunger pumps are admirably suited on account of their high efficiency at all loads and until recently this type was the most economical to install. Of recent years the design of steam turbines driving centrifugal pumps has so advanced that these have, for units over 1,000 water horse power, a steam consumption at full load equal to or lower than that of the reciprocating engine and the saving in capital cost of both the machinery and the building justifies the selection of the turbine, despite its reduced efficiency at low loads.

The table below shows the progress which has taken place both with regard to the size and the efficiency of the individual units since the Board came into being.

Year.	Largest Unit in Operation.			Steam Consumption in lbs. per water horse power hour.
	Name.	Type.	Water Horse Power each unit.	
1904 ...	Riverdale Hampton.	Triple ...	530	20·0
1925 ...	No. 6 Walton	,, ...	945	10·4
1929 ...	Nos. 6 and 7 Kempton Park.	,, ...	1,008	9·9
1932 ...	No. 3 Surbiton	Turbine ...	1,250	10·53
—— ...	Nos. 4 and 5 Hampton (under con- st·uction.	Compound turbine.	2,821	7·8*

* Guaranteed.

Facing page 26 a photograph of the "Sir William Prescott" engine at Kempton Park is reproduced. In the foreground is a steam turbine of equal horse power driving centrifugal pumps.

For the supply of high level areas it is more economical to repump the smaller quantities of water required than to maintain an unnecessarily high pressure in the trunk mains and about 11 per cent. of the supply is dealt with in this way. A photograph of the interior of the Brixton pumping station where water received from Surbiton is repumped to the higher areas around Norwood and the Crystal Palace is reproduced opposite. This station is typical of one of the Board's oil engine stations. Six engines are shown in the photograph and a seventh has recently been added. Each unit has a water horse power of about 150 and is capable of pumping 3·5 million gallons per day against a head of 200 feet or 1·75 million gallons per day against a head of 400 feet.

Well Pumps.

For the purpose of raising water from their wells the Board operate 68 units, having an aggregate water horse power of 10,247, but on account of the limited quantity of water available at each well the individual units are small, 47 being under 150 water horse power.

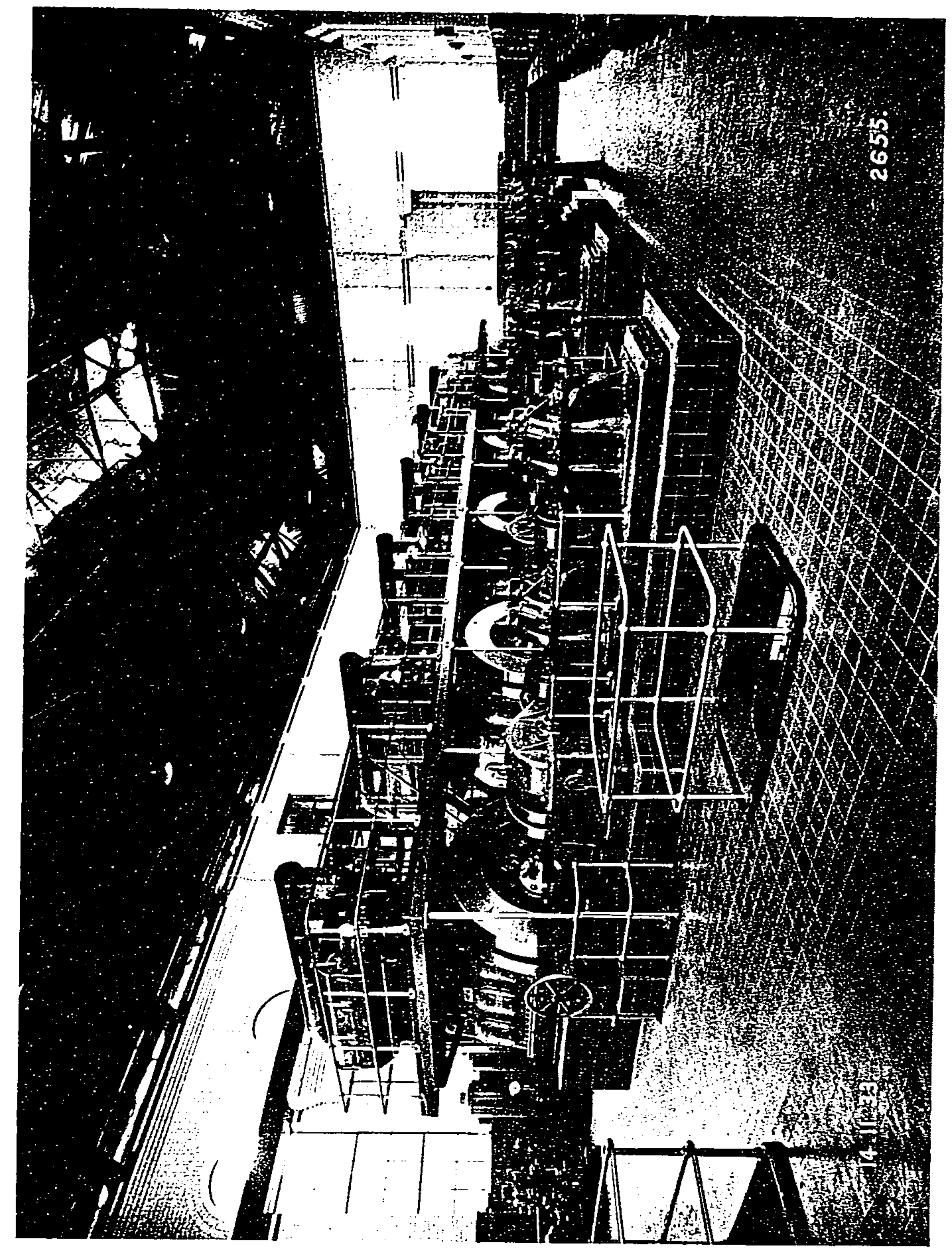
At most of the well stations the well and surface pumps are operated by the same engine, but at a few stations separate units are employed for each purpose.

