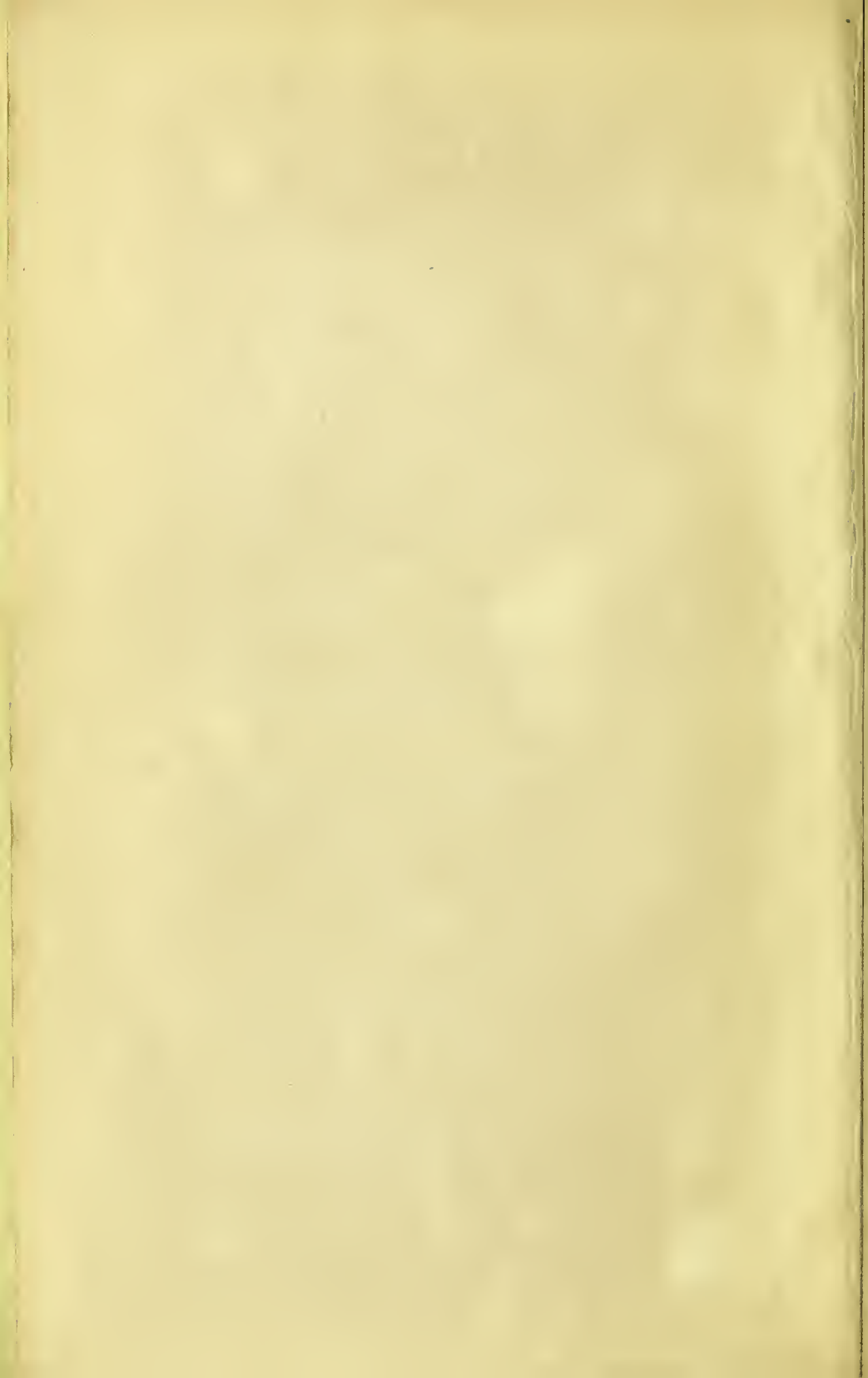


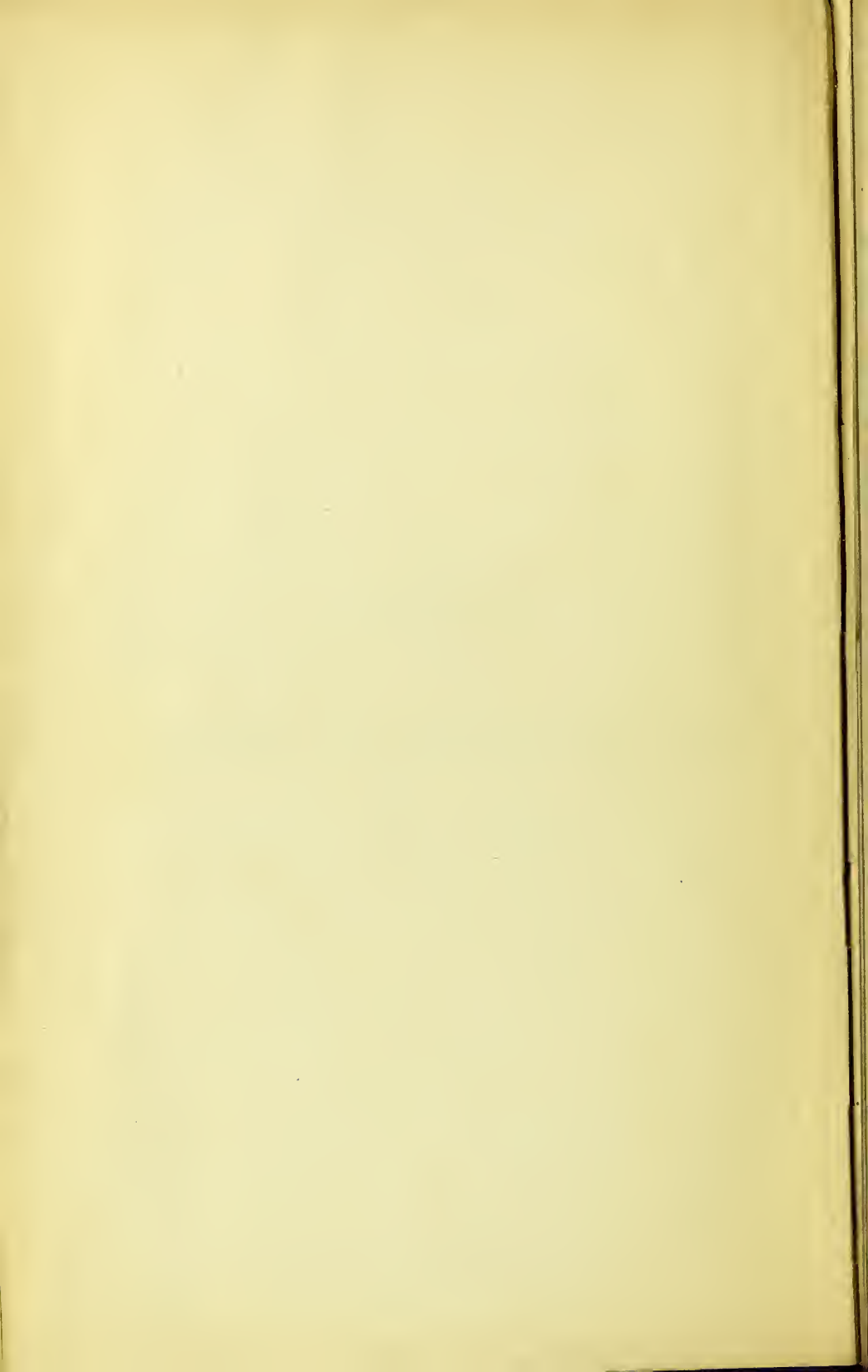


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HISTORY
OF
THE WATER SUPPLY TO GLASGOW.



HISTORY
OF
THE WATER SUPPLY TO GLASGOW,

From the Commencement of the Present Century.

WITH DESCRIPTIONS OF THE WATER WORKS PROJECTED, EXECUTED,
AND FROM TIME TO TIME IN OPERATION.

AND

AN APPENDIX,

CONTAINING TABLES OF CAPITAL, REVENUE, AND EXPENDITURE OF
THE LOCH KATRINE AND GORBALS WATER WORKS; AVERAGE DAILY QUANTITY OF
WATER SUPPLIED TO GLASGOW AND NEIGHBOURHOOD; EXTENSIONS OF PIPING; RAIN-
FALL IN THE DIFFERENT DISTRICTS; ANALYSES OF DIFFERENT WATERS; AND
CHEMICAL AND MEDICAL REPORTS ON THE QUALITY OF WATER
SUPPLIED IN VARIOUS LOCALITIES.

BY JOHN BURNET,

SECRETARY TO GLASGOW CORPORATION WATER WORKS COMMISSIONERS.

GLASGOW:
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1869.

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TO THE

HON. SIR JAMES LUMSDEN OF ARDEN, KNIGHT,

PRESENT LORD PROVOST,

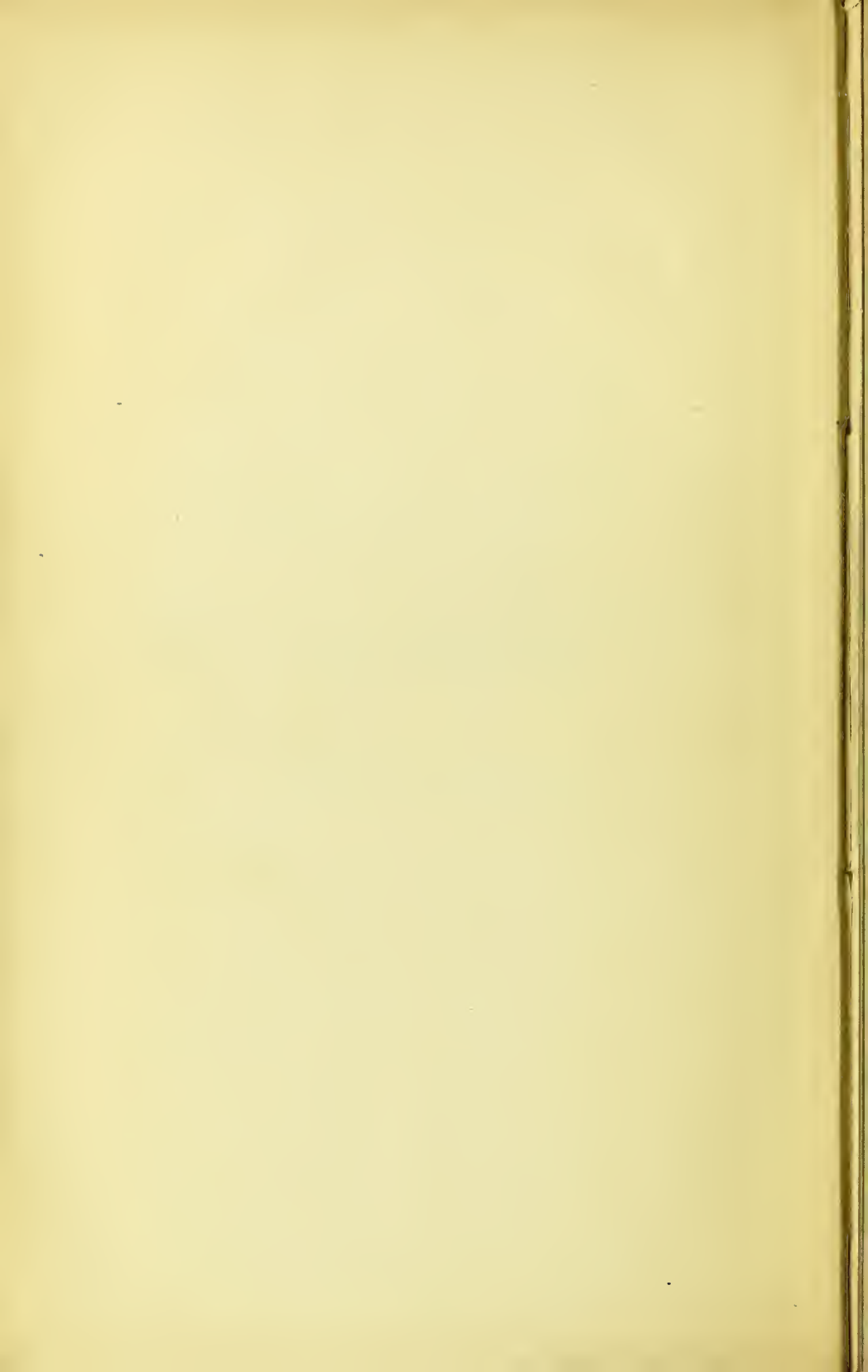
AND TO

THE PREVIOUS LORD PROVOSTS, AND OTHER MEMBERS OF THE SUCCESSIVE
WATER COMMITTEES OF GLASGOW,

THE FOLLOWING PAGES, PREPARED AT REQUEST OF THE COMMITTEE,

Are Respectfully Inscribed.

GLASGOW, *July*, 1869.



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HISTORY

OF THE

WATER SUPPLY TO GLASGOW.

AN ample supply of good water to large towns, for domestic and manufacturing purposes, has been always considered an object of paramount importance; and at no period of our history has its importance been more apparent than it is at the present time. The great benefit derivable from it in promoting health, cleanliness, and comfort, is universally acknowledged, while the importation to this country of new and previously unknown disease, and the frequent recurrence of epidemics, have of late years greatly enhanced its value in a sanitary point of view. Much attention is properly now paid to the necessity for measures to protect and preserve public health; and none have been found so efficacious as the introduction and general distribution, among all classes, of pure and wholesome water. The efforts of the authorities and leading citizens of Glasgow to secure this object for their city, at length crowned with success, have been long continued, persevering, and enterprising; and it is thought that an authentic and articulate account of the means which have been employed in the struggles to attain it, was well worthy of preservation as part of the city annals. These considerations have suggested the present attempt to give a brief historical account of the numerous schemes which have been projected and executed, from time to time, during the present century, in order to secure a satisfactory water supply for the city, their varied successes and failures, and the ultimate complete accomplishment of

the object, by the execution of the Water Works now so happily in operation. The details, it is hoped, may prove alike interesting and instructive not only to the present but also to future citizens of Glasgow, as well as tend to induce and encourage exertions in other towns to obtain similar public benefit.

THE STATE OF THE WATER SUPPLY PRIOR TO THE FORMATION OF WATER COMPANIES.

At and prior to the commencement of the present century the only sources of water supply available to the inhabitants were a few pump-wells, erected at different parts of the city. There were thirty of these wells, erected on twenty-four of the principal streets and thoroughfares, with one on the eastern public Park, or Green, and a few private wells attached to property belonging to private citizens. The inadequacy of such provision for the population of a city numbering, at the time of the census in 1801, 83,769, and then rapidly increasing, had become very obvious. The quality of the water in some of the wells was, even at that early time, from being impregnated with sewage or other deleterious matter, considered highly unsafe and objectionable. The constant pressure, too, and annoying detention of the inhabitants from all parts of the city at others of these wells, requiring them to wait their turn to obtain the needful supplies of this essential necessary of life, was felt to be a great inconvenience, causing much waste of time and no inconsiderable trouble. Improved and increased means of supply were therefore urgently required, and loudly called for. The Magistrates of the time, joined by a few leading citizens, made various attempts to remedy this state of things, employing engineers to make surveys, plans, and estimates for the purpose, but without success. Difficulties were constantly started, not the least frequent of which, in those anti-speculative days, was the impracticability

of raising the necessary funds. At length, in 1804, Mr. William Harley, an enterprising citizen, constructed, on his own responsibility and at his own expense, an extensive tank or reservoir, on what is now West Nile Street, into which he led water by pipes from springs in his lands of Willowbank. From this he carted water in cisterns and barrels all over the city for sale, and found eager and ready purchasers of the pure element, to whom he sold it at the rate of one halfpenny per stoup—a wooden vessel for carrying water, then in use in almost every household. This, however, was entirely a private speculation of Mr. Harley, and as such was attended, it has been said, with some success, yielding, as it did for a time, considerable profits, estimated by some at not less than £4,000 per annum. But the scheme was in its nature temporary, and unsatisfactory to meet the rapidly increasing demand, and was destined soon to give place to means of supply more suitable and permanent.

THE FORMATION OF, AND THE STATUTORY POWERS OBTAINED BY, THE GLASGOW AND CRANSTONHILL WATER WORKS COMPANIES.

In the year 1806 the Magistrates and Town Council of Glasgow, joined by a number of influential citizens, resolved to form themselves into a Company for supplying the city and suburbs with water, and applied to Parliament by a bill for incorporation and powers. The preamble of this bill set forth that the city and suburbs of Glasgow are at present very scantily supplied with water; that it was of great consequence to the inhabitants that they should have a constant supply; and that the several persons therein named were willing to undertake to procure such supply—to be raised from the river Clyde into reservoirs, to be formed on part of the lands of Dalmarnock; thence to be conveyed in pipes under ground through the lands of Dalmarnock and other

property, and along the street or road leading into and situate within the burgh of Glasgow, called the road to Camlachie; thence along Sydney Street into reservoirs, to be formed on part of the lands of Middle and New Gallowmuir, within the city, for distribution in the city and suburbs. This was the description of the proposed undertaking, as given in the preamble of the bill, which passed into a law, by the Act 46 Geo. III., cap 136, on 21st July, 1806. By this Act the Magistrates and Town Council, and the several persons therein named, were incorporated as one body corporate and politic, by the name of "The Company of Proprietors of the Glasgow Water Works," with full powers to purchase lands, tenements, or heritages, for the use of the undertaking; to raise money among themselves not exceeding £100,000, to be divided into shares of £50 each, and to execute the proposed works. The Magistrates and Council subscribed for, and held to the last, twenty of these shares. It was specially provided by the Act, that no person should be answerable for more than the amount of his shares, and that £6,000 should be set apart out of the profits to answer contingencies, before any dividend should be paid. It was farther provided, that the communication pipes between the company's pipes in the streets and the respective houses of the inhabitants were to be laid at the expense of the latter. It is worthy of remark, too, that at this early period the Act, among other beneficial provisions, expressly enacted, "That the furnace of every steam engine to be erected by the said company of proprietors shall be constructed upon the principle of consuming its own smoke."

The first committee of management was named in the Act, and consisted of the Lord Provost of the city for the time being, and Messrs. Gilbert Hamilton, John M'Caul, Kirkman Finlay, John Tennent, Alexander Oswald, John Mair, James Spreull, James Cleland, and James Hill, all well known and highly respectable citizens, not one of whom, it is believed, now survives. The Lord Provost was appointed chairman; and three of the members were to retire annually, and other three to be elected in their stead.

In the year 1808 a rival company was formed by the name of "The Company of Proprietors of the Cranstonhill Water Works," and applied to Parliament by a bill for "An Act for the further supply of the City and Suburbs of Glasgow, and Places adjacent, with Water." The preamble set forth that the city and suburbs were very scantily supplied with water; that a company was lately formed under the name of "The Company of Proprietors of the Glasgow Water Works," for the purpose of introducing a supply of water from the river Clyde, at the eastern extremity of the said city; that the said company was incorporated by an Act of Parliament, passed in the forty-sixth year of the reign of His then Majesty, intituled "An Act for Supplying the City and Suburbs of Glasgow with Water;" that it was of great consequence to the prosperity of the city and suburbs, and places adjacent, that the inhabitants thereof, and manufacturers residing therein, should have a constant and abundant supply of so necessary an article, and at a reasonable rate; that these important objects could be best accomplished by there being more companies established and incorporated, for supplying the said city and suburbs, and places adjacent, and particularly at the western extremity thereof; that the several persons therein named were willing to undertake to procure an additional supply, to be raised from the river Clyde into reservoirs, to be formed on part of the lands of Cranstonhill and adjacent grounds, situated at the western extremity of the said city, which the said persons had purchased from Richard Gillespie of South Woodside and Walter Logan of Cranstonhill; the water to be conveyed thence by pipes under ground, through and along the road leading by Anderston to Glasgow, Argyle Street, Trongate Street, and the other streets in Glasgow, to be distributed through Anderston and the city and suburbs of Glasgow. This bill passed into a law by the Act 48 Geo. III., cap. 44, on 27th May, 1808. The company of persons promoting it were in like manner incorporated, and empowered to raise money among themselves for making and maintaining the reservoirs and other works authorized,

not exceeding in whole £30,000, to be raised in shares of £50 each, with power to borrow £10,000. The sum to be set apart for contingencies was not to be less than £3,000. In other respects the provisions were very similar to those of the Glasgow Company's Act.

In the year 1812 the Cranstonhill Company applied for and obtained another Act, 52 Geo. III., cap. 52, passed 20th April, 1812, "To enable the Company of Proprietors of the Cranstonhill Water Works to raise more Money for the further Supply of the City and Suburbs of Glasgow, and Places adjacent, with Water." By this Act the company was authorized to borrow money, not exceeding the further sum of £10,000, and to sell shares to that extent at a price not less than £50 per share.

In the year 1819 the Glasgow Company applied for and obtained another Act, 59 Geo. III., cap. 67, passed 14th June, 1819, "For Altering and Enlarging their Powers." By this Act the company was empowered, in addition to the sum of £100,000 formerly authorized to be raised, to sell such further number of shares, not exceeding two thousand, as a general meeting of proprietors, called for the purpose, might authorize. They were also empowered to borrow £50,000, and to divide among themselves, or to use or otherwise dispose of, as might be found expedient for the purposes of the undertaking, the £6,000 formerly set apart to answer contingencies. As to rates, the charge for a domestic supply was, by this Act, fixed at a rate not exceeding £7, 10s. per centum per annum on the rental of dwelling-houses when the rent was under £100, and not exceeding five per cent. when the rent amounted to £100 or upwards; and not more than £10, nor less than 10s., was to be levied from any inhabitant in any one year.

In the same session of Parliament the Cranstonhill Company also applied for and obtained an Act, 59 Geo. III., cap. 117, passed 2d July, 1819, to "enable them to improve their Works," on the ground, as stated in the preamble, that the population and manufactures of the city had since the passing of the said Acts (in 1808 and 1812) greatly

increased, and were still increasing; and the Company had already expended the whole sums of stock and loans authorized to be subscribed and borrowed by the said two Acts, in making and maintaining their Works, from which the inhabitants had derived very great advantage and benefit, although the proprietors had not received any return for the sums so expended; that in order to render the supply of water more abundant and regular, the Company had it in contemplation to erect works for raising water from the river Clyde into reservoirs to be formed on parts of the lands of Dalmarnock, situated to the south-east of the city, which had been purchased by the Committee of Management, pursuant to power granted by the first-recited Act, for behoof of the said Company of Proprietors, from Patrick Playfair, Esq. of Dalmarnock, and conveying the same thence by pipes under ground, through and along the road leading from Dalmarnock Ford to Glasgow by Bridgeton and Calton, and through and along any of the streets of Glasgow and suburbs thereof leading towards the then reservoirs of Cranstonhill, and to connect such pipes with the pipes then used by the Company for distributing water over the said city and suburbs; and also to make a reservoir or reservoirs upon grounds purchased by said committee of management, pursuant to such power, for behoof of the said Company, at Garnethill; and to convey the water in pipes thereto, either from the reservoirs at Cranstonhill, or from the works to be erected by them on the grounds situated at Dalmarnock, for enabling them to supply the higher parts of the city and suburbs. By this Act the capital of the Cranstonhill Company was increased to £200,000; the original £50 shares, as well as the new stock of £140,000, were to be divided into shares of £25 each; and the Company was authorized to borrow the further sum of £50,000. The provision in the former Act requiring the Company to set apart £3,000 to answer contingencies, which does not appear to have been ever complied with, was repealed; and the Rates were fixed in precisely the same terms as in the Glasgow Company's Act

of that session. In passing this Act, Parliament seems to have thought it necessary to require some security that the new works proposed, which were estimated to cost £30,950, 1s., would be executed, as by one of the sections it was enacted "That the whole of the said sum of £30,950, 1s. shall be subscribed before any of the power given by this Act shall be put in force." This condition was no doubt complied with; and new works for raising water from the Clyde at Dalmarnock, a short distance below the Glasgow Company's Works, and a much better source of supply than the Clyde at Cranstonhill, were executed, and carried into operation.

The two Companies carried on their works in competition with each other, under their respective Acts of Parliament, for a number of years—the Glasgow Company with some success, but the Cranstonhill Company most unprofitably, as will be afterwards seen. At length, in 1833, it became obvious that the competition could not be longer continued; and in that year the two Companies entered into an arrangement for amalgamation, which they endeavoured to get sanctioned by Parliament in 1834; but this, as well as a subsequent attempt to the same effect, was unsuccessful, in consequence of the opposition of the Town Council, on the ground that it would deprive the inhabitants of the benefit of the competition which the law as it stood gave them. But a third effort in 1838 was more successful, and an Amalgamation Act, 1 & 2 Vict., cap. 86, passed on 27th July, 1838. The preamble narrated that the Cranstonhill Company had only been able from its commencement in 1808 to make dividends amounting in all to *less* than 20s. per cent., and in order to prevent further loss they were desirous of selling their works to the other Company. It was also held out, as a ground for amalgamation, that the acquisition of these works by the latter would enable them to supply the city and suburbs more efficiently, and at lower rates. On these grounds the Act passed; but some important conditions were imposed for the public benefit. The capital stock was reduced and

restricted to £267,550, instead of £326,050, the capital of the two Companies actually expended, which was directed to be divided into 5,351 shares of £50 each. One-fourth part of this stock was appropriated to the shareholders of the Cranstonhill Company, and the other three-fourth parts to the shareholders of the Glasgow Company. The maximum of future dividends was fixed at 7 per cent., and the Company was taken bound to furnish a supply of "good wholesome water" to every inhabitant occupying a dwelling-house, at the following rates, viz.:—At a rate not exceeding £6, 10s. per cent. upon rental, under deduction of one-tenth when the rent was above £5 per annum (equal to about 1s. 2d. per pound on full annual rent or value), and at a rate not exceeding 5s. per annum when the rent was at or under £5. The proviso in former Acts, that more than £10 nor less than 5s. should not be taken in any one year from any inhabitant, was repeated, and the rate for supplies to manufacturers, vintners, and others (not domestic), was to be levied according to agreement. There was an obvious defect in this Act, inasmuch as it did not take the united Company bound to lay pipes where *necessary*, but only to give a supply where they had already laid them, which left the important matter of domestic supply very much to themselves, as pipes were only laid where the return was expected to be remunerative. This was afterwards much insisted on in Parliament in opposition to the proposal to continue the supply in the hands of a private Company. The Company was taken bound, however, so far as practicable, consistently with the necessary supply for domestic use, to furnish factories or public works with water at certain specified rates, and to the Commissioners of Police such quantity as they might require, not exceeding 2,500,000 gallons per annum, for cleansing the squares, streets, lanes, and closes of the city and suburbs, at the rate of 10d. for every 1,000 gallons. The progress of the bill for this Act was carefully watched by an energetic opposition, and many other beneficial provisions were introduced into it, amongst others an obligation to keep the mains constantly charged

with water for extinguishing fires, under a penalty of £50 for each failure or neglect—an obligation, however, which was frequently disregarded and violated.

After the passing of this Act in 1838, the Glasgow Company had the entire supplying of the city in their own hands; and although they continued it for a number of years, they completely failed to satisfy the public respecting the quality of their water, which was of a very inferior description. They consequently encountered much opposition, as will be immediately seen, on the part of the citizens, by whom many opposing schemes were projected, in order to procure a purer and better supply. They appear, indeed, to have latterly become satisfied themselves that they could not maintain their position without providing a better supply; for in the year 1845 they gave notice of a bill to be promoted in the then ensuing session of Parliament, to introduce it. The preamble of the bill which they promoted for this purpose set forth, that it would be attended with public advantage and convenience, if they were empowered to introduce an additional supply of water from Loch Lubnaig, in the county of Perth, one of the tributaries of the river Forth. This bill, notwithstanding considerable opposition, passed into a law, by the Act 9 Vict., cap. 21, on 14th May, 1846. The Act, however, was afterwards found to be impracticable, by reason of the extent of the compensation water which the Act required them to send down the river Teith for the mill-owners and others in that district, and it was never carried into execution, but remained a dead letter in the statute book. They never afterwards got another Act, as will appear in the sequel, although they strenuously endeavoured to obtain it.

THE WORKS EXECUTED BY THE GLASGOW AND CRANSTONHILL COMPANIES UNDER THE POWERS OF THEIR ACTS.

Both Companies having selected the river Clyde as their source of supply, the works of the Glasgow Company were established, in terms of their first Act, at Dalmarnock, on the banks of the river Clyde, about three miles above Glasgow bridge; and those of the Cranstonhill Company, in terms of their Act, at Cranstonhill, about three-quarters of a mile below it. The execution of the different works commenced soon after the respective Acts of Parliament passed. Under the advice of the celebrated James Watt, then of the firm of Bolton & Watt, and Mr. Thomas Telford, the eminent engineer, who furnished plans for the works, the Glasgow Company proceeded to form, on the north bank of the river, filtering beds and ponds, and to erect two steam engines made by Bolton & Watt. They also formed reservoirs in Sydney Street, Drygate, and Rottenrow, to which the water was pumped from Dalmarnock by the engines. But these filtering beds were soon found insufficient and unsuitable, and various plans were proposed for improvement, among others, a plan to construct filters and subsiding reservoirs on the south bank of the river, which was adopted; and for this purpose lands were acquired from Mr. Farie, of Farme. The filters formed there consisted of a brick tunnel or culvert built along the south bank, below the level of the bed of the river. The river bank at this part consisted entirely of sand, and the joints of the brickwork were left open, to allow the water to percolate into the culvert from the river. The quantity of water supplied by the tunnel was estimated at 3,000,000 gallons a day on an average. It varied, however, with the state of the river, being least when the river was low, and at those times contained much lime and some iron. Strange to say, this inadequate system of filtration was the only one adopted for about thirty years. As the city increased, the quantity of water was found insufficient, and other filters

were constructed in 1839, after the amalgamation of the two Companies, and these were added to from time to time. The area of ground occupied by the filters, subsiding reservoirs, and other works at Dalmarnock, extended to 22 acres, and at Cranstonhill Works to 12 acres. The filtered water was at first conveyed across the river to the pumping engines by a 15-inch spherical-jointed pipe designed by Watt. Three additional pipes, one of 18, another of 25, and a third of 40 inches, were laid in the river in later years. There can be no doubt that the defective means of filtration at these works caused much of the dissatisfaction which afterwards prevailed. At the Cranstonhill Works there was a similar tunnel along the river bank, and relative filters. They were more extensive than those at Dalmarnock, in proportion to the quantity of water passing through them, and consequently the quality of the water was generally better.

The whole pumping apparatus of the united Company, as it stood at the time their works were superseded by the introduction of the water supply from Loch Katrine by gravitation, may now be described.

There were altogether three pumping stations, and thirteen pumping engines, of 898 horse-power in the aggregate, distributed as follows:—

At Dalmarnock,.....	1 of 18 horse-power,	18	
„	.....4 of 80	„	320
„	.....2 of 180	„	360
			— 698
At Cranstonhill Works,...	1 of 10	„	10
„	„ 3 of 30	„	90
			— 100
At Drygate,.....	2 of 50	„	100
			— 100
		13	— 898

The engines were all single-acting condensing beam engines, with the exception of the two at Drygate. The two largest at Dalmarnock were erected about 1840, after the amalgamation, and, with the engine house and boiler

shed, are stated to have cost £23,000. The others, which were much older, were made by Bolton & Watt. The three 30-horse-power engines at Cranstonhill Works were erected when the works were moved from Cranstonhill to the point on the river a little below the Glasgow Company's Works, in 1819.

The two 180-horse-power engines at Dalmarnock, named respectively "Samson" and "Goliath," were made and erected by the Neath Abbey Company, Wales. They were upon the Cornish principle, and of the most approved construction at the date of their erection. The cylinders were of 72 inches diameter and 10 feet stroke. "Samson" was used for pumping water to the high districts of the city, against an indicated pressure of 85 lbs. on the square inch. The pump barrel was 24 inches diameter and 10 feet stroke, discharging into a main of 20 inches diameter. It latterly made 780 strokes an hour, or 13 a minute, and threw 21,884 cubic feet an hour, or over 3,000,000 gallons a day. "Goliath" was used for pumping water to the low districts, against an indicated pressure of 40 lbs. on the square inch. The pump barrel was of 30 inches diameter and 10 feet stroke, discharging into a main of 36 inches diameter. It made 840 strokes an hour, or 14 a minute, and threw 38,000 cubic feet an hour, or over 5,500,000 gallons a day. There were eight boilers to these two engines, each 25 feet long, of 7 feet diameter, with internal flues of 3 feet diameter. The boilers were worked at 15 lbs. on the square inch. These valuable engines and boilers were all broken up and disposed of as old metal, after the introduction of the supply by gravitation from Loch Katrine.

Taking the average of the last thirteen years of the working of the engines, one waggon (24 cwt.) of coal kept one engine working for 1.65 hours; and the effective work, taking an average for the same length of time, was 186,000 foot-pounds per lb. of coal consumed. The cost of pumping, taking all the engines at Dalmarnock and Cranstonhill Works together, as ascertained from the accounts of the

Company by Dr. Rankine, in the arbitration entered into to fix the compensation to be allowed the Company, was, during a long series of years, at the rate of almost exactly 400,000 gallons raised one foot for a penny; that is, 4,000,000 foot-pounds for a penny.

There were three main pipes leading from the Dalmarnock Works to the city, one of 14 inches diameter, with flange joints, laid in 1808, one of 20 inches, laid in 1821, and one of 36 inches, laid in 1830. From the Cranstonhill Works there was one main of 21 inches diameter, laid when the new works were erected in 1819. In addition to these there were numerous subsidiary pipes, varying from 12 to 2 inches diameter. The two Companies had parallel lines of pipes in most of the streets in the city. There were five reservoirs on elevated sites in the city, one at the Drygate pumping station, one in Rottenrow, one on the top of Garnethill, and two at Cranstonhill.

The supply of water was constant in the lower parts of the town, and intermittent in the upper. The pumping station at Drygate was used for forcing water to the highest levels within the limits of supply, including Garngad Hill, Blythswood Hill, Garnethill, the West-End Park, and Partick Hill. The reservoir in Drygate into which the water was pumped from Dalmarnock was capable of holding about 800,000 gallons, at an elevation of about 100 feet above high water; and from this level it was forced to the requisite additional height, by the two horizontal high-pressure engines there, one of which was erected in 1854, and the other in 1857, the year after the works were transferred to the City Corporation. These two engines were designed by the late Mr. Daniel Mackain, engineer of the Company, who for the long period of thirty years acted with great fidelity and zeal in that capacity, at first for the Cranstonhill, and afterwards for the united Company. He was unanimously elected to the same office under the present City Corporation Commissioners, after the works were transferred to them, and he was continued in office until he died, deeply regretted, on 8th February, 1859.

Such is a rapid sketch of the nature and extent of the works of the two Companies to which the city was indebted for its water supply for about half a century, and there can be no doubt that these works were very serviceable to the community for a great part of that time. The Clyde, as the source of supply, was sometimes pretty free from objection, and in the ordinary state of the river it was a good soft water, not unpleasant to the taste when properly filtered; but during floods it was much discoloured by clay, and in certain seasons deeply stained with peat. Larger subsiding reservoirs and more effective filtration would have removed to a great extent this colouring matter, but there never were filters sufficiently extensive to pass the large quantity of water required by the city. In some states of the river, indeed, nearly one-half of the whole quantity supplied from the Dalmarnock Works was pumped into the city direct from the river, without any filtration whatever. The constantly increasing number and extension of manufactories and dyeworks on the banks of the river, no doubt, also contributed considerably to affect injuriously the quality of the water. As regards quantity, there was less ground for complaint, excepting, perhaps, on the higher levels; to supply which the engine power of the Company did not certainly keep pace with the increase of the city. But extensive, as well as expensive in construction and maintenance, although the old works undoubtedly were, it should not be matter of wonder that in the process of time they became insufficient and unsatisfactory, when the unprecedented ratio of increase of population, and consequently of works and factories, is considered. The following table will show the progressive increase of population from 1811, the date of the first census after the works of the two Companies came into operation, down to 1855, when the Glasgow Corporation Water Works Act passed, and also the average daily quantity delivered to the city and suburbs, so far as that appears to have been ascertained at the time, or has been preserved:—

Population, including Suburbs.		Quantity of Water Supplied per Day, so far as ascertained.	Per Head of Population.
		<i>Gallons.</i>	<i>Gallons.</i>
1811 ⁽¹⁾ ,.....	110,450	...	...
1821,.....	147,043	...	...
1831,.....	202,426	...	...
1838 ⁽²⁾ ,.....	250,000	6,500,000	26
1841,.....	274,324	...	...
1845 ⁽³⁾ ,.....	320,000	9,500,000	30
1848,.....	322,334	...	...
1851,.....	344,986	...	...
1852 ⁽⁴⁾ ,.....	360,000	14,000,000 ⁽⁵⁾	39
1855 ⁽⁶⁾ ,.....	378,986	...	...

(1). First Census after the two Companies' Works commenced.

(2). The Two Companies amalgamated this year.

(3). Gorbals Company projected.

(4). Gorbals Extension, Loch Katrine, and Loch Lubnaig Bills promoted.

(5). Includes Gorbals supply (3,000,000).

(6). Loch Katrine Act obtained.

Last year (1868) the population supplied by the works had increased to about 519,000 persons, and the average daily quantity of water delivered, to 25,400,000 gallons, or 49 gallons per head of the population; and when these figures are contrasted with the population and supply in 1855 and previously, it is easier to imagine than describe the condition in which the city and suburbs of Glasgow must now have been in regard to water supply, if the Loch Katrine Act had not then passed.

But, in justice to the proprietors of the old works, it must be here stated that they commenced, and appear to have carried on, their works with the best intentions, with much benefit to the community, and with little pecuniary advantage to themselves. The Cranstonhill Company was projected and carried on for the avowed purpose of giving the community the benefit of competition, and this no doubt

tended to keep down the water rates at a low figure, while the Company was a losing concern from the commencement. Nor was the Glasgow Company, although for part of their career far more prosperous, upon the whole a remunerative undertaking. Between 1824 and 1827 the Cranstonhill Company disposed of one-half of their whole capital at about one-fifth of its nominal value; and from its beginning in 1808, to the amalgamation with the Glasgow Company in 1838, a period of thirty years, the whole dividends paid to the proprietors did not amount to 1 per cent. The Glasgow Company, formed in 1806, paid no dividend till the year 1814, eight years after its establishment. No doubt, for a number of years afterwards, and up to 1833, they paid 7 per cent., during which time their shares rose to a considerable premium; but after this, as will appear in the sequel, they encountered much opposition and expense, and their dividends, as well as the market value of their shares, suffered much fluctuation and diminution. In 1838, when the amalgamation took place, the capital of the united Company was, it has been seen, largely reduced by Parliament, involving a loss to the Cranstonhill Company of £45,000. But while the two Companies unquestionably supplied the city under these circumstances for a long time, it is equally true that the quality of their water during the latter period of their existence was most unsatisfactory, on account of the defective means of filtration employed. This dissatisfaction will be more apparent when the unceasing efforts made to improve the water supply from 1834 downwards are taken into view.

THE VARIOUS SCHEMES PROJECTED DURING THE SUBSISTENCE OF THE WATER COMPANIES FOR IMPROVING THE WATER SUPPLY.

The city of Glasgow being almost wholly surrounded by high lands, there are consequently a number of sources from which it might have been all along supplied with good

water by gravitation. A number of schemes were accordingly projected from time to time on this principle, some of which never came to maturity, but a few were fully investigated. The various sources of supply suggested are shown on the map appended.

In 1834, when the amalgamation of the two Companies was first proposed to Parliament, the Town Council opposed it, not only on the ground that it deprived the community of the benefit, such as it was, of the competition which had so long existed, without providing better means of supply, but also on the ground that it tended to perpetuate a system which, as many thought, had been too long tolerated, in the hope and expectation that such opposition might bring about the introduction of a better supply. With this view, as part of their opposition, the Council employed Messrs. Grainger and Miller, of Edinburgh, to look out for a better source. This was the commencement of a struggle which the Glasgow Company maintained with the citizens for more than twenty years, but under which they finally succumbed in 1855, when the Loch Katrine Act passed.

The result of Grainger and Miller's investigation was the recommendation of the Earn Water, a tributary of the White Cart, as a fitting source of supply. This was the first scheme proposed; but the Council did not follow it out, for what reason does not now appear. The Earn discharges into the White Cart at a point about seven miles southward from the city, at an elevation of 300 feet above the Clyde at Broomielaw. They proposed three storage reservoirs upon the Earn, and a large compensation reservoir on the Cart near to Eaglesham. The area of the drainage ground to the lowest reservoir on the Earn was stated to be 5,371 acres, and they calculated the quantity of water available for the city to be 10,000,000 gallons a day, which was considerably more than the quantity at that time supplied by the two Water Companies. The water was to be led by a conduit along the east side of the valley of the Cart to Castleton, on the high grounds above Rutherglen, three miles distant from Glasgow, where it was proposed to form a town reservoir.

M A P
 SHOWING
 THE DISTRICT NORTH OF THE RIVER CLYDE
 AND THE
 VARIOUS SCHEMES
 WHICH WERE SUGGESTED.

ARMOUR & STEVENSON ENGINEERS, LITHOGRAPHERS, GLASGOW.





260 feet above the Clyde, and about 70 feet above Garnet-hill, which, at that time, was the highest ground within the city. The estimate of cost was about £200,000, including new distributing pipes.

In 1836 a new Water Company was formed, with Mr. Thom, of Rothesay, as engineer; and after examining a number of sources, including the Clyde at Stonebyres, Mr. Thom prepared parliamentary plans for two projects—one to bring water from the North Calder, at a point near Airdrie, and the other from the river Avon, below Stonehouse. He appears to have had difficulty in recommending either scheme, but ultimately abandoned the Avon, and preferred the North Calder. This scheme included two storage reservoirs near Airdrie, and an aqueduct seven miles long, to a town reservoir, which, however, was so low that all the high grounds in the city, including Rottenrow and Blythswood Hill, would have required to be supplied by pumping. The quality of the water, besides, was found to be objectionable, from peat and the steeping of flax. The cost was estimated at £160,000, including distribution in the city. The plans were found defective; and the Company under which Mr. Thom acted, abandoned their scheme after it had taken the form of a bill.

The principal feature of the Avon scheme was a fine situation for a storage reservoir at Stonehouse, capable of holding 300,000,000 cubic feet. The water was to be drawn by an aqueduct to a town reservoir on Cathkin Hills, above Rutherglen, 150 feet above the Clyde, and about three miles from the city; the whole distance being about twenty-one miles. The scheme would have yielded 15,000,000 gallons a day; but the Avon during some seasons of the year was found to be deeply tinged with moss. The drainage area is shown on the map. This scheme was also opposed and abandoned.

In 1837, Mr. Stirrat, of Paisley, who had acquired some information on the subject of water supplies in connection with the Paisley Water Works, proposed the Rowbank and the Cowdenmill Burns—streams deriving their supply from

the high grounds between the valley of Loch Lebo, the Laveron Water, and the Black Cart—as suitable sources of supply; but this scheme does not appear to have been ever seriously entertained. In this year also the Directors of the Company of Proprietors of the Glasgow Works themselves, foreseeing that ere long their works would have to be abandoned, ordered an examination of the whole country round by Mr. Wilson and Mr. Anderson, their secretary and manager at the time, with the view of constructing new works, in order to supply the city by gravitation; but what these gentlemen did or recommended, does not appear. It is certain that their investigation did not lead to any practical result.

In 1838, Mr. Matthew Moncrieff Pattison, of Glasgow, who was quite an enthusiast on the water question, strenuously advocated the urgent necessity for an improved supply, and tried to revive the North Calder and Avon schemes, but without success; and in 1843 a number of other old projects were revived, and two new ones were started by Mr. Smith of Deanston,—one to pump water from Loch Lomond, and another to form reservoirs in Dumbarton Moor at the sources of the River Kelvin; while Grainger and Miller, after another examination of the country, reported in favour of the Endrick Water—a stream flowing from the North side of the Campsie Fells, and discharging into Loch Lomond. The Allander Water, flowing from the Kilpatrick Hills, and the Clyde at Hyndford Bridge, were also urged as sources of supply about this time.

In 1841-2 the Glasgow Company, again apparently aroused to a proper sense of the necessity for improving the supply, employed Mr. Simpson, of London, to examine all the schemes that had been proposed up to that time, but this renewed effort, like the former, appears to have proved fruitless.

In the early part of 1844 Mr. Neil Robson, C.E., and the late Mr. Thomas Kyle, investigated the projects to bring water from the Clyde above Hyndford Bridge, and from the Avon a mile and a half below Strathaven. Mr. Kyle in

that year also made surveys of the Endrick scheme, and in the latter part of the year a new Company was again formed, with Mr. Rendal, of London, as engineer. He preferred the Avon to all the other sources, and recommended a scheme for taking the water from the river above Strathaven. This recommendation was adopted, and plans were prepared and deposited in parliament; but it was found, on examination of the estimates, that there had been a miscalculation, and that the proposed capital would not execute the works. The bill was therefore abandoned.

The Clyde above the Falls had been frequently suggested as a source of supply—first, it is believed, in 1780, by the famous Henry Bell, whose name has been always honourably associated with the early application of steam to the purposes of navigation. This scheme also was revived and matured by Messrs. Robson and Kyle in 1844, and, as so matured, consisted of a conduit 28 miles long, from a point on the river Clyde a mile and a half above Hyndford Bridge to a town reservoir at Cathkin, 442 feet above high water. It was now proposed to construct a settling reservoir at Hyndford Bridge, on the north bank of the river, $46\frac{1}{2}$ acres in area, 27 feet deep, at an elevation of 605 feet, and two others along the line of aqueduct; the conduit to cross to the south bank of the Clyde a little above Lanark Cotton Mills, and to be continued on that side to Cathkin. Compensation reservoirs would have been necessary, and there were some 'good sites for these upon the Douglas Water, which falls into the Clyde a little below Hyndford Bridge. The Clyde water there, however, was found to be deeply tinged with moss during summer floods, and the scheme was not further prosecuted.

The Endrick scheme, as proposed by Mr. Kyle, was to construct a reservoir on the stream above the Fintry Mill, of 45 acres in extent, and to carry a conduit down the valley of the Endrick, and along that of the Blane, to a reservoir near the village of Torrance, and thence to a town reservoir on Hamilton hill 272 feet above high water. The total length to the town reservoir was 27 miles. It was

intended to intercept the streams crossed by the conduit on the south side of the Campsie Hills, and to run a catchwater drain, north and west of the reservoir on the Endrick, by Culcreuch House, thus including $33\frac{1}{2}$ square miles, or 21,000 acres of water-shed.

The Avon scheme, recommended by Mr. Rendal, included some expensive and peculiar arrangements for separating the moss water. The large reservoir, $2\frac{1}{2}$ miles above Strathaven, would have contained 285,000,000 cubic feet, but the site proposed for the main embankment turned out bad. It was part of this scheme to lead the water by an aqueduct into a town reservoir above Rutherglen. The scheme would have furnished about 14,000,000 gallons a day.

In 1845 two rival schemes were started,—one by Messrs. Lewis Gordon and Lawrence Hill, then of Glasgow, to bring water from Loch Katrine, and the other by the Glasgow Company, to bring water from Loch Lubnaig, both Lochs being situated in the Perthshire Highlands, and both tributaries of the river Forth. The Loch Katrine scheme was supported by a numerous body of citizens, who formed themselves into a Company for promoting it; their prospectus was issued in September, 1845. The failure of so many previous schemes for improving the water supply to the whole city led to the formation, in this year also, of an independent Company in Gorbals for the supply of that district of the city, to be particularly noticed hereafter. And the Glasgow Company, although they had at this time expended not less than £415,000 upon their old works, resolved to oppose both the Gorbals scheme and the more formidable Loch Katrine scheme, while at the same time they prosecuted with great vigour their Loch Lubnaig scheme. The promoters of the Loch Katrine scheme did not persevere, being assured by the old Company that theirs was a *bona fide* project, and the sole object of the promoters being, as they avowed, to procure for the city a better supply, by whomsoever it might be obtained. The Loch Katrine scheme of this year was therefore withdrawn, on payment of £1,000 towards the expenses which had been

incurred. The Gorbals Company, however, persevered with their limited scheme for that district; and having adduced before a Parliamentary Committee, in support of the bill which they promoted, an overwhelming amount of evidence of the impure state of the water supplied by the Glasgow Company, their bill passed, notwithstanding the most determined opposition. This was a decided inroad upon the exclusive domain of the old Company, so long-contested, and proved to be the beginning of the end so long and so much desired. Their bill, however, for bringing water from Loch Lubnaig for the whole city, including Gorbals, strange to say, also passed. Both bills received the Royal assent in 1846, and the Gorbals Company proceeded at once with the execution of their works; but the Glasgow Company having been taken bound by their Act, as a condition of the power then granted, to provide compensation water to be sent down the river Teith, according to an average flow in that river of three years, to be fixed by gaugings appointed to be taken by Messrs. William Fairbairn, of Manchester, and James Leslie, of Edinburgh, two neutral engineers, it was ascertained by the result of their gaugings that the prescribed compensation water was more than the Company could give, that sufficient storage had not been provided, and that their scheme was therefore impracticable. It accordingly fell to the ground; and the works authorized by their Act, as already remarked, were never executed. While the old Company were thus engaged taking their gaugings, the Gorbals Company were proceeding vigorously with the execution of their works, which were completed and the new water introduced to their district in 1848. With a very few exceptions, the whole inhabitants of Gorbals took the new water, it being greatly purer, and the supply more regular and constant. The consequence was that the annual revenue of the old Company fell at once to the extent of £4,000.

In 1849 the Gorbals Company, encouraged by the success of their first measure, resolved to extend their works so as to provide a supply for the whole city and suburbs. Their

plans for this purpose were prepared by their engineer, the late Mr. William Gale, and deposited preparatory to an application to Parliament for additional powers; but from the depressed state of the money market at the time, their new scheme was not supported, and was not carried out, and matters remained in *statu quo* for the three following years.

In 1852 another war of competition broke out, which was carried on at great expense, without intermission, for three successive sessions of Parliament. This was the hottest and most conclusive of all, and in the end brought about the desired result. The Gorbals Company again took the field with their extension scheme. Another Loch Katrine scheme was brought forward, this time by Professor Rankine and Mr. John Thomson, who at same time publicly advocated and pressed upon the Town Council the necessity for taking the water supply as a public trust into their own hands; and in order still further to demonstrate their sincerity and earnestness, they promoted the formation of a Company to carry out their scheme, and had a provisional committee appointed, and other arrangements made for the purpose; but these preliminary steps were not followed out, the Town Council having now decidedly resolved to take the matter into their own hands, and not to trust longer to the professions or actings of a private Company. The old Company, however, again entered the field of competition with another Loch Lubnaig bill, while the Town Council, on the other hand, resolved to oppose all these competing schemes together. It was strongly felt by the citizens generally, as well as by the Town Council, that the old Company not having executed the works authorized by their Act of 1846, confidence could not longer be reposed in them, and that it was due to the community, who were daily suffering from delay, to dispute their right to obtain another Act, which might prove in their hands as abortive and useless as the former. The result has demonstrated the wisdom of the course thus adopted. The Gorbals bill was thrown out on the standing orders, the old

Company's bill was opposed on the merits, and a Committee of the House of Commons, after a determined contest, rejected it on 23d June, 1852. The Council immediately followed up their successful opposition in the manner to be explained, reflecting the highest degree of credit upon all concerned. But before entering upon the detail of the proceedings of the Town Council, which is intended to be given at length subsequently, it will be proper to notice more particularly the formation of the Gorbals Company and their Works.

THE FORMATION AND STATUTORY POWERS OF THE GORBALS GRAVITATION WATER COMPANY.

The district of Gorbals forms the Southern portion of the Municipality of Glasgow, separated from the Northern portion by the river Clyde. Prior to 1846 it was a separate burgh of barony, governed by its own Magistrates, chosen by the inhabitants, subject, however, to the approval of the Magistrates and Council of Glasgow, as Barons superior, and regulated by its own Police Acts and Police establishment. In 1846 it was, along with other suburban burghs, amalgamated with the city proper by the Act 9 and 10 Vict., cap. 289, entitled, "An Act to extend the Municipal Boundaries of the City of Glasgow; to amend the Acts relating to the Police and Statute Labour of the said City and adjoining districts; and for other purposes in relation to the Municipality and Police of the said City," passed 27th July, 1846. It had been included, along with other suburbs, in the limits of the Acts of the Company of Proprietors of the Glasgow Water Works, and the inhabitants were supplied with water by that Company. The unsatisfactory nature of the supply, however, had been long felt in the district, as well as in the city; and the inhabitants earnestly participated in the desire, everywhere manifested, to procure a better supply. The failure of so many projects originating on the North side

of the river, to secure this reasonable object for the whole city and suburbs, had induced a general feeling that it was not to be soon accomplished by further similar attempts; and accordingly, in 1845, it was resolved to form an independent Company in Gorbals, in order to prosecute a scheme for the supply of that district by itself. At this time the population had increased to no fewer than from 60,000 to 70,000 persons, and was steadily increasing. Following up this resolution, a Company was speedily formed, under the able and energetic advice and direction of Mr. Andrew Gemmill, who had been long municipally connected with Gorbals, and at the time held the office of Chief Magistrate. He was the last Chief Magistrate of the district. This Company being formed, the late Mr. William Gale was professionally engaged as their engineer—a gentleman well qualified, as the result proved, for the successful prosecution of the scheme; and the necessary preliminary investigations and surveys having been made by Mr. Gale, and the usual Parliamentary plans prepared by him, notices of a bill to be promoted in the then ensuing session of Parliament were forthwith published. It was entitled, “A Bill for the further and better supplying with Water the Barony or Regality of Gorbals and places adjacent;” and the preamble set forth that the inhabitants of Gorbals, the Burgh or Town of Pollokshaws, and the town or village of Govan, and places intermediate and adjacent, in the counties of Lanark and Renfrew respectively, are inadequately supplied with pure and wholesome water; and it would be of great advantage to them if a plentiful supply were provided for domestic, manufacturing, and other purposes; that such a supply may be obtained from a certain stream called the Brock or Brockburn, and the tributary streams uniting therewith, situated in the parishes of Mearns, Neilston, and Eastwood, in the county of Renfrew, if the Company therein named were authorized to take and divert the waters of the said stream and its tributary streams and springs, and to construct reservoirs and other

works necessary for storing and conducting water thereto by pipes or conduits ; and that the persons therein named and others were willing, at their own expense, to make and maintain the necessary works for affording such supply of water to the inhabitants.—This bill, after encountering much opposition by the Glasgow Company, and a severe struggle before a Committee of the House of Commons, became law by the Act 9 and 10 Vict., cap. 347, passed 3d August, 1846. By this Act Messrs. Robert Bunter, Thomas Brownlie, George Binnie, Alexander Harvey, John Mitchell, John Walker, David Wilkie, John Bain, James Craig, John Willox, Andrew Gemmill, and all other persons who had subscribed or might thereafter subscribe to the undertaking, and their successors and assigns respectively, were united into a Company for the above purposes, under the name of the Gorbals Gravitation Water Company, and were incorporated as a body corporate, with perpetual succession and a common seal ; and the usual power was conferred on them to purchase and hold lands and tenements for the purposes of the undertaking.—The capital was fixed at £120,000, the number of shares at 1,200, the amount of each share at £10 ; and power was given to borrow money on mortgage or bond to the extent of one-third part of the capital. The gentlemen above named, with the exception of Mr. Gemmill, were appointed the first Directors of the Company, and Mr. Gemmill the first Secretary. Power was granted to construct the works, and the period allowed for their completion was fixed at two years from the passing of the Act. It gave all the usual powers for constructing and maintaining the works authorized ; and compensation was provided for parties who might be affected by the Company intercepting and appropriating the streams, springs, or drainage water to be taken. With respect to the rates to be levied for water supplies, the Company were authorized to fix and determine these under this special proviso, that they were never to exceed five per centum on the valued rent of the premises in respect of which the rates were chargeable ; but this limitation was made applicable to private dwelling-houses

and to water for family use only. Water for other than domestic purposes was to be supplied at such rates and upon such terms and conditions as should be agreed upon between the Company and the person desiring it. The profits of the undertaking were limited to seven per cent. Such were the main provisions of the first Act obtained by this Company.

In 1850 the Company obtained another Act, entitled, "An Act to amend the Gorbals Gravitation Water Company's Act, 1846; to authorize the Extension of the Works, and the Construction of new Works to supply the Town or Royal Burgh of Rutherglen and other places with Water." The preamble narrated the former Act, and that, in exercise of the powers thereby granted, the Company had constructed extensive works, and had obtained, and were now distributing, a copious supply of water, greatly to the advantage and comfort of the district, and that it was expedient to enlarge the same; that the Royal Burgh of Rutherglen and the towns or villages of Barrhead, Nitshill, Hurlet, and places intermediate and adjacent, and the population, trade, and commerce thereof, had of late years greatly increased, and were increasing; that the present supply was inadequate; and it would promote the health, comfort, and cleanliness of the inhabitants, and would also be advantageous to trade, commerce, and manufactures, if a plentiful and continuous supply of pure water were provided; that the works of the Company were capable of extension; and that it was expedient that some of the provisions of the first Act should be altered, amended, and enlarged. The limits of this Act included all the burghs, towns, villages, districts, and places above mentioned. The expense of the works authorized was estimated at £30,000, which the Company were empowered to raise by the creation of new shares, and to borrow on mortgage one-third of that additional capital. The period fixed by the Act for the compulsory purchase of lands for the works authorized was limited to three years, and the time for completing the works to five years. The Company, however, did not

extend their works to any of the burghs, towns, villages, or other places specified, within the time fixed, and this part of their powers expired.

In 1853 the Company applied for and obtained a third Act, 16 and 17 Vict., cap. 98, passed 8th July, 1853, entitled, "An Act to amend the Gorbals Gravitation Water Company's Acts; to authorize the Extension of their Works in order to supply the Royal Burgh of Renfrew and Suburbs, and other places, with Water, and for other purposes." The preamble of this Act is in exactly similar terms to those of the former, with this addition, that the Royal Burgh of Renfrew was now included, and the necessity for raising more money is set forth. The expense of the proposed additional works was estimated at £10,000, and the Company was authorized to raise that further sum, and an additional sum of £20,000, to complete the works authorized in 1850, by the creation of new shares. The Company was also authorized to borrow on mortgage one-third of this additional capital. The sole object of this Act appears to have been the extension of the original works to Renfrew. The same rates were provided as were authorized to be taken by the first-recited Act, as well as the same remedies for recovery; and in this, as well as in the immediately preceding Act, it was stipulated that, in the absence of special agreement to the contrary, the occupier of any buildings or premises, and all other persons who should by themselves, their servants, or members of their families, draw water from the wells or fountains of the Company should be held to be the persons with whom the Company had contracted (except in cases where the Company might charge the owners, in terms of the Act of 1846), and be liable in the payment of the charge for the same. It was further provided, that nothing in this Act contained should prejudice or affect any agreement then existing between the Company and the Town Council of Renfrew in regard to the supply of water to Renfrew. Such were the main powers and provisions of the Acts obtained by the Gorbals Gravitation Water Company.

AGREEMENT REFERRED TO.

It is contracted, agreed, and ended between the Gorbals Gravitation Water Company, incorporated by "The Gorbals Gravitation Water Company Act, 1846," on the first part, and the Magistrates and Town Council of the Royal Burgh of Renfrew, on the second part, as follows:—Whereas it has been represented by the said second party to the said first party that the Burgh of Renfrew is at present very inadequately supplied with pure wholesome water, for the use of the inhabitants thereof, and that it would be greatly for the benefit of the inhabitants, and the prosperity of the Burgh, particularly with reference to the feuing grounds belonging to the Corporation, if the said Water Company would extend their works and pipes so as to introduce a supply of water into the Burgh, in connection with the works of the Company: and whereas the said first party having entertained the proposal so to extend the supply, conferences were held with the Directors of the said Company, and deputations from the said Town Council, with the view of arranging and fixing terms, the result of all which has been that the parties have agreed to the conditions after specified: Therefore the said parties have agreed and do hereby agree to the following articles and conditions, viz.: *First*, That the said Company shall take the necessary measures for introducing into Parliament, at the earliest period, a bill for an Act to supply the said Royal Burgh of Renfrew and inhabitants thereof with water, at the rates and on the terms contained in "The Gorbals Gravitation Water Company Act, 1846," and in "The Gorbals Gravitation Water Company Act, 1850" (with liberty to the Company to introduce into the bill, if they think proper, power to supply other places than Renfrew, not comprehended in the said Acts, or for any other purpose connected with their Company), and to prosecute the bill, and to obtain the Act, if possible, with all due diligence; and on the Act being obtained, that the Company shall lay pipes along the turnpike road leading from Glasgow to Renfrew, and introduce a supply of water thereby into the

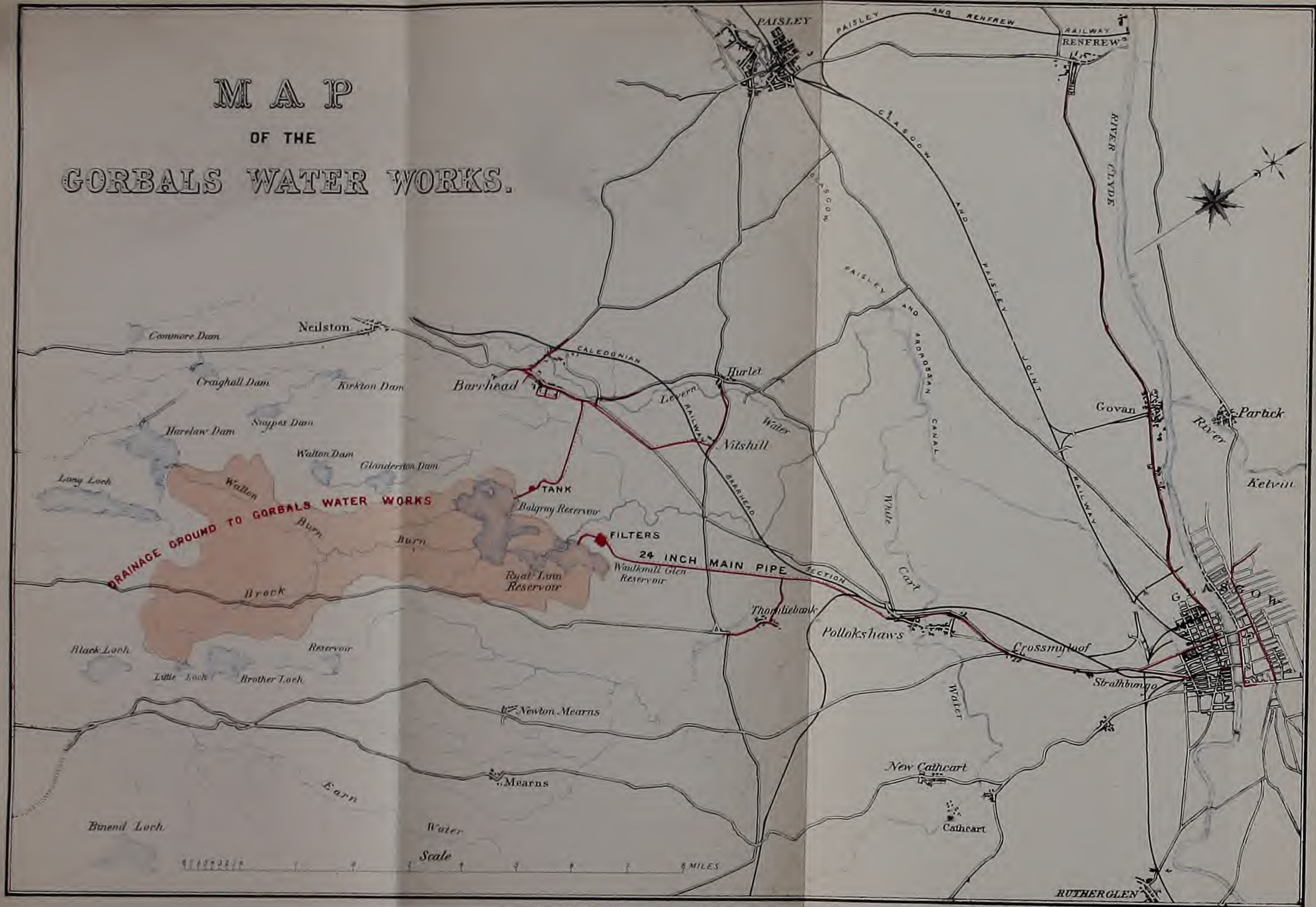
said Burgh, for the said purposes, with all convenient expedition. *Second*, That the said Magistrates and Town Council shall not only petition Parliament in favour of the said bill, but also bear the charges of two or three witnesses going to London, to give evidence to prove the preamble of the bill, in so far as the same shall apply to the expediency or necessity of supplying the said Burgh with water; and the Council shall also obtain the consent of the trustees of the said turnpike road to Renfrew to the Company using that road for the purpose of laying and maintaining the said pipes. *Third*, That the said Magistrates and Town Council shall contribute to the Company towards the expense of applying for and obtaining the said Act, and of the expense of the pipes to be laid by the Company for affording said supply, the sum of one thousand seven hundred and fifty pounds sterling, and shall pay that sum to the Company by the following instalments, viz.:—Five hundred pounds on the first day of January, Eighteen hundred and fifty-three; five hundred pounds on the Royal assent being obtained to the Act; and the balance, being seven hundred and fifty pounds, on the water being introduced by the Company into the Burgh: but in the event of the bill, in so far as the same shall apply to the supplying of the said Burgh with water, being opposed in Parliament, the Council shall pay to the Company two hundred and fifty pounds farther, in equal proportions at the said two last-mentioned periods, at which the other sums above specified are payable; and in the event of the said Company failing to obtain an Act for the purposes foresaid, they shall repay to the said Magistrates and Town Council the foresaid first instalment of five hundred pounds to be advanced by them on first January, Eighteen hundred and fifty-three, as aforesaid. *Fourth*, That the Company shall allow the Magistrates and Council to flush water into the common sewers of the Burgh when necessary for cleansing the same, but that only at the sight and under the control of the manager or engineer of the Company, but not at any time when it may happen that, in the opinion of the manager or engineer, it would be inex-

pedient to use the water for that purpose, as endangering the supply of water for the other purposes of the Act: and the said parties hereby enact and bind and oblige themselves and their successors in office, the one to the other, to implement, fulfil, and perform the said conditions and obligations to each other, in all particulars, under the penalty of one hundred pounds sterling attour performance: and the parties consent to the registration hereof in the Books of Council and Session, or others competent, therein to remain for preservation, &c.—Dated 15th October, 1852, Registered in the Books of Council and Session, 29th December, 1853.

THE WORKS EXECUTED BY THE GORBALS GRAVITATION WATER COMPANY UNDER THE POWERS OF THEIR ACTS.

These works were constructed by the Company, in terms of their statutory powers, upon the Brockburn, already described as a tributary of the White Cart, which flows through Pollokshaws and Paisley, and discharges into the river Clyde a little below Renfrew, and as executed, will be shown on a map to be appended. The sum of £180,000 appears to have been expended in the execution of the works and relative expenses. The water is drawn from the Brockburn, which is but a small stream, having its sources near Brother Loch and Long Loch, in the south-east of Renfrewshire; and to all appearance, at first sight, seems quite inadequate to yield the supply it does. The water is collected in reservoirs, and, after being filtered, is supplied to the southern district of the city by gravitation. The hills on that side of the city are all trap, and yield excellent water, where not injured by peat. The drainage area has been variously stated; but it is believed the amount estimated by Mr. William Gale, in a report made by him in July, 1845, to the Gorbals Company, then projected, namely, 2,560 acres, is, as nearly as may be, correct. This estimate,

MAP OF THE GORBALS WATER WORKS.





and the following Tables of Analyses and Rainfall, up to 1862, will serve to show both the quality and quantity of water derivable from the works:—

ANALYSIS OF GORBALS WATER.

DR. PENNY, February, 1854.

Organic matter,	Grs. per Gall.
Carbonate of Lime,	1·531
Sulphate of Lime,	1·152
Sulphate of Magnesia,	0·946
Muriate of Magnesia,	0·284
Alkaline Chlorides,	0·344
Oxide of Iron,	0·720
Silica,	0·043
	0·177
TOTAL,	5·197
Hardness,	3·2°
GASES PER GALLON.	
Carbonic Acid,	Cub. Ins.
Oxygen,	0·55
Nitrogen,	2·25
	4·70
TOTAL,	7·50

ANALYSIS OF THE EARN WATER.

DR. PENNY, 1854.

Organic matter,	Grs. per Gall.
Mineral matter,	1·665
	3·275
TOTAL,	4·940
Hardness,	2°

RAINFALL IN GORBALS DISTRICT.

	Elevation 300 Feet.	Elevation 550 Feet.	Elevation 700 Feet.
	Gorbals Works.*	Middleton.	Black Loch.
	Inches.	Inches.	Inches.
1849, . .	47·55	†	†
1850, . .	46·20	†	†
1851, . .	44·71	†	†
1852, . .	60·42	†	†
1853, . .	39·97	†	†
1854, . .	44·60	†	†
1855, . .	30·80	35·50	39·90
1856, . .	38·87	42·25	51·50
1857, . .	35·04	41·70	45·70
1858, . .	43·94	51·70	†
1859, . .	51·02	57·65	†
1860, . .	40·47	44·72	†
1861, . .	57·00	66·08	69·25
1862, . .	57·60	68·98	68·70
Average, .	45·58	51·07	55·01

* Average of two Gauges at the Gorbals Works. † No returns for these years.

The fall of rain in the neighbourhood of the reservoirs varies from 60 to 36 inches per annum, and it increases about 30 per cent. towards the upper end of the drainage ground.

There are four reservoirs of the following dimensions and capacity:—

	Height of Top Water above Ordinance Datum.	Depth of Water when Full.	Area of Water Surface.	Capacity.
	Feet.	Feet.	Acres.	Cubic Feet.
Balgray Reservoir, .	352	40·0	153½	119,492,266
Ryat Linn Reservoir, .	313	27·9	21	11,976,389
Littleton Reservoir, .	297	14·0	4	1,353,368
Waulkmill Glen Reservoir,	296	49·3	47¾	36,541,310
Totals, . . .			226¼	169,363,333

The lowest of these reservoirs is constructed at the distance of about 4½ miles from the upper sources of the stream, about 6 miles from Glasgow, and together have

a water-shed of about 2,560 acres. From their capacity, it will be observed that there are provided about 66,000 cubic feet of storage for each acre of water-shed, which has been found sufficient not only to equalize the flow of the stream during a dry season, but also to assist in such a season to increase slightly the minimum yield of the stream. The works were not all executed at the same time. The three lower reservoirs were constructed, under the powers of the Act of 1846, during 1847, and 1848; the uppermost and largest, under the powers of the Act of 1850, during 1853 and 1854; and the extension of the works to Renfrew, under the powers of the Act of 1853, soon after the Act passed. This gradual development, it has been said, was intended from the first; and the clauses in the Acts regulating the quantity of water to be given out as compensation to the parties interested in the lower part of the stream were framed accordingly. It was intended, when the whole was developed, that the compensation water should be one-fourth of the whole available water of the stream during a dry season. The quantity was fixed at $9\frac{1}{2}$ cubic feet per minute for each 10,000,000 cubic feet of storage. It afterwards amounted to 161 cubic feet a minute, or 1,450,000 gallons a day. The quantity of water available for the district from the whole stream was estimated in 1846, when the first Act passed, to be 4,000,000 gallons a day, and experience has proved this estimate to be correct. The compensation water is therefore 27 per cent. of the whole, or a little over a fourth; but any loss on this head, by reason of the size of the reservoirs, is more than made up by increased security against scarcity during dry seasons, and increased purity of the water by subsidence. At the rate at which the works have been drawn upon for the supply of the district, the reservoirs contain, when full, about 220 days' supply; but if 4,000,000 gallons a day were sent into the district, the storage would be equal to 194 days' supply, including compensation water in both cases. A new course for the stream was constructed along the margin of the reservoirs, commencing at the top of the Balgray reservoir, where an

embankment was thrown across the original stream, to admit of the water being run to waste or passed into the reservoir,—the discharge being regulated by two ranges of sluices, each 20 feet wide. By this channel also the water from the stream is passed down to the lower reservoirs, where there are arrangements for admitting it; and this is frequently done when the stream is not in flood. The upper reservoirs thus form, and, in fact, are treated as, settling ponds. The new channel is about $1\frac{1}{4}$ miles long and 16 feet broad, and receives the by-washes from the reservoirs. It has a fall of 1 in 500 along the edge of the reservoirs; but in passing from the level of one reservoir to that of another the falls are rapid,—in some cases over rock and in others over strong masonry. The main embankment of the Balgray reservoir is 520 yards long, 47 feet high, and 28 feet wide at top; and the Westerly embankment 330 yards long, 25 feet high, and 12 feet broad at top. The embankment of the Ryat Linn reservoir is 176 yards long, 36 feet high, and 14 feet wide at top. That of the Waulkmill Glen reservoir is 200 yards long, 12 feet broad at top, and 60 feet high. All the embankments are formed with slopes of three to one on the front, and two to one on the back, with pitching and puddle walls in the usual way. In no case was there any difficulty in finding a water-tight foundation for the puddle. The arrangements at the Balgray and Waulkmill Glen reservoirs are similar. In each case there are two cast-iron pipes through the embankment, 24 inches in diameter, and connected at the reservoir side with a large cast-iron upright cylinder, with openings at various heights furnished with sluices; and the whole is encased in a tower of masonry, communicating with the top of the embankments by a foot-bridge. Water can thus be drawn from the reservoirs at various levels, and the valves can be removed or repaired in case of accident. In the case of the Ryat Linn reservoir there is no tower; but there are two pipes through the embankment, each 17 inches diameter,—one with a sluice worked along the inside face of the embankment, and the other with a valve on the outside of the embankment.

The conduit from the lowest reservoir to the filters is an arched stone culvert, 4 feet broad by 4 feet high, and 340 yards long. There is a self-acting apparatus where the pipes through the lowest embankment discharge into this conduit, which admits of the flow from the reservoir being regulated by a sluice placed at the filters. There are two distributing tanks and two sets of filters: each set can be worked while the other is under repair. Each set of filters is divided into three transverse sections, any one of which can be cleaned without stopping the action of the others. The filters are upon the Lancashire principle, the sand being removed when foul, washed, and again replaced. When any filter has ceased to discharge its proper quantity of water, about one inch of sand is removed, and a new filtering surface exposed. The sand is washed, when removed from the filter, by an upward current of water in cast-iron boxes. The area of the filtering surface is 34,000 square feet, or 3,800 square yards; and during 1863 the average quantity of water passed through was 3,350,000 gallons a day, or 875 gallons a square yard per twenty-four hours. If the full yield of the stream, or 4,000,000 gallons a day, were passed through, it would be at the rate of 1,045 gallons per square yard a day,—equal to a vertical descent of the water of $\cdot 15$ inches per minute; and the filters have often done as much as this without any difficulty. The question of the velocity of the water in filtration is, however, relative to the quality of the water before passing to the filter. The practice of the best authorities, in dealing with the average qualities of river and stream waters in England, is to pass only 700 gallons a day through one square yard of filtering surface, which is at the rate of one-tenth of an inch of vertical descent per minute. That the Gorbals filters do more, and still produce water that can be seen through in the distributing tanks to a depth of 16 feet, shows that the water is comparatively pure before filtration. The whole cost of filtration is under £30 per annum per million gallons a day, exclusive of the loss of sand in washing. £15 is found to be a liberal allowance for this loss, making the

total cost of filtration £45 per annum per million gallons a day. In comparing the proposed Gorbals extension with the Lake schemes, the cost of filtration, which the latter did not require, was variously estimated from £200 down to £120 per annum per million gallons a day, and this sum capitalized was added to the estimated cost of the works. These estimates may not be more than enough in the case of some waters, but the filtration costs less at Gorbals. The two tanks into which the water passes from the filters are each 220 feet long, 66 feet broad, and 19 feet deep. They contain 3,250,000 gallons, and are 240 feet above ordnance datum when full. The main pipe to the town passes from these tanks, the inlets being furnished with valves and copper wire-cloth strainers. The main is 24 inches diameter, but it was not sufficient to discharge the whole water which the stream and reservoirs would give, with a sufficient effective pressure, in the city. Provision was accordingly made at the difficult points, when the works were constructed, for a second 24-inch main being laid down.

The extension scheme proposed by the Gorbals Company in 1849, and again in 1852, was, in its essential features, the same as was proposed by Grainger & Miller in 1834, extended to meet the increased requirements of the city; but its merits or defects were not on either occasion brought out in Parliament. The proposal was to impound the water of other tributaries of the Cart, including the Laveron Water, the Earn Water, and the upper sources of the river Cart itself. The details of the scheme, as proposed in 1852, varied from that proposed in 1849; and as presented before Stephenson and Brunel in 1855, to be afterwards noticed, it included about 18,500 acres of gathering ground, exclusive of the Brock Burn, already appropriated, which was estimated to yield, as just stated, 4,000,000 gallons a day. After a careful inquiry, the minimum available rainfall of the district was estimated at 30 inches, and the reservoirs and other works to yield 17,000,000 gallons per day, in addition to that available from the existing works. Additional gathering ground on the Cart, extending to 12,000 acres, was pointed out, from which

8,000,000 or 10,000,000 gallons per day might have been also got, making the total yield of the district, after deducting a liberal allowance for compensation, 30,000,000 gallons per day. It was asserted that up to 30,000,000 gallons per day the scheme had the advantage of requiring a less immediate outlay of money than the Loch Katrine one, with the power of graduating the expenditure as the demand increased, for at least fifteen years. The comparison as to cost was in favour of the Gorbals scheme up to 20,000,000 gallons per day, to the extent probably of £120,000, and about the same difference would have continued up to 30,000,000 gallons; but beyond this the scheme could not have been extended without including some sources which were objectionable in point of colour. Messrs. Stephenson and Brunel, however, in comparing it with the other projects which have been noticed, involving artificial reservoirs, including the Endrick, Clyde, Avon, &c., stated in a report to the Corporation that, "After a careful consideration of all the circumstances, and an examination of the country, we have come to the conclusion that the extension of the present Gorbals Water Works, as proposed by Mr. Gale, is the only plan which complies with the requisite conditions of quality and quantity; and in our opinion it is the only scheme which can be usefully considered in comparison with the proposed appropriation of the waters of the lakes." Each of these two schemes "offers some advantage peculiar to itself, which renders it more difficult than might at first be supposed to arrive at a positive conclusion as to any general superiority of the one over the other." Notwithstanding this opinion, the Loch Katrine scheme was unhesitatingly preferred. Being laid out on a scale of 50,000,000 gallons per day, it was evident that this Gorbals extension scheme could not compete with it.*

* For these and other Engineering details the Editor has been indebted to an able paper read to the Institution of Engineers in Scotland, by Mr. James M. Gale, M. Inst. C. E., the present Engineer of the Glasgow Corporation Water Works Commissioners.

PROCEEDINGS OF THE TOWN COUNCIL WITH REFERENCE
TO THE WATER SUPPLY.

It is interesting to note the various resolutions adopted and steps taken by our civic rulers during the present century on this subject, as recorded in their minutes. It appears, then, that so far back as the latter end of 1799, or beginning of 1800, the Council appointed a special committee of their number to consider and report on a plan for supplying the city with water, and that, on 19th April, 1800, this committee gave in a report, together with a letter and estimate by Bryce M'Quiston, then a land-surveyor and engineer in Glasgow, whom they had consulted and employed to assist them in their investigation. In his letter Mr. M'Quiston strongly recommended a scheme for raising water from the river Clyde by steam engines, from no fewer than *five different* situations on the river. This was a rather astounding proposal to begin with; and the committee, doubting its propriety, did not recommend it, "unless" (as was quaintly added) a "very large" sum was procured by individual subscriptions,—which were not forthcoming; and therefore the Council ordered the report, with letter and estimate, to be "*laid up* in the Town's Charter Chest," there to lie *in retentis*, in case and until the Council should afterwards think proper to have recourse to them, but which they do not appear to have ever required to disturb. In the year 1805, however, the subject was again taken up in a much more resolute and effective manner, a number of influential citizens having then projected and formed themselves into a Company for the purpose of providing a sufficient water supply. The Magistrates and Council joined this Company, subscribing £1,000 for twenty £50 shares in the undertaking; and on 28th February, 1806, were called on by the Company to petition Parliament for leave to bring in a bill for supplying the city with water, and incorporating the subscribers to the undertaking as a Company, with perpetual succession and a common seal, under the title and designation of "The Company of Proprietors of the Glasgow Water Works."

This leave was obtained, as a matter of course ; but the Council do not appear to have had anything to do with the preparation of the bill, as, on 26th May, 1806, they appointed a committee of their number to examine it, with instructions "to take care that the interests of the town and of the community were properly attended to,"—which they no doubt did. But while the Council thus took an interest in and supported the Glasgow Company, they resolved, on 9th June, 1807, not to take any share in the undertaking of the Cranstonhill Company. Both Companies, it has been seen, obtained their Acts, and executed their respective works ; and it was not till the year 1829 that any difference appears to have arisen between the Council and them in regard to their quantum or mode of supply ; but in that year a difference did arise ; and on 13th February the Council appears to have requested and held a meeting with the Managers of the Glasgow Company, for conference on the subject of complaints which had been made to them of the irregularity and insufficiency of their water supplies, particularly for extinguishing fires. At this meeting the Company, although professing—as the minutes bear—a strong disposition to accommodate the public, maintained that they had already done all that they were bound to do by their Act, which, they contended, only required them to allow water in their pipes to be taken and employed for extinguishing fires, and not to keep a supply of water in their pipes during the night. They therefore declined giving up their practice, which admittedly had been to withdraw the supply of water from the inhabitants during the night. Nothing further appears to have been done at that time to remedy the evil complained of, although undoubtedly the same ground of complaint long continued to exist. The committee was continued for further conference ; but it does not appear that any further conference took place. This ground of complaint, however, having been strongly urged against the Company, when they afterwards applied for the authority of Parliament to amalgamate the two Companies, no doubt led to the adoption of more stringent

provisions on the subject in the Amalgamation Act of 1838.