At ten well stations no force pumps are employed as the water is merely raised to the surface and delivered into the adjoining New River through which it flows to the filtration plants.

With the exception of two stations at which borehole pumps are in operation, all well pumps are of the bucket type with many different kinds of foot valves and both wood and iron pump rods are employed.

From the great variety of well pumps constructed by the late Water Companies and the Board reference can only be made to two of the latest installations.

The vertical triple expansion engine at the Deptford works is the largest of the well engines, having a total water horse power of 794. The three well pumps are operated from an extension of the crank shaft and the nine surface pumps beneath the engine are driven direct and by beams. These surface pumps supply three different zones at pressures of 200, 300 and 400 feet and have a total output of 7·7 to 12·4 million gallons per day, which can be divided, within limits, between the different zones to suit requirements. The capacity of the well pumps is 7·2 million gallons per day, the difference being made up by Thames-derived water received from Hampton or Walton.



BRIXTON PUMPING STATION.

For standby purposes there are three steam turbines operating centrifugal surface pumps and one water turbine driving a borehole pump.

At the Sundridge station there are two boreholes in each of which are installed pumps of one million gallons per day capacity against 40 feet head, one being operated by an electric motor and the other by a water turbine. Two 4-cylinder oil engines each drive through gearing a turbine surface pump of a capacity of one million gallons per day against 570 feet head and a 25 kilowatt generator.

The greatest lift is 277 feet at Hadley Road, the lowest being 11 feet at Sundridge and the average 113 feet. The highest head at which the surface pumps operate is 570 feet at Sundridge.

Boilers and Fuel.

The boiler plant consists of 80 Cornish, 164 Lancashire, 90 water tube and 29 miscellaneous boilers. The majority of the water tube boilers, together with a number of the Lancashire boilers, are mechanically fired and at the newer stations all the latest devices for handling coal and ash and recording temperatures and CO_2 are installed. While the individual boilers are relatively small, the largest being the Thompson boilers at Surbiton, rated at 18,000 lbs. of steam per hour, efficiencies as high as 83·7 per cent. are obtained and the operating results compare favourably with those of large electricity generating stations.

The Board use annually about 162,000 tons of coal at a cost of about £176,000. This is purchased on the basis of a guaranteed calorific value, tests of all consignments of fuel being carried out at the Board's coal-testing laboratory, and adjustments on a sliding scale made to payments if the calorific value of the coal varies more than 2 per cent. from that guaranteed.

In addition to coal, 3,610 tons of fuel oil, and 1,526,400 units of electricity were purchased for pumping purposes during the year 1936–37.

The annual cost of pumping exclusive of renewals on revenue account is about £555,000 or £5 8s. 0d. per million gallons supplied.

Buildings.

Many of the pumping stations are buildings of some magnitude and are constructed in a substantial manner. As an example a photograph showing the exterior of the Littleton pumping station is reproduced opposite.

DISTRIBUTION.

Practically the whole of the 8,054 miles of trunk, distribution and service mains owned by the Board are of cast iron. The largest size of pipe laid in the streets is 48-inches in diameter and although 2-inch and 3-inch mains still exist no pipe smaller than 4-inches is now laid. There are 543 miles of mains of 24-inches diameter and over, but the greatest proportion of the distribution network is composed of 4-inch pipes of which there are no less than 3,950 miles or 49 per cent. of the total length.

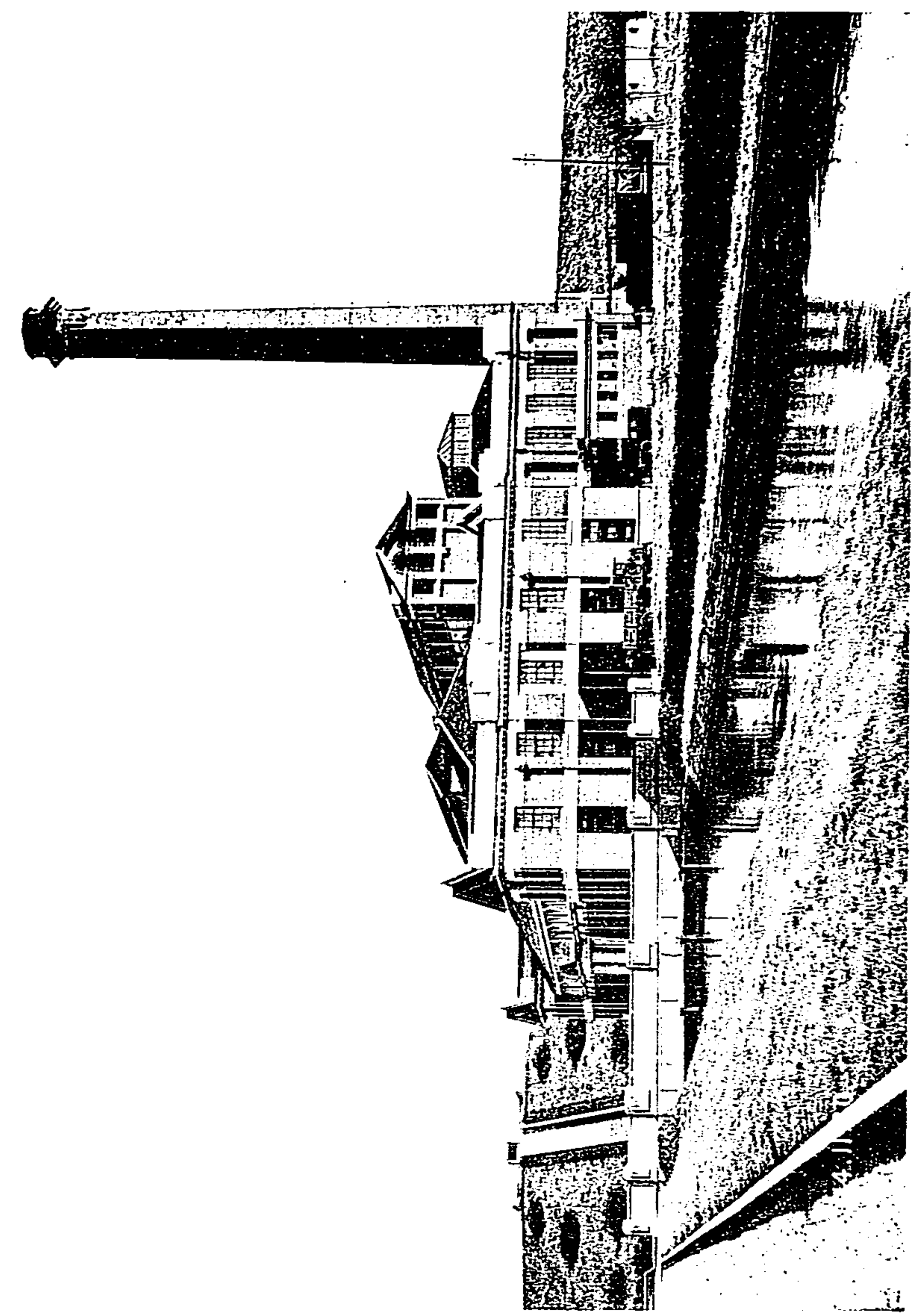
The Board inherited eight separate distribution systems which were only connected at a few points. During the past thirty years these have been gradually merged and by means of an elaborate system of intercommunication alternative supplies are now available in most areas.

Since neither the London water nor the soil—except in the case of certain clay areas—have any deleterious effect on cast iron or lead, there are to-day cast iron mains of over 100 years of age in service and in excellent condition.

Owing, however, to the frequent disturbance of the sub-surface by other authorities, the proximity of underground structures and other apparatus to the Board's mains and the vibration due to heavy traffic, steel pipes lined internally and sheathed externally with bitumenous composition are now being introduced for trunk and certain distribution mains. Spun iron pipes are also used with satisfactory results and where cast iron mains are laid in clay areas the pipes are protected by a sheathing of bitumenous composition.

The principal trunk mains are those carrying water in an easterly and north-easterly direction from the Thames Valley stations, for which purpose no less than 21 mains of diameters between 21-inches and 48-inches are employed. Another important group of trunk mains conveys water southwards from the works on the New River and the Lee.

Some of the pumping mains are of considerable length. For example, the 48-inch main from Kempton to Bishop's Wood reservoir, Highgate, is 17 miles long; the length of the 36-inch main from the same station to Finsbury Park is 19 miles, and that of the 42-inch main from Hampton to Nunhead



LITTLETON PUMPING STATION.

is 16 miles. The pressures in the trunk mains do not exceed 300 feet, those in the three mains referred to being 295, 180 and 230 feet respectively.

Integral with the distribution system are 95 service reservoirs situated on high ground and containing a total of 341·6 million gallons, but since the majority of the consumers are situated between the pumps and the reservoirs the latter act mainly as "jack-heads." The highest service reservoir is that at Betsom's Hill in Kent, which contains 313,000 gallons, the top water level being 818·00 feet above O.D. The largest is at Honor Oak in South London, which has a top water level of 144·00 feet above O.D., and contains 56 million gallons.

The annual costs of distribution are about £559,610, which sum includes the repairs and maintenance of the communication pipes taken over from the consumers in 1933. All the main extensions and larger repairs are executed by contractors, the Board's staff only being employed on minor distribution works.

Some 340 inspectors are employed upon the inspection of fittings and the suppression of waste on 1,438,600 services and the reading and changing of 53,000 meters on the trade and non-domestic supplies. A system of Deacon meters enables the waste on the majority of the services to be readily detected.

ORGANISATION OF ENGINEERING DEPARTMENT.

Until recently the Board's area was divided into the Northern, Western, Southern and Kent Districts, each in charge of a District Engineer who controlled the abstraction, storage, filtration, pumping and distribution of the water within his area. In addition, the large works in the Thames Valley were under the charge of a Resident Engineer. A commencement has recently been made to change this organisation for one in which the executive control will be based upon the nature of the duties instead of on geographical areas, and in future the abstraction, storage and filtration over the whole area will be under the control of one officer designated the Supply Engineer. A Mechanical Engineer will be responsible for all pumping operations and the design and erection of new machinery, while distribution will be in the charge of a Distribution Engineer. These three officers will have their headquarters at the Head Offices of the Board.

A New Works Engineer controls the civil engineering and architectural staff who prepare the schemes for new works and supervise their construction.

New constructional work is usually carried out by contract under the supervision of the central staff, and the importance of their work may be gauged from the fact that since April, 1919, the Board have spent £10,610,500 on capital works and £1,026,000 on renewals.

A section under a Superintendent of Supplies deals with applications for new supplies as well as with the assessment of charges, the installation and maintenance of meters, the detection and prevention of waste and the inspection and testing of fittings.

The purchase of stores and materials, covering a wide variety of articles, is undertaken by a section under a Chief Stores Officer. The major items purchased per annum are 162,000 tons of coal, 3,610 tons of fuel oil, and 11,960 tons of cast iron pipes.