In 1832 another question was raised by the Water Company, which afterwards gave occasion to much discussion, litigation, and expense. On 18th January of that year there was presented to the Council a memorial from the Directors of the Water Company, expressing their apprehensions that the filters and other works of the Company would be materially injured by the then contemplated removal of the weir, which was at that time situated in the river on the west or lower side of the Jamaica Street bridge, and objecting to its removal. This memorial was met in a very conciliatory spirit by the Council. The weir was afterwards removed from time to time, at the desire of the Company, further up the river; and was latterly placed as far up as the east side of Hutcheson bridge, where it still remains; but there is now fortunately every prospect of its removal from that position, and from the river altogether, in consequence of the recent passing of the "Glasgow Corporation Water Works Amendment Act, 1866." The Council steadily and persistently maintained, through a long course of years, the propriety of removing this obstruction to the free tidal flow of the river and its upper navigation,—which was long disputed, first by the Glasgow Water Company, and latterly by the owners of factories on the river banks. But it was at last accomplished by the Act just referred to; and ere long, as is confidently anticipated, it will be numbered among the things that were, and no longer obstruct the full and natural use and enjoyment of a noble river.

It was in the year 1833—James Ewing, Esq., being then Lord Provost—that the Glasgow Company and the Cranstonhill Company first seriously announced their intention to amalgamate. This they did by circular; and the Council at once remitted it to a committee for investigation, who reported, on 9th October, 1833, that they had considered the subject, viewing it as affecting the general interest of the community at large, particularly the poorer

classes, as well as the pecuniary interest of the Corporation as holders of stock; that in taking shares originally the object of the Magistrates and Council was to promote an undertaking likely to prove of great public advantage; and that although the proposed union might raise the value of the shares held by the Corporation, the committee did not think that, as guardians of the public welfare, the Council could allow such a consideration to come into competition with the general interests of the community. It was therefore resolved by the Council to withhold their consent to the union, and to request a conference with the Managers of the Companies. That conference took place without any practical result; and the Council resolved, on 23d October, to leave any further negotiation or opposition to their successors in office, the Reform Act about that time coming into operation. A new remit to a committee was accordingly made by the Reformed Council on 4th December, 1833—Robert Grahame, Esq., being now Lord Provost—who reported, on 23d January, 1834, on all points the same as the former one, recommending to the Council the following specific resolutions, viz.:—“1. That the Council should oppose all attempts to obtain, either by private agreement or legislative enactment, a monopoly in the supply and sale of so necessary an article of life as water. 2. That the committee be authorized on the part of the Corporation, as holders of water stock, and as representing the community, to apply in due form for a copy of the heads of the proposed bill; and, if they shall think it advisable, after deliberately considering the same, to hold a conference with the Directors of the Water Companies, with the view, if possible, of effecting an amicable adjustment. 3. That the committee be empowered, in the event of their not being able to come to an amicable arrangement with the Companies, to adopt all such measures as they shall consider expedient or advisable, by petitioning both Houses of Parliament, and employing counsel and agents to oppose the bill, or otherwise for obtaining such provisions in the bill as in their opinion will afford adequate and fair protection to the general interests of the community.

4. That the Lord Provost, or, in his absence, one of the Magistrates, be authorized to subscribe, in name and behalf of the Magistrates and Council, the necessary petitions to both Houses of Parliament against the bill, in the event of the committee being of opinion that such measures are necessary."

The Companies refused to delay their bill for amicable adjustment, as suggested; and the Council, on 3d February, resolved to transmit a petition to Parliament against it, authorizing at same time their committee to send a deputation to London to watch it and oppose its progress. At a meeting of Council, held on 27th February, Bailie Mills considered it unnecessary to incur the expense of sending a deputation to London; but Bailie Muir and Mr. Douglas having explained that the Companies had declined acceding to any of the reasonable arrangements proposed to them, and urged the necessity of opposing the bill in Parliament, with a view to the interests of the inhabitants at large, the Council repeated and confirmed their former resolution, and approved of a deputation proceeding immediately to London. The bill was accordingly opposed and defeated.

Notwithstanding the loss of their bill, the Companies persisted in maintaining their demand for union; and, on 23d March, 1834, Mr. Henry Dunlop, as a member of Council, gave notice of the following motion, viz.:—"1. That although the charges and profits of any joint-stock Company for supplying the public with water may be regulated in some measure by Act of Parliament, yet the public can have no security that the supply shall be either abundant or of good quality, if it be furnished exclusively by one Company. 2. That the election of the Town Council being now vested in a very large constituency, it would be for the benefit of the public that the works for supplying the city with water should be conducted under their control,—that they should belong to the Corporation, and that the profits should be applied to public purposes. 3. That as the works already erected are sufficient for supplying the city with water, it would be an unnecessary expenditure of

capital to establish new works, provided the present Companies are willing to sell them to the Corporation upon fair and reasonable terms. 4. That a committee be appointed to treat with the present Water Companies, and ascertain upon what terms they would dispose of their works and privileges." This motion was remitted to a committee, who afterwards submitted a long report, which was ordered to be printed. The subject was fully considered, but no arrangement was effected; and on 15th October, 1835, the Council, on the motion of Mr. John Ure, again resolved to negotiate for the purchase of the works, and appointed another committee for this purpose, who also failed to effect an arrangement. In reporting this to the Council, on 14th January, 1836, the committee stated that they could not discover why the Water Works should not be placed under the direction of a public board like the Police, which, however important, was certainly not so indispensably necessary as water. The report was accompanied with the heads of a bill to be promoted for this purpose. The report was approved of, and, along with the heads of the bill, ordered to be printed and circulated; and on 19th February, 1836, the bill, as it had been amended, was approved of, and Mr. Dunlop was requested to proceed to London to take charge of it. On 27th February, 1836, Mr. Pattison gave notice of his intention to move, "That the Council do memorialize Government regarding the unjust and tyrannical proceedings of the Water Companies in their attempt to unite and form themselves into a powerful monopoly, by which, if successful, they would become complete masters of the city, to the deep and irreparable injury of the citizens. In the course of this month, too, public meetings of the inhabitants of Gorbals and of Glasgow were held, deputations of citizens waited on the Council with remonstrances, and the whole community were greatly excited. At length Mr. James Campbell—now Sir James—on 13th April, 1836, moved, in his place at the Council board, seconded by the late Mr. David Hope, "That the bill now in Parliament promoted by the Council be withdrawn, provided the Water Com-

panies withdraw theirs," which was carried unanimously; and the secretary of the Water Companies having immediately intimated that their Directors had come to a similar resolution, the strife ceased. Thus, amid much excitement and determined hostility on the part of the inhabitants, the Council's opposition to union was again successful.

The Companies, although defeated a second time, do not appear to have been subdued, as at a meeting of Council, held on 29th January, 1838, the Lord Provost, Henry Dunlop, Esq., read and laid on the table a letter from their secretaries, transmitting copy of a bill which it was said they were about to introduce into Parliament for union; and again, as formerly, the first object of the Council appears to have been to obtain by negotiation an amicable arrangement,—for which purpose a large committee was appointed, with the Lord Provost as convener. But all the committee's efforts to this end, as usual, failed; and on 19th March, 1838, they were under the necessity of sending a deputation to London to oppose the bill. The Committee of the House of Commons appear to have carefully considered the bill; for at a meeting of Council, held 19th April, 1838, the Lord Provost stated that, in opposing the Bill in London, he had strictly adhered to the conditions ultimately resolved upon by the Council, and that the Committee had not yet found the preamble proved; but had, after some discussion, appointed a sub-committee of their number—one nominated by the Water Companies, and one by each of the parties opposing the bill—to draw up the terms upon which the sub-committee were of opinion the parties should agree, or on which otherwise the bill ought to be prepared, with a view to its being passed; and he submitted to the Council the terms suggested by the sub-committee before the recess, which were in a great measure the same as those ultimately agreed upon by the Council, and were upon the whole equally favourable to the public. These terms are embodied in the Amalgamation Act of 1838; for the bill, as finally adjusted, passed. The report of the deputation who had charge of the opposition was approved

of; and the Council voted their best thanks to Bailie Paul and James Hutchison, Esq., for the zealous and able manner in which they carried the instructions of the Council into effect. In the following month, accounts of the expenses incurred in opposition were produced, amounting altogether to £1,701, 19s. 3*d.*; to which a note is added, that Mr. Hutchison had "declined to accept of his personal expenses as a member of the deputation."

The water question, which had so long agitated the Council, was thus set at rest for a time. But within seven years afterwards it was again revived by the appointment of a special committee in reference to the Gas as well as the Water Works; and this committee, by a report in October, 1845, agreed unanimously that it would be a great public benefit if the supplying of water and gas to the inhabitants was taken out of the hands of private joint-stock companies, and placed under the control and management of the Magistrates and Council, or of Commissioners on behalf of the public; and without committing themselves in any way as to the terms proposed by the Directors for a transfer of their works, agreed by a majority to recommend to the Council to authorize notices being given of the intention to bring in a bill next session of Parliament for the purpose. But when this report came before the Council, the recommendation it contained as to the Water Works was disapproved of by a majority of 16 to 7; and the consideration of the other recommendation, as to the Gas Works, was reserved. The subject does not appear to have been again taken up at that time, and it is to be regretted that it was not; for there can be little doubt that if both objects had been then successfully prosecuted, great advantage would have accrued to the inhabitants.

The late Very Reverend Principal Macfarlan, of Glasgow College, who was for many years, as representing the College, a Director of the Glasgow Water Company, was, it is believed, the first to suggest the Perthshire Highland Lochs as the best sources that could be selected for obtaining a pure and abundant water supply for the city by gravitation; and

accordingly, in 1845, while James Lumsden, Esq., was Lord Provost, the Company projected their scheme, and promoted a bill for bringing an additional supply of water from Loch Lubnaig. The Council opposed this bill, but only on one ground, directed against a clause holding the owners of house property at and under £10 of yearly rent liable for the water rents of such houses, instead of the occupiers. On 19th March, 1846, the Council, on the motion of John Robertson, Esq., resolved to petition Parliament against this clause; and on 10th April following, the Council received and heard a deputation from a public meeting of house proprietors and others, praying for the co-operation and assistance of the Council in maintaining an opposition by them against it. In the discussion before a committee of Parliament which ensued, the clause was modified to the effect of postponing its operation until the promoters should actually bring in water from Loch Lubnaig—which, as has been stated, they never did. The bill, with this altered clause, passed on 14th May, 1846; but the Company were not satisfied with it; and on 25th November, 1847—Alexander Hastie, Esq., being then Lord Provost—their secretary intimated to the Council, by letter, that they had published Parliamentary notices of their intention to apply for *two bills* in the then ensuing session of Parliament, and requested the appointment of a committee of Council to confer with them on the subject. The following committee was accordingly appointed, viz.:—The Lord Provost, the Magistrates, including the Bailie of the River, the Dean of Guild, the Deacon Convener, and Messrs. John Leadbetter, James Anderson, William M'Lean, John M'Dowal, William Brodie, Archibald M'Lellan, Duncan M'Phail, and Bailie Stewart—the latter to be convener. But like all former attempts at amicable arrangement, this one also failed; and on 20th January, 1848, the Council resolved to petition against both bills. One object of these bills was to obtain a repeal of the clause as to house proprietors, and the other, to transfer the Company's works to the Corporation. These bills do not appear to have been prosecuted to an issue, and

their objects, consequently, were not attained. At length, on 5th September, 1850—the late Sir James Anderson being now Lord Provost—the Council, no doubt annoyed by the tantalizing and fruitless proceedings of the Company, and the increasing unsatisfactory state of the water supply, on the motion of Sir James, seconded by William Campbell, Esq., appointed a committee to inquire “as to the system on which the city is at present supplied with water, and to report what measure they would recommend for its improvement.” The committee which was appointed in terms of this motion consisted of the Lord Provost, Bailies Orr, Dreghorn, Bryson, M'Dowall, and Pearson, the Dean of Guild, Messrs. William Bankier, Robert Stewart, Andrew Liddell, W. P. Paton, James Moir, Peter Hamilton, James Scott, Archibald M'Lellan, and William Campbell—the Lord Provost, convener. But before this committee had reported, the Lord Provost, at a meeting of Council held 8th November, 1850,—in consequence, it is presumed, of the time for giving Parliamentary notices drawing near,—gave notice that at next meeting he would move “That notice be given of a bill to *take over* the works of both the existing (Glasgow and Gorbals) Water Companies.” This motion was made on 14th November, 1850, and was seconded by Bailie M'Dowall; but Mr. Andrew Gemmill moved, seconded by Bailie Gourlay, that it is not expedient that such notice should be published; and Mr. M'Lellan, as a further amendment, moved that the proposed notice be delayed till the report of the committee is submitted to and considered by the Council, seconded by Mr. John Fleming. Mr. Gemmill withdrew his amendment in favour of Mr. M'Lellan's, and several members of Council having expressed their opinions, the vote was taken, when the amendment was carried by twenty-three to nineteen, and thus Sir James Anderson's judicious efforts were for a time frustrated. But there can be no doubt that his motion laid the foundation for those measures which were afterwards adopted for “taking over” the works of both Companies, and vesting them in the Council as a public trust for the benefit of the community, with power to take an additional supply of

water from a better source, ultimately accomplished and now enjoyed. In the meantime, pursuant to the resolution carried by Mr. McLellan's amendment, further negotiations with the Companies were entered upon, but again without effect; and the committee of Council, on 22d October, 1851, reported that they could not recommend to the Council to agree to their terms.

Matters remained in this state for some time, Sir James Anderson's term of office expiring, and Robert Stewart, Esq., being elected, in his place, Lord Provost in November, 1851. The general public, however, were not inactive. In that year, or in the beginning of 1852, the joint-stock company was projected under the auspices of Dr. W. J. Macquorn Rankine and Mr. John Thomson, C.E., as engineers, for bringing water from Loch Katrine. The promoters of this private company, however, not having met with the requisite support, or probably foreseeing the obstacles and difficulties they would have to overcome in superseding a similar private company which had so long existed, their engineers, on 1st March, 1852, addressed an able letter to the Magistrates and Council in the following terms:—

We beg leave respectfully to submit to your consideration the following proposals for improving the water supply of Glasgow.

The present supply of water to the City and Barony of Glasgow, and the Suburbs north of the Clyde, raised by pumping from that river, is known to receive the drainage of a great extent of moss, of a still greater extent of cultivated land, of mines of coal and ironstone, and of many towns, villages, and manufactories, and hence to contain in solution and diffusion impurities of a disgusting and unwholesome nature, which are not removed by filtration; and the sources of such impurities must be expected to be continually increasing. To facilitate the pumping of this supply from the Clyde, a weir is maintained, which injures the navigation by interrupting the tidal flow, and intercepting the current of fresh water.

For many years it has been generally admitted that some abundant source of pure water ought to be found to supersede the Clyde in the supply of Glasgow, and that the mountainous districts

which exist in various directions round the city appear to offer the means, not only of doing this, but of substituting the natural descent of water by gravitation for the costly operation of pumping—a change which would not only effect a considerable annual saving, but would greatly facilitate the extension, throughout the whole of the city, of the system of constant service, now recognized to be essential to economy, comfort, and health.

This principle has been virtually admitted by the existing Glasgow Water Company themselves; for in the session of 1846, when, amongst other projects, one was proposed by Messrs. Lewis Gordon and Laurence Hill, junior, to bring water to Glasgow from Loch Katrine, the Glasgow Water Company, in order to defeat that project, applied for and obtained an Act to enable them to supply Glasgow from Loch Lubnaig. This scheme, it is true, as laid out by the Company, is impracticable, from cost and from engineering difficulties, and no part of it has been carried into effect; but it answered the purpose of making all other schemes which have yet been proposed for the supply of Glasgow by gravitation prove abortive, with the exception of that comparatively small work, designed by the late Mr. Smith of Deanstown, which now supplies the Gorbals and Southern suburbs.

Considering that six years have elapsed since the Glasgow Water Company obtained an Act for bringing in water on the principle of gravitation and constant service, and yet that nothing whatsoever has been done by them towards the execution either of that or of any other project for improving the water supply of Glasgow; considering, also, that the work authorized by that Act is (as we shall afterwards more fully show) impracticable as laid down on their plans; that it can only be rendered practicable by obtaining a new Act, to authorize extensive alterations in its line and levels; that even then its expense would be enormous; and that in fact the scheme seems to have been laid out, not for execution, but merely as an obstacle to the success of better projects,—it must be obvious, that in order to have the supply of water to Glasgow established on sound principles, it is absolutely necessary that it should be undertaken by some new body.

There can be no doubt that this undertaking would be profitable to a Commercial Company, as well as advantageous to the public. The annual expenditure and depreciation upon works acting by gravitation is trifling compared with that on a pumping establishment, and does not increase in proportion to the quantity of water

supplied. The proposed scheme would be enabled, partly by the reduction of working expenses, and partly by the facility of providing, with little or no increase of outlay, large quantities of water for sale, by bulk, for manufactures and engine-power, to realize a profit out of a much lower water-rent than that levied by the existing Company.

We beg leave, however, to suggest that the benefit to the public would be still greater if the management of the supply of water to Glasgow were undertaken by your Corporation, as Commissioners or Trustees of a distinct fund, to be raised by debentures, or by a power of borrowing, on the security of the water-rents; for the gradual extension of the city, leading to an increase of rental, and of the sale of water by bulk, would be taken advantage of, not to increase the dividend on shares, but to lower the water-rents.

This system is well known to have been carried out in Manchester with perfect success, on a scale at least as large as that now required for Glasgow, and under greater difficulties.

We therefore beg leave to lay before you the results of extensive investigations, in which we have for some time been engaged, in order to ascertain the source which best combines the advantages of abundance and purity of the water, facility and security in construction of the works, and economy in their execution, maintenance, and management.

With this object we have carefully examined those sources which appeared to us the most eligible. Our attention has been directed principally to the ranges of hills to the north of the Clyde, for the following reasons:—

First. A great elevation can be obtained at a moderate distance from Glasgow.

Secondly. The prevailing rocks being either igneous or of the primary formation, the water is exceeding soft, and free from mineral impregnation.

Thirdly. The extent of moss and of cultivated land is so small that the quantity of organic matter in the water is imperceptible; and

Fourthly. The entire absence of mines removes all apprehension of danger to the works from subsidence.

Beginning with the ranges nearest to Glasgow, we examined all the available streams of the Campsie and Kilpatrick hills. Here, although the quality of the water is excellent, considerable expense

would have to be incurred, and engineering difficulties encountered, in the formation of store reservoirs.

We next examined the district at the south-west end of the Grampian chain, containing the sources of the Forth and the Teith, and abounding in large lakes of extreme purity.

The advantages in economy, safety, and durability, of a natural over an artificial store reservoir are so great, that in all cases where a lake can be found, of sufficient purity and abundance, and of a suitable site and elevation, it ought to be preferred to any other source of supply.

Two natural reservoirs of this kind are, from their elevation, available to Glasgow—Loch Lubnaig and Loch Katrine. We have carefully examined both of these lakes, the mountains and streams which supply them, the rivers which they discharge, and the routes by which their waters may be conducted to Glasgow. In every point of comparison, the preference must be given to Loch Katrine, for the following reasons:—

First. Its elevation is higher than that of Loch Lubnaig, although its distance from Glasgow is not greater; consequently, a conduit of less size and cost will suffice to convey a given quantity of water from Loch Katrine than from Loch Lubnaig; and from a conduit of the same size a greater quantity of water will be discharged.

Secondly. Another advantage arising from the higher elevation of Loch Katrine is the greater facility and cheapness with which the conduit can be carried across the ridges of high ground which lie between Loch Katrine and Glasgow.

In the plans of the Glasgow Water Works Extension, deposited by the Glasgow Water Company in 1845, the comparatively low level of Loch Lubnaig, and the consequent necessity of a moderate slope for the aqueduct, have been so little attended to, that the proposed Town Reservoir is marked at a site so high that it would be impossible to fill it; the aqueduct, as shown on the section, being carried at Craigmaddie (about seven miles from Glasgow), down to a tank lower than the proposed water-level of the reservoir.

Thirdly. Owing to the conformation of the country, the works along the proposed aqueduct will be much lighter on the line from Loch Katrine than on that from Loch Lubnaig, some works on the latter line being so heavy as to amount, practically, almost to a bar to the undertaking. The aqueduct from Loch Katrine has to

cross the valleys of the Endrick and the Kelvin only; that from Loch Lubnaig has to cross the valleys, not only of the Kelvin and the Endrick, but of the Forth and the Teith also; the latter two valleys being comparatively of great magnitude, and having a formidable ridge of mountains between them, which would have to be traversed by a tunnel two miles long, through rock of the toughest description. The necessarily low level of the Loch Lubnaig aqueduct is the occasion of another tunnel near Milngavie, of three miles in length, and through whinstone; which tunnel could not be completed in less than five years.

The only tunnel of considerable length required on the Loch Katrine is one of about a mile long.

Fourthly. Advantage can be taken of the form of the natural outlet of Loch Katrine to maintain the water at its winter level, for the purpose of storage, by operations of a simple and inexpensive character; while to produce the same result at Loch Lubnaig would be very expensive and difficult.

Having for these reasons selected Loch Katrine as a natural reservoir for the supply of Glasgow, we shall now describe generally the method by which we contemplate to make it available.

As to purity and softness, the water is unparalleled. It is supplied by streams rising in a district of mica slate, almost entirely uncultivated and uninhabited, and contains only *two grains* of solid matter in a gallon.

The hardness, according to Dr. Clarke's scale, is less than one degree, thus excelling the celebrated water of Aberdeen.

It is at all times so clear that filtration might be dispensed with, even after the greatest floods, as we have ascertained by observation.

The extent of the district which drains into Loch Katrine is above 30 square miles, about one-sixth of which area is occupied by the lake itself. By the operation already referred to, of storing water up to the winter level of the lake, the present ordinary summer flow in the river Teith might be maintained, for the benefit of the landed proprietors and millowners, and a surplus of 40,000,000 gallons per day afforded, the whole or any requisite part of which might be brought into Glasgow.

The aqueduct by which Glasgow might be supplied would be about 36 miles in length, and would consist of a conduit excavated or built for about 24 miles, and of iron pipes for the remaining 12 miles. We propose that the conduit should be made, from the

first, large enough to discharge 40,000,000 gallons per day, because very little reduction of expense would arise from making it smaller. Along the 12 miles where pipes are requisite, it will be sufficient, at first, to lay a single line of pipe 4 feet in diameter. The inclination being 5 feet per mile, this pipe will be capable of discharging 20,000,000 gallons per day, or one-half of the total available quantity; that is to say, of supplying a population of 600,000, or double the present number, with 25 gallons per individual per day, for domestic and sanitary purposes; amounting in all to 15,000,000 gallons per day, with a surplus of 5,000,000 gallons to be sold to large consumers.

This aqueduct should communicate with a Town Reservoir, on one of the small hills immediately to the north of Glasgow, capable of containing one day's supply, and at an elevation of about 250 feet above high-water mark, that being sufficient for the extinguishing of fires in any part of Glasgow without the aid of engines.

The cost of these works, including contingencies, we estimate at £260,000. This is the capital requisite to bring 20,000,000 gallons of water per day from Loch Katrine to Glasgow. The cost of laying distributing pipes suitable to the present extent of the city, including contingencies, would be about £200,000.

The letter goes on to show how the interest of this capital, at 5 per cent., with the annual working expenses, repairs, and depreciation included, estimated at £6,000, making in all £29,000 annually, could be raised; and in conclusion states,—

It thus appears that the Corporation of Glasgow might provide an ample supply of pure water, sufficient not only for the present inhabitants, but for future generations, at a price much less than that which is now paid for the existing very deficient and impure supply. It may be observed that the funds of the Corporation can incur no risk from the undertaking; for it is proposed that the Lord Provost, Magistrates, and Council should, by themselves, or through a committee to be named by them, as in the case of the Police, act merely as Parliamentary Trustees for the execution and management of the works. The necessary funds, as already stated, would be raised by debenture or by loan, on the security of the rates, as was done in the case of the improvements on the

navigation of the Clyde. The Corporation might, in order to promote a scheme so advantageous to the city, either take a certain amount of the debentures, or make a loan to the Commissioners, to enable them to commence the works, as they did in the instance referred to; but it is believed that there would be no difficulty in raising, even without this aid, from the public at large, the capital required for the accomplishment of an object of such vast importance to all classes.

As a means of giving a constant, plentiful, and cheap supply of pure soft water for domestic, sanitary, and manufacturing purposes, and at the same time of affording a surplus capable of being applied to the production of an economical moving power, so as to diminish the number of steam engines within the city, and thereby to lessen the impurity of the atmosphere of Glasgow, we respectfully submit this scheme to your consideration.

(Signed) W. J. MACQUORN RANKINE.
JOHN THOMSON.

59 ST. VINCENT STREET,
GLASGOW, *1st March, 1852.*

Notwithstanding the previous resolutions of the Council and its committees, and the opinion of the engineers in the letter just quoted, to the effect that the water supply should be in the hands of the Magistrates and Council, as Trustees on behalf of the public, Bailie Gourlay, on 23d September, 1852, gave notice of the following motion to support a new joint-stock company, viz:—

“That, considering the present state of the question as to the supply of water for the city, and with reference to the necessity for the most effective sanitary measures being adopted, this Council is of opinion that they are called upon, without any further delay, to promote every practicable measure for improving and greatly increasing the existing supply.

“That a company has recently been projected to supply the city by gravitation from Loch Katrine, which appears to the Council to offer the only feasible plan at present contemplated for furnishing an adequate supply of pure water for the wants of the north side of the city, the inhabitants on the south side of the Clyde being satisfied with the

supply already furnished by the Gorbals Gravitation Company, while the Glasgow Water Company have taken no means to carry into effect the powers which they obtained from Parliament, in 1846, to bring in water to the city from Loch Lubnaig.

“That in these circumstances this Corporation resolve, with a view to the promotion of the projected scheme for supplying water from Loch Katrine, to take shares in the Company to the extent of £10,000, on the following terms and conditions:—*First*, That the Loch Katrine Company shall be bound, at the sight of the Cleansing Committee of Police, or such other committee as may be named on the part of the public, to supply such a quantity of water as may be necessary for all sanitary purposes, cleansing closes, public baths, &c. *Second*, That to meet the proportion of expense of the works applicable to the sanitary supply before mentioned, the Magistrates and Council shall consent to the imposition of such a rate, not exceeding one penny per pound on the rental of the city, to be levied along with the Police Assessment, as may be equal to the estimated expense of the sanitary supply. *Third*, That in order to secure the proper application of the sanitary rate, and the due supply of water for sanitary purposes, three members of Council shall be, *ex-officio*, directors of the Loch Katrine Company.” This motion came on for discussion on 15th September, 1852, and was supported in an able speech by Bailie Gourlay, seconded by Mr. James Drummond; but Mr. Moir moved as an amendment, seconded by Mr. Alexander Harvey, that the subject should be remitted to a committee for consideration and inquiry as to the best and purest source from which water could be obtained. The amendment was well supported by, among others, Sir James Anderson and Mr. McLellan, who were “still of opinion, with the former committee, that they would never have a better supply in Glasgow, unless the Corporation took it boldly up, and worked out a scheme of their own.” After considerable discussion the motion was withdrawn, and a committee appointed, to report that day fortnight, em-

bracing the whole subject, "either in connection with the present scheme—the Loch Katrine scheme—or by offering an independent plan, if they should think fit;" and this committee having met on 29th October—present Bailie Gourlay, chairman, the Lord Provost, Bailie M'Dowall, Sir James Anderson, and Messrs. Peter Hamilton, James Moir, David Dreghorn, Alexander Harvey, Thomas Pearson, and Archibald M'Lellan—a deputation from the Directors of the Glasgow Water Company, consisting of Messrs. John Henderson, John Orr Ewing, Richard Kidston, and Robert Galbraith, with Mr. Mackain, their engineer, and Mr. Guthrie, their treasurer, were introduced, and stated to the committee that they had now obtained a very satisfactory report from Mr. Leslie, engineer, to the effect that, after survey and examination, he was satisfied that a better and more abundant supply of pure water for the city could be obtained from Loch Lubnaig than from any other source. The deputation further stated that the Directors had in consequence resolved to apply for an Act, in the approaching session of Parliament, to authorize them to bring water from Loch Lubnaig; and that both Mr. Leslie and their law agent, Mr. Bannatyne, had assured them that there was still sufficient time to enable them to have all the necessary surveys and plans completed within the period prescribed by the standing orders of Parliament. The deputation, after answering several questions put by different members of the committee, having withdrawn, the whole subject was considered and discussed by the committee; and it was ultimately agreed and resolved unanimously, to report to the Council "that it appears to this committee, as it did to the former one, when the subject was under consideration two years ago, to be most desirable that the power of supplying the city with water should be vested in the Magistrates and Council, as a separate trust for the benefit of the inhabitants, rather than in any private company; and the committee recommend that the Council should authorize the requisite steps being taken for the purpose of accomplishing this object at the earliest possible period. With

that view, and to enable them to judge as to the best course to be followed under all the circumstances, the committee recommend that an engineer of the greatest eminence should be consulted; and that, after he has examined all the available sources of supply in the neighbourhood, his opinion and advice should be requested as to the source he would recommend to be taken, in order to afford the inhabitants the best and most abundant supply, by gravitation, of the purest water that can be obtained." This report was brought up to next meeting of Council by Bailie Gourlay, who moved its approval and adoption, seconded by his former seconder, Mr. Drummond. In doing this, he explained his reasons for departing from his arguments at the previous meeting, in favour of supporting a private company, "believing (as he said) that the Corporation would be better without this additional charge;" and that "it would have been folly in him to maintain his opposition against the united judgment of gentlemen who were just as anxious that the city should be well supplied with water as he was, although they differed as to the means." The motion was carried without division; and well it was so, as, if it had been otherwise, the community might have been still saddled and trammelled with a private company, yearly dividing profits among themselves, and exercising, like the old company, uncontrolled dominion over the supply; for it is feared that the infusion of two or three Members of Council into a Board of Directors, composed otherwise of *interested* partners (like the Lord Provost's appointment as president of the old Company) would have had but little effect.

The principles upon which the Council were in future to act being thus finally settled, the first and most important duty of their committee was to make a judicious selection of an Engineer for "advice and assistance;" and, after the most careful inquiries, in London and elsewhere, they were fortunate in securing the services of John Frederic Bateman, Esq., C.E., of Manchester and London, who was, on 7th December, 1852, unanimously appointed by the Council

their Engineer. Meanwhile the Glasgow Company were vigorously proceeding with their measures for promoting, in the ensuing session, another bill for bringing water from Loch Lubnaig; and on 24th February, 1853, it was resolved by the Council, on the motion of Bailie Gourlay, seconded by Mr. Dregghorn, to oppose it. Mr. Bateman having met the committee in Glasgow on 4th January, and received his instructions, immediately proceeded to make the necessary investigations and surveys; and on 2d March, 1853, made his first report to the committee, the import of which was communicated to the Council by the following minute:—

Under his appointment, Mr. Bateman came to Glasgow on 4th January last, when he met the committee, and immediately entered on the important duty entrusted to him. On 4th March current, Mr. Bateman again attended the committee, and submitted a very able and satisfactory report, in which he states that, in accordance with the instructions given to him, he had examined into the merits of the various schemes proposed for supplying the city with water, and had examined the surrounding country generally, with the view of ascertaining the best means of accomplishing that object. As the Loch Lubnaig scheme is now the only one before Parliament, he confines his report to an examination of the merits of that scheme, and to a comparison of it with such others as may be laid out or executed in the same district. Mr. Bateman then enters into a full and detailed statement and explanation, to show how water could be brought into the city either from the sources of the river Endrick or from Loch Katrine, and contrasts these schemes with the scheme proposed by the Water Company, of bringing water from Loch Lubnaig; and the conclusion at which he arrives is stated in the following terms, viz.:—"I have now, I trust, sufficiently explained the features of the three important schemes which, it appears, can be laid out in the district north of Glasgow, each equal to the supply of 20,000,000 gallons of pure water per day—viz., the Endrick, the Loch Lubnaig, and the Loch Katrine—to satisfy you (the Council) that the Loch Lubnaig scheme proposed by the Glasgow Water Works Company is not the cheapest nor the best. I have no hesitation in recommending to you to oppose this scheme in Parliament."

In the recommendation thus given by Mr. Bateman, that the bill of the Company should be opposed in Parliament, the committee fully concurred; and they accordingly directed that the necessary petition should be prepared and lodged against the bill; which was done. And having come to this resolution, the committee thought it right to intimate their determination to the Water Company; in consequence of which, a correspondence ensued between Mr. Forbes, one of the town-clerks, and Messrs. Bannatyne and Kirkwood, the agents of the Company. By this correspondence it was intimated, on the part of the Council, their intention to oppose, and by the Company their determination to persevere. It was also intimated by Mr. Forbes to the Company, that the leading grounds of opposition would be that the power of supplying water to the city should be vested in the Magistrates and Council, for the benefit of the inhabitants, rather than in a private company; that the scheme of taking water from Loch Lubnaig for the supply of the city was not the best; that it would be more expensive than others that could be recommended; and that the Council would be prepared to bring forward a better scheme next session. On the motion of the Lord Provost, seconded by Bailie Gourlay, the report and correspondence were unanimously approved of; and it was resolved that every necessary measure should be taken for maintaining an opposition. It was further resolved, in accordance with a recommendation of the committee, "That at the earliest possible period the necessary steps should be taken, by the introduction of a bill into Parliament in the next session, and otherwise, for vesting the power of supply in the Magistrates and Council, and for obtaining that supply from the best source;" with full discretionary power. A deputation was accordingly appointed to proceed to London, consisting of the Lord Provost, Bailie Gourlay, and Mr. Charles Gray; and after a severe struggle before a Committee of the House of Commons, which lasted fifteen days, the deputation, on their return from London, reported on 30th June, 1853,

that the decision of the Committee of the House of Commons was in the following terms:—

The Committee have unanimously agreed that the preamble is not proved. The Committee, in giving this decision, wish it to be understood that they have arrived at no conclusion that the power of supplying the city of Glasgow with water ought to be transferred from the Company to the Corporation; but, in the event of such transfer taking place, they think that the offer on the part of the Company to settle the terms of the arrangement by arbitration is a fair and reasonable one.

In this state of matters the deputation and committee of Council recommended, and the Council resolved, that Mr. Bateman should be authorized "to complete his survey of the whole district around Glasgow, on the south as well as on the north side of the Clyde, with as little delay as possible, and to report his opinion as to the source he would recommend should be taken in order to afford to the inhabitants the best and most abundant supply, by gravitation, of the purest water that can be obtained, in terms of the former resolution of the Council;" and the committee was authorized to carry this resolution into effect. The Council further, on the motion of Mr. McLellan, unanimously voted their best thanks to the Lord Provost and the other members of the deputation for their valuable services in London in successfully opposing and defeating the bill.

Thus ended the last Parliamentary contest with the Glasgow Water Company on the question as to the party in whom the power of supply should be vested; for, although the Committee of Parliament refrained from expressing an opinion on this vexed question, the Company appear to have become satisfied that it was no longer expedient to dispute it; and therefore the only remaining questions related to the compensation which would be due to the Company for the surrender of their works, the solution of which was greatly aided by the expressed opinion of the Committee in favour of arbitration.

PROCEEDINGS OF THE TOWN COUNCIL CONTINUED—
THEIR WATER BILLS OF 1854 AND 1855.

Under the instructions of the Council to Mr. Bateman, to complete his survey of the whole districts around Glasgow, he proceeded at once to do so, and so early as 15th August, 1853, attended the committee, and submitted and read to them his second report, in the following terms:—

*To the Honourable the LORD PROVOST, the MAGISTRATES, and
TOWN COUNCIL of the CITY OF GLASGOW.*

MY LORD AND GENTLEMEN,—I have just completed a second examination of the Clyde, and all the streams on the south of the city from which it has been suggested that a supply of water might be obtained, and I have again gone over all the sources to the north formerly examined and reported upon. I believe that I am now in possession of sufficient information to enable me to lay before you the essential facts and features of each district, with such an analysis of their advantages and disadvantages as will afford you the means of determining which scheme of supply it will, all circumstances considered, be most expedient to adopt.

The Parliamentary inquiry which has been so recently concluded by the rejection of the Loch Lubnaig project of the Glasgow Water Company has very fully brought to light the facilities and the difficulties which would attend the execution of a scheme for bringing water from Loch Katrine. The practicability and the probable cost of constructing the necessary conduit and works have been thoroughly investigated and clearly established, and the character and extent of the arrangements which it may be necessary to adopt for compensating the mill-owners and other parties interested in the waters of the river Teith have been pretty definitely ascertained. The quantity of water also which it is necessary to procure, in the first instance, and the provision which it appears expedient to make for the future extension of the city, and the probable increased demand which would attend the supply of very pure water, have been fixed with more certainty than could otherwise have been expected.

It may be assumed that at least 20,000,000 gallons of water per day, in addition to the supply to be afforded by the Gorbals

Company, should be provided for the immediate wants of the inhabitants; and looking at the rate at which the city is increasing, and the more than proportionate increase in the quantity of water used, it appears probable that this quantity will not meet the wants of the place for more than ten years after the completion of the works.

The present population of Glasgow and Gorbals is about 360,000 persons. The water supplied by the two Companies is about 14,000,000 gallons per day, equal to nearly 40 gallons per head upon the whole population, although it is admitted that many are not supplied. The increase in the population appears to be about 3 per cent. per annum. Three years should be allowed for the execution of any work after its commencement, before water could be supplied; but allowing only three years from the present time, the population may then be expected to amount to about 400,000 persons, and the requisite daily supply, at 40 gallons per head, to 16,000,000 gallons. Should the supply be then in the hands of the Corporation, with the obligation of supplying every house in the city, the whole 20,000,000 would be required, unless the waste which is now presumed to exist could be prevented.

In ten years after the completion of any new works, or thirteen years from the present time, the city may be expected to have increased to 520,000 or 530,000 persons. For these the requisite supply would not be less than 25,000,000 gallons per day, and this without allowing for increased trade consumption, upon which much of the success of the work in a financial point of view must depend.

Any scheme of supply, therefore, entitled to your consideration, should enable you to procure at first from 20,000,000 to 25,000,000 gallons per day, and be so arranged as to afford means for large subsequent extension.

With the probable cost and capability of the different projects which have been laid out to the north of the city you are already acquainted. With some trifling alterations as to the lengths and estimates, which a more minute subsequent survey rendered necessary, the particulars given in my first report may be taken as substantially correct.

From the numerous difficulties and defective arrangements which appear to attend the project for bringing water from Loch Lubnaig, independently of its greater cost, and from its rejection

by the Committee of the House of Commons, after the most patient investigation, this scheme may be considered as out of the question in our present inquiry.

The Loch Katrine scheme, as brought under the notice of the Committee, was laid out for 40,000,000 gallons per day, and the Endrick Water was estimated to afford 17,000,000 per day, and arranged with a view to subsequent extension to Loch Katrine.

This latter scheme, however, I cannot now advise you to entertain,—at all events, not as one for immediate construction, whatever may be thought of it as a future supply in aid, when the resources of Loch Katrine may be exhausted. When I saw the district in the winter and in the spring, and according to the specimens of water which were sent to me as late as the end of May, all the streams yielded water of very beautiful and superior quality. The water was also generally admitted, by those who professed to be intimately acquainted with it, to be unexceptionable; and it was therefore assumed that it could be delivered to the inhabitants without the necessity of filtration. Nearly all the streams, however, are now, and have been for the last five or six weeks, so deeply stained by peat, that the water in its natural state is quite unfit for the use of a town, and would require very perfect and slow filtration to remove the colour. They will probably remain more or less discoloured to the end of autumn, when the return of cold weather will arrest the decomposition of the peat. The result is, that though the winter water is eminently pure, and the summer and autumn water may be rendered so by proper filtration, still the cost of this operation, added to the limited quantity of the whole supply, places this scheme at a disadvantage compared with others which have been projected.

The same observations as to colour apply to the river Duchray and the Allander Water, both of which during the present summer rains are considerably coloured. I fully expected some discoloration in the Allander; but I anticipated that the Duchray would yield fine water at all seasons of the year. The expectation, therefore, which I held out in my first report of a supply of 10,000,000 or 12,000,000 gallons of pure spring water per day being obtainable by the Loch Katrine conduit, in dry seasons, in its course from Loch Katrine, seems scarcely well founded; and although I do not doubt that a considerable supply at such seasons may be thus obtained, it would probably be safer to estimate the supply as derivable from Loch Katrine solely. The water of

that lake is all that can be desired; and notwithstanding the heavy rains which have darkened Loch Lomond and Loch Lubnaig, and rendered their water distinctly though slightly brown, Loch Katrine remains clear, cold, and bright, and all but absolutely colourless.

As it appears, then, that no better scheme to the north of the city can be laid out than that for bringing in the water of Loch Katrine, it will be necessary to compare it with what I have now ascertained may be accomplished on the south.

You are aware that I was desirous of postponing my report on the waters of this district until I had an opportunity of examining them in summer and in autumn, when the effect of the peaty and cultivated soil over which they passed could be more fully perceived than in the cold temperature of winter. I have just seen them after the soaking rain which has occurred during the warm weather of the last five or six weeks, and have had them several times examined by one of my assistants during that period. I never saw running stream so darkly stained as the Clyde at Hyndford Bridge, and its tributaries below that point. As seen in the streams, the water is as dark as strong clear coffee in a coffee cup; and I much doubt if any filtration which could practically be carried out would effectually remove the colour. In addition to the peaty stain which is imparted to the water, the high cultivation of the country, and the extent to which it is treated as arable land, have the effect of rendering the water turbid after heavy rain, by allowing the finer particles of the soil to be carried from the surface. This of course destroys the brilliancy and purity of the water; and neither the Clyde itself, nor any of its tributaries, would be fit for domestic use at any season of the year without filtration.

The peculiar character of the district, and the absence of any material quantity of spring or pure water within a reasonable distance, prevent the adoption of the system of separation which has been successfully carried out at Manchester, and is now being very generally adopted in mountainous districts which yield water of different qualities. In the district which supplies Manchester with water, about one-half of that which can be collected is perfectly clear and colourless, and the other half more or less turbid and discoloured,—all the streams in fine weather, in summer or winter, yielding equally good water. The pure water is separately conveyed, or separately stored, if more than

required for use, and the turbid water allowed to flow into reservoirs set apart for compensation to mills, or run to waste. Simple self-acting arrangements enable each stream to take one or other course, according as it is small in volume, and consequently pure, or large and turbid.

Apart, however, from the objectionable character of the water of the Clyde, none of the schemes which have been projected, and, in my opinion, none which can be suggested, are entitled to much consideration, or to be put into competition with the proposed extensions of the Gorbals Water Company.

The important schemes which have at one time or another been projected for bringing water from the Clyde or its tributaries are—

1st. A project for taking it from the Clyde direct, near Hyndford Bridge, above its junction with the Douglas.

2ndly. From the Avon, at Stonehouse, projected by Mr. M. M. Pattison in 1836.

3rdly. From the Avon, above Strathavon, as laid out by Mr. Rendel in 1844.

There are some others of less importance which I have not examined.

The report then described specially these three schemes, which it did not recommend, for various reasons affecting either the quality of the water or the cost of executing the works, and then proceeded thus,—

It now only remains to examine the capabilities and proposed extensions of the Gorbals works. These are works in every way worthy of attentive consideration. At present they afford a supply of about 3,000,000 gallons per day; and new works in course of construction will enable the Company to impound water heretofore running to waste, and to increase the supply to about 4,000,000 gallons per day.

The collecting ground to the present works is 2,750 acres. The rain cannot safely be taken at more than 45 inches per annum. (The average of the three years 1842, 1843, and 1844, at Netherplace, in the heart of the district, was only 44 inches; and this gauge appears to register 10 or 12 per cent. more rain than is received by the gauge at the Gorbals Water Works.) From this must be deducted about 15 inches for evaporation and absorption, leaving

30 inches as the available rainfall. This would give a daily supply of 5,128,000 gallons. Deducting the compensation to mills, according to the Act of Parliament, which, when the reservoirs are finished, will amount to 1,310,712 gallons per day, there will remain a net daily quantity for the supply of the city of 3,817,000 gallons.

The water of the streams they have already acquired is, in point of colour, the best I have seen on the south of the Clyde, and would, I believe, by slow and perfect filtration, be rendered quite unexceptionable in all respects. The present system of filtration, though ingenious and sufficient for separating the grosser particles carried in suspension, is not calculated for clarifying the water to the extent it requires.

The extensions which have been proposed by this Company, according to their deposited Parliamentary plans, would increase their total gathering ground to 18,457 acres, for which they have provided abundant storage for about one-half, and about half enough for the remainder.

Say 9,000 acres, the water of which will be wholly stored, at 30 inches of rain per annum, will give about 16,850,000 gallons per day. Deduct compensation as per Act of 1846, 6,000,000 " "

Leaving 10,850,000 gallons per day.

For the remaining 9,000 acres the produce must be calculated by the capacity of the reservoirs, added to the natural stream during a period of 120 days of drought, after deducting proper compensation to the stream, which may perhaps be taken at 5,000,000 gallons per day.

The storage in this district is 217,000,000 cubic feet, equal to a daily supply for 120 days of . . 11,250,000 gallons.

Add natural stream, say 7 feet per second, or 3,500,000 "

14,750,000 "

Deduct compensation, say . . . 4,750,000 "

10,000,000 "

Add former quantity, . . . 10,850,000 "

20,850,000 "

Deduct supply from present sources, . . 3,817,000 "

Leaves as the daily supply from new sources, 17,033,000 gallons.

The water of this district is none of it so good in summer as that which the Company now possesses. Some of it is very objectionable; but on the average it is better than any equal quantity on the south of the city. Storage and very slow filtration may probably render it perfectly pellucid.

I have very carefully gone into the calculations and probable cost of this scheme, and I estimate the cost of constructing all the extension works included in the Parliamentary plans, and conducting the water to Glasgow, exclusive of filtration and of any outlay upon the works now constructed or authorized,

at	£238,000
For filtration and the annual cost capitalized,	70,000

Total, £308,000

for 17,000,000 gallons additional water properly filtered,—equal to about £18,000 per million gallons. Adding the present supply, the total quantity would be about 21,000,000 gallons per day.

Mr. Gale, the Engineer of the Company, has brought under my notice contiguous districts, extending over about 12,000 acres, from which he considers additional supplies might be obtained. One portion of this lies at a considerable distance; another is already very largely used and economized by the bleachfields near Barrhead, and ought not to be diverted from that district, which may ultimately require the whole. Upon much of the remainder it does not seem probable that sufficient storage can be obtained; and the water is not of first-rate quality. On the whole, I think that the utmost which could be calculated upon as available from these districts would not exceed 8,000,000 or 10,000,000 gallons a day, and the cost would certainly not be less than £20,000 per million gallons.

Twenty-six or twenty-seven million gallons, therefore, in addition to the present supply, forms the utmost quantity which, by any reasonable extension, may be expected in this direction, the probable cost of which would be about £500,000.

I have already, in an early part of this report, shown the probability of at least 25,000,000 gallons per day being required within thirteen years of the present time, and urged the importance of adopting works which would allow large subsequent extension when this quantity was exhausted.

The Gorbals district does not appear to meet these require-

ments; and any material extension of those works, therefore, is not a scheme which I would recommend for your adoption, when there is another open which, at less ultimate cost, would meet all present and future demands.

Loch Katrine seems to stand alone in the field. No other source will meet all the requirements of the case.

This conclusion being arrived at by an examination of cost and capability, it will be unnecessary to go into a comparison of the relative qualities of the water, the peculiar features of the collecting ground, the relative circumstances of the districts, or the nature of the works required.

In all these considerations the Gorbals district would have to yield the superiority to Loch Katrine. In the single item of first cost for the first instalment of water is it superior to its competitor, and this advantage would disappear in favour of Loch Katrine at the expiration of some ten years after the introduction of the water.

The probable cost and other particulars of the Loch Katrine scheme are before you in my first report, and the subsequent Parliamentary investigation fully confirmed all I then stated.

For 20,000,000 gallons per day brought to the city, the cost may be given in round numbers (after allowing for items omitted in the comparison with the cost of the Loch Lubnaig project) at about £470,000, or about £23,500 per million gallons. For 40,000,000 gallons, at £600,000, or £15,000 per million gallons.

I need not dwell on the purity of the water, nor on the simplicity of the works when executed. The city of Glasgow would be supplied more abundantly, more cheaply, and probably with more beautiful water than any city in the world; and I am convinced that the results would, in a pecuniary point of view, as well as in the increased salubrity and prosperity of the city, prove in the highest degree satisfactory.

For the chemical qualities and other properties of the waters of the different districts I beg to refer you to the full and valuable report of Dr. R. A. Smith, whose assistance upon that branch of the inquiry I was permitted to obtain, and who for many years has been largely engaged in the analysis and examination of the waters of a large portion of the kingdom. In the Appendix you will find some of the more important and valuable information as to the fall of rain in various places, the

consumption of water, &c., which I have received from the Engineers of the different Companies, or for which I am indebted to the courtesy of private individuals.

In considering the question, I have of course assumed that you become the purchasers, by agreement or otherwise, of the property and interest of the two existing Companies, and that, when the new works are completed, the whole duty of the supply of the city will be in your hands. I need scarcely observe that it will materially facilitate the preparation of plans and details for an application in the next session of Parliament for the requisite Parliamentary authority, if early arrangements for such purchase could be made.

In the event of your determining to adopt the project for bringing water from Loch Katrine, the present pumping establishment of the Glasgow Water Company will of course, on the introduction of the Loch Katrine water, be discontinued; but it will be desirable to render the supply of the Gorbals Company as perfect as possible by the construction of proper filters, and the more perfect completion of the works. The population in the more immediate neighbourhood of these works is increasing so rapidly that most, if not all the water which was included in the proposed Extension Bill of this session, will probably be required for the supply of its own neighbourhood through the intervention of the water works; and this is rather an additional reason why the supply for the remainder of the city and its populous suburbs should be sought for in another locality.

I have the honour to remain,

Your very obedient Servant,

JOHN FREDERIC BATEMAN.

Dr. Smith's report on the quality of the water will be given, along with other similar reports, in a subsequent part of the narrative, or in an appendix.

Mr. Bateman's admirable reports having met with the approval of the committee, were ordered to be printed and put into the hands of every member of Council, with a view to their being considered by an early meeting. That meeting was held on 8th September, and the Lord Provost, in then moving the adoption of the reports, stated,—

That the Council having already unanimously agreed that the supplying of the city of Glasgow with water should be taken into their own hands, they had now arrived at a point when it was necessary that something definite should be done. In a short time they would require to lodge the Parliamentary notices for a bill, and previous to that, surveys had to be made, and made accurately, which would necessarily require some time. The reports which had been submitted to them were from a gentleman who was free from any local or party bias. The Council had received his candid opinion in reference to the various schemes which had been projected, and he (the Lord Provost) must state that, however high the opinion formed of Mr. Bateman's professional qualifications, the committee's appreciation of his abilities had been more than borne out. For his own part, he had never met with a more judicious or a more talented individual. That being the case, perhaps his opinion would carry more weight with the Council than otherwise. Mr. Bateman had examined the whole of the schemes. Loch Lubnaig, of course, had been thrown aside, as a Committee of the House of Commons had decided that a proper supply could not be obtained from that quarter. There then came the Avon scheme, of which a great many had long thought favourably; but its great promoter, Mr. M. M. Pattison, along with, he believed, every one else, frankly admitted that the plan proposed by Mr. Bateman was the best. He had gone over Mr. Bateman's reports carefully, and was thoroughly convinced that the Loch Katrine scheme was decidedly the best. The water was pure, and perhaps better than could be obtained from any other source in Scotland. Dr. Smith, an eminent chemist, stated in his report that the water from Loch Katrine was almost absolutely pure, clear to the utmost, and without colour. That eminent chemist was also of opinion that in many public works the Loch Katrine water would have a distinct money value which could be calculated by the increased value of the goods in the market, and the diminished labour. Dr. Smith proceeded to say, "How much the value is in a sanitary point of view, and as affecting the habits of the people, it is not possible to calculate, as the gain in these respects must have a much higher than a money value." While the people of a community were fearful of that scourge, Asiatic cholera, again visiting this city, the great aim and object of them all should be to secure an abundant supply of pure water, for there could be little doubt that abundance and purity of water had an

immense effect on the general health of a community. We used to boast of the purity of our springs, but they had now become so corrupted as in many cases to be absolutely deleterious, and we could no longer look to them as affording any material increase to the supply provided by the Water Company. In reference to the benefits which public works would derive by the introduction of the Loch Katrine water, Dr. Smith said he could have enlarged on the nature of such water in improving the quality of certain manufactures, and in cheapening processes; and he (the Lord Provost) believed that it would be found in Manchester, where they had got pure water, the proprietors of the public works, such as bleachers, dyers, and printers, were removing them into that city. A similar result, he had no doubt, would follow in Glasgow. He might mention that the Gorbals scheme had also been alluded to, and Mr. Bateman was at first disposed to view it favourably, but, on further examination, he had given it as his opinion that it would not be answerable. It was quite true that, for a limited supply, the Gorbals scheme would be cheaper than the Loch Katrine; but they must look to the present extent and the rapid extension of Glasgow, and that 40,000,000 gallons of water per day would be required to meet the demand. There could be no doubt that Loch Katrine would ultimately be found to be the cheapest scheme. Coming to the expense, he admitted that it would have been comparatively small had there not been another Company in existence, and it was equally true that the works of the present Company might not be required, and go down; but they must bear in mind that the Glasgow Water Company had supplied this city in time of need, and that for many years their dividend had been small; and while he for one would never agree that they should receive an extravagant sum, he could not, in justice, withhold from them a fair consideration for their property. It would be observed from the report, that, if a private arrangement with the Directors of the Water Company was not come to, they were willing to agree to an arbitration, and he for one was not at all afraid of arbitration; only let the question be looked at in all its bearings, and this Corporation had nothing to fear. He would just say, in conclusion, that at one time he was of opinion the Corporation should not take the supply of water into their own hands; but he was of quite a different opinion now. The Public Health Committee had recommended that the corporations of all large towns should do so; and it was worthy of observation, that on the

principle of gravitation, when the works were once formed, the expense of maintenance and otherwise was very small indeed. If the report was agreed to, the necessary surveys would be proceeded with, after which the committee would come to the Council for further instructions.

The Lord Provost's motion was seconded by Bailie Gourlay, and a spirited discussion ensued, which resulted in an adjournment of the debate. At the adjourned meeting, the following explanatory letter received from Mr. Bateman was read:—

MANCHESTER, 19th Sept., 1853.

To the LORD PROVOST,

MY LORD,—I am induced to trouble you with another letter, for the purpose of removing some misapprehensions under which certain members of your Council appear to labour.

It seems to be assumed that some £700,000 or £800,000 must be laid out on the Loch Katrine scheme, and three or four years must elapse before a drop of water could be procured for the city, while for £200,000 laid out in extending the Gorbals, an immediate supply could be obtained. This is altogether erroneous. Of the two schemes, the Loch Katrine works would be completed long before the other; and nearly, if not quite as soon as by the partial completion of the Gorbals, a limited, but very imperfect additional supply could be obtained from them. Of all the operations connected with the construction of water works, the formation of large reservoir embankments is the most difficult and tedious. Those for the Manchester Water Works were commenced in 1848 and 1849—some four and a half and others five years ago. They are embankments of 70, 80, 90, and 100 feet in height, and are not yet quite completed, while a tunnel of 3,000 yards in length, and the covered watercourses and pipes in connection therewith, were finished, ready for the passage of water, within two years after commencement. The tunnel and watercourse portion of the works may be taken to represent the Loch Katrine conduit, and the reservoirs are similar in their character to the works to be constructed in extension of the Gorbals. It is true that in Manchester a partial supply of water was obtained as soon as the watercourses and pipes between the city and the works were completed, but for a long time it was very limited and precarious, and it would be so, no doubt, in the case of the Gorbals.

I have endeavoured to show in my second report the quantity of water which may be expected to be required in three years from the present time, and that nearly all the water which could be reasonably expected in the Gorbals district would then be required. By that period it is possible, and, in twelve months more, pretty certain, that the full supply of 20,000,000 gallons per day could be obtained in all perfection from Loch Katrine, while a limited portion only, and in unsatisfactory condition, could be supplied by the Gorbals extensions.

I ought, perhaps, to have stated in my second report the probable costs of laying pipes and distributing the water in the city. Were the works to do *de novo*, the cost would vary from 5s. to 10s. per head upon the whole population, according to the pressure upon the pipes, the price of iron, the quantity of water to be distributed, and the close or scattered character of the district to be supplied. In Glasgow, for 20,000,000 gallons per day, it would probably be from £150,000 to £180,000. Deducting the available extent to which pipes are now laid by the two existing Companies, a sum probably between £60,000 and £80,000 would be quite ample to re-arrange and complete the distribution. Assuming it at £80,000, and adding this sum to the estimates of the two schemes respectively, they would be, for Loch Katrine, £540,000 for 20,000,000 gallons per day, or £27,500 per million; and for the Gorbals, £388,000 for 17,000,000 gallons per day, or £22,800 per million.

I need scarcely draw your attention to the calculations in my second report, which go to show the probability that, in a few years after the completion of the Gorbals works, should they be adopted, the water would be exhausted, and further districts would be sought for; nor need I again allude to the superiority which Loch Katrine possesses for obtaining further supplies at little additional cost.

I find, on looking over the reports as printed, that an error has crept into the second report, which I should be glad to have corrected. The estimate for the Loch Katrine project is estimated, page 34, at £470,000, or about £22,000 per million gallons. It should have been £23,500 per million.—I remain, my Lord, your very obedient servant,

J. F. BATEMAN.

Mr. Gemmill moved the following amendment to the Lord Provost's motion:—

That it is inexpedient to consider the reports until heads of the proposed bill are submitted, and that the matter be recommitted to the committee, with instructions to bring up a distinct report of the principles of the bill, and particularly specifying the rates to be levied, and on whom to be imposed; and the maximum sums which it is proposed shall be paid for the works of the existing Water Companies.

This amendment was supported by Mr. Gemmill in a vehement speech against the scheme recommended by Mr. Bateman, and in favour of the Gorbals Extension Scheme, and was seconded by Mr. John Mitchell; but he was answered, both on the physical and the financial aspects of the question, by Bailie Gourlay and other members, to the satisfaction of the meeting, as the result proved; for, on a division, the motion was carried by a majority of 30 to 3; against which resolution Mr. Gemmill, for himself and all who might adhere to him, protested, and at same time intimated that he would hold the members who voted in the majority *personally* liable for any expenses which might be incurred in carrying the resolution into effect.

Nothing daunted by protest or threat, the committee proceeded with the execution of the duty committed to them; and their first steps, after issuing orders for the necessary surveys, estimates, and plans, were directed to making arrangements with the existing Water Companies, and with Messrs Finlay and Company of the Deanston Works, as well as with the owners of land, water, and fishings to be affected. The latter included the Duke of Montrose, Lord and Lady Willoughby d'Eresby, the Earl of Moray, the Duke of Argyll, as acting for the heir of the late Mr. Callendar of Craigforth, &c. In the course of a few months, aided by the active and unremitting exertions and influence of Mr. Bateman in this direction, great progress was made with these negotiations. The Glasgow Company agreed to sell their works, leaving the price or compensation to be

fixed by arbitration; the proprietors of the Deanston Works fixed with Mr. Bateman the extent of compensation water to be provided for them; and the principal landowners were also satisfied. These arrangements, it was thought, had almost entirely cleared the way for the unobstructed prosecution of the bill. It was accordingly prepared, and, after being considered in committee, was introduced by the Lord Provost to a meeting of Council on 15th December. His Lordship, in doing so, explained that by this bill they were not promoting what could be called a "new, hurried, or crude" measure, but only what had been often previously resolved on; and he reminded the meeting that in 1850 the Council had resolved to take the water supply into their own hands, that a similar resolution had been adopted in 1852, and that this was the third successive Council which had considered the measure. He was aware that it was thought by some that the Council should promote a bill to supply the city without regard to the existing Companies or their interests at all; but this, he said, had been tried elsewhere, and had not succeeded. Liverpool had attempted a policy of this kind, and had failed. His Lordship then gave a summary of the provisions of the bill (which, with a few alterations in matters of detail, were the same as those contained in the Act ultimately passed), and concluded by moving that the Council should proceed with the bill; and this being duly seconded, Mr. Brodie moved as an amendment that Gorbals should be excluded from its provisions. But this amendment was at once negatived, and the Lord Provost's motion was carried by a majority of 30 to 14. The Council subsequently discussed the clauses in detail at several meetings; and the bill, as in this manner adjusted, was ordered to be submitted to Parliament.

The Committee of the House of Commons met on 20th March, 1854—the Right Honourable George Bankes, M.P., in the chair—and there appeared the following formidable array of counsel, agents, and parties, viz.:—Mr. Sergeant Wrangham, Mr. Hope Scott, Mr. Sergeant Bellasis, and Mr. Burke, as counsel for the promoters—Messrs. Richardson, Loch, and

Maclaurin, agents; Messrs. Webster, as agents for the Duke of Argyle; Mr. Merewether and Mr. J. J. Johnston, as counsel for the Gorbals Gravitation Water Company; Mr. Calvert and Mr. Hawkins, as counsel for Thomas Steel and others; Mr. Briggs Andrews and Mr. R. M. Kerr, as counsel for Mr. Archibald M'Lellan and others; Messrs. Deans and Rogers, as agents for the Town Council of Rutherglen; the agents of Lord and Lady Willoughby d'Eresby; Mr. C. Reive, as counsel for Mr. and Mrs. M'Naughton of Inverurosachs; Messrs. Robertson and Simson, as agents for the working classes and ratepayers of Gorbals; Messrs. G. and T. W. Webster, as agents for the town of Stirling and the Commissioners of the Forth Navigation; and Messrs. Grahame, Weems, and Grahame, as agents for the Proprietors of the Forth and Clyde Navigation and James Finlay and Company.

Mr. Hope Scott was heard to open the case on behalf of the promoters of the bill; and the Lord Provost, and a number of other witnesses, were examined in support of it. Mr. Andrews was heard to address the Committee on behalf of his clients, owners and occupiers of property in Glasgow, on the north side of the Clyde, in opposition to the bill; and Mr. Andrew Rutherglen, Stationer, Mr. James Taylor, builder, and Professor Frederick Penny of the Andersonian University, were examined in support of the opposition. By the evidence of the last witness, Dr. Penny, a formidable chemical question was raised for the first time. The Professor was put into the witness box to prove that he had made certain analyses of the water of Loch Katrine; that he had himself suggested these to be made, and he now minutely described them; that he had found lead "abundantly present;" that the water is "highly charged with lead," "decidedly poisonous"; and that so far as his experiments went, he should say it would be exceedingly hazardous to supply such water to Glasgow. But he afterwards explained, on further examination, that "his attention had only lately been called to the subject; that he considered "more experiments and inquiries should be made before a final

answer is given; and that it should not be left to the opinion of any one chemist, however distinguished." He afterwards added, "I do not say that the Loch Katrine water would be poisonous to the inhabitants of Glasgow, though it is sent through lead pipes, but I say my experiments (which he admitted were very limited), as far as they have gone, show that great caution should be used, and that further scientific inquiry of the most searching nature should be made; for that water is one of the finest waters I have ever seen: it is unexceptionable in every respect." Such was the import of Dr. Penny's evidence.

At the close of this singular evidence the Committee adjourned till next day; and when they then met, the Chairman intimated that the Committee had desired him to make certain suggestions, with their unanimous concurrence.

It was very obvious, he said, that a most important objection had been offered for the consideration of the Committee; and in order to elucidate that point—a point upon which the Committee could not pretend to be very well informed—the Committee must require the fullest possible information before they could venture to say how far it was or was not safe to proceed with this measure. The Committee had observed that as the petitioners did not in their petition prominently suggest anything of this nature as an objection to the bill as promoted, the promoters were not entitled in their opening speech to dwell upon that, as they might otherwise have done; but the Committee had considered that the scope of that petition did authorize the introduction of this evidence; and even if that had not been the case, a suggestion from any party would have induced the Committee to have called for it, as it was a matter of such great importance. The Committee had had a witness before them whom they presumed to be a person of character, and skill, and science, who had spoken upon this subject. The Committee would of course expect, and indeed require, to have many others, or at all events some other high authorities, called before them. Those authorities, perhaps, might, or they might not, conflict. If they were agreed, the opinion of the Committee would bow to their judgment and experience; but if there were serious confliotions, the matter would require earnest consideration on the part of the Committee. The Committee had

observed that this matter of the water was not stated in the petitions; and for that reason the Committee were not surprised that the promoters of the bill had not dwelt upon this very material part of the case, and which, indeed, hardly appeared to be a question when they opened their case. There was, therefore, no blame to be imputed to them at all for any failure of conduct, because they had put forth what they thought strong grounds for inducing a Committee of the House of Commons to adopt what they considered to be a beneficial measure, and they were not bound to anticipate objections which were not palpably raised. But this objection having been brought before the Committee, it was of that extreme importance, that he, in the name of the Committee, was authorized to say, that if the promoters thought it might require time for them to prepare themselves to answer this line of objection, the Committee would not be at all indisposed to give them further time, if they would now apply for it, and that on that application the Committee would now adjourn for any reasonable period. He was also desired to state that the Committee felt that evidence of this kind could not be met by mere cross-examination, because it must be the balance of weight of testimony of able men that would weigh with the Committee; that it was not the personal cross-examination of the witnesses that would materially affect the view of the Committee. It was a question of science; and the Committee must have the opinions of scientific men brought to bear upon so important a point before they would venture to find a decision that might or might not affect the health of the inhabitants of Glasgow. He was also empowered by the Committee to suggest whether it might not be better to proceed to other branches of the inquiry, bearing upon the case of the opponents of the bill, leaving this branch for further investigation, if the opponents of the bill thought it expedient to do so. If they did not, it would be for the promoters of the bill to say, ay or no, whether they would ask for such reasonable adjournment as might enable them to be fully confident to give the best evidence that could be procured upon this very important point. The Committee considered that it would also give time to the opponents, if necessary, to bring other samples of the water, against which no such objection as that which seemed to be pointed at in the cross-examination could be raised, because this was not a question to be tried upon accidents. The Committee must have the whole matter brought before them fully and

clearly; for they felt that the guilt would in fact lie upon the Committee if they sanctioned a supply of water which was in any respect dangerous to health.

Mr. Sergeant Bellasis, on behalf of the promoters, now stated that, appearing as he did for a public body, he felt that they could not proceed with the case if there was the slightest shadow of a doubt of the propriety of using the water in question. His clients desired to be most fully satisfied, and would not proceed with a case upon which so much doubt as the last witness had thrown upon it was raised; therefore he not only acquiesced in the proposition which had been made by the Committee, but, on the part of his clients, he *desired* an adjournment; and such an adjournment would give an abundant opportunity of inquiring into it by such persons as might be employed for that purpose; and he suggested, as it was a thing that could not be done hastily, that perhaps it would not be considered too long an adjournment till after Easter. What would have to be gone into was not merely a chemical but a practical inquiry. It would be necessary to send scientific men to inquire into the result of water, similar to that now proposed to be brought into Glasgow, which was already supplied to other towns, and what its effect was upon the pipes of such other towns, and also what the effect would be of conducting the water through several miles of conduits and iron pipes before it came to be distributed in the leaden pipes, and into other similar matters. Under these circumstances, he would request an adjournment till after Easter.

Mr. Andrews was heard to address the Committee in objection to the adjournment, and urged that his clients for whom he appeared were individuals who had brought their evidence forward at great expense; and he maintained that the promoters had shown default in the manner in which they had promoted their bill before the Committee, and that it was their bounden duty, before they brought a gigantic scheme of this kind forward, not merely to have analyzed the water, but to have ascertained primarily, as a matter of

the deepest importance, what the action of this water was upon lead, and that he had himself particularly called the attention of the promoters of the bill, in his cross-examination of Dr. Smith, to the subject.

After some further remarks by the learned counsel on both sides, the Chairman intimated that the Committee did not regard the question before them as simply one of difference between party and party, but as one which concerned the public at large; and, having to exercise the duty of judging upon the matter, the Committee felt that they could not exercise that judgment aright unless there was further evidence before them; and, as the petitioners had not given notice to the promoters of the bill that this was a main point upon which they would rely, the Committee were disposed to give an opportunity to the promoters, which probably otherwise they would not have done, of supplying that evidence which they would have brought forward if they had had such notice: there was consequently no injustice done to either party by granting the adjournment proposed.

Mr. Andrews thereupon stated that it had not been his intention to trouble the Committee with any further general evidence, but merely to confine himself to evidence upon the point last raised in respect of the water; and the Chairman intimated that in this he had exercised a sound discretion. The Committee then adjourned to Tuesday the 9th of May.

In this state of matters the Lord Provost and the other members of the deputation lost no time in considering most seriously the course to be pursued in compliance with the suggestions of the Committee of Parliament. On 29th March—the very day following the adjournment—they held a meeting in London for the purpose, which was attended by the Lord Provost, Messrs. Gourlay, Gray, Scott, and Harvey, as well as by Mr. Forbes and Mr. Bateman. At this meeting the latter submitted an outline of the means to be employed to establish the real state of scientific opinion and experience, and the facts of the case, embracing the

laying down of pipes, both of iron and lead, at the outlet of Loch Katrine, in such manner as to imitate as nearly as possible the mode in which the water would be supplied to the city,—the making of experiments there and elsewhere to test the action of the water upon lead,—and the most searching inquiries, at the various towns and places supplied with very pure water, as to its effect upon lead. The following scientific gentlemen were named as well qualified to make the requisite experiments and give evidence, viz. :—Professors Graham and Thomson, Mr. Dugald Campbell, Dr. Swaine Taylor, Dr. Lyon Playfair, and Professor Hoffman, all of London, and Professor Anderson, of Glasgow. It was agreed also that Mr. Lamond, as agent of the opponents, should be invited to name a scientific person to witness and co-operate in the investigation. By such means it was confidently anticipated that all ground of doubt would be dissipated.

All these measures were immediately commenced, and prosecuted with great diligence and complete success. But, curiously enough, as will be presently seen, the further evidence so much desiderated before the adjournment, as to the safety of introducing the water to the city for domestic use, was never afterwards required or called for; another obstacle having arisen, before it fell to be considered, which proved fatal to the bill. After the adjournment a report was issued by the Lords Commissioners of the Admiralty, instigated, no doubt, by the Commissioners of the Forth Navigation, strenuously objecting, on public grounds, to the abstraction of so much water as was proposed from Loch Katrine, which would otherwise continue to flow into the river Teith, and thence into the Forth. This objection was founded on the fancied importance of the Forth navigation, the injury that would accrue to it, and the supposed absence of necessity for taking a water supply to Glasgow from that source. The report set forth that, between the Humber and the Firth of Cromarty, there was no other harbour or anchorage into which large ships of war could safely run for shelter or rendezvous, other than the Firth of Forth,—more particu-

larly the reach above Queensferry, where the shelter was said to be complete; but, as the Firth of Cromarty was away from any important interests, the Firth of Forth must be considered the only war port north of the Humber, and therefore a most fitting place for a naval arsenal; that the rivers Teith and Forth were the tributaries at the head of the tideway which served to keep the navigation open; that of these two rivers the Forth proper was a comparatively sluggish and turbid stream, bringing down much silt, while the Teith had a rapid and great descent, and was a remarkably clear water, so that in joining the Forth about two miles above Stirling it served to dilute the turbid water of the Forth, and then, by doubling its volume and momentum, to carry away the silt and maintain a navigable channel; in support of all which the opinion was quoted of Lieutenant Cudlip, R.N., who, it was said, had made a survey and chart of the Forth from Queensferry to Stirling Bridge. Then it was stated that if the city of Glasgow could be supplied from no other source than the Teith, the question might be a difficult one; but the report proceeded to show that such a supply might be got from the Gorbals Water Company, the district of the Campsie Hills as gathering grounds, and all those streams running westward into Loch Lomond, and, as a last unfailing resource, the Loch itself—ignoring entirely the fact that these and all other means of supply round the city had been explored by competent engineering skill, and found wanting. The conclusion arrived at in the report was, that their Lordships conceived, that except on most urgent grounds, and when no other resource can be found, sanction should not be given to a measure injuriously interfering, as they assumed, with the Forth navigation, and that they must therefore withhold their assent to so much of the bill as proposed to abstract or diminish the sources or feeders of the Forth navigation.

When the Committee re-assembled on 9th May, instead of proceeding to hear the promoters' evidence as to the purity of the water, they intimated a desire, first, to consider the

Admiralty report; and allowed the promoters to adduce evidence they had offered, to rebut it. This evidence was at once brought forward; and it was proved, among other things, that whereas the report bore that *half* of the water of the river Teith was to be abstracted, it was impossible that more than *one-sixth* of the water flowing down that river could be withdrawn; that in floods the volume of water to be taken to the city, even at the ultimate quantity of 50,000,000 gallons per day, would not be more than one four-hundredth part of the water which in heavy floods runs past Stirling; that at the time of flood, and during such periods as the lakes might be re-filling after having been drawn down in dry weather, the diminution in the water of the river at Stirling would not be more than *one-fortieth* or *one-fiftieth* part; and that in dry weather the volume of the river would be sensibly *increased*.

After hearing this evidence the Committee ordered the parties to withdraw, when Mr. Webster, as counsel for the Admiralty, made the following extraordinary statement:—"Before the parties leave the room, perhaps it may be proper for me to state that the Admiralty are of opinion the evidence given discloses no facts which were not known before the report was made, or anything which, in their opinion, would militate against the course which they have taken." One of the members of the Committee upon this remarked—"I think it is a most unusual thing for the Admiralty to send such a statement forth to a Committee. I rise to a question of what I consider constitutional order. I must say what has been just stated by the learned gentleman is unprecedented in Parliamentary history, or in the proceedings of Parliament." The Chairman—"I think we had better clear the room: no doubt the learned counsel has been merely exercising his duty." The Committee room was accordingly cleared, and on counsel and agents being called in, the Chairman stated: "In this case the Committee have come to the decision that the preamble of the bill is not proved."

The bill was thus lost; but the deputation thought that

they might succeed in getting their case re-heard; and the Lord Provost, before leaving London, did, by means of communications made to Sir James Graham, then First Lord of the Admiralty, and to Lord Palmerston, then Home Secretary, endeavour to get the bill recommitted; but from the advanced period of the session this was found to be impracticable; and the deputation, after consulting the committee of Council in Glasgow, authorized a notice of motion, which had been actually given in the House of Commons for its recommittal, to be withdrawn. The procedure at this last stage will be best learned from the following

REPORT BY THE DEPUTATION.

It is with no ordinary feelings of regret that the deputation have to report, officially, the rejection of the bill; the Committee of the House of Commons, in consequence of the adverse report of the Lords Commissioners of the Admiralty, having found the preamble not proved.

The report of the Admiralty was not published till after the Committee had adjourned, on 28th March last, to allow time for investigating an allegation made by the opponents of the bill, that the water of Loch Katrine was so pure as to be injuriously affected by the action of lead; and that it could not, therefore, be delivered with safety to the inhabitants through leaden pipes.

To that important inquiry immediate attention was given; because, upon the result depended whether the bill, in so far as regarded a supply of water to the city from Loch Katrine, could, under any circumstances, be proceeded with.

So soon, however, as it was found that the evidence to be adduced would show, in the most satisfactory manner, that the water could be delivered with perfect safety to the inhabitants, a memorial was immediately prepared and forwarded, through Mr. Macgregor, to Sir James Graham, pointing out the erroneous data on which the report of the Admiralty was founded, and setting forth correctly the true circumstances of the case. An interview was also requested with Sir James Graham, which he granted; at which, although he would not agree that the report of the Board should be withdrawn, he expressed his willingness that evidence

to rebut the allegations in the report should be given by the promoters before the Committee on the bill, the effect of which he would subsequently consider ; and without pledging himself to any precise course, stated that he would be disposed to withdraw further opposition if the evidence relied upon in the report should appear to be shaken.

The Committee on the bill re-assembled on 9th May last, when both the promoters and the opponents of the bill naturally expected they would have proceeded to hear the evidence regarding the purity of the water, to adduce which the adjournment had been granted. That evidence, which the deputation consider most conclusive and satisfactory, has been printed, and a copy will within a few days be sent to each member of Council.

In place, however, of allowing the promoters to adduce that evidence, the Committee intimated their desire in the first place to consider the Admiralty report, which, from the first, they said they thought would be fatal to the preamble of the bill. As a favour to the promoters, they agreed, however, to hear evidence tending to rebut that report, but intimated that such evidence should be limited to two witnesses. With this determination the deputation had no alternative but to comply ; and as the best means of informing the Council of what subsequently took place before the Committee, the deputation now submit printed copies of the minutes of the proceedings of the Committee, containing the evidence adduced, with reference to the report of the Admiralty. That evidence, the deputation think, speaks for itself, and is quite satisfactory. It had not, however, the desired effect ; as the Committee, by a majority, found the preamble of the bill not proved, on the ground of the Admiralty report.

In arriving at this determination, it is believed the majority of the Committee were very much influenced by a statement made by the counsel for the Admiralty, to the effect " that the evidence, so far as it had gone, had been under the consideration of the Admiralty, and that they were of opinion it had disclosed no facts that were not known and considered before the report was drawn up, or that could militate against the principles and conclusions contained in that report."

After this unfortunate result, the deputation were anxious to have had a further interview with Sir James Graham, which was requested on their behalf by Mr. Hastie, but declined by Sir James, on the ground that individually he could not interfere, but

that he would give every attention to any further representation on the subject which might be made to the Board.

A statement was accordingly prepared, copies of which are now submitted. Along with that statement the deputation transmitted a copy of the evidence above referred to, adduced before the Committee, in the hope that on perusing it the Lords of the Admiralty would have seen cause to withdraw their opposition, and allow the bill to proceed.

In this expectation, however, the deputation were disappointed, as, by their answer to Mr. Hastie, the Admiralty intimate that they cannot now interfere further in the matter.

But at a subsequent interview the Lord Provost had with Sir James Graham (which had been arranged for before the official answer was received), Sir James stated that he would not oppose a recommittal of the bill.

From the importance of the measure in a sanitary point of view to the city of Glasgow, the Lord Provost also considered it his duty to apply to Lord Palmerston, as Secretary of State for the Home Department, on the subject; which he did by the letter dated 20th May, a copy of which is subjoined to this report.

It was also strongly urged upon the Lord Provost, who, with Mr. Forbes, Town Clerk, remained in London till the determination of the Admiralty should be known, that an attempt should be made to get the bill recommitted; and after deliberate consultation with parties competent to advise, and after seeing the members of Committee, it was resolved that the requisite notice should be given. But it was afterwards found, as the session was expected to be a short one, that unless some arrangement could be made with the opponents of the bill, by which further opposition would be avoided, there was little chance of there being sufficient time to carry the bill through both houses of Parliament, even should the Committee be inclined to pass it. After consulting with the committee of Council, the notice for recommitting the bill was therefore withdrawn.

In concluding this report, the deputation must again express their great regret that a department of the Government should have felt itself called upon to oppose a bill so essential and important, in every point of view, to the city of Glasgow; and as the necessity of a further and more abundant supply of pure water to the city is admitted by every one, the deputation hope that before

the next session of Parliament some means may be found by which the objections of the Admiralty will be removed, so as to enable the Town Council still to obtain the necessary powers for bringing that supply from Loch Katrine; which the deputation believe would be one of the greatest benefits ever conferred on the city of Glasgow.

6th June, 1854.

ROBT. STEWART, *L. P.*

JAMES GOURLAY.

JAMES SCOTT.

Thus terminated the Parliamentary proceedings adopted in promoting the bill of 1854, which cost the citizens, as was afterwards reported to the Council, no less than £11,094, 10s. 10*d.*, and this sum, added to the Parliamentary expenses incurred in the previous session by the opposition, to the Water Company's bill, increased the bill of costs to upwards of £17,000, and still nothing accomplished! But although Parliamentary proceedings were for a time stopped, discussion and strife at Council meetings did not by any means cease, but rather became more intensified and violent. The proceedings of the deputation and their report were unanimously approved of by the large general committee of Council on the bill; yet much unpleasant discussion, mingled too often with unseemly personal vituperation and threatening protests, frequently occurred, which it would serve no good purpose to record in detail here; such detail, it is thought, may be with more propriety overlooked and forgotten. At length the Lord Provost in Council moved, seconded by Mr. M'Adam, the approval and adoption of the report of the deputation, which, with its relative documents, had been printed and distributed among the members. Mr. Gemmill, as usual, moved an amendment, which on this occasion was, that the report be not approved of; and an angry discussion ensued, which, incredible as it may seem, was protracted for three hours and a half, during which points of order and privilege, personal quarrel, and other extraneous matter were discussed *ad nauseam*; but little light certainly was thrown on the real merits of the question. On a division,

the Lord Provost's motion was carried by a majority of 30 to 9 ; and Mr. Gemmill again protested, that if the expense of the new bill as well as of that defeated was paid out of the Corporation funds, it would be at the risk of the majority. So much for the bill of 1854.

The procedure of the Council in order to promote another measure, the bill of 1855, soon afterwards commenced. And it is pleasant to note that it was evidently entered upon, even at this early stage, in a far more conciliatory spirit by all parties. The former combatants seemed as if they had exhausted their strength in war, and had become willing to study the arts of peace. At a meeting of Council held on 31st August, 1854, the Lord Provost moved the appointment of a committee "to consider and report as to the best means to be adopted with a view to the introduction of an abundant supply of water by gravitation from Loch Katrine; *with power to adopt such measures as will remove objections*, and enable the committee to report fully to the Council ;" which was seconded by Mr. Scott ; and the only amendment now proposed was one by Mr. Dreghorn, to the effect that after the words "Loch Katrine" the words "or elsewhere" should be inserted, intending thereby that other sources of supply might also be considered ; which was at once agreed to as perfectly *harmless*. And a committee of twenty-one members was appointed to carry out the resolution,—viz., the Lord Provost ; Bailies Gourlay, Mitchell, Harvey, and M'Dowall ; the Dean of Guild, Sir James Anderson, and Messrs. Scott, Bankier, Orr, Moir, Gray, Drummond, John Thomson, Murray, M'Adam, James Taylor, Dreghorn, D. Y. Stewart, Pearson, and Young. This committee met on 7th September, when the whole question was fully discussed and considered, and a sub-committee appointed to consult Mr. Bateman on the present state of matters, and also, if they deemed it necessary, to appoint one or more other engineers to consult with him, and report on the subject, particularly as to the objections of the Admiralty. A sub-committee was afterwards named out of the large committee, with full discretionary powers, and consisted of the Lord Provost,

Bailies Gourlay and M'Dowall, and Messrs. Orr, Scott, Gray, Moir, and James Taylor.