The number of workmen employed in the department is 4,470, the various grades including engine drivers and cleaners, stokers, fitters, electricians, turncocks, inspectors, meter exchangers, trenchmen, labourers, and other grades peculiar to waterworks undertakings.

NEW WORKS.

The Board are undertaking a comprehensive programme of large new works estimated to cost about £6,500,000. These comprise three large storage reservoirs, two trunk mains, and the complete reconstruction of the filtration and pumping plant at the Hampton works.

Storage Reservoirs.

Lee Valley.

One storage reservoir for which powers were obtained by the East London Water Works Company in 1900 is now under construction in the Lee Valley.

This reservoir will have a capacity of 3,180 million gallons with a top water area of 334 acres. The embankment, which will contain about 3,000,000 cubic yards of material and have a maximum height of 43 feet, will be 3·5 miles in length. The contractors are John Mowlem & Co., Ltd., whose tender of £682,156 was accepted by the Board in

July 1935, and the reservoir is due for completion in March, 1939. This reservoir will have a connecting main from the "King George's" reservoir, but a separate pumping plant for raising water from the River Lee will be provided.

Thames Valley.

In their Act of 1935 the Board obtained powers for the construction of two storage reservoirs in the Thames Valley, one at Walton and the other at Staines, to contain 4,000 and 4,400 million gallons, respectively. The banks will have a maximum height of about 53 feet, the depth of water being 50 feet. It will not be necessary to construct new intakes or engine houses in connection with these reservoirs, but the existing pumping plant will be remodelled. Most of the land has been acquired and the surveys and borings already completed. It is proposed to let the contract for the construction of the Staines reservoir this year and that for the Walton reservoir in 1938. The estimated cost of these two reservoirs, including land, is £2,636,000, and when the three reservoirs have been completed the Board will have increased their storage capacity by 11,600 million gallons or by 59 per cent. on the present total of 19,657 million gallons.

Trunk Mains.

Two new trunk mains will be laid from the Thames Valley, the first, 17 miles in length, will be 42-inches in diameter, and commencing at the Hampton works will terminate at the service reservoirs of Honor Oak and Nunhead, in Camberwell. The water pumped through it will not only augment the supply to South London, but will be repumped farther east to meet the needs of consumers in the rapidly developing areas in Kent.

The second main, 18 miles long, will be laid from the Kempton Park works to the reservoirs at Bishop's Wood and Fortis Green, in Hornsey. For the first 14 miles, as far as Cricklewood, its diameter will be 60-inches and thence to its termination the diameter will be reduced to 48-inches. This main will enable the supply to practically all parts of London north of the Thames and west of the River Lee to be augmented.

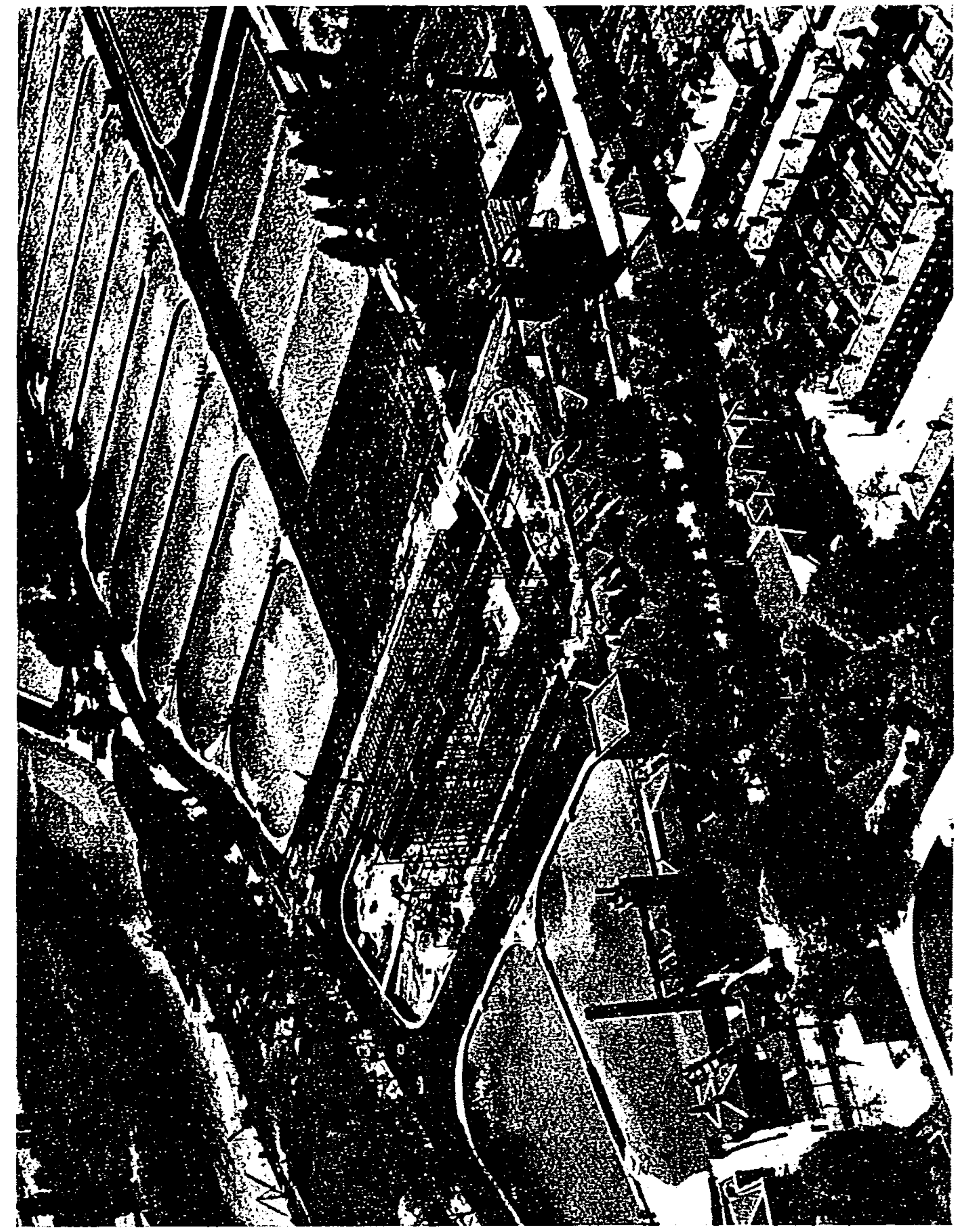
Both these mains will be laid with steel pipes externally sheathed and internally lined with bitumenous composition, and it is estimated that the 60-inch and 42-inch mains will cost £677,000 and £521,500, respectively.