The committee immediately proceeded to take the usual preliminary steps for promoting another bill, contingently on their getting a favourable opinion from the engineers to be consulted, in order that another session of Parliament might not be lost. Arrangements were also speedily made with the former opponents; and on reporting progress at a meeting of Council on 2d November, the Lord Provost was enabled to make the following very satisfactory statement:—

After the re-appointment of the committee (said his Lordship), we put ourselves in communication with several parties; but the first thing we did was to appoint two eminent engineers. Our object was to obtain the aid of gentlemen who stood at the very top of their profession, who were unconnected with this part of the country, and who had never been employed in any scheme for supplying Glasgow with water. The gentlemen we obtained were Mr. Stephenson, M.P., Engineer of the Menai Bridge, and Mr. Brunel, Engineer of the Great Western Railway. We obtained the services of these eminent men with some difficulty, especially in the case of Mr. Stephenson, who has of late declined to undertake work of this kind. They have already been over the ground, including the Gorbals Works and the sources of supply in the Highlands, and they have also visited the Forth, that they might be able to give evidence on that point if required. We have not yet been furnished with their report; but we hope they will be satisfied that the Loch Katrine scheme is the best. If their views are adverse to this scheme, then it will drop; but if they recommend it, as has been done by other engineers, then it will be the duty of the Council to go on with that scheme, in terms of their recommendation. After this we put ourselves in communication with the Commissioners for the Forth Navigation. These gentlemen are composed of the Town Council of Stirling, with representatives from the counties of Perth, Stirling, and Clackmannan. After visiting and negotiating with them in Stirling, and after they had met us here, we have arranged to pay them the sum of £7,000, in lieu of all damage which may be done by our works to the navigation of the Forth. This will enable them to procure a dredging machine, and to take away the fords which injure the

flow of the river. Our next duty was to arrange regarding the salmon fishings of the Forth. There are certain clauses regulating compensation in all the Fishery Acts, and we offered them these in the first instance; but we afterwards offered them others; and I think the new arrangement is better than any that could be effected by these old clauses. We were told that the city of Perth had such clauses for the Tay, and that they had been the means of expensive and troublesome arbitrations. In some cases there had been an increase, and in others a decrease in the fishings; and in these cases the Corporation of Perth found itself called on to pay for the decrease which took place, while they got no advantage from any increase which arose. This being the case, and the sum involved not being large, we thought it better to settle the matter at once and finally,—that is, we pay £80 per annum for the Stirling, and from £30 to £40 for the Craigforth fishings, while there are some others, the payment for which is merely nominal. This, of course, only takes place in the event of the Craigforth proprietors agreeing to accept the arrangement, of which I think there is little doubt. When, for the sum of £130 or thereby, we will get rid of all questions of law and arbitration, I think it is most desirable that the arrangement we propose should be completed. Next we come to the case of the Gorbals Water Company. I was authorized by the general committee, and afterwards by the sub-committee, to meet with one of these gentlemen, and to endeavour to come to some arrangement. I made a similar attempt last year; but I did not then accomplish it. But this year I have accomplished it. The bargain we have made is to pay them 6 per cent. upon their capital stock of £180,000. Before doing so, and before fairly concluding the bargain, we thought it right that an experienced accountant should examine the books of the Company, from the commencement of the undertaking till the present time—to see, in short, that all was straightforward. This examination has been made, and I hold the report of the accountant in my hand. It is a most voluminous document; but the result is, that after a most searching inquiry, everything has been found quite right. Our accountant says that the books are better kept than almost any other books that have come under his notice. He gives all the details; but in the present stage of the business it would not be proper that I should state them here. This I may state, however, that the revenue is gradually increasing, and that the sum of six per cent. is legitimately paid out of revenue. They

have a large sum at their credit in their profit and loss account. The revenue is increasing, and our accountant says it will continue to increase. The new reservoirs will afford a large surplus of water; and if this is not required for Gorbals, it will enable us so far to assist the north side until we get the larger supply from Loch Katrine. I hope this arrangement will be found satisfactory. I may only state that the Directors of the Gorbals Company gave every facility for the examination of their books and affairs, and upon their part everything was open and fair. These works have also been examined by Mr Bateman. They are capital works, and have been completed to the satisfaction of all those connected with them. Your committee, after making this arrangement, considered it right to look to the other opposition which had been made to the last Loch Katrine bill. In the first place, we had the inhabitants of Gorbals. Last year we announced that we would ask the same rates from Gorbals as were to be charged from the inhabitants on the north side of the river. By many this was considered scarcely fair; for the Gorbals people had already an Act of Parliament entitling them to a supply of water at a rate not higher than 5 per cent. This being the case, I recommend that we should insert a clause in the new bill, to the effect that in all time coming we should not charge the inhabitants more than they are paying at present. Having done this, we shall get quit of opposition from the Gorbals inhabitants. They ask no more; and their leading men are pleased with the arrangement we are about to make. I next come to what is known as the public rate. Last year we were to charge 2*d.* in the pound. The landlords met us in London with a proposal to pay 1*d.* in the pound. The deputation in London had not power to agree to this proposal; but this year I propose that the landlord's rate should be 1*d.* in the pound; and thus we will get quit of opposition from that quarter. Even by the bill of last year, had it passed, the public rate would have come down to the penny in the course of a very few years. I am not aware of any other opposition, unless it should start up from some head-quarter. Of course, the old Company are quite willing that the arrangement of last year should still continue. The arrangement we then made is quite agreeable to them. There is just one other question to which I have to allude, which is before us, and that is the action of the water upon lead. I need not, I think, go into details upon this subject. You have all read the report of our own chemists, and you are, no doubt,

aware that there is a report upon the lead question from other chemists. The members of the committee have seen that latter report, and do not think that there is much in it, nor do the Gorbals Directors themselves think there is anything in it. We have sent it to our own chemists, and they have expressed a similar opinion regarding it. The Gorbals chemists make no allusion to towns supplied with water of the same kind as Loch Katrine, such as Aberdeen, Whitehaven, and Inverness, where as yet no person has been poisoned or hurt. I may also mention that the proprietors along the line, including the Duke of Montrose and Lord and Lady Willoughby, have been settled with this year, as they were last year; and I take pleasure in saying that the duke has personally taken a great interest in this measure. I have seen him often, and heard from him often on the subject, and he has shown much anxiety to promote the interests of Glasgow in this respect. He said, indeed, that connected with this city as he is, that it would ill become him to do anything which might prevent Glasgow obtaining a full supply of pure water. Lord Moray has also arranged with us very satisfactorily. I have also to state that Mr. Buchanan of Carbeth is again willing generously to give us his ground for nothing. All the opposition, therefore, that can come from landholders along the line is confined to one small question of pounds, shillings, and pence. It is now necessary that I should say something regarding the Admiralty. The Admiralty gave their report last year at the request of the Commissioners for the Forth Navigation. These gentlemen have now been settled with, and I have no doubt their opposition will be got quit of. The Admiralty said in their report that they had no other object in view but that of protecting the navigable rivers under their charge. These rivers have been protected; they have received compensation; and I think that these gentlemen (the Admiralty officers) having no object in view but to do their duty faithfully and conscientiously—and as we have settled with the local gentlemen,—when this is the case, I say, I have no doubt that the Admiralty will withdraw its opposition when the bill is before them, and they will perhaps withdraw it even before then. In conclusion, I have to state that we have received valuable assistance from many gentlemen. I may mention the name of one gentleman who, at much inconvenience, came from his country seat to assist us. He has aided us in his capacity as proprietor of fisheries, and as a proprietor along the Forth. I allude to Mr.

Stirling of Kippendavie. Indeed, but for his assistance, I am afraid that these negotiations would have been broken off. He helped us materially in connection with the salmon fishery question and the compensation to the Forth Commissioners, and I know that he will do all in his power to assist us in securing the removal of the other obstacles. After some further observations, his Lordship congratulated the Council on the almost certain prospect of carrying this great measure, and concluded by moving the approval of the report.

This statement was received by the Council with much "gratification at the business-like manner (as Mr. Gemmill expressed it) in which this matter was now proceeded with," alleging, as he did, that "if the same course had been followed last year, they would in all probability by this time have been in possession of an Act of Parliament for supplying the city with water." After some remarks by Sir James Anderson, Andrew Orr, Esq., and other members, the minutes and report referred to in the motion were unanimously approved of; and it was remitted to the committee to proceed with the bill: whereupon the Lord Provost congratulated the Council on their unanimity, there being, out of the fifty members composing the Council, no fewer than forty-nine present. And this being the last meeting of Council at which the Lord Provost would preside, Bailie Gourlay moved, as is usual on the occasion of Provosts retiring, "that the best thanks of the Council be tendered to the Lord Provost for the very efficient and faithful manner in which he has discharged the duties, and for the many and important services rendered by him to the Council and to the community at large, especially during the time he has held the office of Lord Provost;" which motion, strange to say, was seconded by his former opponent, Mr. Gemmill; and being supported by Bailie M'Dowall, was unanimously and enthusiastically adopted.

The term of office of Lord Provost Stewart having thus expired, and another election of Councillors having taken place, the new Council, on 7th November, 1854, elected as his successor Andrew Orr, Esq., now Sir Andrew Orr of

Harviestoun; and Mr. Stewart having been again returned to the Council by the ward he formerly represented, he and Mr. Orr were re-appointed members of the committee on the water supply. From the time of his election, Lord Provost Orr took a very active part in the business of this committee—attending every meeting, besides presiding at meetings of Council. It may be here mentioned, as best indicating his attention to the business, that he appears from the minutes to have attended from that time twenty-five out of twenty-six consecutive committee meetings, and was besides a member of two deputations of three to London,—one in the month of March to promote the bill in the House of Commons, and the other in June to support it in the House of Lords. His tact and experience were essentially serviceable, particularly in the negotiations for arrangements with former opponents, many of which were not concluded prior to his election; and several troublesome and difficult questions arose in adjusting special *terms* of agreement, one of which became the subject of a reference to Mr. Sergeant Wrangham and Mr. Hope Scott. He corresponded also, in his official capacity, with the Board of Admiralty as to the removal of their objections; and the clauses of the bill, which, after being considered in committee, underwent considerable discussion at meetings of Council under his presidency; so that he contributed largely to the conciliatory measures which were adopted for carrying the bill to a successful issue.

The report of Messrs. Stephenson and Brunel, which had been long and anxiously waited for, was received by the committee in the month of February. In this report it was stated by these eminent persons that, in considering the very important subject which they had been requested to report upon—namely, the supply of water to the city of Glasgow, and more especially the eligibility of the plan proposed by Mr. Bateman for applying the waters of Loch Katrine to this purpose—they had had the advantage of considering the results of many previous inquiries; they had also personally inspected the localities, and had sought for and received the fullest information from the parties to

whom they applied for that information ; they had found that every source of supply which the neighbourhood of Glasgow afforded had been at one time or another suggested, and the advantages and disadvantages of the several plans discussed ; that although they had not adopted many of the various arguments that had been advanced, or founded their own opinions upon them, yet they had the advantage of feeling that no possible source of supply could have escaped their notice ; that in the numerous statements and reports which had been brought under their view, although much might be contained in them with which they could not agree, and much on which it would not be safe to rely, yet nearly every fact useful to be known, and every suggestion worthy of consideration, either in favour of or adverse to the various projects, had thus been brought together. The result of all this extensive and careful investigation, which the report detailed at considerable length, was thus stated :—

From what we have said, it will be evident that it is our opinion, that if a high degree of purity and freedom from colour is desired as regards quality, and if the future power of extending the supply beyond 30,000,000 gallons is a necessary condition as regards quantity, and if the encouragement of manufacturers requiring large quantities of very pure water is considered important, the Loch Katrine project is decidedly to be preferred to any other ; and the manner in which Mr. Bateman has proposed to obtain that supply appears to us judicious. We have referred to the subject of the doubts that have been raised as to the safety of using the Loch Katrine water on account of its power of acting upon lead, a power possessed by most pure waters, which, if it operated practically in the manner alleged, would long since have caused, or would now lead to, the employment of some other material for the pipes and reservoirs : we do not feel called upon to take upon ourselves any responsibility upon such a question. Water of precisely similar quality, and having the same power, has been hitherto so used in contact with lead, without any evil consequences. It is so used in large quantities in many towns and many isolated cases, at the present time, without any practical evil. We should not have had any anxiety on the subject before the point had been specially raised in this case, and so fully dis-

cussed as it has been. We have carefully read all the evidence that has been given, and the statements of experiments, and the reports made ; and we cannot find any evidence that would lead us to expect any practical inconvenience, but, on the contrary, strong evidence confirmatory of our previous impression, that in practice this action does not take place, or at least does not produce any injurious results. We should therefore continue to drink such water with the same confidence as hitherto—the confidence of ignorance, we confess, but at the same time, that of experience,—the same which regulates half our actions in this life. We cannot conclude our report without again expressing our opinion of the importance of establishing stringent regulations, and encouraging contrivances and arrangements, for economizing the use of water, particularly in a large and crowded city ; and especially of the importance of attending to this subject at an early stage, and before the population has contracted habits, and constructed their buildings and all the various apparatus connected with water arrangements, in such a way that an excessive supply becomes indispensable, and the application of a remedy all but impossible. We are convinced that all the benefits of an ample supply of water for domestic purposes, as affecting comfort, health, and cleanliness, will be much increased by the results, and even by the habits, attending its economical application.

ROB. STEPHENSON.

I. K. BRUNEL.

The committee unanimously approved of this report, and ordered it to be submitted to the Council, with a recommendation that, in terms of their previous contingent resolution, the bill should now be proceeded with ; and at a meeting of Council, held on 22d February, this recommendation was at once adopted, *one member only* now dissenting.

The Committee of the House of Commons met on 19th April, the arrangements with former opponents, above referred to, having been in the intermediate time all completed—Sir William Somerville in the chair. Mr. Sergeant Wrangham, Mr. Hope Scott, and Mr. Sergeant Bellasis appeared as counsel for the promoters, there being no appearance for any opponent, except the Magistrates and Council of Renfrew, for a clause which was conceded. Mr. Sergeant

Bellasis was heard to open the case on behalf of the promoters, and four witnesses were examined, *pro forma*, briefly, viz. :—Robert Stewart, Esq., Mr. Brunel, Dr. Alfred Swaine Taylor, Dr. Forbes, of Inverness, and Mr. Bateman. At the close of Mr. Bateman's evidence, the chairman announced that in the opinion of the Committee the preamble of the bill was proved.

The Committee then adjourned till the following Monday to consider clauses, and at the adjourned meeting Mr. Hope Scott stated that all opposition had been met and arranged, but that at the last meeting the Committee had raised the question of public fountains or public stand-pipes, and he had to submit that it was very undesirable to introduce any alteration on the bill as it now stood, and urged reasons for this; whereupon the chairman intimated to the learned counsel that the opinion of the Committee was that there should be not fewer than thirty-two fountains in the city of Glasgow, distributed in such proportions as the Commissioners should determine. A clause to meet this view was submitted to the Committee, and agreed to, and the chairman was directed to report the bill with its amendments to the House. The bill being accordingly reported, was read a third time and passed.

The usual steps were immediately taken for carrying the bill to the House of Lords; and then, to the surprise of everybody, a new opponent appeared in the person of Mr. David Bell of Blackhall and Craigmore, as an *individual* citizen of Glasgow. He was the *only* petitioner to the House of Lords against it, and a Committee of the House met to consider it on 18th June, 1855—the Marquis of Westminster in the chair. The same counsel and agents appeared for the promoters; and Mr. Bell appeared "*in person*" in support of his petition. Mr. Sergeant Bellasis being heard in support of the bill, submitted that Mr. Bell had no *locus standi*; and the Committee, after hearing Mr. Bell in answer, sustained the objection, which speedily put an end to Mr. Bell's pretensions. The merits of the scheme, with the report of the Admiralty, were then considered; and Mr.

Stewart, Dr. Alfred Swaine Taylor, and Mr. Bateman being again examined as witnesses (in respect, as the chairman explained, of the Admiralty's report, which had not been withdrawn, although no appearance was now made in support of it), the Committee thereupon decided that the preamble of the bill was proved. The clauses were then read, and, with a few immaterial amendments, agreed to; and the bill being as usual reported to the House, was then read a third time and passed, and received the royal assent on 2d July, 1855.

The deputation having, on their return to Glasgow, reported this result to the Council on 12th July, 1855, their gratifying report was of course approved of; and on the motion of James Moir, Esq., seconded by Bailie George Mitchell, the thanks of the Council were unanimously voted to Mr. Stewart "for the great interest he had taken in this important measure, and for the successful issue to which he had brought it;" and Mr. Stewart acknowledged the compliment paid to him. Thus at last ended the long, exciting controversy in the Council, as well as in Parliament; and the greatest boon ever conferred on the inhabitants of Glasgow was finally secured. The Parliamentary expenses had now increased to the large sum of £25,954, 15s. 1d.!

THE POWERS AND PROVISIONS OF THE GLASGOW CORPORATION WATER WORKS ACTS.

These will be best learned by referring to the Acts themselves; but a concise digest or outline of them here may not be unacceptable.

The first of these Acts (18 and 19 Vict., cap. 118) is entitled "An Act to authorize and empower the Magistrates and Council of the city of Glasgow to supply with Water the said city, and suburbs thereof, and districts and places adjacent; to purchase and acquire the Glasgow Water Works and the Gorbals Gravitation Water Works; and to introduce

an additional supply of Water from Loch Katrine; and for other purposes." The preamble, after reciting all the Acts connected with the supply of water to Glasgow and Gorbals from 1806 downwards, narrates that the present supply of water to the city of Glasgow, suburbs thereof, and places adjacent, is inadequate and insufficient, both in quantity and purity, for the wants and convenience of the present and rapidly-increasing population, trade, and manufactures of the said city and suburbs and places adjacent; that it is expedient the supply of water to the said city and suburbs and places adjacent should be provided by and placed under the control, regulation, and management of the Magistrates and Council of the said city; that the undertakings of the company of proprietors of the Glasgow Water Works, and the Gorbals Gravitation Water Company respectively, and their whole rights and privileges, lands, buildings, streams, reservoirs, works, and other property, should be vested in the said Magistrates and Council; that it is necessary for the health, comfort, and convenience of the inhabitants that a more abundant supply of good, pure, and wholesome water should be afforded to the inhabitants; that the Magistrates and Council of the said city are desirous, and it would be of public advantage, that they should, as Commissioners for that purpose, be authorized to introduce such additional supply of water from Loch Katrine into, and to distribute the same to and among the inhabitants of, the said city, suburbs thereof, and districts and places adjacent; and for that purpose, and for the purpose of affording a supply of water to the parties at present interested in the water flowing from the said loch, to impound, take, and draw off the water of the said loch, and to make and maintain such aqueducts or conduits, and to lay down, make, and maintain such lines of pipes, and to execute all such other works as may be necessary for these purposes; that they should also be empowered to make and maintain, in connection with the said works, a service or distributing reservoir at or near to Muirhouse of Drumclog, near the village of Milngavie, in the county of Stirling, and to convert Loch

Venacher and Loch Drunkie, both in the county of Perth, into compensation reservoirs, by raising and drawing down the waters thereof.

After this recital of general objects, the Act contains the following leading provisions:—

1. *Administrative.*—The Magistrates and Council of Glasgow, and their successors in office, are appointed Commissioners; and they are empowered to appoint out of their own number a committee, to be called “THE WATER COMMITTEE,” for carrying into execution the purposes of the Act. The Treasurer is directed to keep a separate and distinct account, to be called “The Glasgow Water Account,” of all moneys received and paid; and the Commissioners are vested in the undertakings of the two former Companies, with their whole rights and privileges, lands, buildings, streams, reservoirs, works, and other property (but subject always to the burdens, debts, and obligations of the Companies)—for which the Commissioners are to make compensation: the compensation in the case of the Glasgow Company to be fixed by agreement or arbitration, and in the case of the Gorbals Company by paying them a fixed allowance, at the rate of six per cent per annum on their capital stock of £180,000.

By the decree arbitral afterwards pronounced in an arbitration with the Glasgow Company, their capital was fixed at £345,380, partly ordinary and partly preference stock; and on the former, amounting to £303,700, the shareholders were allowed four and a half, and on the latter, amounting to £41,680, six per cent.

The compensation thus fixed to the shareholders of the two Companies respectively is directed to be paid by perpetual annuities, to be called “The Glasgow Corporation Water Works Annuities;” and the Commissioners are authorized to issue annuity debentures to every shareholder for the share or shares held by him; which are directed to be registered, numbered, renewed, and paid or transferred in the form and manner prescribed. The annuities are declared to be moveable or personal estate, and

transmissible as such, and not to be of the nature of real or heritable estate.*

2. *Works*.—The Commissioners are authorized to make, construct, and maintain the works delineated on the Parliamentary plans and sections, and all necessary reservoirs, conduits, works, and conveniences connected therewith, and to enter upon and compulsorily take and use such lands, lochs, streams, and waters as shall be necessary for the purpose. But they are restricted from raising or storing the water in Loch Katrine, without consent of proprietors, to a greater height than four feet above the ordinary summer level, and from drawing the water down to a greater extent than three feet below that level; and in Loch Venacher, to any greater extent than one foot above or one foot below the levels shown on the sections—that is, five feet eight inches above, or six feet below, the ordinary summer level, thus giving there eleven feet eight inches of range: the Commissioners may also raise Loch Drunkie twenty feet.

The Commissioners are further restricted from taking any greater quantity of water from Loch Katrine, for the supply of the city, suburbs, and places adjacent, within the limits of the Act, than 50,000,000 gallons in any one day, reckoned from midnight to midnight; and are taken bound to cause to flow from and out of Loch Venacher, for the supply of the river Teith and the various mills and other property situate thereon, not less than 6,480,000 cubic feet during every day in the year, such daily quantity to be discharged into the said river at the time and in the proportions following; (that is to say) 6,000 cubic feet of water per minute for twelve hours of every day, and 3,000 cubic feet of water per minute for the remaining twelve hours of every day; the larger quantity to be discharged into the said river between the hours of one o'clock in the morning and one o'clock in the afternoon, or thereabouts. And provisions are introduced for these restrictions and obligations

* This provision extended to mortgages, by 28 Vict., cap. 69, sec. 18.

being observed, by requiring the construction, maintenance, and inspection of gauges, &c.

The Commissioners are also required, in the construction of the new artificial outlets or other works at the mouth or outlet of Loch Katrine and Loch Venacher respectively, so to construct the works and regulate the flow of water therefrom, that salmon or other fish may at all times, or during such time as water shall be discharged, freely pass into or from the said lochs respectively. The Commissioners are empowered from time to time to alter, enlarge, or increase the number of the pipes for conveying water from Loch Katrine to the city and suburbs and places adjacent within the limits of the Act, under this proviso, that the supply of water, within the limits of the Act, on the south side of the Clyde from the Gorbals works, shall not be diminished to the prejudice of consumers of water within the district.

3. *Water Supplies*.—The limits of the Act are declared to comprise and include the city of Glasgow and suburbs thereof, and districts and places adjacent, including the royal burghs of Rutherglen and Renfrew, the burghs, towns, or villages of Partick, Pollokshaws, Govan, Barrhead, Nithill, and Hurlet, and places intermediate and adjacent. And the limits for compulsory supply, to comprise the ancient royalty of the city and royal burgh of Glasgow, as the same are defined and described in an Act passed in the 2d and 3d years of King William the Fourth, entitled “An Act to amend the Representation of the People in Scotland,” or as may from time to time be defined in any amendment of that Act. The Commissioners are required to cause pipes to be laid, and water to be brought, throughout all the *streets* within the limits of compulsory supply (communication pipes and other apparatus being provided, laid down, and maintained at the cost of the owner or occupier), a sufficient supply of water for domestic purposes, including a supply for any water-closet or closets and fixed bath or baths in dwelling-houses. The supply of water for domestic purposes beyond the limits of compulsory supply to be also

given when required by so many owners or occupiers of houses as that the aggregate amount of water rate payable by them annually, at such rates as may be fixed by the Commissioners, shall not be less than one-tenth part of the expense of providing and laying down the pipes; but such requisition not to be binding on the Commissioners unless such owners or occupiers shall severally execute an agreement binding themselves to take such supply for three successive years at least—the burgh of Renfrew only excepted as to the latter conditions.

The Commissioners may also furnish a supply of water for other than domestic purposes, at such rates and upon such terms and conditions as shall be agreed on between the Commissioners and the persons desiring the same; and it is provided that as far as possible the rates for such supplies shall be uniform to all persons in the same circumstances and requiring the same extent of supply.

4. *Rates.*—The Commissioners are required once in every year to estimate the money necessary to be levied for the purposes of the Act, and to assess and levy (1.) A rate, to be called “The Domestic Water Rate,” from the occupiers of all dwelling-houses, and of such parts or portions of all shops and buildings as may be used as dwelling-houses, upon the full annual value of such houses, shops, and buildings, and of any gardens or land attached or belonging thereto respectively. (2.) A rate, to be called “The Public Water Rate,” from the owners of all kinds of property within the limits of compulsory supply, not exceeding one penny in the pound of the full annual value of all such property, excepting the property of any Railway Company or Canal Company, the stations, depots, and buildings of which Companies being only rateable; provided also that the owners of any garden not attached to, or occupied with a dwelling-house, and of all arable, meadow, or pasture land within the said limits, shall be rated according to one-fourth part only of the annual value thereof respectively; and that no person who shall be the owner of any of the foresaid descriptions of property and premises shall be liable to be rated to either of the said

rates in a greater proportion than according to one-fourth part only of such annual value, unless the mains or other pipes of the Commissioners shall be laid down and properly supplied with water, within fifty feet from the outer wall, fence, or boundary of such premises. (3.) Rates are also authorized to be levied beyond the limits of compulsory supply, but within the limits of the Act, as the same may be fixed by the Commissioners; but it is provided in regard to the latter, that the rates shall not exceed on the north side of the river Clyde the rates authorized to be levied by the Acts relating to the Company of proprietors of the Glasgow Water Works, and on the south side, the rates authorized to be levied by the Acts relating to the Gorbals Gravitation Water Company. (4.) Power is given to rate the *owners* of all dwelling-houses not exceeding £10 of yearly rents, instead of the occupiers, allowing the owners an abatement of 10 per cent. (afterwards increased to 20 per cent. in the case of houses under £7, and to 15 per cent. in the case of houses rented from £7 to £10). An appeal to the Commissioners, and afterwards to the sheriff, by parties dissatisfied with the rating by the surveyor, is also provided.

5. *Borrowing Powers.*—The Commissioners are authorized to borrow on mortgage, or on bank credit account, any sums not exceeding £700,000; the money to be applied in defraying the expense of purchasing and acquiring lands and other property, and of executing the works authorized by the Act, and to no other purpose whatsoever. The Commissioners may fund debt, and issue certificates of funded debt in the form and manner prescribed; and provision is made for setting apart a sinking fund from and out of any surplus moneys appearing upon the yearly balance of the Glasgow water account.*

Such is a condensed outline of the powers and provisions of the Glasgow Corporation Water Works Act, 1855. Four

* The borrowing powers were largely increased by subsequent amendment Acts.

amendment Acts were afterwards passed, viz.:—(1.) An Act to authorize the Commissioners to raise a further sum of money, and to amend the Act of 1855 (19th April, 1859). (2.) An Act to authorize the Commissioners to raise a further sum of money (15th May, 1860). (3.) An Act to authorize the Commissioners to construct a bridge for carrying the aqueduct from Loch Katrine to Glasgow over the river Endrick; to provide for the better distribution of water; and for other purposes (2d June, 1865). And, (4.) An Act to authorize the Commissioners to construct reservoirs and other works, and to take water from the river Clyde; to provide for the removal of the weir across the said river; and for other purposes (6th August, 1866). But it is not necessary to detain the reader with any detail of the special provisions of these Acts. Let it suffice to observe that the chief object of the first three was simply to enable the Commissioners to carry out more effectually the first Act of 1855; and the fourth will not only enable the Commissioners to provide a further supply of water for manufacturing purposes, thereby saving to that extent the purer water of Loch Katrine for domestic purposes, and for certain trade processes requiring water of greater purity, but it will also enable the Clyde Navigation Trustees to accomplish the removal of the weir, so long called for, and so much an object of desire by the inhabitants.

THE EXECUTION OF THE WORKS UNDER THE ACTS.

Immediately after the passing of the Act of 1855 the Commissioners met to carry it into effect. On the fourth Thursday thereafter, as the Act directed, their first meeting was held—Lord Provost Orr in the chair; and on his motion the meeting at once proceeded to appoint the “Water Committee” authorized; and resolved that it should consist of sixteen members, one to be selected from each of the sixteen wards of the city. The first committee consisted of the following members, viz:—

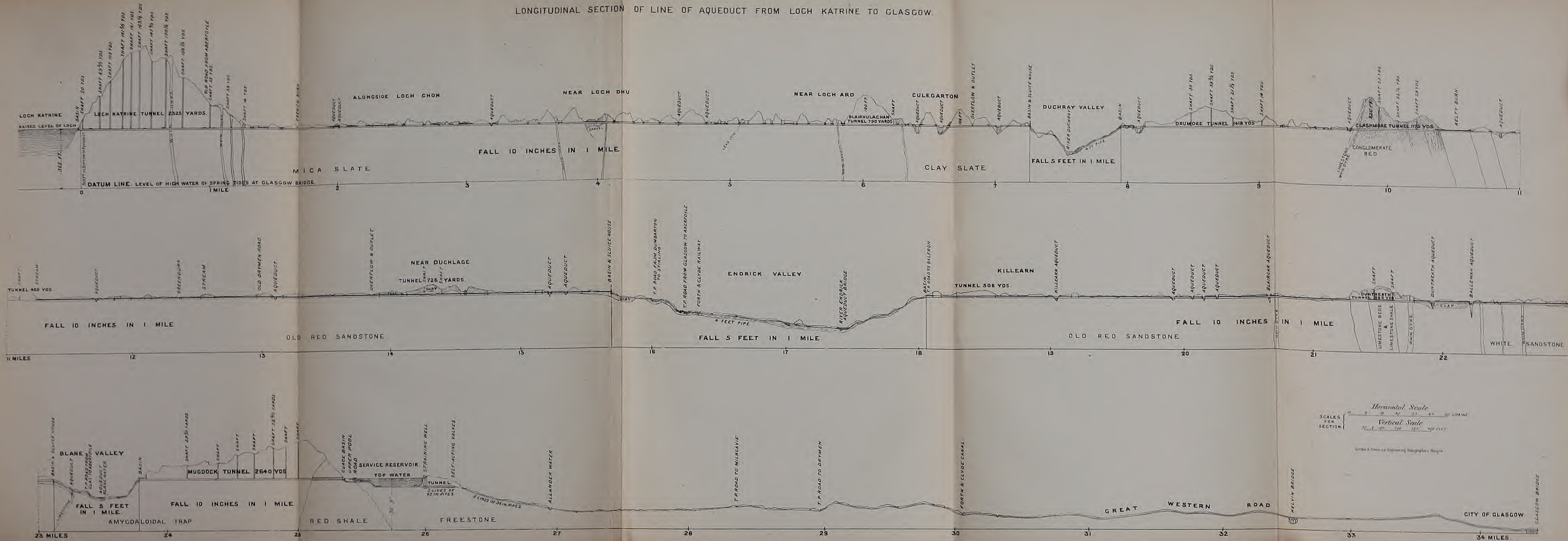
JOHN THOMSON, Esq., from First Ward.
 JAMES MOIR, Esq., from Second Ward.
 ROBERT NEILSON, Esq., from Third Ward.
 CHARLES GRAY, Esq., from Fourth Ward.
 JOHN STEWART, Esq., from Fifth Ward.
 THE LORD PROVOST, from Sixth Ward.
 JAMES DRUMMOND, Esq., from Seventh Ward.
 JAMES GOURLAY, Esq., from Eighth Ward.
 JAMES HANNAN, Esq., from Ninth Ward.
 ROBERT STEWART, Esq., from Tenth Ward.
 JOHN M'DOWALL, Esq., from Eleventh Ward.
 WILLIAM MURRAY, Esq., from Twelfth Ward.
 DR. JOHN AITKEN, from Thirteenth Ward.
 WILLIAM MACADAM, Esq., from Fourteenth Ward.
 ANDREW GEMMILL, Esq., from Fifteenth Ward ; and
 WILLIAM ALLAN, Esq., from Sixteenth Ward.
 ROBERT STEWART, Esq., to be *Convener*.
 JAMES GOURLAY, Esq., *Sub-Convener*.

Under this committee, changed and renewed as it was from time to time, the Act was vigorously carried into execution. Their first proceeding was to arrange terms with Mr. Bateman for superintending the execution of the works, and, having done this, to appoint him Engineer; the next, to appoint a Clerk and Secretary, and a Treasurer, with appropriate duties. Instructions were then issued for the preparation of Specifications for Contracts; and, on Mr. Bateman's recommendation, the following judicious divisions were adopted, and advertisements from time to time were published, and estimates obtained, as follows, viz.:—For

No. 1, or Blairhulachan Contract, for the Aqueduct from Loch Katrine to the Valley of the Duchray Water,				£92,500	5	1½
No. 2, or Mugdock Tunnel Contract (betwixt Strath- blane and Mugdock),				20,500	0	0
No. 3, or Mugdock Reservoir Contract,				40,158	15	0
No. 4, or Keltie Contract, for the Aqueduct from the end of No. 1 to the commencement of the Piping at the Valley of the Endrick,				99,000	0	0

Carry forward, £252,159 0 1½

LONGITUDINAL SECTION OF LINE OF AQUEDUCT FROM LOCH KATRINE TO GLASGOW





	Brought forward,	£252,159	0	1½
No. 5, or Duntreath Contract, for the Aqueduct from the end of the Piping at the Valley of the Endrick to the commencement of the Piping across the Blane at Strathblane,		48,573	9	10
No. 6, or Pipe-laying Contract between Mugdock Reservoir and the City,		18,226	9	11
No. 7, or Works at the outlets of Loch Katrine and Loch Drunkie,		8,497	4	4
No. 8, or Loch Venacher Contract, comprising Works for raising this Loch and discharging Water from it,		20,538	0	0
No. 9, or Endrick Contract, for Pipe-laying across the River and Valley of the Endrick, joining the Works under Contracts 4 and 5,		9,514	14	5
No. 10, or Blane Contract, Pipe-laying across the Water and Valley of the Blane, joining the Works under Contracts 5 and 2,		4,489	2	6
Contract for the supply of Pipes,		126,394	0	0
Contracts for the supply of Pipes for the City—Two Contracts,		24,074	12	6
For Pipe-laying in the City,	£8,300	7	7	
For taking up Old Pipes,	1,855	17	9	
		10,156	5	4
		£522,622	18	11½

It was very satisfactory to the Commissioners to find, when the execution of the whole line of works was thus contracted for, that the aggregate amount of the various Contracts was actually within that of the Parliamentary Estimates.

The Water Committee having resolved to celebrate the commencement of the execution of the works by a suitable ceremonial, the 20th May, 1856, was fixed for this purpose; and on the morning of that day the committee, accompanied by a number of the Magistrates and other Commissioners, proceeded by Loch Lomond to the head of Loch Chon, where the work was to commence, and there met some owners and lessees of land on the line, and a few invited friends. When the company had assembled, and formed a circle on a mound or rising ground at the spot, Mr. Stewart, as chairman of the committee, addressed the meeting, explaining its

object; and having done so, he called upon the Very Rev. Principal Macfarlan, who was present, having kindly accepted an invitation to witness the ceremony, to invoke the divine blessing on the undertaking; whereupon the Principal offered up the following solemn and impressive prayer:—

O Lord, thou art the Supreme Architect of heaven and earth. By thee were all things made, and without thee was not anything made that was made. How manifold are thy works! in wisdom hast thou made them all: the earth is full of thy glory.

Thou hast made the heavens and the earth by thy mighty hand and thy stretched out arm, and there is nothing too hard for thee. Of old hast thou laid the foundations of the earth, and the heavens are the workmanship of thy hands. They all shall perish; but thou remainest: they shall wax old as doth a garment; like a vesture shalt thou fold them up, and they shall be changed. All thy works throughout thy wide dominions praise thee; thousand thousands minister unto thee. We adore that mighty power, that unerring wisdom by which all things were created; and we especially bless thee, thou God of goodness, that to multiply life and joy thou hast formed man in thine own image, and never hath thy love failed towards him. Even when we have forgotten thee, thou hast not forgotten us. Thou hast looked upon us in compassion when there was no other eye to pity, no other hand to help. Thou hast sent the Son of thy love to enlighten us in true knowledge, to deliver us from the penalty and the punishment of our transgressions, and to restore us to thy favour.

Blessed be thy grace, Heavenly Father, that through thy tender mercies this day-spring from on high hath visited us: praise be to the glory of thy grace wherein thou makest us accepted in the Beloved, through whom we have redemption by His blood, even the forgiveness of our sins, according to the riches of thy grace. We glorify thee, O God, for all the means of grace, instruction, and improvement with which we are favoured. We thank thee for the ordinances of religion, and for the unbounded opportunities thou givest us of extending our acquaintance with thy works and acknowledging in these the hand by which they were produced. We desire, O God, to thank thee for all the capacities of acquiring knowledge, and all the opportunities of improvement which we enjoy. We thank thee for the rich stores of literature and science

by which the discoveries and knowledge acquired by mankind are perpetuated from age to age, and daily improved, and by which we are enabled, studying the properties of matter, to apply these to the most useful purposes. We desire, O God, to bless thee that our lot is cast in a land of equal law, of social order, of peace, protection, and quietness, to pursue undisturbed our duties and occupations. We implore thy blessing on the authorities by whom these gifts of thine are watched over, and the laws administered. O Lord, we implore thy blessing on our gracious Sovereign the Queen, her Royal Consort Prince Albert, and all the members of the Royal Family. We beseech thee to preside in the High Court of Parliament, to direct and overrule their measures and deliberations for the glory of thy name and the well-being of thy people. We desire especially to implore thy blessing on the important and magnificent undertaking the commencement of which we have this day been called to witness. Bless, we beseech thee, that great and populous city for whose immediate benefit it is intended. Bless its magistrates and rulers, and those who sit with them in council, the ministers of thy Word, and the whole body of the inhabitants. Bless especially those to whom is delegated and intrusted the immediate inspection and carrying forward of the undertaking now commenced. May they execute the important duty intrusted to them faithfully, wisely, and successfully. Grant thy blessing to those who have engaged to perform the various parts of its workmanship. May they, O God, discharge their duty faithfully, and skilfully bring all their labours to a successful and prosperous termination. Be gracious to those employed on the works in all their various capacities. Oh, do thou protect them from sickness, from any fatal injury, from any serious accident or misfortune; and may all be so conducted that there shall be no lamentation or distress in the case of any one. Gracious God, may this great work be brought to a successful conclusion, for a blessing to thousands on thousands of the people now alive, and their posterity for ages yet to come. And do thou accept of the humble homage of our praise, thanksgiving, and supplications to thee, through Jesus Christ, our strength and mediator. Amen.

Mr. Bateman then briefly described the works; and a deep trench having been prepared, which exposed a portion of the rock through which the aqueduct was to be formed

with certain borings made therein for blasting, Mr. Bate-man, addressing Mr. Stewart, said, "I am requested by the Contractors to present you with this drill and hammer, for the purpose of your giving the last stroke to one of the holes into which the powder is to be put, which will by and by explode in your hearing. The steel of the hammer and the drill are made from Scotch iron, the handle of the hammer from a piece of oak, part of the old Glasgow bridge, adorned at one end by a carving representing the Lady of the Lake and Rob Roy, and the box to contain them is made of the oak of Glasgow Cathedral. Everything about them is Scotch, except the man in whose hand they are held; and the Contractors beg your acceptance of them, in order that you may give a finishing and successful blow to this initiatory work; and long may Glasgow flourish by the blasting of this rock!" The blow being accordingly struck, a royal salute of twenty-one *blasts* immediately followed, amidst the cheers of the assembled crowd, the exciting martial music of bagpipes, and the joy and rejoicing of all present.

The committee and their party then proceeded to the Trosachs Hotel, where they dined, and returned to Glasgow next day.

Robert Stewart, Esq., retired from the Water Committee in November, 1856, and Andrew Galbraith, Esq., who was then elected a Magistrate of the city, became a member of the committee in his room, with Lord Provost Orr as chairman, and William Murray, Esq., deputy-chairman. The works and business of the commission, after this change, were carried on with unabated zeal and activity. The important arbitration with the Glasgow Water Company was entered upon and decided, after a long and anxious trial in Edinburgh, before John Inglis, Esq., then Dean of the Faculty of Advocates, now Lord President, as umpire; and William Anderson, Esq., Accountant, Glasgow, of Messrs. Kerr, Anderson, & Brodie, and James Allport, Esq., of the town of Derby, Manager of the Midlands Railway, as arbiters. A resident surgeon, as well as a teacher and chaplain, for the

works, were selected and appointed. Contractors were arranged with, and kept to work, and the business of the commission generally was continued with unflagging interest. At length, Lord Provost Orr's term of office drawing to a close, the Magistrates and Council, in view of this, on 30th October, 1857, on the motion of Bailie Young, seconded by Bailie Thomson, "unanimously, and by acclamation, voted their best thanks to the Lord Provost for the highly satisfactory and able manner in which his lordship had filled the chair and discharged the duties of chief Magistrate of the city during the period of three years he had held office."

Mr. Galbraith was now elected Lord Provost, and Chairman of the Water Committee—Mr. Orr continuing a member of the committee. The same warm and active interest in the success of the water scheme was always manifested by Lord Provost Galbraith as had been evinced by his predecessors. In his time, contracts for the important works at Loch Venacher and others were entered into and executed; the Royal Cottage at Loch Katrine, and other houses for inspectors, were built; various difficult questions of compensation were discussed, adjusted, and settled,—among others, the famous Glengyle claim, which, after much discussion and evidence in an arbitration, was reduced by the Hon. Charles Baillie, then Lord Advocate, now Lord Jerviswoode, as umpire—Messrs. James Horne and Robert Mathieson being arbiters—from £93,500 to £1,805; and the works were brought to completion during this civic reign.

The magnitude and arduous nature of the work accomplished almost exceeds belief. It was thus described by Mr. Bateman to Section G of the British Association at the Meeting in Aberdeen, in September, 1859:—

The Loch Katrine aqueduct, for the supply of the city of Glasgow with water, is one of the largest works of the kind which has ever been constructed in this or any other country, either in ancient or modern times.

The Act for the construction of this work was obtained by the municipal authorities, after much careful investigation into the

best mode of improving the supply of water to the city, in the year 1855, and the works were commenced in the following spring. The money for defraying the cost is borrowed on security of an unlimited rate upon the houses and property within the city.

The undertaking is specially distinguished by the great extent and beauty of the Highland lakes from which the water is brought—the excessive purity of the water—the difficult and rugged character of the mountainous country through which the works for its conveyance have been constructed—and the large volume of water, no less than 50,000,000 gallons per day, which will be obtained for the supply of the city.

The lakes appropriated to the purpose of the water works for the use of the city, and for the supply of the mill-owners, fisheries, and other interests on the rivers from which the water will be abstracted, are,—Loch Katrine, 8 or 9 miles in length, with a surface of 3,000 acres; Loch Venacher, 4 miles in length, with an area of 900 acres; and Loch Drunkie, with an area of about 150 acres; having altogether a water surface of upwards of 4,000 acres, and containing within the limits to which they may be raised or lowered about 1,600,000,000 cubic feet of water.

The drainage area of Loch Katrine is 22,800 acres, and of Loch Venacher and Loch Drunkie 23,000 acres—making a total of 45,800 acres. On this the average fall of rain is between 70 and 80 inches per annum. That which falls on the collecting ground of Loch Katrine is about 80 inches on the average of five years' observations. If all the water which flows from the rugged mountain-sides into Loch Katrine were impounded, it would afford a regular daily supply of 80 or 90 million gallons. The storage which is provided by the works which have been executed is equal to 50,000,000 gallons per day for 120 days without rain. It is obtained by raising the water by proper masonry and sluice-gates at the outlet 4 feet above the ordinary summer level, and by drawing it down, if necessary, to 3 feet below that level—giving 7 feet in depth in all. In like manner, the requisite storage for compensation to the river Teith, which consists of a regular guaranteed quantity per day, is obtained by raising Loch Venacher 5 feet 8 inches above its ordinary summer level, and drawing it down 6 feet—giving 11 feet 8 inches in all; and by raising Loch Drunkie 20 feet.

The works at the outlets of the lakes are interesting and important works—at Loch Venacher especially. Provision is made for the discharge of floods, as well as for the daily regulated supply,

and for securing the passage of salmon and other fish by properly constructed "salmon ladders."

Loch Katrine is 360 feet above the tide at Glasgow—an elevation which allows for the loss of fall in the conveyance of the water, and still secures a pressure of 70 or 80 feet above the highest summit of land within the city.

The aqueduct from Loch Katrine to the city is about 34 miles in length, 10 or 11 of which consist of ridges of rock of the hardest description, forming the spurs of Ben Lomond, which towers to 3,000 feet above the level of the works.

Through these ridges, in a tolerably straight direction, the aqueduct is carried, principally by tunnelling, the tunnels being 8 feet in diameter, and having a fall of 10 inches in the mile. Across three deep and wide valleys the water is conveyed by cast-iron pipes, 4 feet in diameter, with a fall of 5 feet per mile; and at the distance of about 26 miles from Loch Katrine, near Mugdock Castle, a large reservoir of about 70 acres in extent, and containing 500,000,000 gallons of water, has been constructed.

From this reservoir, the top water of which is 311 feet above the sea, the water is taken to the city by two lines of cast-iron pipes, each 3 feet in diameter, one being about 7, and the other 8 miles in length.

Of the 26 miles which lie between Loch Katrine and the service reservoir, 13 miles are tunnelling, $3\frac{3}{4}$ miles are iron piping, and the remainder, where the ground has been cut open, is an arched aqueduct of 8 feet in diameter, having the same inclination as the tunnels. Where the ground has been excavated, it is filled in again over the aqueduct, which is covered throughout, and the surface restored to its original condition.

There are in the whole work seventy distinct tunnels, upon which forty-four vertical shafts have been sunk for facilitating and expediting the completion of the work. The first tunnel commences immediately upon the aqueduct leaving Loch Katrine. It is 2,325 yards in length, 600 feet below the summit of the hill, and has been worked, in addition to the open ends, by twelve shafts, five of which are nearly 500 feet deep. This tunnel is in gneiss and mica slate. The last tunnel is at the southern extremity of the aqueduct, just before it enters the service reservoir. It is 2,650 yards in length, almost wholly through whinstone, at a depth of 250 feet below the summit of the hill.

Besides these, which are the two longest tunnels, there are, at

intermediate places, others of 700, 800, 1,100 and 1,400 yards in length.

The rock tunnelled through was in most parts of the most obdurate description. For several miles along the side of Loch Chon, where the work passed through a succession of ridges of mica slate largely mixed with quartz veins, the progress did not exceed three lineal yards in a month, although the work was carried on day and night. In the Loch Katrine tunnel, and generally in the mica slate, the ordinary average progress was about five yards in a month. In drilling the holes for blasting the rock with gunpowder, a fresh drill or chisel was required for every inch in depth upon the average. About sixty drills were constantly in use at each face, and the cost of gunpowder alone was from 27s. to 30s. per lineal yard. The character of the rock, however (as had been clearly foreseen when the work was determined upon), was such that no water occurred in any of the tunnels or workings so long as they were in the mica slate and clay slate, and there was, therefore, none of the inconvenience, delay, and cost from the presence of water which usually attend extensive tunnelling. When the works left the slate rocks and entered the old red sandstone, tunnelling was avoided as much as possible, from fear of water; but even in this formation it was met with in much less quantity than had been anticipated.

Not to speak of smaller constructions, there are twenty-five important iron and masonry aqueducts over rivers and ravines, some 60 feet and 80 feet in height, with arches of 30 feet, 50 feet, and 90 feet in span; and, in addition to about 46 miles of new pipes within the city for distributing the water to the inhabitants, there are about 20 miles of large cast-iron pipes, of 3 feet, 3 feet 6 inches, and 4 feet in diameter, for conveying the water to the city.

The number of people employed, exclusive of iron founders and mechanics, has generally been about 3,000; and for the greater part of these, huts and roads and all other accommodation had to be provided—the country for the most part being of the wildest and most inaccessible description.

The accuracy with which the works have been executed is most creditable to the resident engineers and inspectors. The difference between the levels taken for Parliamentary purposes and those subsequently taken when the works were set out for construction was only 1-50th part of a foot, or about $\frac{1}{4}$ th of an inch, in the 26 miles between Loch Katrine and the Mugdock Reservoir; and so

truly have the tunnels been driven, that the junctions can only be distinguished by the different directions of the drill holes.

The works will be completed for the conveyance of water to the city within $3\frac{1}{2}$ years of the time they were first commenced, and within the time originally contemplated, and at a total engineering cost of about £630,000, being about 10 per cent. beyond the Parliamentary estimate, after allowing for some additional works.

Her Majesty the Queen has graciously signified her intention to be present at the ceremony of opening the works at Loch Katrine, on the 14th October next.

JOHN FREDERIC BATEMAN, C.E., F.G.S., &c.

The following additional particulars will be read with interest:—The Blairhulachan Contract, which included about two-thirds of the most rugged portion of the work, being about $7\frac{1}{4}$ miles in length, fell into the Corporation's hands at a pretty early date, owing to the difficulties which had to be surmounted proving too much for the contractors. The Commissioners were thus enabled to ascertain accurately the quantity of materials used in performing the work. The length of direct tunnelling on this contract is about $4\frac{1}{2}$ miles, the remaining length consisting of open cutting, afterwards arched and covered in, and iron and masonry aqueducts. The quantity and cost of materials used in blasting the rocks are as follows:—

170 tons of blasting powder, at £62 per ton, . . .	£10,540	0	0
86,950 rings of double tape-fuse, 25 ft. each =			
307,917 yds., or 175 miles, at 10d. per ring, . . .	1,539	11	8
92 tons of drill iron, at £14,	1,288	0	0
9 tons of steel, at £63,	567	0	0
Total,	£13,934	11	8

This sum, divided by the length, gives about £2,000 per mile as the cost of materials consumed in merely blowing the rock to pieces. The gin ropes employed at the shafts on this contract were 5,466 yards in length, or upwards of three miles. The other contracts were not, on the average, so expensive as this; but, on the whole, the cost of gunpowder and fuse, and drill iron and steel, must have amounted to about £30,000. At the picturesque "turf and timber" village of Sebastopol, as the miners called it, at the head of Loch Chon, several hundreds of the work-people were accommodated.

Provision stores, reading rooms, a school-house, and church were provided for them. The deaths at this village were less than one-half per cent. on the average number of men employed during the whole period of the works. Happily, the deaths from accident, notwithstanding the dangerous character of the works, did not amount to half-a-dozen; and the same general immunity from fatal accident was observed of all the other contracts.

The excess of expenditure over the estimates has been, it is believed, justly ascribed to the unparalleled difficulties experienced from the almost unworkable material encountered in the execution of the work, and the consequent failure of some of the contractors to implement their contracts. This, unfortunately, is no uncommon result in regard to all great public undertakings. It was thus justified in this instance by Mr. Bateman, at the banquet given in his honour by the Lord Provost and Magistrates, and other leading citizens of Glasgow. "If (said he on that occasion) every engineer exceeds his estimate, it is not every engineer who is fortunate enough to produce a result half as large again as he promised. The engineering cost of these works was to have been about £540,000 for 20,000,000 gallons per day. They have cost about £700,000, but they have produced 30,000,000 gallons a day. I take no credit to myself for this result, but it is a fortunate fact notwithstanding. By all rules of calculation, the 4-foot cast-iron pipes across the Duchray Water, the Endrick, and the Blane ought not to deliver more than 20,000,000 gallons of water per day, with the inclination which has been given to them of five feet of fall per mile. They do, however, with a much smaller inclination than that, already deliver 26,000,000 gallons per day; and there is no doubt that, as soon as a slight alteration is made in some of the works in the hills, at least 30,000,000 gallons a day may be passed through them. This is owing chiefly, I believe, to the smooth, glassy surface which has been given to the pipes, by being coated with coal pitch, to prevent corrosion—an improvement which I first introduced in the Manchester Water Works about twelve years ago, and into all other soft-water supplies since that time. Whatever the cost has been, however, it is satisfactory to know that you are not called upon to pay a single penny more in the pound than you formerly paid for the inferior supply from the Clyde; and, more than this, the saving in articles of domestic consumption to which water is applied, such as soap, and tea and coffee, effected by the exquisite purity and softness of the water,

as compared with the harder water you have been accustomed to use, is nearly equal to your whole water-rate, and is equivalent to a free gift to the city of £1,000,000 sterling. In the consumption of soap alone, the saving to the inhabitants on the north of the river will be £30,000 a year. The total population of Glasgow may be taken at present at 460,000; deduct for Gorbals, 110,000; total on north of river, 350,000. Mr. Porter estimates the average annual consumption of soap at 9·2 lbs. per individual. This, at $5\frac{1}{2}d.$ per lb., will give £72,000 as the annual cost of soap, on the average of the country, consumed by the 350,000 persons on the north of the Clyde. Since the introduction of the Loch Katrine water, careful returns show that nearly one-half of the soap formerly used will now suffice."

Before closing the description of the works, the construction of the distributing reservoir at Mugdock is well worthy of special notice.

This reservoir is about three-fourths of a mile to the north of the village of Milngavie, and is formed by placing embankments across two valleys, which, meeting within the site of the reservoir, form a basin of considerable area and capacity. Including all its superficies, the reservoir is about 84 acres in extent, but the water area will be about 60 acres, the capacity about 600,000,000 gallons, and the average depth 37 feet. A large portion of the basin is 50 feet in depth; the greatest depth is 58 feet; and the water can be drawn off for the city to a depth of 52 feet. Altogether, it will contain a supply for twenty-five days, at the rate of 25,000,000 of gallons per diem. The embankments are of the respective heights of 69 and 53 feet; the length at the top, 405 and 246 yards; the inner slope, which is covered with stone pitching 2 feet thick, is 3 horizontal to 1 vertical, and the outer slope, 2 horizontal to 1 vertical. This slope is covered with soil 9 inches thick. The embankments are formed of puddle and earthwork. The puddle is placed in the centre of the embankment, and runs from end to end longitudinally, and from the bottom or foundation to the top-bank level, the base of the puddle in all cases being carried below the original surface of the

ground, and founded upon a water-tight material. The puddle, which is on an average 7 yards thick, is supported on both sides by earthwork, which forms the bulk of the embankment. The puddle is as hard as the solid rock; and, in point of strength, the Roman wall in the neighbourhood is a joke to this Mugdock embankment. At the north end of the reservoir, where it meets the outlet of the Mugdock tunnel, a heavy masonry basin is constructed, and into this the water flows immediately after leaving the tunnel. From this basin the water may be taken direct to the city without mixing with the water in the reservoir, by a line of pipes 48 inches in diameter, passing through the bottom of the reservoir; or it is passed into the reservoir over weirs or overflows placed in the side of the basin. The pipes just mentioned, with which branch communications are made for drawing off the water from the reservoir, leave it through a short tunnel cut through rock, and enter a well or shaft, also cut out of the rock to the depth of 63 feet, placed near the east end of the main embankment, and in which the various valves for regulating supply, &c., are fixed. In this well or shaft, provision is made for straining the water by passing it through copper-wire sieves, if required, or the water can be passed through to the city without being strained. The water is conveyed from this well by two ranges of pipes 42 inches in diameter, laid in a tunnel a quarter of a mile in length, driven through a hill which intervenes between the reservoir and the Glasgow road. At the lower end of this tunnel the pipes branch into four ranges of pipes 36 inches in diameter: only two of these lines are yet laid. At the end of the tunnel, also, self-acting valves are placed, which are so balanced and arranged that, whilst admitting of a free and uninterrupted flow of water for the supply of the city, should any sudden burst of a pipe take place between the reservoir and the city, the valves immediately close and stop the supply.

Arrangements are also made by means of which the water may be run out of the reservoir and passed into the Allander, should any repairs be required in the reservoir

itself. Only one line of pipe is laid through the reservoir at present, but preparation is made for a second line when required.

The course of the piping from the Mugdock reservoir on to Glasgow is as follows :—Shortly after leaving the conduit leading from the reservoir, the pipes enter the Glasgow Road, along which they pass until they reach the Allander, from whence to the Cannisburn Toll, a distance of nearly two miles, they pass through the fields, lying side by side. The pipes are carried above the Allander Water, and sometimes above, and sometimes below (according to level), the various small streams passed on the route. Just before reaching the toll at Cannisburn, the lines diverge, the one line passing to the east, and entering the Garscube Road, and the other passing to the west, and entering the parish road from Cannisburn to Annisland, and thence joining the Great Western Road. The pipes are carried over the Kelvin at Garscube by cast-iron arches, forming a valuable addition to the width of the bridge, by the construction of a footway over the pipes. The crossing over the Kelvin on the Great Western Road is executed in a similar manner. The Forth and Clyde Canal is also crossed twice, once at Temple Lock, where the pipes are simply laid below the bed of the canal, and again at Maryhill, where a tunnel is driven below the canal, in which a cast-iron pipe is placed, equal in area to two 36-inch pipes—the two ranges having to be united immediately before entering the tunnel, and separating again directly after leaving. Stop valves are placed at Maryhill on each side of the canal, at the Garscube Bridge, at Annisland Toll, and immediately above Cannisburn Toll, where the lines diverge. Manholes for entering the pipes are placed at about every half-mile of distance. Air valves are placed on all at the summits; in the hollows, branches are put out for the purpose of cleansing the pipes; and all along the line from Milngavie to the city, branches have been left at intervals for the supply of the district on the line of road, whenever such supply is agreed for. It may be added that the Maryhill line of pipes is for the high

service district of the city, and the line by the Great Western Road is for the low service district, or larger portion of the city; but they are so connected at Annisland Toll, and at the junction of Great Western and St. George's Roads, that in the event of accident the supply may be continued without interruption by a single line.

The works were thus brought into direct communication with Glasgow; and the re-arrangement and redistribution of the piping within the city having been promptly and expeditiously effected under the able superintendence of the resident engineer, Mr. Gale, the pure and copious stream from Loch Katrine soon found its way into the city, to cheer and gladden, and impart health and comfort to, the hearths and homes of the inhabitants.

At the north or Loch Katrine end of the works they were completed by a granite tablet built into a pediment over the entrance to the Loch Katrine aqueduct, on which there is cut the following inscription:—

GLASGOW CORPORATION WATER WORKS.

Designed in 1853 and 1854.	Robert Stewart, Lord Provost.
Act of Parliament, 1855.	} Andrew Orr, Lord Provost.
Works commenced, 1856.	
Works completed, 1859.	Andrew Galbraith, Lord Provost.
Opened by Her Majesty Queen Victoria, 14th October, 1859.	
John Frederic Bateman, Engineer.	

It may be proper to describe a little more particularly than is done by the general statement which has been quoted, the peculiar construction of the works executed.

The basin at the entrance or inlet to the aqueduct is 55 feet long by 40 feet wide inside, with three iron sluices, each 4 feet by 4 feet, for regulating the flow into the aqueduct; and there is a line of strainers across the middle, to prevent fish, &c., passing down. The basin is a fine piece of masonry, and with the cottage and surrounding scenery forms a very interesting part of the works.

The works at the original outlet, at the foot of the loch, consist of a dam of masonry built across it, with two sluices 4 feet broad and 4 feet high, two salmon stairs, 6 feet wide, in the dam, and a waste weir 100 feet long; and this simple work controls no less than 5,500,000,000 gallons of water!

The works at the outlet of Loch Venacher consist, in like manner, of a dam of masonry across the mouth of the loch; but there is here also a new channel constructed for the river, in order to admit of the water being drawn down below the old summer level. The new channel is 700 yards long and 50 feet wide. At the lower end is placed a compensation gauge weir 100 feet wide, formed by a continuous cast-iron plate brought to a thin edge at the top. At the upper end of the channel, next to the loch, there is a range of cast-iron sluices built into substantial masonry 110 feet long and 15 feet thick, with eleven arched openings for discharging the water. Three of the sluices have a clear width of 4 feet, and a height of 4 feet; four are 6 feet wide and 2 feet high; and the remaining four are at the upper end of the salmon ladders, formed to allow the fish to get into the loch at its different levels. These are each 6 feet wide between the walls, and have a general inclination of 1 in 12. Their sloping channels are formed into a succession of pools by planks upon edge placed across the channel, over which the water falls. The height of the planks is varied as the level of the water in the loch changes, so as to keep a depth of from 15 to 20 inches always flowing over. The top of the dam is roofed in, and forms a sluice-house for protecting the working gearing. The waste weir of the loch is 150 feet wide, and is a continuation of the masonry of the dam across the top of the new river channel. Recently this weir has been altered, in order to afford greater facilities for salmon entering the loch. Raising the level of the loch involved several road diversions, and at the upper end, where the ground is flat, about 150 acres of meadow land, known as "Lanrick Mead," are covered when the loch is full. These works cost about £26,000.

The level of Loch Drunkie has been raised 25 feet by two

earthen embankments, with puddle walls in the usual way, and the area of the loch increased about 60 acres. The northerly embankment is 150 yards long and 21 feet high; the other, which is at the original outlet of the loch, is 40 yards long and 32 feet high. Through this embankment there is a cast-iron pipe 24 inches diameter, with a valve at the outer end to regulate the discharge.

The aqueduct bridges over the ravines are, on account of the nature of the district, peculiar. There are five extensive ones, of the lengths respectively of 124, 154, 212, 147, and 332 yards, all of similar construction. At the ends of the bridges, or shallowest parts of the ravines, the aqueduct is a cast-iron trough, supported on a solid dry stone embankment carefully set by hand, 9 feet wide at top, with a batter of 3 inches to the foot on each side. The deeper parts of the valleys are crossed by malleable-iron tubes, 8 feet wide by $6\frac{1}{2}$ feet high inside, supported by piers at intervals of 50 feet. The bottoms and sides are $\frac{3}{8}$ -inch thick, and the tops $\frac{1}{4}$ -inch thick, strengthened by angle and T iron. The cast-iron troughs, which are 8 feet broad, 4 feet deep, and $\frac{5}{8}$ -inch thick, were at first intended to pass about 20,000,000 gallons a day, but provision was made for adding to the height of the sides when additional water was required, and additional height has been added. The bottoms of the malleable-iron tubes are 3 feet below the bottoms of the troughs. The tubes will pass 50,000,000 gallons a day without alteration. The aqueduct at the crossing of small mountain streams, of which there are a good many, is carried in cast-iron troughs similar to those already described, supported upon cast-iron beams over the space left for the stream.

The first valley which intervenes requiring to be crossed by piping is that of the Duchray Water, about 55 chains wide. The pipes are 4 feet diameter in 9 feet lengths, with spigot and faucet joints, run up with lead in the usual way. At the lowest point the pipes are under a pressure of 165 feet. The river itself is crossed by cast-iron girders of 60 feet span; and here, as well as at the small

basins at each end of the piping, and at other places where masonry was required, provision is made for laying two additional lines of pipes, one 4 feet and the other 3 feet in diameter.

After passing through the ridge of old red sandstone conglomerate by the Clashmore tunnel, the aqueduct for 5 miles is for the greater part in open cutting, with masonry sides and dry rubble arch, covered with 2 feet of puddle.

The Endrick valley, like that of the Duchray, is crossed by a 4-feet syphon pipe $2\frac{1}{4}$ miles long. It was at first laid under a pressure in the bottom of the river Endrick, where the pipes were $1\frac{1}{8}$ inches thick, of 235 feet; but under the authority of the Amendment Act, 1865, the pipes have been raised from the bed of the river, and carried over it by a spacious bridge, constructed, along with a relative diversion of road, under an arrangement with the road trustees of the district. The pipes are carried across small depressions in the valley by resting them upon stone piers, and at the crossing of two roads, and of the Forth and Clyde Railway, they are further supported by cast-iron brackets. The pipes at these exposed places have flange joints. There is a short tunnel, 110 yards long, on this length of piping, of dimensions sufficient to carry the three lines of pipes.

The construction of the aqueduct for the 5 miles extending from the valley of the Endrick to the valley of the Blane, presents the same general features as those already described. Good building stone was abundant in this district, and the bridges are all of masonry.

The piping across the Blane is about 54 chains long, with a depression of 125 feet. The Blane Water itself is crossed by a stone bridge, and there are basins at each end of the pipes, as at other parts of the works.

The last piece of the aqueduct—the Mugdock tunnel (2,640 yards long)—already referred to, was carried through a ridge of amygdaloidal trap separating the valley of the Blane from the valley of the Allander. The tunnel is 250 feet below the summit of the hill.

The aqueduct, from its commencement at Loch Katrine to

the Mugdock reservoir, is $25\frac{3}{4}$ miles long—13 of which were tunnelled, $3\frac{3}{4}$ miles are iron piping across valleys, and the remaining 9 miles are open cutting and bridges. Where the ground was cut open, the surface was restored after the aqueduct was built. At the bridges the aqueduct is covered with timber, to prevent its being choked by snow. The most of them are furnished with grooves in the masonry, to receive stop planks, and with discharge sluices, to facilitate the emptying of the aqueduct when it is necessary to inspect or make repairs. Overflows are constructed at a number of the bridges, to discharge the water, if it should be necessary to stop the flow suddenly at any point.

The total cost of the aqueduct was £468,000, or an average of £18,000 per mile.

It has been stated that the 4-foot pipes across the valleys on the line of aqueduct were intended to deliver 20,000,000 gallons a day. These pipes, however, discharged 24,000,000 gallons a day, without their being completely gorged, and their ultimate discharge has yet to be determined. The whole of the pipes used in the works were coated with coal pitch and oil, according to the process patented by Dr. R. A. Smith, of Manchester, and first used by Mr. Bateman in the Manchester Water Works. This coating, when well done, imparts a smooth glassy surface to the pipes, and prevents, at least for a number of years, the usual and, it may be said, inevitable oxidation. It is believed that this coating had considerable influence upon the discharge of the pipes. In the opinion of scientific persons, this influence has been known to extend, in the case of cast-iron pipes coated with pitch, and of glass pipes, to an increase of nearly one-third in the discharge; and it is also understood that in regard to large sizes, the diameters of the pipes exercise a more decided influence on the discharge than has been heretofore assigned to them.

The construction of the Mugdock reservoir and the line of piping from the reservoir to the city have been already described.

THE DISTRIBUTION IN THE CITY.

The following interesting account of the distribution of water in the city is extracted from Mr. Gale's valuable paper, read before the Institution of Engineers in Scotland, 16th March, 1864:—

The low district main is brought in by the Great Western Road, and supplies the West End of the city as far as St. George's Road; east of this point the supply is restricted to the district lying below a contour line 50 feet above high water. There are two junctions between this main and the Gorbals pipes; and by these the supply from the Gorbals works is supplemented, as the 24-inch main pipe from these works is not now sufficient to supply the large population upon the South side of the river. The high district main supplies the whole of the city east of St. George's Road, and above the 50 feet contour. The quantity of water intended to be ultimately discharged by the low district main will produce a loss of head of 19 feet a mile; but it will retain, during the time of greatest drought, an effective pressure of 116 feet where it enters the district of distribution. The high district main is intended ultimately to lose head at the rate of 12 feet a mile, and will retain an effective pressure of 52 feet on the top of Garnet Hill, when the velocity of the water in the pipe is greatest. A few isolated outlying districts, including Garngad Hill and Springburn, require cisterns to secure a supply during certain hours of the day; but, with these exceptions, the supply is constant at high pressure. When the loss of head in the mains, arising from an increased consumption in the city, exceeds the amounts above stated, and reduces the effective pressure below what is necessary or desirable, additional mains may require to be laid from Mugdock.

To diminish the extent of the districts which may be affected by any accident to the pipes, two junctions are formed between the high and the low district mains—one near Cannisburn Toll, about 3 miles from Mugdock, and another at Clarendon Place, St. George's Road. There are other junctions between the principal branch mains in the city, and in this way each district can be supplied in more than one direction.

At the Mugdock reservoir, self-acting closing valves,* intended

* Referred to at page 120, in describing the reservoir.

to shut off the water on the occasion of a pipe bursting, are attached to each line of pipes; and stop valves are fixed at intervals along the line of mains both in the country and city. On the side next the reservoir, at each stop valve, there is a momentum valve, designed to prevent concussion in the pipes by the too sudden closing of the stop valves. On the top of each rising ground there is an air valve, and in the bottom of every hollow a cock for flushing out the pipes, and for emptying them when repairs are to be made. Manholes are placed at intervals along the lines of the large mains, and close to all the large valves, to afford admission to the inside of the pipes for inspection, and to make repairs.

The self-acting closing valves were designed for the purpose of immediately shutting off the water in the event of a burst pipe, without relying upon the watchfulness of the men in charge. The arrangement was suggested by Sir Wm. G. Armstrong, of Newcastle, and was first introduced by Mr. Bateman in the Manchester Water Works. It was subsequently introduced in the Liverpool Water Works. The valve is of the character of a large "throttle valve" fixed across the pipe, and in its normal position presents little obstruction to the flow of the water. It is held in its position by a disc, which projects into the pipe, and is fixed at the end of a long lever or pendulum, being prevented from yielding to the pressure of the water acting against it by reason of its velocity, by counterbalance weights, adjusted to resist the ordinary or any fixed velocity. If a burst upon the main, or any other accident, produces a velocity in excess of this, the disc yields to the increased pressure, and lets loose a catch, which allows a heavy weight attached to the axis of the large throttle valve to close the valve. A simple mechanical arrangement is introduced for preventing it from closing too rapidly, whereby the mass of water in motion would be too suddenly arrested; and the same contrivance is, by means of a small force-pump, made available for re-adjusting it in its horizontal position. Upon several occasions when the mains were first subjected to the pressure from the reservoir, and upon one or two occasions afterwards, these valves acted in the circumstances under which they were designed to act, and were the means of preventing considerable loss and damage. Upon two occasions, and before the machines, which are delicate in their action, were properly adjusted, they gave false alarms.

The great difficulty to be overcome in opening or shutting a

large stop valve under any considerable pressure is the power required to move it. The pressure exerted by a column of water of 100 lbs. on the square inch against a slide valve 36 inches in diameter is 45 tons; and to overcome the friction of the ordinary brass facings, by the usual appliances of screw and lever, under this pressure, with a moderate number of men, is practically impossible. In designing the Manchester Water Works, Mr. Bateman resolved to overcome this difficulty, and open competition was invited for a large valve that could be opened and shut by one man. Sir William G. Armstrong's idea was adopted of dividing the valve into compartments, one of them being reduced in area so as to be equivalent to a small valve, and easily opened by one man. The smaller division is the first opened; and the passage of the water through this opening so much reduces the pressure upon the slide of the larger compartment, that it also can be opened with ease. In shutting, the small slide is the last closed. This arrangement was adopted by Mr. Hawksley in the Liverpool Water Works; but from the great size of the valve when the opening was made, the full diameter of the pipe, and the difficulty of fixing them in the streets, the total opening in the valve was reduced so as to require one foot of head to pass the same quantity of water through the valve which the pipe was intended to deliver. This modification has to some extent been introduced in the stop valves used in the Glasgow Water Works; and all valves above 16 inches in diameter are of this construction. The clear water-way is $4\frac{1}{2}$ square feet, against 7 square feet, the area of the pipe, the smaller slide having an area of 1 square foot, and the larger $3\frac{1}{2}$ square feet. To pass this contraction with a velocity of 4.4 feet per second in the pipe, which is the velocity the water in the high district main will have, when the loss of head amounts to 12 feet a mile, the velocity is increased to $6\frac{3}{4}$ feet a second in passing the valve. According to Weisbach, and considering the contracted area to be of the nature of a diaphragm, the head absorbed in passing would be about 5 inches; but as the approaches are curved, the actual loss is probably less than 3 inches. In the case of the low district main, where the velocity of the water is greater, the loss of head will be 1 or 2 inches more. There is not a more important item in the whole economy of a large work for the supply of water than the stop valves; and to have a machine certain in its action, and of good workmanship, is of the first importance to those engaged in the management of

the distribution. The Armstrong valves have given the greatest satisfaction in the Glasgow Water Works; and they must be looked upon as one of the greatest improvements lately introduced in the distribution of water under pressure. The only alteration upon them that the experience in Glasgow has suggested, is still further to reduce the area of the small slide, both for the purpose of giving increased power in opening and closing, and to obviate concussion due to rapidly stopping the flow in the pipe when shutting the valve.

The momentum valves, placed in front of the self-acting and large stop valves, are designed to prevent concussion in the pipe by the sudden closing of the valve. In the stop valves this is effected partly by the construction of the valve itself, which cannot be shut quickly; but in the large pipes it was thought proper still further to diminish risk of accident from this cause. They are simply safety valves constructed upon the principle of the equilibrium or double-beat Cornish valve, and are so adjusted and weighted that they open and discharge a little water when the pressure exceeds that to which they have been adjusted.

In arranging piping on a large scale, it is of great importance to provide for the free and rapid escape of the air from the pipes when they are being filled with water, and for the subsequent discharge of that which accumulates on the summits, from being disengaged from the water in the ordinary working. An air valve which allows of air being discharged under both the above circumstances, and which is self-acting, was designed during the progress of the Manchester Water Works. It is the same in principle as Bateman and Moore's fire-cock. In the Glasgow Works they have been placed on the summits on all pipes down to those of 6 inches diameter.

At the junction of the two great mains from Mugdock at St. George's Road, pressure gauges are attached to the pipes, and a record of the indications kept night and day. These gauges not only afford valuable information of the available pressure at all times on the mains, but they also indicate with unerring accuracy when any accident has occurred to any of the leading mains either in the city or between the city and the reservoir, and thus admit of action being taken sooner than could be done under any other arrangement.

In a city increasing so rapidly as Glasgow, it was necessary to provide for great alterations in those districts which are at present

only partly built upon. The districts to be permanently supplied by the two mains at present laid down were restricted to the more densely built parts of the city, and the suburbs were left to be provided for by future mains, in the manner in which their development might indicate. The sizes of the distributing pipes were arranged with reference to the number of families any given district or street would probably ultimately contain; but in the centre of the city, and in those localities occupied by warehouses and factories, and in which fires are frequent, the sizes were fixed more with reference to the demand for water during fires than to the quantity consumed for domestic or trade purposes. The distributing pipes branching from one main have been interlaced with those branching from another, so that any fire can easily be reached from the fire-cocks attached to both mains; and in the event of accident to either main, there would still be water in half the fire-cocks in the district.

The pipes of the Glasgow Water Company were retained and incorporated in the new arrangement where the sizes would suit; but from the mains lying with the wide end to the east, while the new supply entered from the west, and from the greater part being old, and many of the branch pipes too small and much corroded, the cost of the re-arrangement was very great. Further complications arose from the pipes of the old Cranstonhill Company having been connected to those of the Glasgow Company; from the Glasgow Company having at one time a separate system of pipes for the supply of unfiltered water; and from the extensions of the piping to keep pace with the demand for water not having been executed after any fixed plan, but with reference only to economy or the exigency of the moment. Four and five lines of pipes in a street were common, and some streets had more than this number, while the stop valves were of very imperfect construction. The pipes were connected and interlaced in a most confused manner, and after no regular system; and only a few of the workmen connected with the establishment were aware of their various ramifications. All this has been altered and simplified, and those not wanted have been lifted. Every pipe has a stop valve where it leaves the distributing main, and a cleansing cock at the farther end. Large pipes only are connected, and these connections are opened during repairs only.

The pipes which were laid down by the Gorbals Company in 1847 did not require any alteration. They had all turned and

bored joints up to 9 inches diameter; and this joint, with a space for lead in the event of the joint proving defective, was extended to 12-inch pipes in the piping connected with the Loch Katrine Works; and lately, pipes of 15 inches diameter with this joint have been put down, with the most satisfactory results.

There are 2,700 fire-cocks in the city, placed at intervals of 40 yards in the more densely built parts of the city; increased to 60 yards in the suburbs. They are upon the principle of the common ground cock, with the water admitted to the inside of the key, which is hollow. Previous to the introduction of the Loch Katrine water there were only 570 fire-cocks in the city, mostly of objectionable construction; and as the pressure on the mains was never very great, fire engines were indispensable, while most of the water had to be carted to the engines, causing great confusion in the adjoining streets during a fire. All this has been altered: the fire engines are now seldom used, the pressure from the mains being sufficient to reach the highest houses; and the carting of water is entirely discontinued, and a considerable annual saving is the result.

In addition to these, there are 1,200 of Bateman and Moore's fire-cocks, which are applied as cleansing cocks and air valves. They are available in cases of fire, as well as the cocks above mentioned, and are extremely useful in discharging the air in filling the pipes. In Manchester and many other towns these cocks are used exclusively as fire-cocks, with the best results.

The water meter is another very important and useful instrument connected with the distribution of water. Those used in Glasgow are Kennedy's patent, which is a piston meter constructed on the principle of measurement by capacity. There are upwards of 500 of them in use in Glasgow, and the revenue derived from the sale of water to manufacturers and others is £15,000 per annum. It rose £6,000 a year during three years prior to 1867, and is still increasing. The importance of having a thoroughly good machine for the measurement of water under pressure cannot be over-estimated. Sixteen or seventeen years ago such an instrument was not known, but a competition invited by the Gorbals Company, in 1848, was the means of bringing out several.

In 1838 the consumption of water per head in Glasgow, over the whole population, was 26 gallons. In 1845 it had increased to 30 gallons a head. In 1852 it was 35 gallons a head on the north

side of the river, supplied from the Glasgow Works, and 38 on the Gorbals side. When the Loch Katrine scheme was designed, in 1853-54, 40 gallons a head was adopted as a liberal allowance, and one thought to be in excess of all future requirements; but in 1867-68 it had reached 49 gallons a head per day. The quantity of water sent into the city during the year was, on an average, about 22,000,000 gallons a day from the Loch Katrine Works, and 3,640,000 gallons a day from the Gorbals Works,—in all, about 25,640,000 gallons a day, which was supplied to a population of about 450,000 persons. Of this quantity 2,600,000 gallons a day were sold by meter for trade purposes, equal to 5 gallons per head,—leaving 45 gallons per head as the net consumption for domestic and other purposes. The quantity of water used in the manufacturing towns of Lancashire is about 20 gallons a head a day for all purposes. In Manchester, with a population nearly the same as Glasgow, it is 22 gallons a head, and the quantity sold for trade purposes is from 5 to 8 gallons a head. In Sunderland with a population of 130,000, it is 15 gallons a head, of which 3 go to manufacturers. In Nottingham it is 17 or 18 gallons a head, of which 5 or 6 are sold for trade purposes. The great excess of the consumption of water in Glasgow is due, in great measure, to waste from imperfect water fittings, and from negligent or improper use of them. Some allowance should probably be made for the difference in the circumstances of the distribution in Glasgow as compared with the towns above mentioned, but there is still a large quantity, probably 15 gallons a head, which runs to waste without benefiting any one, and which, if saved, might soon materially reduce the water assessment.

Thirty years ago the gross revenue of the two Water Companies was less than £25,000 per annum; while now, the annual revenue of the Water Commission is upwards of £99,000. So rapidly have the population and manufactures of the city increased, that the Commissioners have, since 1856, been enabled to expend about a million of money in executing the new Water Works, and at the same time to pay the large annuities guaranteed to the shareholders of the former Water Companies, without adding to the amount of the water rates. It appears pretty certain that ere long the Commissioners may be enabled not only to commence and carry on contributions to the sinking fund directed to be set apart by the Acts, but also to reduce still further their water rates.

The great and steadily advancing financial progress of the works since 1855, together with the increase of the population and rental of the city, and also the annual extension of piping and average daily quantity of water supplied, will appear in the Appendix.

THE ACTION OF LOCH KATRINE WATER UPON LEAD.

It may well be considered superfluous at this distance of time to take further notice of this ground of objection to the Loch Katrine scheme. The objection from the first was entirely theoretical and speculative,—such as is not unfrequently resorted to in Parliamentary contests by the promoters of competing schemes, and withdrawn, or not insisted on, when the coveted object of opposition—satisfactory compensation—is secured. It has been seen that Messrs. Stephenson and Brunel, in their Report, of February, 1855, expressed a pretty confident opinion, founded on experience as well as evidence, that in practice such “action does not take place, or at least does not produce any injurious results.” To this can now be added, after nine years’ trial, the opinion and experience of the whole population of Glasgow. The water has been used in every form during these nine years, and in not one instance has the slightest evil or inconvenience resulted. On the contrary, the water has given to every inhabitant, capable of appreciating it, the most unbounded satisfaction, and the public health has been preserved and improved. In such circumstances it is indeed wholly unnecessary to refer to anything like evidence or authority to dissipate the groundless doubts and apprehensions which were started in opposition, in order to reassure the inhabitants of the perfect wholesomeness and safety of this excellent water; but, as matter of history, a brief reference to the great exertions made to disprove the objection, and their complete success in demonstrating the triumph of facts and experience over chemical theories and laboratory experiments, may be instructive.

It appears, then, that the scientific gentlemen named at

the meeting held immediately after the adjournment of the Parliamentary Committee, on 29th March, 1854, were all (with the exception of Dr. Lyon Playfair, whose other avocations did not enable him to undertake the duty) specially employed, and at once proceeded to examine the water, to analyze its quality, and to ascertain its effect upon lead; and in order to aid and facilitate their investigation, a small Water Work, for the purposes of experiment, was constructed at the outlet of Loch Katrine, to which a quantity of old and new iron pipes, old and new lead cisterns, and old and new lead pipes (as then in use in Glasgow), were supplied; and the work was placed under the charge of the late Mr. Mackain, the Engineer of the Glasgow Water Works, with instructions to do everything exactly in the same manner as if he were supplying water to Glasgow in the ordinary way. When the pipes and cisterns were laid and fixed, the experiments were placed under the charge of Mr. Dugald Campbell, with whom were subsequently associated Professor Anderson, as a Chemist, and Mr. G. H. Hill, Mr. Bateman's assistant, as an Engineer. The results of experiments here made were most satisfactory, in favour of the perfect safety of the water. Specimens of the rocks, limestone, and clays were procured from the line of aqueduct, and carted to the experimental works, and the water subjected to contact with these materials for a similar time and extent to that which would be the case in practice. The line of aqueduct was to cross a thin bed of limestone, then enter the old red sandstone formation, through which it was to extend about 11 miles, and through the succeeding strata of the coal measures $1\frac{3}{4}$ miles more, making the total length nearly 13 miles, and the time eleven or twelve hours. It was shown by the experiments that the contact of the water with these materials, for a less number of hours than would be the case in reality, deprived the water of all sensible action upon lead, and consequently that no possible danger could attend the use of the water when delivered in Glasgow.