Contracts for the provision of the pipes and the laying of one section of the 42-inch main have been let.

Remodelling of Hampton Works.

The Board's works at Hampton are an amalgamation of the works of three of the late Water Companies, the first engine houses having been constructed in 1854. The present output is 65 million gallons per day, and this will be raised to 120 million gallons per day by the construction of an installation of 32 primary filters, having a total area of 43,680 square feet to operate in conjunction with 35·25 acres of the existing slow sand filter beds. A complete new pumping station, consisting of eight steam turbines driving centrifugal pumps and electrical generators with a total water horse power of 15,116 and supplied with steam at 300 lb. pressure per square inch by eight water tube boilers, will be housed in a new steel-framed engine house now in course of erection. In addition new conduits varying from 78-inches to 36-inches in diameter to bring the additional raw water to the works and to convey partly filtered and filtered water in the works will be constructed. The estimated cost of these and the ancillary works is £1,496,250.

An aerial photograph of Hampton works taken in May, 1937, is reproduced opposite. Some of the existing engine houses can be seen stretching along the road in the foreground, with the steel framework for the building to house the new pumping plant in the centre of the picture. A number of slow sand filter beds are also shown, and of these the three of rectangular shape to the right of the new engine house are to be taken for the site of the proposed primary filters.



HAMPTON WORKS.
New engine house under construction.

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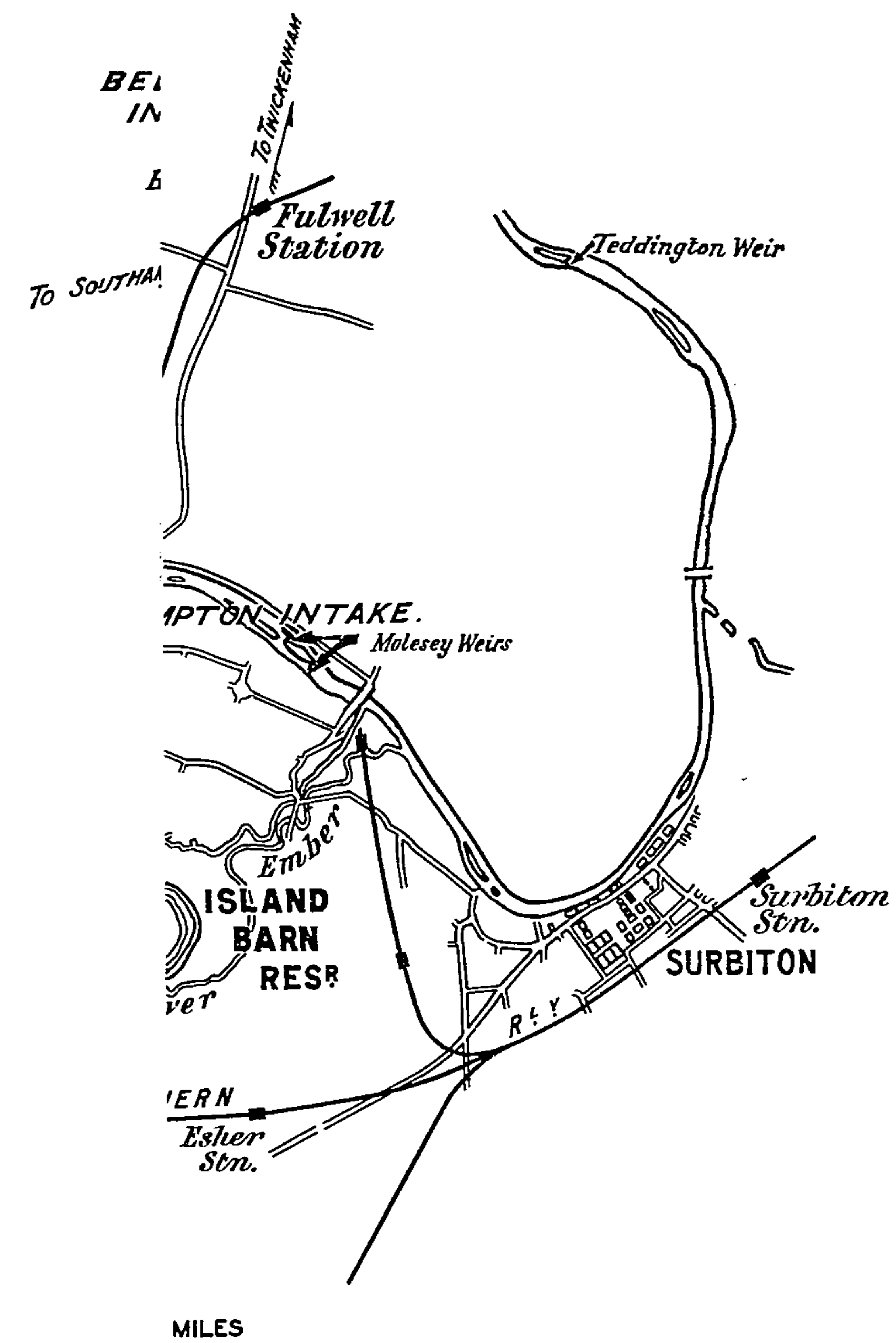
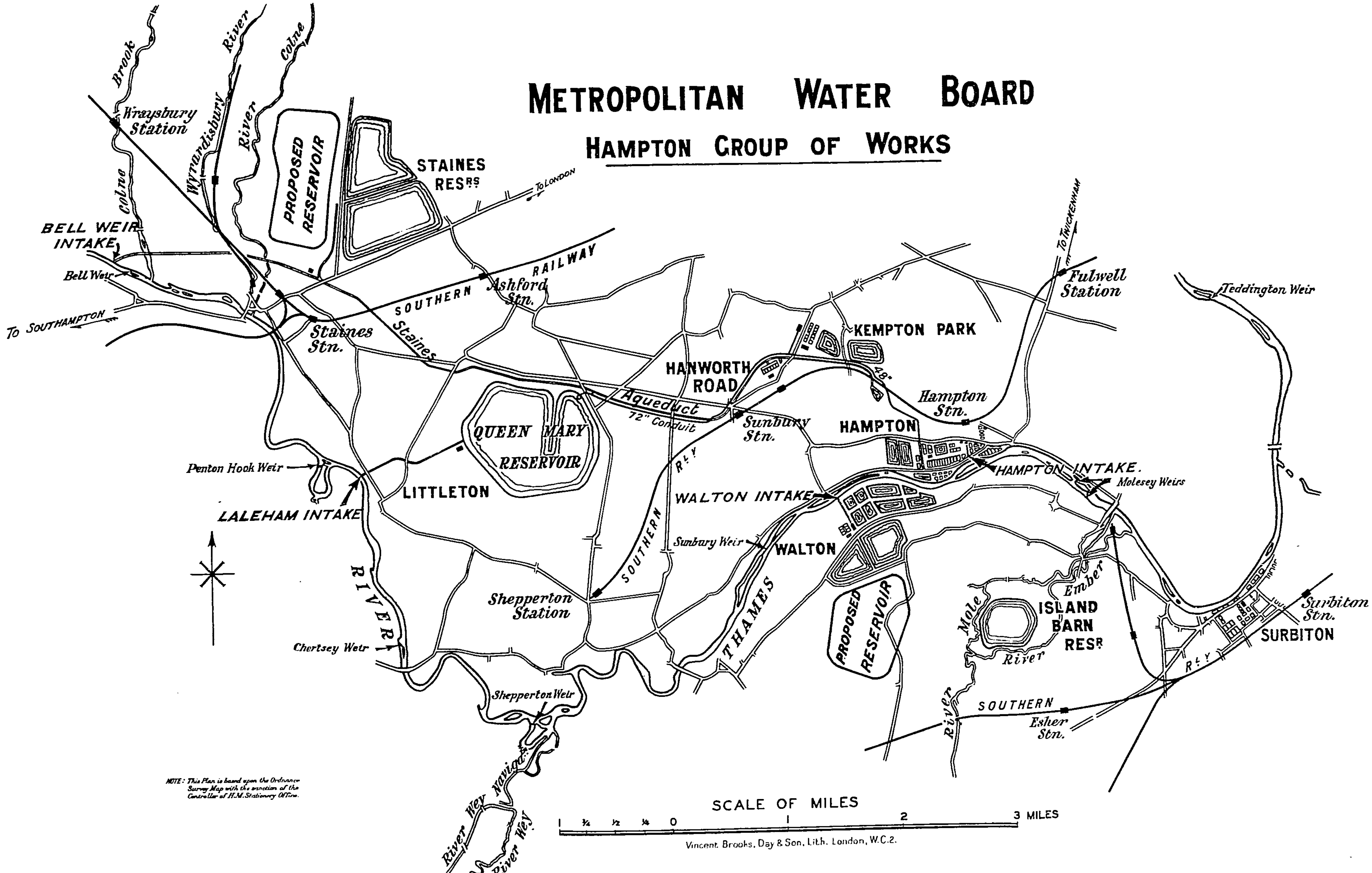


J.R. DAVIDSON, M.Inst.C.E.,
Chief Engineer.

METROPOLITAN WATER BOARD

HAMPTON GROUP OF WORKS



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Chief Engineer.