Another important point to which attention was directed, was the effect which had been produced in towns or places

supplied with water of similar quality. Towns situated in similar geological districts, or supplied with water of very pure quality, were accordingly selected for examination, and gentlemen were sent to various parts of England, Scotland, and Wales, to prosecute the investigation. The places visited were,—In Scotland, Dumfries, Edinburgh, the then present and projected sources of the Gorbals Company, the Gare Loch, Lochgoilhead, Inverary, Tarbet, Inversnaid, Loch Lomond and the Leven, Perth, Aberdeen, Inverness, Dunkeld, Taymouth, Loch Tay, Loch Rannoch, Loch Ness, Loch Lubnaig, and other places in that district; in England, the Lake district of Cumberland and Westmoreland, including Ulleswater, Penrith, Windermere, Ambleside, Grassmere, Derwentwater, Keswick, Cockermouth, Ennerdale Lake, and Whitehaven; and in Wales, Bala, and Bala Lake, the River Dee, Bangor, Beaumaris, and other places; also Manchester, Sheffield, Macclesfield, Bolton, Rochdale, Chorley, Heywood, Blackburn, Accrington, Darwen, and Bury; and water was procured from Londonderry in Ireland, and from New York in America. In all cases, the towns or places supplied were served through lead pipes and cisterns, and in no single instance had a trace of lead been discovered in the water which had passed through the pipes.

Of the places visited, those selected for particular examination were Whitehaven, supplied from Ennerdale Lake; the works on the River Leven, from Loch Lomond; Inverness, supplied from Loch Ness; Bolton and Blackburn in Lancashire, and Sheffield in Yorkshire; the three last, in common with most other places in hill districts, being supplied by means of reservoirs constructed for the storage of flood waters. Mr. Campbell and Mr. T. T. Mitchell visited Inverness; Dr. Anderson examined Whitehaven; and the officers of the Water Works, and medical gentlemen from these and some of the other places, tendered evidence that no injury had been sustained by the supply of water which acts on brightly polished lead, but that, on the contrary, much comfort and advantage had resulted, and the mortality of the several places had been diminished.

Many of the rivers, after flowing out of lakes, the water of which had violent action on lead, and passed over sandstone or other neutralizing geological formations, were traced down, to ascertain how soon and from what apparent cause the water is deprived of its power to act on lead. Among these were the Eamont, flowing out of Ulleswater; the Derwent, out of Bassenthwaite Water; the Dee in Wales, out of Bala Lake; the Tay, out of Loch Tay; and the Teith, from Loch Katrine. It was found that the Eamont lost its action very soon after leaving the lake, upon entering a limestone district. The Derwent, which flows over the slate rocks of the Cumbrian formation, retained its action to near Cockermouth, where it enters limestone. The Dee, from Bala Lake, retained its action to a considerable extent till mixed with water from the Caradoc sandstone; and the Tay, till after running for some distance over old red sandstone. The Teith, which passes over this formation when it leaves Loch Venacher, lost much of its power before it joined the Forth, though—in consequence, probably, of the large body of water, and the gravel, which prevents any close contact with the softer beds of sandstone—the action was not so much diminished as in other cases.

At Bolton-le-moors, in Lancashire, a town having a population of 80,000 persons, the water which had supplied the town for nearly thirty years is extremely soft, and acts very powerfully upon bright lead. It is distributed to the inhabitants through lead cisterns and lead pipes in the ordinary manner. Dr. Black, a physician who had resided there for upwards of twenty years, and during that period been uniformly supplied with the Water Works water through lead pipes, and had himself ascertained its power of rapidly corroding bright lead, declared that he had never known a case of injury arising from the use of the water.

At Blackburn, where the action of the water was less powerful, though still considerable, Mr. Dugdale, an eminent surgeon in the town, then Mayor of the borough, Chairman of the Water Company from its formation in 1844, expressed the strongest opinion of the perfect safety with which the

water had been supplied to the inhabitants through lead pipes, and of the great advantage which had resulted from its use.

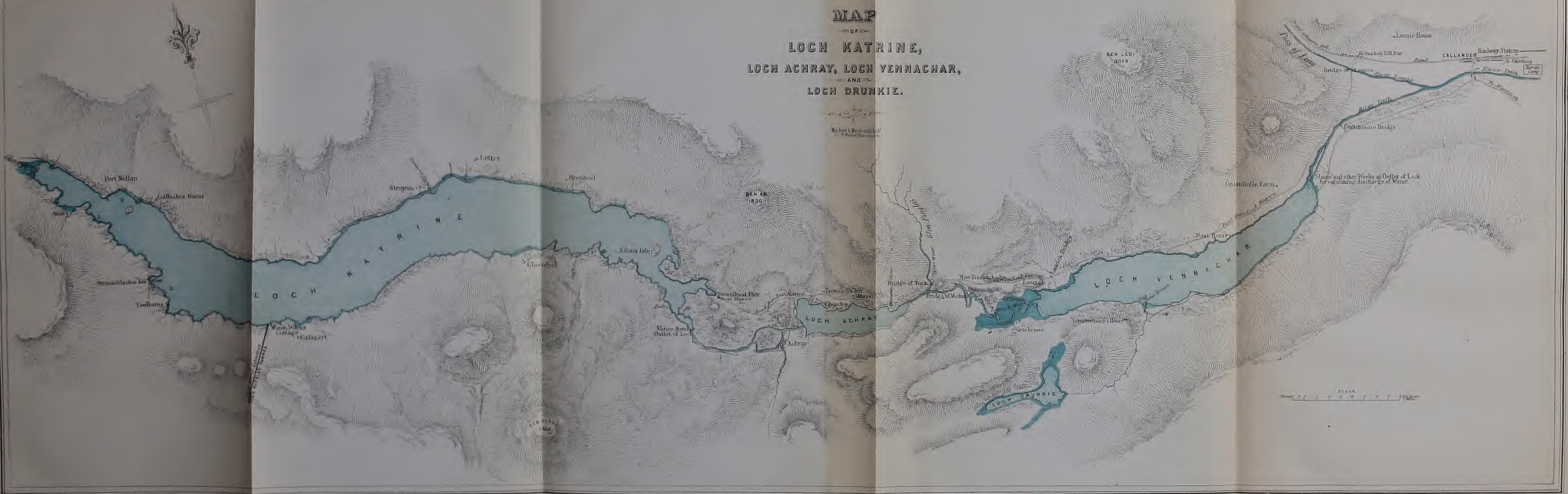
At Sheffield, the water, which had been supplied to the inhabitants for nearly thirty years, acts upon bright lead nearly as energetically as that of Loch Katrine. It is almost uniformly delivered into leaden cisterns, being conveyed to the cistern, and from thence to the taps for domestic use, in leaden pipes. Mr. Gunson, the manager of the works, and who had held that situation since their establishment, received the water he had used in the way above described, and stated it to be the universal system of the town. He was perfectly astonished when he saw the effect upon the water by a similar experiment to that of Dr. Penny, never having heard of the slightest injury or inconvenience arising from its use. Mr. Wright, the medical gentleman who had attended his family, received his own supply of water in the same way, and was a surgeon in extensive practice, connected with all the medical institutions of the town. He had never heard of a case of lead-poisoning connected with the supply of the water through lead, nor of any injurious effect whatever. The information from other places was to the same effect.

Such were the extraordinary and expensive exertions made to overcome the theoretical doubts and apprehensions started as to the safety of Loch Katrine water for the supply of Glasgow, in the belief and expectation that the objection so strenuously urged before the Parliamentary Committee on that ground would be persisted in; but, instead of this, it has been seen that when the time came it was wholly abandoned, the question of *compensation* being settled.

Extracts from some of the Reports of the eminent chemists and medical men engaged in the numerous investigations will be found in the Appendix.



MAP
OF
LOCH KATRINE,
LOCH ACHRAY, LOCH VENNACHAR,
AND
LOCH DRUNKIE.



THE INAUGURATION

OF

LOCH KATRINE WATER WORKS.

At a meeting of the Lord Provost, Magistrates, and Council of Glasgow, as Water Commissioners, held in the Council Hall on 21st July, 1859, the Lord Provost announced the gratifying fact, that there was now every reason to believe that these important Works would be completed early in the following month of October, and suggested the propriety of soliciting Her Majesty Queen Victoria to honour the citizens of Glasgow with her presence at an Inaugural Ceremony on the auspicious occasion of opening the Works. This suggestion was no sooner made than it was unanimously and enthusiastically applauded by the meeting, and a special committee was appointed to carry it into effect, to consist of the Lord Provost, Sir Andrew Orr, James Hannan, James Howie Young, and William M'Adam, Esquires, Chairmen of Committees. The whole of the City Magistrates were afterwards added to this Committee, with full discretionary powers to make all necessary arrangements.

This Committee, having immediately met on the subject of the remit to them, resolved to communicate the resolution of the Commissioners to the City Member, Mr. Dalglish, and through him, to Lord Elgin and other influential noblemen and gentlemen, in order to ascertain whether an application to Her Majesty to honour the citizens, as proposed, was likely to be favourably entertained; and if so, to learn the most fitting and suitable time to make the application. Having done so, the Committee were glad to learn that, if the application was made soon after Her Majesty's arrival at Balmoral for her usual autumnal residence there,

it would no doubt be graciously received, and the desire of her loyal subjects, the citizens of Glasgow, complied with.

The Committee accordingly postponed their application until early in September, when it was known Her Majesty would revisit her Highland home; but they then specially commissioned James Hannan, Esq., then Chairman of the Committee on New Works, and their Engineer, Mr. Bateman, to proceed to Balmoral, in order to make the application, and learn the royal pleasure. These gentlemen having done so, reported, in the course of a few days, the complete success of their mission; that their respectful request had been most graciously acceded to by the Queen; and that Her Majesty's Ministers in attendance at Balmoral had made arrangements for the Inauguration taking place on Friday, the 14th of October,—Her Majesty to travel by Edinburgh, and to leave the Palace of Holyrood on the morning of that day, proceeding by railway to Callander, and thence by the royal carriages to Trossachs and Loch Katrine, returning to Edinburgh by the same route in the evening. These arrangements were immediately made known to the public, through the medium of the newspaper press; and the announcement of them was received by the inhabitants with the most unbounded joy and satisfaction.

The Committee immediately thereafter took steps to secure that the ceremony should be in all respects worthy of the occasion. The duty of advising as to and superintending the necessary preparations and decorations, was assigned to James Graham, Esq., a member of the Town Council and Master of Works, and John Carrick, Esq., the City Architect,—who afterwards received a vote of thanks from the Commissioners for the manner in which they fulfilled the trust reposed in them.

The Queen's Own Regiment of Glasgow Yeomanry Cavalry and the Glasgow Volunteer Rifle Corps, at an early period, tendered their services as an escort and guard of honour to Her Majesty; and their offers were at once cordially accepted by the Commissioners. In consequence,

however, of the Yeomanry being unable to leave their county without obtaining a "route" from the Commander of the Forces in Scotland, and of certain difficulties which occurred in regard to this matter, they were obliged to deny themselves the honourable duty which they had undertaken to perform; but 400 of the Volunteers mustered on the occasion, and took part in the ceremony. About eighty members of the Glasgow Celtic Society also volunteered their services, and attended in full Highland costume.

The following was prepared and submitted to Her Majesty for approval:—

PROGRAMME.

Her most gracious Majesty the Queen, and His Royal Highness the Prince Consort, with several members of the Royal Family and their suite, will leave the Palace of Holyrood on Friday, the 14th October, about 10 o'clock A.M., and reach Callander by railway about half-past 11, where the royal carriages will be waiting the arrival of the train.

The royal *cortege* will proceed through Callander and onward by the road leading to the Trossachs and Loch Katrine, which will be closed for carriages from 10 A.M., in order to prevent obstruction to the royal progress.

Triumphal arches and other demonstrations of loyalty are in course of erection in Callander and neighbourhood.

The military arrangements will be subject to the commanding officer who may be charged with them; but it may be stated that the Queen's Own Royal Regiment of Glasgow Yeomanry Cavalry (numbering about eighty) have loyally tendered their services, and will, if approved of, be in attendance at the railway station to act as a guard and escort to the royal *cortege* from Callander to Loch Katrine, or to perform any other duty that may be assigned to them.

A strong body of police will also be stationed at Callander, on the road, and at Loch Katrine.

The Chamberlain of the Earl of Moray (who is lord of the manor for a large portion of the land between Callander

and Trossachs) will, if permitted, escort or accompany the royal *cortege* through his lordship's estate.

The Lord Willoughby de Eresby, as lord of the manor, will be in attendance at Callander, and Lady Willoughby at the commencement of her estate at Trossachs, to escort the royal party to the place of embarkation at Loch Katrine.

A salute from artillery placed on the adjoining heights will announce the embarkation of Her Majesty.

The Lord Provost and Magistrates, and three Chairmen of Committees of the Glasgow Corporation Water Commissioners (not exceeding in all fifteen or sixteen persons), will be on board the steamer to receive Her Majesty, and to accompany the royal party to the mouth of the aqueduct (situated on the south bank of the lake), where the intended ceremony of opening the Works is to take place.

The steamer will sail close up to a platform constructed at the mouth of the aqueduct, so as to admit of the royal party stepping on to it from the steamer.

The Duke of Montrose, as lord of the manor, the Lord Lieutenant and Sheriff of Perthshire, the Members of Parliament for the city of Glasgow, a deputation from the Celtic Society of Glasgow (numbering about eighty) in their national Highland costume, and other distinguished guests, will be in attendance at the place of ceremony; and several companies of the recently-formed Glasgow Volunteer Rifle Corps will, if permitted, line and guard the place of ceremony and road to the cottage.

CEREMONY.

When the royal party is arriving at the platform, the band will perform the "National Anthem."

The Lord Provost will present an Address, by the Lord Provost, Magistrates, and Common Council of the city of Glasgow, as Water Commissioners.

Thanksgiving for the accomplishment of the work, and prayer for a blessing upon it, will be offered up by one of the city clergymen.

The Queen, if it please Her Majesty, may then give in-

structions for opening the sluices, or do so herself, by opening a small tap which will set in motion machinery for raising the shuttles, thereby admitting the water of the loch to the aqueduct.

The Queen, if it please Her Majesty, will then declare the Water Works open.

The band will perform "Rule Britannia."

The discharge of artillery on the adjoining heights will announce the completion of the ceremony; and this, it is expected, will be immediately followed by similar discharges of artillery from Stirling and Edinburgh Castles, and by the ringing of bells in the city of Glasgow.

After the ceremony, the royal party will be conducted to the Commissioners' cottage, situated about 150 yards distant from the aqueduct, where luncheon will be provided.

After luncheon, the royal *cortege* will return by the same steamer, carriages, and route, to the Palace of Holyrood.

JOHN BURNET, *Secretary*.

On 8th October the Lord Provost received the following communication on the subject from His Grace the Duke of Newcastle:—

BALMORAL,
8th October, 1859.

MY LORD PROVOST,—I have the honour to acknowledge your letter of the 6th, inclosing a Programme of the proceedings to be observed at the Inauguration of the Glasgow Water Works on the 14th instant.

I have submitted the Programme to the Queen; and I have the honour to inform you that Her Majesty has been pleased to approve of the arrangements proposed.

I have received Her Majesty's commands to write to the proper authorities respecting the attendance of the artillery from Leith.

As I perceive that addresses are to be presented to Her Majesty on the occasion, I request you to favour me, with as little delay as possible, with copies of them.

I have the honour to be, my LORD PROVOST,
Your obedient humble Servant,

NEWCASTLE.

The LORD PROVOST of Glasgow.

On the following day the Secretary had the honour to receive the following letter :—

BALMORAL,
9th October, 1859.

SIR,—I have to acknowledge your letter of the 7th October. All necessary arrangements have been made by the Department of the Master of the Horse, for the conveyance of Her Majesty along the road to which your letter refers ; and I believe you may be satisfied that they will be found sufficient to insure the Queen's convenience as well as safety.

The artillery will be provided, if the Lord Provost applies to the Earl of Melville.

As regards the band of the Sussex Militia, it would be very unusual for Her Majesty to take any steps for her own reception on such an occasion ; and I can offer you no opinion. I can, however, state that the Queen would prefer that there should not be a band of music on board the steamer.

I wrote to the Lord Provost yesterday respecting the Programme.

I am, SIR,

Your very obedient Servant,
NEWCASTLE.

JOHN BURNET, Esq.

Intimation of these arrangements was immediately given to Henry Home Drummond, Esq., the acting Lord-Lieutenant of Perthshire, and to the Sheriff of that county, within whose jurisdiction the ceremony was to take place ; and also to the Duke of Montrose, Lord and Lady Willoughby de Eresby, the Earl of Moray, and Mr. Hamilton of Leny,—the land owners through whose estates Her Majesty was to pass on her journey from Callander to Loch Katrine. The Duke and Duchess of Athole were invited to attend the Inauguration, and did so, the Duke bringing with him a large party of his Highlanders with two pieces of artillery. The Earl of Mansfield ; Sir James Colquhoun, Lord-Lieutenant of Dumbartonshire ; Lord Robert Clinton, M.P. ; Mr. Dalglish, M.P. ; Mr. E. S. Gordon, Sheriff of Perthshire, and other distinguished guests, were also present.

The Lord Provost Galbraith and a number of the Com-

missioners proceeded to the Trossachs on the afternoon of the day before the Inauguration, in order to satisfy themselves that the arrangements ordered had been completely carried out, and that they might be in readiness to receive the Queen on her arrival from Callander on the following day.

A few days before, the Secretary was authorized by the Committee to advertise authoritatively travelling routes, for the information and guidance of the general public, which he did in the following terms:—

“1. LOCH CHON ROUTE—By rail to Balloch, and steamer on Lochlomond to Inversnaid, thence to the place of ceremony, about six miles. Coaches will be put on the road from Inversnaid; but these may not be sufficient to carry all. The scenery is fine; and, if the day is good, the walk will be of great interest and beauty. A footpath has been formed from Coulbarns to the place of ceremony.

“2. ARROCHAR ROUTE—By steamer to Arrochar, thence by walk or drive to Tarbet, two miles. Cross Lochlomond by steamer or small boat to Inversnaid, thence to the place of ceremony, as in route first.

“3. ABERFOYLE ROUTE—By rail to Bucklyvie, where there will be omnibuses to Aberfoyle, about six miles; or drive or ride from Glasgow to Aberfoyle. It is understood there will be carriages from Aberfoyle to the head of Loch Chon, about ten miles, thence by footway directly over the hill to the place of ceremony, about a mile and a half.

“4. CALLANDER ROUTE—By rail to Callander, where the Queen will be received, both going and returning. From Callander to Trossachs, about ten miles, by conveyance, except when the road is closed as to carts and carriages by order of the Sheriff. Her Majesty will embark at the Trossachs' end of the loch, where she will also disembark on returning after the ceremony, and proceed thence along the road to Callander.”

At the meeting of Committee authorizing this advertisement, Sir Andrew Orr stated that, having been lately at the mouth of the aqueduct on Loch Katrine, he had found,

as part of the arrangements there, that two navvies had volunteered to navigate a boat down the tunnel after the royal opening,—in which boat, he added, any one still sceptical as to the completion of the aqueduct, and desirous of having his scruples removed, might have a seat.

A number of the Commissioners and their friends left the Dundas Street railway station at an early hour on the morning of 14th October.

The party proceeded by rail to Balloch, where they embarked on board the steamer "Prince of Wales." At Balmaha they received on board the Duke and Duchess of Montrose, Lord Ernest Bruce, Mr. and Lady Charlotte Montgomery, Captain and Lady Agnes Murray, Lady Emily Foley, Lady Violet Graham, Mr. Huddleston, Q. C.; Mr. Mitford, of the Foreign Office; Mr. Thomas Price, and Lady Harriet Herbert. About half-past nine o'clock the steamer reached Inversnaid, when the whole party disembarked. They had still a distance of six or seven miles to travel; and this part of the journey was accomplished under considerable difficulties. The weather had been all morning most unpropitious, and when the party left the steamer rain was falling heavily. The Commissioners had provided all the vehicles which could be obtained for the purpose of conveying their friends to Stronachlachar, but a large number were obliged to find their way thither on foot. After reaching Stronachlachar, some of the party proceeded to the mouth of the tunnel in boats, while others found their way thither round the margin of the loch, and there awaited Her Majesty's arrival.

A landing platform having been erected, as arranged, opposite the mouth of the tunnel, the steamer, with the Queen on board, sailed close up to it. Here a fine floral arch was erected, and a covered way, laid with scarlet cloth, led from the steamer to a raised dais laid with rich velvet, and covered over with a beautiful rustic canopy. Under this canopy was placed the handle with which the Queen was to open the sluices, and with her royal hand send on the first water from Loch Katrine to Glasgow. This handle led by underground connection rods to a small hydraulic engine.

From the dais there was another covered way which led to the Commissioners' cottage, where luncheon was provided for the royal party. The cottage had been most exquisitely furnished and decorated by Mr. Colquhoun and Mr. J. B. Bennet, of Glasgow. In the neighbourhood a large wooden erection was built and fitted up as a refreshment saloon.

About half-past one o'clock the royal steamer hove in sight; and the fact was announced by a joyous cheer from the assembled multitude. Her Majesty had travelled from Balmoral to Holyrood on the preceding day, and had left Edinburgh that morning at ten o'clock, accompanied by His Royal Highness the Prince Consort, the Princess Alice, and the Princess Helena. His Grace the Duke of Newcastle, Secretary of State for the Colonies, accompanied the royal party; and the ladies in waiting were Lady Churchill and the Honourable Miss Cathcart. The other members of the royal suite were General Grey and Lieutenant-Colonel Ponsonby.

The royal train, consisting of two state carriages, reached Callander at half-past eleven, and Her Majesty was there received by the Honourable Lord and Lady Willoughby de Eresby. A guard of honour, composed of detachments of the 42d and 79th Highlanders, was drawn up at the railway station, which was beautifully decorated. A magnificent triumphal arch, composed of heather, flowers, and tartan, was erected at the station, and a salute of artillery greeted Her Majesty's arrival. The royal party drove in carriages from Callander to the Trossachs, escorted by a party of the 13th Light Dragoons. At the bridge of Kilmahog, where there was another triumphal arch, Her Majesty was received by John Philipps, Esq., Commissioner of the Earl of Moray, Lord of the Manor, surrounded by about a hundred of his lordship's Perthshire tenantry on horseback, wearing the tartan of his clan.

When Her Majesty arrived at the foot of Loch Katrine, she was received by the Lord Provost and the friends who accompanied him, on board the beautiful little screw steamer "Rob Roy," which waited her arrival at the pier to convey the

royal party up Loch Katrine to their destination at the inlet or mouth of the tunnel. Unfortunately, the state of the weather prevented Her Majesty fully witnessing the unparalleled scenery of this romantic district.

About two o'clock the "Rob Roy" arrived at the platform with its royal passengers. As soon as the steamer was moored, the Lord Provost and Magistrates, Sir Andrew Orr, Mr. Stewart of Omoa, Mr. Dreghorn, Mr. Bateman, and Mr. Burnet, proceeded to the platform, and formed a line on each side of the way leading to the dais. On Her Majesty stepping ashore, leaning on the arm of the Prince Consort, she was greeted with the most enthusiastic cheers, which she graciously acknowledged. The Queen and her suite having passed on to the dais, the band in attendance performed the "National Anthem."

Mr. Burnet, as Secretary to the Commissioners, then read to Her Majesty the following Address:—

TO THE QUEEN'S MOST EXCELLENT MAJESTY.

Most Gracious Sovereign,—We, your Majesty's dutiful and loyal subjects, the Lord Provost, Magistrates, and Council of the City of Glasgow, beg leave to approach the throne with renewed assurances of our loyal and devoted attachment to your Majesty's person and government. Your Majesty's gracious condescension in deigning to patronise with your royal presence the inauguration of the important works for the supply of pure water to the numerous inhabitants of our populous city—alike important to their social and domestic comfort and enjoyment, as of incalculable benefit to many branches of manufacturing and commercial industry in this city and neighbourhood—will long be held in grateful remembrance by your Majesty's subjects in this portion of your Majesty's dominions, and affords another proof of the fostering care and countenance uniformly bestowed by your Majesty on every work for the promotion of the well-being and happiness of your people.

It is with no ordinary feelings of pride and satisfaction that we are enabled this day to state to your Majesty that we have completed one of the most interesting and difficult works of engineering, and, at the same time, the largest and most comprehensive scheme

for the supply of water which has yet been accomplished in your Majesty's dominions.

The deficient and unsatisfactory condition of the water supply, on which so much of the health and comfort of the inhabitants depended, determined the Corporation of Glasgow, some years ago, to purchase the works of the Water Companies then existing, and to take the supply of water into their own hands.

For this purpose an Act of Parliament was obtained, which received your Majesty's royal assent on the 2d day of July, 1855.

Empowered by this Act, the Commissioners came to these wild and romantic regions for that copious supply of pure water of which the large and rapidly increasing population of Glasgow stood in need. This beautiful and extensive loch of pure water, fed by a large amount of annual rainfall, and lying at an elevation of 360 feet above the sea, was selected as the fountain-head. The rugged district, of 34 miles in extent, which intervenes between the loch and the city, has been penetrated by tunnels, crossed by aqueducts, or traversed by iron pipes, in the execution of the necessary works for ultimately conveying to the city no less than 50,000,000 gallons of water per day.

The tunnel, at the mouth of which your Majesty now stands, and into which the water of Loch Katrine is to flow, is 8 feet in diameter, 2,325 yards in length, and 600 feet below the summit of the mountain under which it passes. It is the first of a series of seventy distinct tunnels of the same diameter, which, measured in the aggregate, are 13 miles in length, the longest being at the southern extremity of the works, and 2,650 yards in length.

Loch Katrine, Loch Venacher, and Loch Drunkie, are all laid under contribution, either for the supply of the city, or for affording an increased and more regular supply in dry seasons, to the River Teith, below Loch Venacher, as compensation for the privilege of diverting 50,000,000 gallons per day to Glasgow. The total area of these lochs is upwards of 4,000 acres, and the available capacity within the limits to which they may be drawn off is 1,600,000,000 cubic feet of water.

The works have been about three years and six months in course of execution, under the able management of our talented engineer, Mr. John Frederic Bateman, and have given employment to about 3,000 men in the country for a large portion of that time, besides ironfounders and mechanics engaged in the manufacture of the iron pipes, and in the various ironwork and machinery

connected with the works. The cost of construction of the new works will be between £600,000 and £700,000, and the total cost of the undertaking to the city, including the purchase of the works of the former water companies, compensation for land, water privileges, and other expenses, will be nearly £1,500,000. The present population of the city and suburbs to be supplied with water extends to upwards of 500,000.

We have thought it to be our duty thus humbly to lay before your Majesty this short sketch of the undertaking which you have been so graciously pleased to honour with your royal countenance ; and we doubt not that the blessings which we confidently expect will attend the introduction of this water into Glasgow, will ever call to the remembrance of its inhabitants how much they owe to the benignant rule, and the pure and virtuous example, of that much loved and ever honoured Sovereign, with whose name this work will now for ever be associated.

That the All-wise and Supreme Disposer of events may continue to bless and protect your Majesty, His Royal Highness the Prince Consort, and your illustrious family, and that your Majesty may be long spared to reign over a free, a happy, and a loyal people, is our sincere and earnest prayer !

Signed by me, Lord Provost and Chief Magistrate of Glasgow, Chairman of the Commissioners, in their name and by their appointment :—In testimony whereof the common seal of the said city is hereunto affixed, this fourteenth day of October, in the year eighteen hundred and fifty-nine.

ANDREW GALBRAITH, *Chairman.*

The Queen listened most attentively to the reading of the Address ; and after it was read, Mr. Burnet handed it to the Lord Provost, when his Lordship presented it to Her Majesty, by whom it was most graciously received and handed to the Duke of Newcastle.

Her Majesty then, in a clear and distinct voice, read the following reply :—

I accept with great satisfaction your loyal and affectionate Address, and thank you sincerely for the expression of your attachment to my throne and person, and for the cordial welcome with which you have received me.

It is with much gratification that I avail myself of this oppor-

tunity of inaugurating a work which, both in its conception and its execution, reflects so much credit on its promoters, and is so calculated to improve the health and comfort of your vast population, which is rapidly increasing round the great centre of manufacturing industry in Scotland.

Such a work is worthy of the enterprise and philanthropy of Glasgow, and I trust it will be blessed with complete success.

I desire that you will convey to the great community which you represent my warmest wishes for their continued prosperity and happiness.

The following gentlemen had then the honour of being presented to the Queen by the Lord Provost, viz.:—Bailies Clouston, Grant, Fowler, Gemmill, Wilson, Brown, Playfair, Young, and M'Adam; Deacon-Convener Morrison; James Hannan, Esq.; Sir Andrew Orr; Robert Stewart, Esq.; Mr. Bateman, the Engineer; and Mr. Burnet, the Secretary to the Commissioners.

The Rev. Dr. Craik then offered up the following prayer:—

Almighty and ever blessed God, who art the Most High over all the earth, unto Thee would we lift up our souls. We would draw near Thee with deep humility, for we are thy weak and sinful creatures, and Thou art glorious in thy holiness. Thou, Lord, art an infinitely powerful Creator. Thou hast measured the waters in the hollow of thy hand, and meted out heaven with the span, and weighed the mountains in scales, and the hills in a balance. We would worship Thee who hath made heaven and earth, and the sea, and the fountains of water. Thou, O Lord, hast granted us life and favour; and for all the faculties with which we have been endowed we would offer unto Thee the sacrifice of thanksgiving. To Thee we are indebted for wisdom to devise, and skill to execute. From Thee are the zeal and fortitude by which enterprises of vast extent are begun and successfully completed. Girded with power, it is in thine hand to give strength to all; and now, O Lord, that we have seen the accomplishment of a work deemed so important as to be inaugurated by the Sovereign of these realms, and recalling the enduring monuments of imperial Rome, we would render our united and heartfelt thanks unto Thee for all the favour which Thou hast most graciously bestowed on this great undertaking, and the varied

energies summoned into exercise from its commencement to its close. Thou hast strengthened the sinews of the labourers; and animated to persevering toil, and by thy blessing on their strenuous activity, the work has gone on fast, and prospered in their hands. For all the skill with which difficulties have been anticipated and overcome, and the success with which the design has been carried into effect, and the glad consciousness of well-doing enjoyed by its benevolent projectors, we thank Thee, O our God, and praise thy glorious name! Grant, O Lord, we fervently pray, that the benefits of this stupendous work may be richly felt by the present inhabitants of that city with which it is connected, and by succeeding generations. May all classes of the citizens be gladdened by the refreshing stream which Thou hast abundantly provided! May it supply a copious and purifying tide, conveying, through thy blessing, health and comfort, even to the humblest dwellings; and ever as such benefits are longer and more widely known, may there arise to Thee, from thousands and tens of thousands, songs of grateful acknowledgment; seeing that, by thy power and blessing, the waters gushed out and the stream overflowed. Bless, O Lord, our native land. Abundantly bless our Sovereign Lady Queen Victoria. Greatly enrich her with all spiritual and temporal blessings. Bless the Prince Consort, Albert, Prince of Wales, and all the other members of the royal family. O God, bestow on them the richest tokens of thy favour. Shower down thy blessing on the Magistrates of our city, and on those who are associated with them. Reward them with better than earthly blessings for their zealous labours in this and all good works, and give them the gratification of feeling that their high endeavour has been crowned with great success. Bless, O Lord, the Christian Church. Grant that the supply of temporal wants may ever remind us of the exceeding richness of thy grace, in thy kindness towards us, through Christ Jesus. Sinners by nature and by practice, may we thus obtain pardon and acceptance. While we contemplate with admiration the works accomplished by man's skill and labour, may we never resign our hearts with exclusive eagerness to any immediate objects of pursuit, forsaking Thee, the fountain of living waters, and hewing out for ourselves cisterns, broken cisterns, that can hold no water. Rejoicing now in the river that makes glad the city of our God, may we be enabled to look, in the exercise of faith, to a pure river of water of life, clear as crystal, proceeding out of the throne of God and of the Lamb. Hear, O God, our

humble supplication, for the sake of Christ Jesus our Redeemer, to whom, with Thee and the Holy Spirit, be ascribed all praise and glory, dominion and blessing, world without end. Amen.

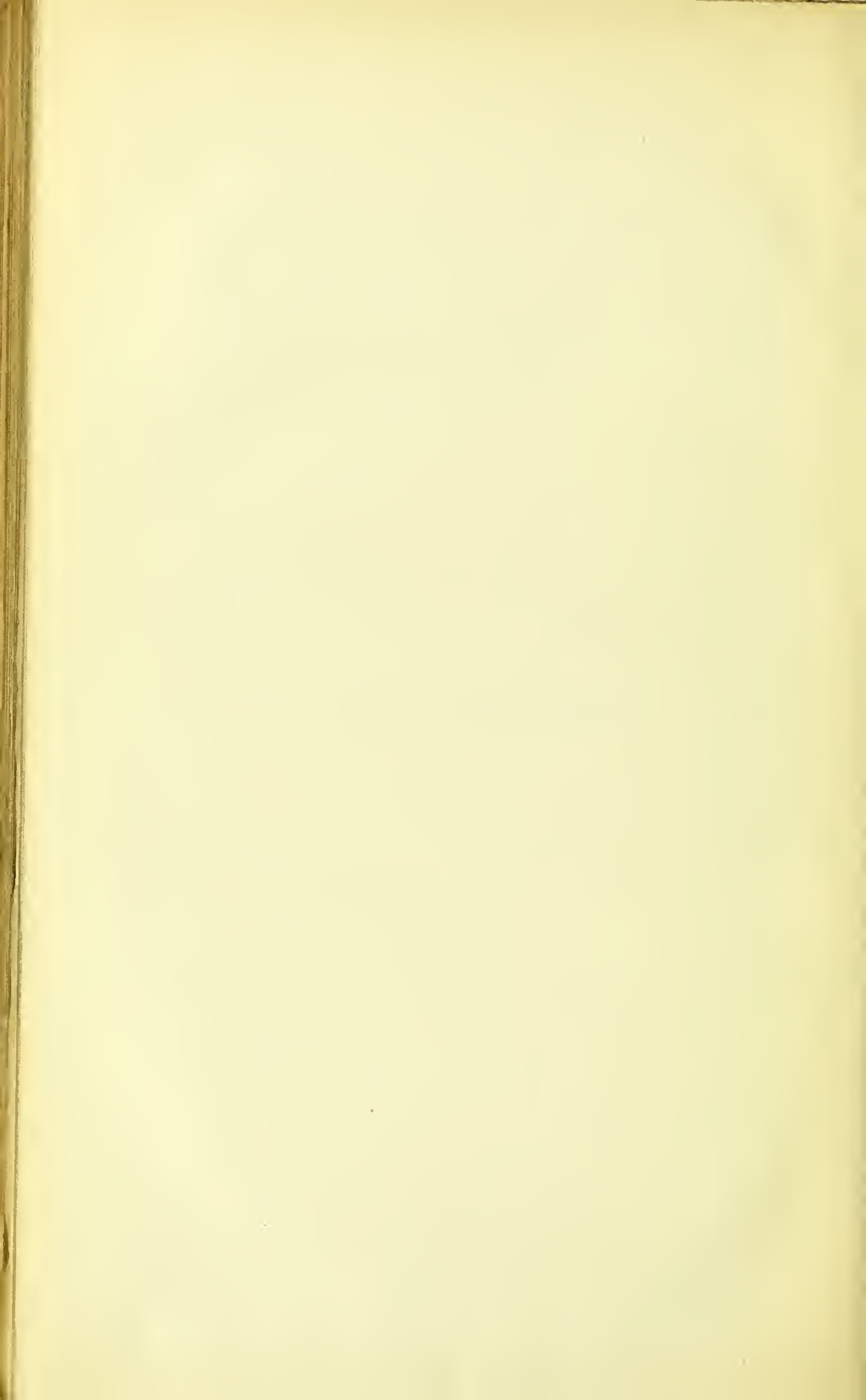
The Divine blessing having been thus invoked, Her Majesty turned the handle placed for the purpose, and, amid the booming of cannon and the applause of thousands of spectators, the Loch Katrine Water Works were declared duly inaugurated. The rushing of the water was distinctly heard by those around. At the request of Her Majesty, the royal party were conducted to the sluice, that they might themselves see the water flowing for the first time from Loch Katrine towards Glasgow. The band played "Rule Britannia." The salutes of cannon which announced the completion of the ceremony were repeated at the Trossachs, and again at Callander. The telegraphic wires conveyed the gratifying intelligence to Glasgow, where the city bells rang merrily in celebration of the event; and also to Edinburgh and Stirling, which at once sent forth from their Castles salvos of artillery.

After inspecting the mouth of the tunnel, Her Majesty was conducted to the cottage, where luncheon was served; and shortly thereafter the royal party re-embarked on board the "Rob Roy," when Her Majesty was again cheered by her loyal subjects; and the party returned to Holyrood by the same route by which they travelled from Edinburgh in the morning.

Thus was completed, and Royally Inaugurated, one of the noblest municipal schemes ever, it is believed, devised and executed for supplying to a large and important commercial and manufacturing community one of the first necessities of life, by works which will doubtless transmit to future ages an enduring testimony to the enlightened wisdom, enterprise, and zeal of the Civic Rulers by whom, from time to time, they were projected, carried on, and ultimately brought to successful completion. Already, in a sanitary point of view, their influence has been sensibly felt,

they have become the object of universal admiration, and their success in a financial point of view has been fully tested and proved, as the annexed tables demonstrate. It is therefore with no ordinary feelings of gratitude and pride that they may be regarded by the citizens of Glasgow, and appreciated by all who take an interest—and who does not?—in the sanitary condition of the people.

APPENDIX.



APPENDIX.

No. I.—STATEMENT OF CAPITAL AND ANNUAL REVENUE AND EXPENDITURE, WITH RENTAL OF THE CITY, AND POPULATION.
From the passing of the Act in 1855 till 1868-69.

YEAR.	CAPITAL.			REVENUE.			EXPENDITURE.			DOMESTIC RATE, PER POUND.		RENTAL OF THE CITY from 1855 to 1869, according to Assessor's Valuation.		Population of Municipality.	
	£	s.	d.	£	s.	d.	£	s.	d.	North Side of Clyde.		Valuation.	Increase.		
										s.	d.				s.	d.
1855-56,													£	370,000	
1856-57,	752,693	3	1	62,335	15	8	58,605	0	0	...	1	0	1,362,168	.....	375,000
1857-58,	964,848	9	0	65,939	19	10	64,823	19	3	1	2	0	1,400,885	38,717	380,000
1858-59,	1,272,940	8	2	68,497	9	7	74,140	4	9	1	2	0	1,462,551	61,666	385,000
1859-60,	1,428,452	0	2	71,449	4	9	85,866	15	8	1	2	0	1,518,756	56,208	390,000
1860-61,	1,565,257	5	6	75,699	0	9½	83,964	8	4½	1	2	0	1,573,165	54,409	395,503
1861-62,	1,574,739	19	5	80,262	6	11	85,098	8	5	1	2	0	1,625,148	51,983	401,000
1862-63,	1,576,812	18	10	87,190	18	8½	84,651	3	4½	* 1	4	0	1,702,113	41,188	410,000
1863-64,	1,588,822	0	11	91,208	9	4	84,186	4	8	* 1	4	0	1,745,390	35,777	420,000
1864-65,	1,596,491	18	9	90,732	10	1	85,439	15	10	1	2	0	1,778,728	43,277	430,000
1865-66,	1,611,126	3	11	90,935	14	3	88,780	9	7	1	0	0	1,808,430	33,338	438,000
1866-67,	1,626,943	10	9	95,708	11	4	91,206	5	1	1	0	0	1,863,024	29,702	440,000
1867-68,	1,666,316	3	9	99,089	15	10	93,961	17	6	+ 1	0	0	1,913,595	54,594	450,000
1868-69,				.....			.....			...			1,987,026	50,571	460,000
										...				+73,431	

* Beyond Municipality, 1s. 2d.
† Largest Increase since 1855. Total Increase since 1855, £624,883. Average Annual Increase, £48,000.
‡ Beyond Municipality on north side, 1s. 1d.
§ Census Return.

158 HISTORY OF THE WATER SUPPLY TO GLASGOW.

No. II.—AVERAGE DAILY QUANTITY OF WATER SUPPLIED.

YEARS.	From LOCH KATRINE.	From GORBALS.	TOGETHER.
	Gallons.	Gallons.	Gallons.
1856-57, . .	12,658,000	3,511,000	16,169,000
1857-58, . .	13,625,000	3,456,600	17,081,600
1858-59, . .	13,907,000	3,624,000	17,531,000
1859-60, . .	14,000,000	4,000,000	18,000,000
1860-61, . .	14,250,000	3,770,000	18,020,000
1861-62, . .	16,304,337	3,374,643	19,678,980
1862-63, . .	16,668,387	3,349,918	20,018,305
1863-64, . .	18,591,271	3,303,976	21,895,247
1864-65, . .	19,063,262	3,350,257	22,413,519
1865-66, . .	20,333,382	3,460,744	23,794,126
1866-67, . .	22,703,617	3,646,428	26,350,045
1867-68, . .	21,692,789	3,743,669	25,436,458

No. III.—EXTENSION OF PIPING.