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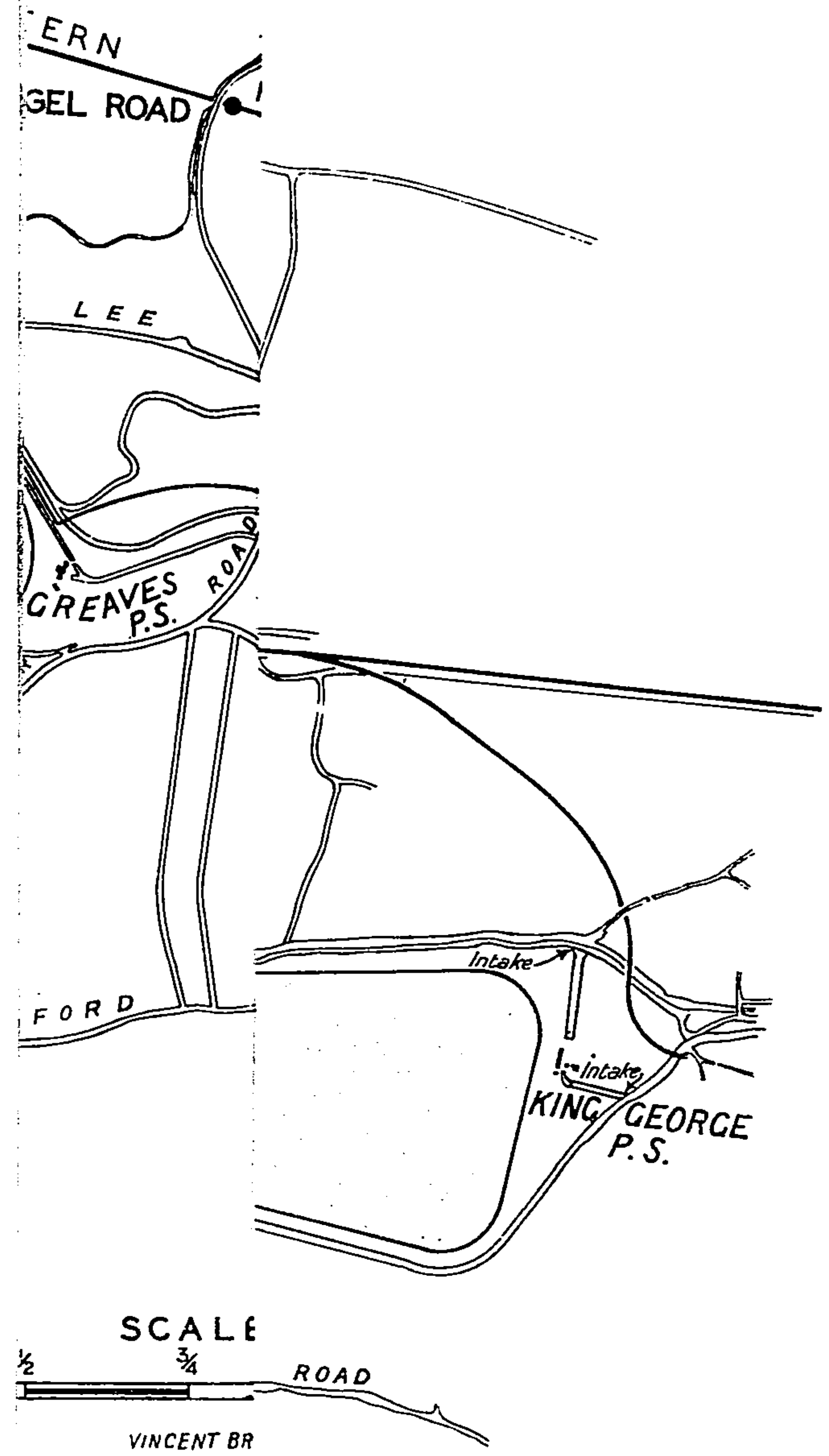
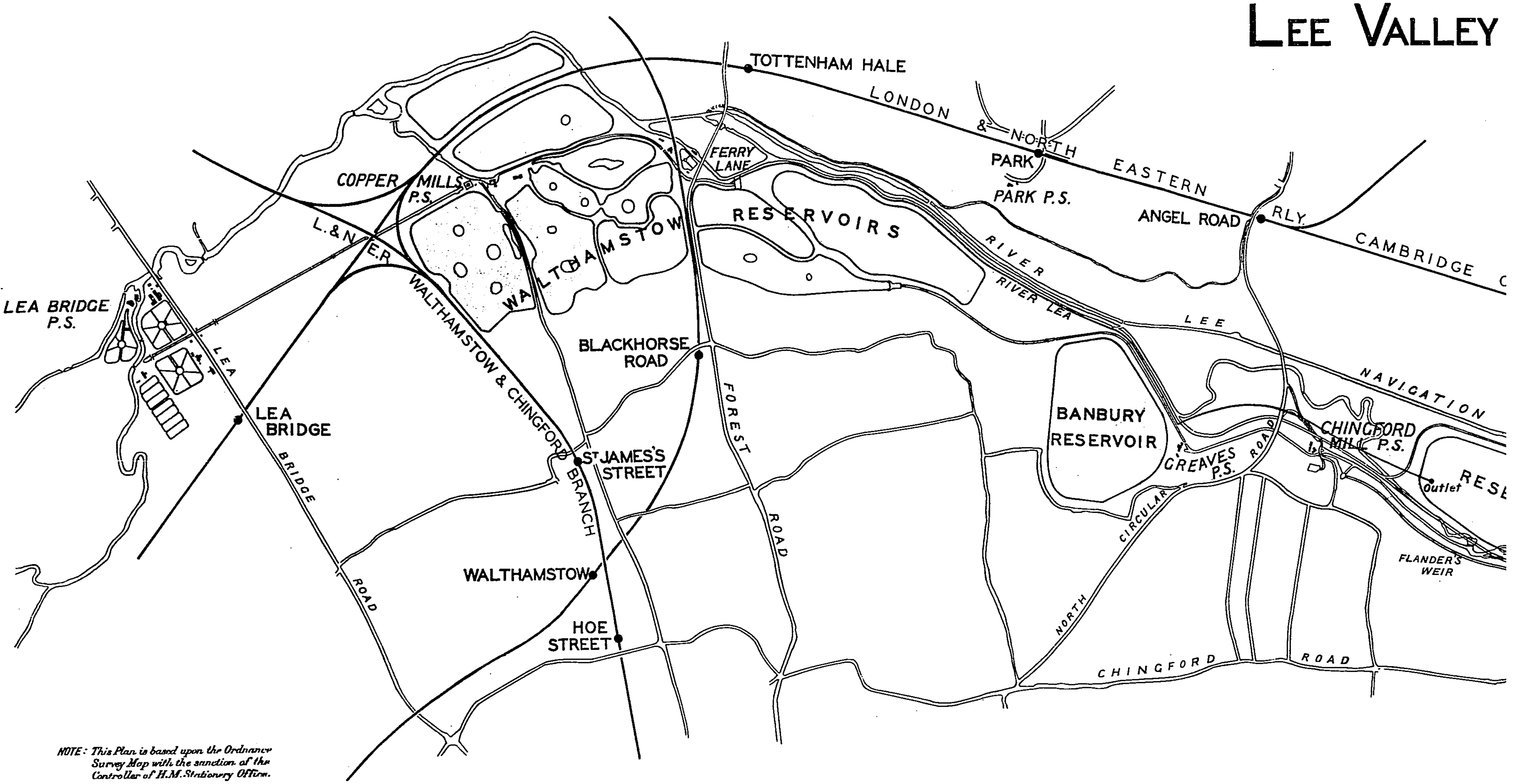


ERN
GEL ROAD
LEE
GREAVES
P.S.
ROAD
FORD
Intake
Intake
KING GEORGE
P.S.
SCALE
½
¾
ROAD
VINCENT BR

METROPOLITA

LEE VALLEY



NOTE: This Plan is based upon the Ordnance Survey Map with the sanction of the Controller of H.M. Stationery Office.

1937 $\frac{13}{62}$

SCALE OF MILES

0 ¼ ½ ¾

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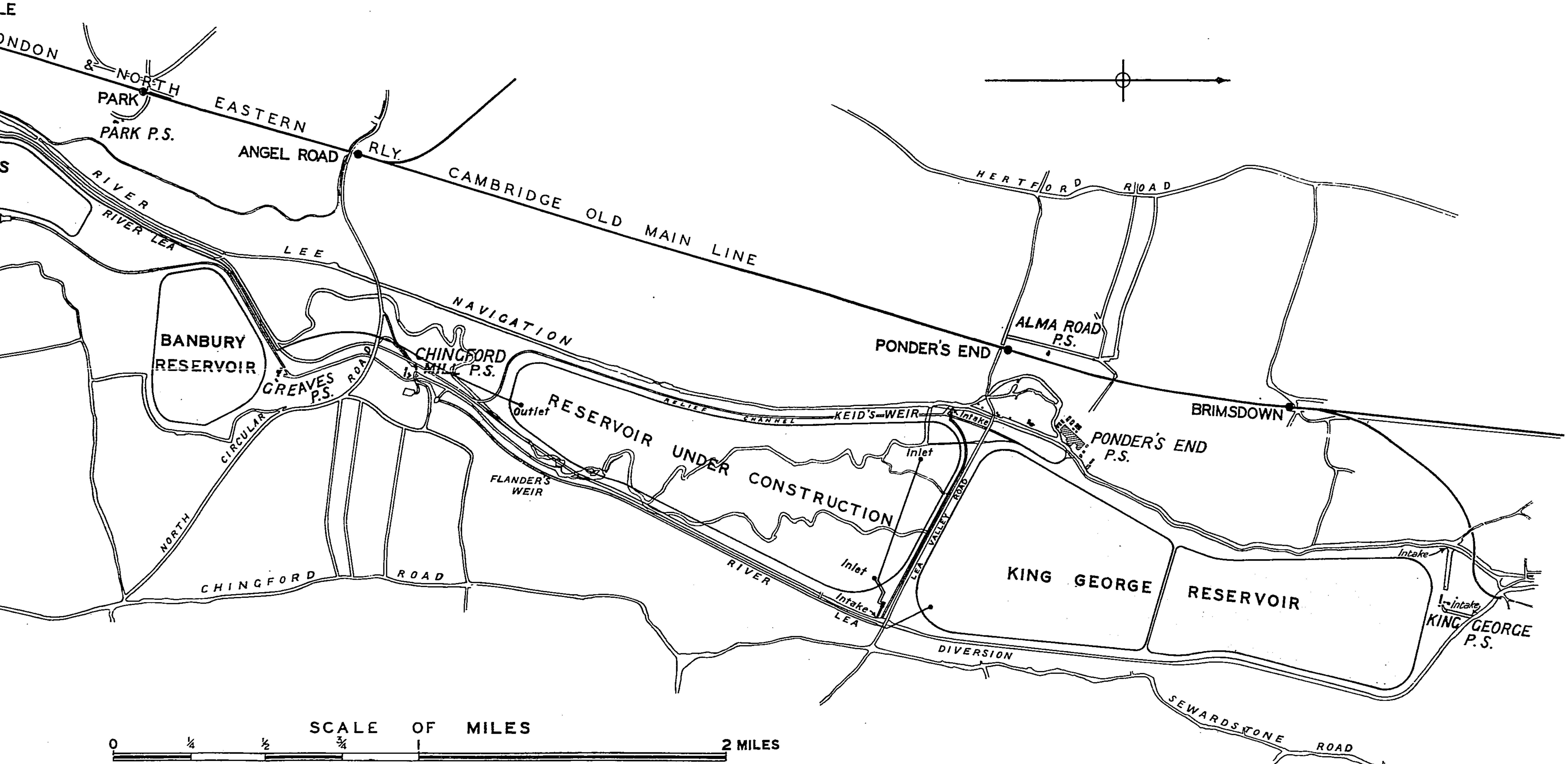
Metropolitan Water Board

Lee Valley Group of Works



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J.R. DAVIDSON. M.INST. C.E.
Chief Engineer.

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