YEARS.	On NORTH SIDE OF CLYDE.	On SOUTH SIDE OF CLYDE.	TOGETHER.
	Yards.	Yards.	Yards.
1856-57, . .	5,569	2,812	8,381
1857-58, . .	15,746	3,121	18,867
1858-59, . .	6,220	1,877	8,097
1859-60, . .	4,094	938	5,032
1860-61, . .	10,590	2,102	12,692
1861-62, . .	7,662*	2,652	10,314
1862-63, . .	7,842*	3,253	11,095
1863-64, . .	5,030*	2,439	7,469
1864-65, . .	8,602*	4,189	12,791
1865-66, . .	6,298*	4,859	11,157
1866-67, . .	5,676	7,849	13,525
1867-68, . .	4,158	4,498	8,656

* Includes Distributing Pipes.—Main Pipes, 6 inches diameter, and upwards; Distributing Pipes, 5 inches diameter, and under.

No. IV.—ANALYSES OF LOCH KATRINE WATER.

	Graham and Hofmann. May, 1854.	Dr. Miller. Water drawn on 14th May, 1854.	Dr. Penny. Water drawn in March and June, 1854.
	Grs. per Gall.	Grs. per Gall.	Grs. per Gall.
Organic Matter,	0·819	1·12	0·900
Sulphate of Lime,	0·378	0·56	0·381
Do. of Potash,	trace.	”	”
Do. of Soda,	0·280	”	”
Chloride of Calcium,	”	0·16	0·144
Do. of Sodium,	0·448	0·29	”
Alkaline Chlorides,	”	”	0·433
Carbonate of Magnesia,	0·154	trace.	0·216
Do. of Soda,	0·147	”	”
Sesquioxide of Iron,	trace.	”	trace.
Silica,	trace.	0·16	0·170
TOTAL,	2·226	2·29	2·224
Hardness on Dr. Clark's Scale,	Under 1°	0·6°	0·8°
Gases, per Gallon,—	Cub. Ins.	Cub. Ins.	Cub. Ins.
Carbonic Acid,	0·09	0·05	0·080
Oxygen,	2·38	2·31	2·424
Nitrogen,	4·66	4·33	4·777
TOTAL,	7·13	6·69	7·281

By DR. WALLACE, 1854 AND 1861.

	Drawn from Loch, 1854.	Drawn in Glasgow, 1861.
	Grs. per Gall.	Grs. per Gall.
Lime,	0·19	0·47
Magnesia,	0·10	0·12
Sulphuric Acid,	0·33	0·36
Chlorine,	0·33	0·30
Alkalies and Carbonic Acid,	0·12	0·51
Alumina and Phosphates,	0·10	0·16
Oxide of Iron,	”	trace.
Silica,	0·01	0·06
Organic Matter,	0·80	0·84
TOTAL,	1·98	2·82
Gases, per Gallon,—	Cub. Ins.	Cub. Ins.
Carbonic Acid,	0·07	0·38
Oxygen,	2·51	2·54
Nitrogen,	4·92	5·58
TOTAL,	7·50	8·50

No. V.—ANALYSES OF LOCH LOMOND WATER.

DR. PENNY, 1854.

	From Loch opposite Inversnaid.	From Outflow of Loch.
	Grs. per Gall.	Grs. per Gall.
Organic Matter,	1·175	1·145
Mineral Matter,	1·650	1·875
TOTAL,	2·825	3·020
Hardness,	0·85°	1°
Gases, per Gallon,—	Cub. Ins.	Cub. Ins.
Carbonic Acid,	0·28	0·34
Oxygen,	2·14	2·08
Nitrogen,	4·52	4·25
TOTAL,	6·94	6·67

No. VI.—ANALYSES OF INVERNESS AND WHITEHAVEN WATER.

MESSRS. MILLER, PENNY, AND REDWOOD, 1855.

	Inverness. — Drawn from River Ness.	Whitehaven. — Drawn from River En.
	Grs. per Gall.	Grs. per Gall.
Organic Matter,	0·80	0·46
Fixed Salts,	1·70	1·60
TOTAL,	2·50	2·06
Hardness,	0·8°	0·7°
Gases, per Gallon,—	Cub. Ins.	Cub. Ins.
Carbonic Acid,	0·746	0·47
Oxygen,	2·294	2·35
Nitrogen,	4·737	5·37
TOTAL,	7·777	8·19

No. VII.—RAINFALL IN THE LOCH KATRINE AND GORBALS DISTRICTS.

DATE.	LOCH KATRINE DISTRICT.										GORBALS DISTRICT.				
	Elevation 275 feet At Loch Venacher.	Elevation 430 feet At Loch Drunkie.	Elevation 270 feet At Bridge of Turk.	Elevation 1,800 feet Between Glen Finlas and Ben Leil.	Elevation 380 feet At Glenyie, head of Loch Katrine.	Elevation 830 feet On summit of hill above Tunnel at Loch Katrine.	Elevation 325 feet At Loch Dhu.	Elevation 60 feet At the Inn at Aberfoyle.	Elevation 1,500 feet On hills between Loch and Loch Katrine. Leda.	Elevation 1,800 feet Head of Duchray Valley. Benlomond.	Elevation 320 feet. At Mungook Reservoir.	Elevation 280 feet. No. 1. Warrick Glen Reservoir.	Elevation 310 feet. Ryat Linn Reservoir.	Elevation 550 feet. At Middleton.	Elevation 700 feet. At Nether Calm. Black Loch.
1854.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.
1855.	93	10.0	8.2	7.5	17.0	11.8	15.2	56.1	67.1	109.0	84	43.28	45.92	35.50	57.55
1856.	69	10.5	5.3	5.0	17.4	13.8	12.8	34.6	67.1	109.0	84	43.28	45.92	35.50	57.55
1857.	63	7.2	5.6	5.6	17.4	13.8	12.8	36.7	67.1	109.0	84	43.28	45.92	35.50	57.55
1858.	39	4.2	4.3	3.5	17.4	13.8	12.8	47.6	67.1	109.0	84	43.28	45.92	35.50	57.55
1859.	43	5.3	4.8	6.3	17.4	13.8	12.8	41.5	67.1	109.0	84	43.28	45.92	35.50	57.55
1860.	1.7	2.3	1.8	1.8	17.4	13.8	12.8	52.6	67.1	109.0	84	43.28	45.92	35.50	57.55
1861.	0.9	1.3	1.0	1.2	17.4	13.8	12.8	40.4	67.1	109.0	84	43.28	45.92	35.50	57.55
1862.	8.2	9.9	7.9	8.5	17.4	13.8	12.8	71.6	67.1	109.0	84	43.28	45.92	35.50	57.55
1863.	26	2.8	2.2	5.1	17.4	13.8	12.8	77.0	67.1	109.0	84	43.28	45.92	35.50	57.55
1864.	7.6	8.4	7.2	4.6	17.4	13.8	12.8	57.8	67.1	109.0	84	43.28	45.92	35.50	57.55
1865.	3.9	3.9	3.6	2.8	17.4	13.8	12.8	46.3	67.1	109.0	84	43.28	45.92	35.50	57.55
1866.	9.9	12.2	9.8	10.7	17.4	13.8	12.8	50.0	67.1	109.0	84	43.28	45.92	35.50	57.55
1867.	65.5	78.0	61.7	62.6	17.4	13.8	12.8	50.0	67.1	109.0	84	43.28	45.92	35.50	57.55
TOTALS.	65.5	78.0	61.7	62.6	17.4	13.8	12.8	50.0	67.1	109.0	84	43.28	45.92	35.50	57.55
AVERAGES.	61.2	67.5	50.4	59.4	92.0	83.1	88.6	55.2	85.9	91.5	49.0	46.7	44.9	53.1	54.7

† Observations incomplete.

* No Returns for these years.

No. VIII.—EXTRACTS FROM CHEMICAL AND MEDICAL REPORTS.

These reports all contain much important matter of detail; but it would occupy too much space to give more in this place than the general conclusions of the different Reporters.

From Report by DR. ROBERT ANGUS SMITH, of Manchester, accompanying MR. BATEMAN'S First Report to the Magistrates and Council.

In conformity with instructions received through Mr. Bateman, I have examined the various districts from which it is proposed to collect water for the City of Glasgow, viz., the high ground to the south, including the drainage ground of the rivers Avon, Douglas, and Clyde, with the Endrick and Loch Katrine districts on the north; also to some extent the water from these districts,—not, however, having attempted complete analyses. The present report, therefore, may be considered preliminary to a fuller investigation, should that be required. . . .

The Loch Katrine District.

The next district to be considered is that great one which forms a large portion of what we call the Highlands. The geological formation is the mica slate, which extends from Cantire to Stonehaven in length, and averages probably twenty miles in breadth. All this district, similar in structure, must supply similar water; and there being so much smooth, hard rock containing nothing or almost nothing soluble in water, and scarcely at all friable, the streams are delivered, even at flood-time, with little matter in suspension, and, I may almost say, no inorganic matter in solution.

I received specimens from Loch Katrine and Loch Lubnaig, taken in winter when the snow was on the ground. The specimen from Loch Katrine was almost absolutely pure water, clear to the utmost, and without colour. The water of Loch Lubnaig was only slightly whitened by a whitish substance, probably slate. The water was taken, in both cases, whilst the lakes were very high from melting snow. In July of this year I went to see the lakes; the rain had been heavy for a week before, except on the day of my arrival and the preceding day, when there had been no rain

after twelve o'clock. There was, therefore, only a very slight period for rest and purification of the water. That of Loch Katrine was, however, nearly as clear as in winter, although a week before it had been stained by floods. It is true I had not an opportunity of seeing it a week before, and was only told that it was brown; but I know also that it must have been the case, as immediately after taking a specimen of the water on July 23d, in the evening the rain began to fall heavily, continuing about twelve hours, and rendering the lake less clear, whilst a stream of great size was rushing from it, tinged sufficiently to render the colour just perceptible in a glass. As this same amount of colour must have existed in the water a few days before, from the previous rain, we have an instance, on a great scale, of almost instant purification. This circumstance would render a very small reserve-supply sufficient, the lake so soon after disturbance becoming perfectly pure again. It may be remarked, that the streams running into the lake at the time when the surface rose so high—as much as a foot in twelve hours—were very much darker than the stream running from it. It is probable that, by the rapidity with which it is drawn off, a good deal of the flood water which had just entered was on the surface, and had not mixed with the great mass of the water of the lake; but even in its short passage it had almost been purified. The lake is a depositing reservoir, sufficiently large for the purification of the most turbid stream from any matter inclined to fall, and its great exposure to the atmosphere answers the purposes of a filter to a large extent. But the great mass of water which enters needs no purification; and it is probable that any coloured matter entering would be lost in the enormous amount of the colourless portion, and be pure without any further process. The streams themselves are clear, and after lying quietly in the lake become brilliant.

We may therefore readily conclude that the water may be drawn off perfectly clear almost at all times, the peculiar circumstances of the case rendering the disturbance caused by a summer rain very transient. Even the flooded water which I saw in Loch Katrine was of such an appearance as to equal the general supply of the Gorbals, as delivered in its best state in the houses. The hardness amounts only to 0.6 of a degree, very nearly equal to distilled water—I should rather say, water distilled several times, as water once distilled is seldom equal to this. It has, in fact, only one fault, if it can be called such: the taste is not so pleasant as water

which has passed through soil, at least in certain formations, or what we call spring water. The action of the porous earth or other material is in fact a very energetic action, sending the water out thoroughly aerated, more so than if it had been tossed about in the air. Still, in almost all cases water loses much of its beautiful softness in going into the ground, which is a counter-balance to its aëration. If the water had passed through the ground without increasing its hardness, there would, in all probability, be no water of great bulk equal to it in the country. As it is, no town will have an equal abundance of such remarkably pure water. . . .

The same kind of water is found in Cumberland, in a similar geological formation; and it is to be remarked that this formation is probably more than any other, in the North of England, Scotland, and Wales, used as a place of recovery for the sick, as well as a place for renewing the strength of the healthy. We may conclude, then, that thorough wholesomeness is a decided and long-established characteristic of this water.

An important point is the coolness of water. On this I can only say, that when I visited Loch Katrine the water was in this respect all that could be desired—a circumstance not always the case with small streams, which in warm weather become heated. Such a continuation of hot weather can scarcely be expected as greatly to affect Loch Katrine. The deep parts of the lake cannot be warmed, and there is motion enough to cause constant mixture. There is, in fact, a large portion of it carefully excluded from light, and resembling a covered reservoir by its depth. . . .

I need not enlarge on the advantages of soft water when they are already so well known, but I may say something on the general advantages of very pure water. There is great difficulty in obtaining water in great quantities so soft and so free from suspended or colouring matter as that of Loch Katrine. I have had occasion to mention the necessity which the bleachers south of the Clyde are under of obtaining spring water in order to finish their goods. For such a purpose Loch Katrine water would be superior, as it is still softer; and no doubt various works requiring pure water would rise up along the line of the supply as far as it was convenient. Water somewhat like this has been known to give a gloss to cotton goods, such as no other water, not even spring water, would give; and printworks have run along the line of a similar supply on the banks of the Leven. Many of our

manufactures would be much improved by the abundant use of pure distilled water, as I may call this from Loch Katrine; and as the supply is unlimited, distilled water would cease to be a rare luxury.

Although none of the proposed plans deal with hard water, yet the Loch Katrine water shows a decided superiority in that respect, also a decided superiority in respect of colour and transparency, causing filtration to be wholly unnecessary. There is, in fact, a great depositing reservoir and purifier already made to hand; and it will certainly be much to be lamented if the distance should be too great to allow it to compete with the other schemes. . . .

In this report I have said nothing about any organic matter but peat, partly because they were winter specimens which I had in my hands till lately, and partly because there is little danger of corrupting matter in any of the specimens, least of all in the Highland water, which may be said practically to be free from organic matter, the beds of the streams being pure stones, giving a proverbial purity which arises very much from a want of those fertilizing elements which produce vegetable and animal life—in fact, the elements for corruption are wanting.

I believe I have given a correct description of the several waters, and expressed their relative value.

That Loch Katrine water is the best may distinctly be pronounced; how much better, it is perhaps impossible to say; but it would certainly, in many works, have a distinct money value, which could be calculated by the increased value of the goods in the market and the diminished labour. How much the value is in a sanitary point of view, and as affecting the habits of the people, it is not possible to calculate, as the gain in these respects must have a much higher than a money value. I could have enlarged on the nature of such water in improving the quality of certain manufactures, and in cheapening processes, as it is a subject less attended to in estimating its importance; but I have confined myself here to general statements.

ROBERT ANGUS SMITH.

MANCHESTER, *2d August, 1853.*

From Report of PHILIP HENRY HOLLAND, ESQ., on the Water of Loch Katrine, and the Endrick Water.

LABORATORY, WHITEHALL,
June 10, 1853.

I have examined two specimens of water sent to me by J. F. Bateman, Esq., C.E., and find the hardness to be, according to Dr. Clarke's scale—

Water from Loch Katrine, 31st May, 1853,..... $\frac{1}{2}$ a degree.

Endrick water, 31st May, 1853,..... $3\frac{1}{4}$ degrees.

Both these specimens of water are of unusual excellence; that from Loch Katrine being remarkably soft. The specimen from Endrick Water was bright, clear, colourless, and tasteless. Tests showed both to be remarkably free from saline matter of any kind.

P. H. HOLLAND.

NOTE.—These samples were taken at the end of a long drought, when it may be assumed that the waters were as *hard* as they ever are. The gentleman who obtained the water, and who is well accustomed to see water in all states, writes, when sending the samples,—“The streams have been seldom known to be drier here. There has scarcely been any rain since February. Loch Katrine water looks beautifully clear; and I do not think it would be easy to find any water in such quantity equal to it.” A few days later, when sending further particulars of the streams in the district, he says,—“I never saw water so clear and transparent as Loch Katrine water. You could see the smallest thing at a great depth; you would almost imagine that there was nothing between the rocks at the bottom near shore and yourself, when the surface was still. The water was surprisingly cold in such hot weather, different in this respect from all the other lochs. Loch Lubnaig water was very clear, but not near so transparent and *cool* as Loch Katrine, and, where deep, appeared darker and more misty, as if slightly tinged by peat or other matter.” . . . The residents on the banks of Loch Katrine state that the water of the lake never contains any animalculæ, and this they attribute to the excessive coldness of the water.

J. F. B.

Memorandum by the late MR. MACKAIN, Engineer to the Glasgow Water Company, as to arrangements made to test the effect of the Water of Loch Katrine on Leaden Pipes and Cisterns. May, 1854.

A point the nearest to Loch Katrine, in the course of the stream issuing from it, from whence a sufficient extent of level

ground could be had for laying the iron pipes, and where there was a sufficient fall in the course of the river, was selected for the experiment.

The length of iron pipes which it was proposed to use in the experiments was 300 yards.

The fall in the river was required—

1st. To give motion to water in the iron pipes.

2d. To give motion to water in the lead pipes.

3d. To admit of cisterns being so placed as to be filled from the leaden pipes.

4th. To permit water to be drawn off from the lower part of the cisterns.

The total fall obtained, between the extreme points of the line of pipes, from river surface to river surface, was about 9 feet.

Where the pipes were laid into the river, there exists the remains of an old dam, which keeps up the surface of the river above it.

The iron pipes used consisted of one line formed by about 130 yards of pipes of 6 inches inside diameter, connected to about 160 yards of pipes of 5 inches in diameter, which made about 290 yards in one curved line.

These had been formerly used in distributing water by the Glasgow Water Company.

A second line of pipes, of 3 inches inside diameter, about 306 or 309 yards long, was laid alongside the other line.

These were new pipes just procured from an iron foundry.

To the first-mentioned line of pipes, which may be called the 5-inch line, there were attached two lines of leaden pipes of three quarters of an inch in diameter, which had been used for conveying water to the houses of people in Glasgow.

Two lines of new leaden pipes of the same diameter; and

One line of new leaden pipe tinned inside.

Below the old leaden pipes were placed two leaden cisterns which had been used in Glasgow.

Below the new leaden pipes were placed two new leaden cisterns.

Below the tinned pipe was placed a new cistern lined with tin.

To the second line of pipes, which may be called the 3-inch line, there were attached two lines of used leaden pipes, beneath which were cisterns which had been used, and two lines of new lead pipes with new cisterns.

To all the cisterns stop-cocks were attached at about 2 inches from the bottom.

A street well, or fountain, was attached to each line of iron pipes, by means of lead and iron pipes which had been used for that purpose in Glasgow. By means of these fountains the poorer classes in Glasgow are supplied with water.

From Report by DR. THOMAS ANDERSON, Professor of Chemistry in the University of Glasgow, and DUGALD CAMPBELL, Esq., Analytical Chemist to the Brompton Hospital in London.

We have minutely examined the water of Loch Katrine, and have personally superintended an extensive series of experiments made at the Trossachs, the results of which are embodied in the following Report:— . . .

As regards its general physical and chemical characters, we shall content ourselves with stating that it is a very clear and colourless water, and of unusual purity, the total quantity of solid matters contained in a gallon amounting to only 2·20 grains, of which 1·35 is mineral, and 0·85 organic matter. The mineral matter is composed chiefly of salts of soda and lime, the exact proportions of which we think it unnecessary to detail. It contains, in solution, 7·25 cubic inches of air per gallon, 4·75 of which were nitrogen, and 2·50 oxygen, along with a trace of carbonic acid. Its hardness was 0·9.

When exposed in open vessels, along with bright lead—that is to say, lead which has been recently scraped, so as to expose a fresh metallic surface—a strong action manifested itself in the course of a very few hours, the lead being covered with a white film, and a deposit of oxide falling to the bottom of the glass.

The conditions under which this experiment was made are, however, materially different from those under which the water would be supplied to the town; and a few further trials convinced us that very trifling modifications were sufficient to affect to a very great extent the nature of the results.

We particularly found that free exposure to the air, and likewise to the sun's rays, increased both the rapidity and intensity of the action; while, on the other hand, exclusion from light and air had a precisely opposite effect. Experiments were made by inclosing the water in leaden pipes perfectly full, and carefully

corked; and though allowed to stand for many days, the action was so small as to be barely appreciable. A similar result was also observed even in open vessels, with lead in the state in which it is usually obtained from the plumber's shop; and though in some instances a slight action was apparent at first, the metal became covered in the course of a few days with a thin coating, which prevented all further corrosion.

From these facts, it became manifest that the first experiments, showing a strong action on lead, could not be taken as fairly representing the nature or amount of the action likely to be exerted on the pipes or cisterns of a large town, and that absolute conclusions could only be drawn from experiments in which the actual conditions of the water supply were more closely imitated. It was, therefore, with much satisfaction that we availed ourselves of the apparatus which Mr. Bateman had caused to be laid down at the Trossachs, and which was as close an imitation as circumstances would permit of the mode in which the water will be ultimately supplied to the city.

The apparatus consisted of two lines of iron pipes—one new, the other old—each of which was connected with new and old lead pipes and cisterns, so as to vary the conditions of the experiment as much as possible. As soon as the work was completed, water was passed through the iron pipes in order to wash out the dirt which had got into them during the operation of laying; and when the water began to flow perfectly clear, it was allowed to run through the lead pipes and cisterns until they were clean, which occupied only a few minutes. The experiments were then commenced by filling the pipes and cisterns. After twenty-four hours, specimens were drawn from all the pipes and cisterns, and others were taken after the water had remained for three and for six days in contact with the lead. All these specimens were examined for lead with the utmost care, and the results were as follows:—(After elaborate details.) . . .

As the result of the inquiries and experiments detailed, we have arrived at the following conclusions:—

1st. The Loch Katrine water acts strongly upon bright lead, freely exposed to light and air.

2d. The Loch Katrine water does not act upon old leaden pipes and cisterns arranged so as to imitate as closely as possible the actual conditions of the water supply of a town.

3d. When the Loch Katrine water is allowed to stand for

some time in *new* leaden pipes and cisterns, a slight action takes place; but even after six days the quantity of lead is too small to exert any injurious effects.

4th. When the water is allowed to flow slowly through *new and old* cisterns, so as to imitate the frequent renewal of the water, which actually occurs when they are in use, not the slightest trace of action could be observed, even by the most delicate tests.

5th. By standing in contact with the old red sandstone, of which the conduit will be made, the Loch Katrine water almost entirely loses its action on bright lead.

6th. The Loch Katrine water scarcely acts on lead alloyed with 5 per cent. of tin.

7th. The waters of Inverness, Whitehaven, Sheffield, Bolton, Chorley, Heywood, &c., all act powerfully on bright lead, but in practice they do not corrode the pipes and cisterns, and no injurious effects have been observed from their use.

As the general conclusion, we are decidedly of opinion that, *as it will be delivered in Glasgow*, the Loch Katrine water may with the utmost safety be preserved in the pipes and cisterns now in use. Even on new cisterns, we do not believe it would have the slightest effect; but should any apprehensions be entertained on this point, the most absolute protection would be obtained by the use of an alloy of lead with 5 per cent. of tin—although we are of opinion that this would be a very unnecessary precaution.

THOMAS ANDERSON.
DUGALD CAMPBELL.

From Report by ALFRED S. TAYLOR, M.D., F.R.S., Professor of Chemistry in Guy's Hospital, London, on "Water from Loch Katrine."

This is in my judgment a water of first-rate quality, and is well adapted for the supply of a town population.

For dietetic use it is perfectly wholesome; and in reference to domestic use, it is well adapted for all the common purposes to which soft water is applied. It does not fur boilers; hence, for manufactures in which steam engines are employed, it will have a remarkable advantage over river or spring water. It will never damage the boilers, or to any injurious extent produce an incrustation within them. . . .

Conclusions.

1. The result of this inquiry is that the Loch Katrine water acts strongly on lead when the metal is bright and highly polished, and there is free access of air to the water and lead.

2. That this water does not exert any noxious action on lead when the metal is in its ordinarily dull state.

3. That the Loch Katrine water, which has been placed in contact with old red sandstone and limestone, obtained from the district which it was proposed that the water should traverse, has no action on lead. The water dissolves a small quantity of salt and carbonate of lime;—these substances protect the surface of the metal from further chemical action.

4. The Loch Katrine water has no action on an alloy of lead and tin, in the proportion of five parts of tin to ninety-five parts of lead.

*On Samples of Inverness Water from Loch Ness and from
the River Ness.*

This water, placed under precisely similar circumstances, acts much more rapidly and more powerfully on lead than that of Loch Katrine. It is quite certain that a chemist, judging only by the action on *bright* and *polished* lead, would condemn this water as unfit for use. But the remarkable fact is, that the water *c*, which is nothing more than *b*, drawn from a tap in the Caledonian Hotel, after distribution by intermittent service through *leaden cisterns and pipes*, does not contain a trace of lead, either in a dissolved or in an undissolved form. Here, then, is a water *acting powerfully on lead*, and *distributed through lead*, yet it *contains no lead*; and it is and has been for a long period used by the population of Inverness in leaden pipes and cisterns without any injury to health. The exemption of the inhabitants from injurious consequences is explained by the water having ceased to act on lead, and by its being found to contain no lead. The interior of the pipes and cisterns has no doubt been speedily coated with a deposit which has wholly prevented any injurious chemical action.

But the remarkable fact is that this water *c*, thus supplied to the inhabitants of Inverness, has not lost the property of acting on lead. If the metal be scraped or polished, and placed in it,

there is a chemical action in a quarter of an hour, and this after forty-eight hours had reached such a degree that a chemist unacquainted with the facts might have been induced to pronounce the water as likely to be dangerous to health if distributed through leaden pipes or cisterns.

The waters supplied to Aberdeen and Merthyr Tydvil act upon lead, but for the reasons above stated, they cause no injury to public health.

The Loch Katrine water may then, in my opinion, be just as safely used for the supply of a town as the water of the River Ness, quite irrespective of all consideration of the neutralizing effect of the geological character of the district through which the water must pass.

ALFRED S. TAYLOR, M.D.

*From Report of ROBERT DUNDAS THOMSON, M.D., F.R.S.,
L. & E., Professor of Chemistry in St. Thomas's Hospital,
College, London, on the "Loch Katrine Water."*

Loch Katrine water I examined several years ago, when it was proposed to be introduced for the supply of Glasgow. I considered it then, as I do now, a water admirably adapted for domestic use, and have not had my opinion in the slightest degree affected by the laboratory experiment exhibited on the Committee's table, as I am convinced, from my acquaintance with the subject, that if the Loch Katrine supply had been introduced to Glasgow, nothing would have been heard of its influence on lead. I found it to contain about two grains of solid matter in the gallon, its constituents being organic matter, common salt, sulphate and carbonate of lime. . . .

Although, in the preceding Report, I have given it as my decided opinion that no more permanent danger is to be apprehended in reference to health from the transmission of Loch Katrine water through lead pipes, and detention in lead cisterns, than there is in the case of other waters supplied to towns, I have always recommended the substitution of iron and other materials for water pipes, as much as possible, for lead; and also, where lead is employed, that it should be alloyed with tin.

ROBERT DUNDAS THOMSON, M.D.

From Report by PROFESSOR GRAHAM, of University College, London, and PROFESSOR HOFMANN, of the Royal College of Chemistry, London.

In conclusion, we would press strongly the facts that the water of Loch Katrine is in no respect peculiar or exceptional in its composition and properties, and that the safety for town use of the class of waters to which it belongs has already been decided by the most ample experience. It is stated by the Commissioners who reported to Government in 1851 upon the Metropolitan Water Supply, "that no recent and authenticated case can be cited of the health of any of the numerous towns lately supplied with soft water being affected by the use of leaden distributory tubes, although apprehensions were often entertained from the introduction of soft water, as at Boston, in the United States, where the subject has excited much attention, and at New York, since the introduction of the Croton River." New York, with a population of 400,000, and Philadelphia, with 300,000, have been supplied, the former for nearly ten, and the latter for upwards of twenty-five years, with a water as soft as that of Loch Katrine, and the water frequently examined for lead, after passing through the usual service pipes of that metal, without any contamination of the water being discovered. The physicians of both places also testify that no case of lead-disease from this cause has been ever heard of. We have also had occasion to examine the water with which the towns of Inverness and Whitehaven are supplied, both before and after passing through lead pipes and cisterns, and find these waters to have the same high degree of softness as the water of Loch Katrine, and also the same decided action upon lead. Yet the injurious action of the metal upon the water in use in these towns has never been observed, nor even suspected, nor can a trace of metal be found in the water which has passed through lead. In fine, the apprehension of danger from the use of Loch Katrine water with leaden service pipes is entirely speculative, and cannot fail to be dissipated the moment that reference is made to the experience of other towns supplied with water of equal softness and purity.

THOMAS GRAHAM.
A. - W. HOFMANN.

From Statement by MR. JOSEPH MITCHELL, Civil Engineer.

I am engineer of the government roads, bridges, and harbours in the Highlands and Islands of Scotland; and have been so for thirty years, having succeeded my father in 1824. I am a native of Inverness; and with the exception of a few years while with the late Mr. Telford in London, have resided there all my life.

There is a gas and water company in Inverness, and I advise them upon engineering matters. The town of Inverness contains a population of about 14,000. The town is built on the banks of the River Ness, where that river enters the sea. The River Ness flows from Loch Ness, a large Highland lake; the distance between the Loch and the town being about five miles. The town has been supplied with water from the River Ness since 1830. There is a pumping engine about a mile above the town, which forces the water into iron mains laid along the streets. The water is distributed from the iron mains into the interior of the houses by lead pipes. The houses have also cisterns to contain a supply of water during the time the engine is not at work. These cisterns are lined with lead; my own house is fitted up in this way. I have two cisterns placed in the attics: one has been there for eighteen years, when I built the house. I made an addition to my house about eight years ago, and placed the other cistern alongside the former one. The water is beautifully clear, and the inhabitants are highly pleased with it.

In using the water as we do through lead pipes and cisterns, we have never found the slightest appearance of any deposit, nor any bad effect, nor any symptom of the water being affected in the slightest degree by passing through lead; it is as beautifully pure when placed on the table for use as if taken out of the river or the lake. I never heard a whisper about any danger in using the water through lead, until some parties connected with the Glasgow Water Bill made inquiries about it a few days ago. That was the first time my attention was called to the subject. They showed me the strong action our water had upon lead, by placing a piece of lead in a tumbler. It created a considerable deposit in a few hours. I was making some alteration in the interior of my house at that time, and had just got a new lead pipe laid into a room which had not yet been in use, and I observed particularly if there was any symptom of the peculiarity referred to, by shutting up the

water for twenty-four hours, and could not observe the slightest difference upon the water, than if taken out of the river. The Ness water taken from the Loch, the river, or a house pipe, has the same effect upon lead, when tried experimentally, as that of Loch Katrine. In practice, however, and from my experience of the water, I am quite satisfied that it can be used through lead pipes for domestic purposes with the greatest impunity; and notwithstanding what I have seen since this subject was brought under my notice, I will continue to use it through lead pipes for the use of myself and family with the greatest confidence.

*A Statement by MR. WILLIAM WELSH FORBES, Member of the
Royal College of Surgeons, Edinburgh.*

I am a native of Inverness, and (with the exception of some years passed in the country, and afterwards at the University in Edinburgh) have resided there all my life.

I have been in pretty extensive medical practice in Inverness for the last twenty-six years, and have attended all classes of its inhabitants.

Inverness is supplied with water from Loch Ness, which flows towards the town by the River Ness. It is pumped up by an engine, situated about half a mile above the town, into iron mains laid under the streets, and is conveyed from the mains to the interior of the houses by leaden pipes. The houses generally have also cisterns lined with lead for storing the water.

The water so supplied from the Ness is very pure and wholesome, and the inhabitants are much pleased with it.

During the whole course of my practice, I never had occasion to attend any one whose illness I could attribute in the most remote degree to the contamination of the water by lead. I never heard of the water, as used by us, being altered in any way by the use of lead cisterns and pipes, nor was the subject ever brought under the notice of myself or any of the other medical gentlemen of the town, as far as I ever heard, until within the last few days, when some parties connected with the Glasgow Water Bill came down to make inquiries about it.

I have tried an experiment upon the Ness water from the Loch, the River, and the lead pipe in my own house, and also upon the Loch Katrine water (all taken by myself), by placing a piece of

polished lead in a tumbler full of the several waters. The action of the Ness water is the same upon the lead as that of Loch Katrine.

From the experience I have had of the Inverness water, and from what I have seen of the Loch Katrine water, I am satisfied that the latter can be used in Glasgow, even supposing it undergoes no change before reaching that city, if distributed through lead pipes, with perfect safety to the health of the inhabitants.

From Statement by MR. WILLIAM BARWICK CLARKE, of Whitehaven, in the County of Cumberland, Surgeon, and a Trustee of the Town and Harbour of Whitehaven.

I have been nearly seventeen years in practice in Whitehaven as a surgeon—for the last thirteen years extensively—and during this time have had ample opportunities, both from my private practice and as one of the surgeons to the Whitehaven and West Cumberland Infirmary, of forming an opinion of the prevailing diseases of the town. Since the introduction of the Ennerdale water I have never seen or heard of any instances of the inhabitants being affected injuriously by it. I have never seen or heard any cases of poisoning by lead in any of its various forms as a consequence of the introduction of the water, nor, upon inquiry amongst the other medical men, have I been able to learn that any of them have.

I am familiar with the symptoms of poisoning by lead; but have only seen one instance of it in the town of Whitehaven during the time I have been in practice there, and that one was the case of a painter, who in the summer season was periodically affected by the complaint, during the time that he was engaged in his business of working among white lead. He was equally affected by his trade, both before and after the introduction of the water.

The water was introduced into the town in May, 1850, and by the end of August of that year the service pipes, which are of lead, were laid into all the houses. From this time the supply from the water works may be said to have been general. The old supply of water, which was from springs in the neighbourhood, and from pumps in the town, was at once discontinued; and from that time up to the present the inhabitants have been entirely supplied by the Ennerdale water.

Having, as stated, never seen any bad effects upon the inhabitants from the use of this water, I may state, on the other hand, that in my own practice I have seen the most beneficial results. There has been a marked diminution in the number of fatal cases from the zymotic class of diseases, particularly from typhus fever, scarlet fever, measles, influenza, remittent fever, diarrhœa, and dysentery. The registry of deaths in my own practice in these diseases gives the following results:—

For the four years previous to the introduction of the Ennerdale water, the deaths from diarrhœa and dysentery were 37; and for the four years subsequently, 12. From typhus and remittent fever, 19 previously; and for the same complaints, 10 subsequently. From scarlet fever, measles, and influenza, 53 previously; and for the same complaints, 7 subsequently. And this is the result, although my practice has been increasing.

On analyzing the statistics of fever, as recorded at the Whitehaven and West Cumberland Infirmary, I find a most remarkable diminution in the number of fatal cases.

The average number of fatal cases for the four years previous to the introduction of the water was $89\frac{1}{4}$, and for the four years subsequently, only $17\frac{1}{4}$. If the average of years is taken for eight years previously, the number of cases was $59\frac{7}{8}$; if for twelve years, $45\frac{1}{2}$; and if for sixteen years, $37\frac{1}{8}$; so that it is quite obvious that, however long the average is extended, the reduction in the number of fatal cases since the introduction of the water has been astonishingly great.

The same beneficial results are evident from an examination of the Superintendent Registrar's returns of the mortality of the town, previous and subsequent to the introduction of the water. . . .

This return shows that, for the four years previous to the introduction of the Ennerdale water into the town, the average deaths were 34·8 per 1,000; and for the four years subsequently, the average deaths were 23·5 per 1,000.

From Report of the Water Commissioners of Boston, U. S., on the Material best adapted for Distribution Water-Pipes; and on the most Economical Mode of introducing Water into Private Houses.

Upon a careful examination of this mass of testimony, we regard it as satisfactorily proved that the water of Cochituate

Lake, which is about to be introduced into the city (Boston), may be safely distributed to private dwellings by means of leaden pipes, without danger to the health of those who may freely use it with their food.

Cochituate water is a very soft and pure water, acts powerfully on lead, and contains only 1-18600th part of solid residue . . .

The Consulting Physicians, in their Report above referred to, although they did not recommend the use of distribution pipes composed of lead, strongly intimated the expectation that the doubts which they entertained might be removed by further experiments. It was important to reconcile the fact, that on immersing lead in water taken from the Fairmount, Croton, and Jamaica Pond Water Works, it undergoes a perceptible partial dissolution, with the well-attested evidence that a large portion of the population of the cities of Philadelphia, New York, and Boston, are in the constant use of water from those works, drawn through leaden pipes, without experiencing from it any injurious effects. The experiments which had been at that date begun by Professor Horsford, and have been since more thoroughly prosecuted by him, afford, in our opinion, a satisfactory solution of this apparent contradiction. These experiments demonstrate that the action of the comparatively pure water of lakes and rivers upon bright bars of lead, which on their immersion in it is distinctly perceptible, ceases after a period of a few days; and that this immediate action of the water upon the surface of lead forms a coating which, for all practical purposes, is impervious to water, and entirely insoluble in it. This coating remains unchanged during any period in which it has thus far been immersed; its appearance after some months or years of immersion, in the case of the Croton, is quite the same as within three or four days from the first immersion. The water on the first and second days in which the lead is so immersed, and during the continuance of any perceptible action on the surface of the leaden bars, shows traces of a mixture of lead, on trial by the ordinary tests; but on the repeated removal of this water, and substitution of other water from the same source, after the coating is formed, no trace of lead is discoverable by the most effective tests after any length of exposure of the water in contact with the lead, which will ordinarily occur. . . .

Professor Horsford, in a letter dated July the 25th, expresses the

following opinion:—"Without an attempt at further enumeration of the conclusions at which I have arrived, I may state, with whatever of emphasis uninterrupted investigation from the first of last February until now may justly give to the opinion, that *Cochituate water may be served from leaden pipes connected with iron mains, without detriment to health.*" The opinion here expressed would command a high degree of confidence if it stood alone. Confirmed as it is by our evidence of collateral testimony, derived from long-continued experience, we consider it entitled to entire confidence. The experiments detailed in Professor Horsford's first Report, exhibiting the chemical action of the water of the Fairmount, Croton, and Jamaica Pond Water Works, and of the Cochituate lake, prove that there is a strong similarity in the effects of the waters from those several sources upon lead.

The ample testimony, founded on the continued use of the waters from the three first-named sources for a series of years, by thousands of families, without a single distinctly-proved case of lead-poisoning, although the water is served from the mains to the dwelling-houses almost universally through leaden pipes, affords as satisfactory demonstration as the nature of the case admits of, that the Cochituate water may be safely distributed in the same way. . . .

The grounds on which lead is preferred for the composition of small distribution pipes are, that the metal is cheap; it is easily formed into pipes of any convenient size or length; it is flexible, and easily adapted to all situations in which it is desirable to place it; it is of sufficient strength to bear the pressure of any ordinary head of water; and if made of a suitable thickness, and provided with proper guards against the effects of a sudden check of the current, it is capable of resisting the extraordinary shock thus produced. It, moreover, preserves the water in a state of purity, and is itself durable, unless dissolved by the action of substances foreign to the source from which the city is to be supplied. Pipes of this material may be laid in a much shorter space of time, and at less cost, than those of cast iron.

We have therefore, on these considerations, resolved to use leaden pipes for conducting the water to houses, except in cases in which the owners or occupants shall make known their preference of iron pipes, and announce their determination to make use of pipes of iron, or of some other material than lead, for the conveyance of the water through their respective houses,

to the place of delivery for use, for culinary purposes. Persons making such requests will be furnished with the water by means of pipes of cast iron.

From Joint Report by PROFESSOR GRAHAM, *of University College, London;* ALFRED S. TAYLOR, M.D., F.R.S., *Professor of Chemistry in Guy's Hospital, London;* DR. WILLIAM ALLEN MILLER, *Professor of Chemistry in King's College, London;* DR. FREDERICK PENNY, *Professor of Chemistry in the Andersonian University, Glasgow;* and PROFESSOR REDWOOD, *of the Pharmaceutical Society, and Secretary to the Chemical Society, London.*

We beg to certify that, after a reconsideration of the various questions connected with the action of water upon lead, and from inquiries personally conducted by some of us in the towns of Inverness and Whitehaven, which are supplied with water much resembling that of Loch Katrine in chemical and other qualities, we have not been able to ascertain that any injury has resulted to the health of the inhabitants of these towns, although they have used for many years water of great softness, conveyed into their houses through leaden service pipes.

The increased supply of water now generally demanded by the larger towns of Britain must in most cases unavoidably be soft in quality, such being the character of the only sources accessible and of suitable purity. The question that remains for the chemist appears, therefore, to be not so much the reception or rejection of a soft water on account of the corrosive action it may exert upon lead, as the proper means of protecting the consumer from injury arising from the contamination of the water by that metal. We would therefore direct attention to the use of tinned lead for such service pipes as shall be laid down hereafter in Glasgow, and to the other precautions which have been described in our previous Reports on Loch Katrine Water.

THO. GRAHAM.
ALFRED S. TAYLOR, M.D.
WM. ALLEN MILLER, M.D.
FREDERICK PENNY.
T. REDWOOD.

LONDON, 26th February, 1855.

From Additional Report by PROFESSOR GRAHAM *and* PROFESSOR HOFMANN, *of the Royal College of Chemistry, London.*

In conclusion, and after the fullest consideration, we would report our deliberate opinion that the existing pipes and cisterns in Glasgow may be used with perfect safety with the Loch Katrine water; that it is only with new leaden pipes and cisterns, on their first use, that any danger could be apprehended; and that in these all risk might be avoided by the slightest care, the water of Loch Katrine becoming always white and milky when largely charged with lead, so that the contamination is made distinctly apparent; and the water even then not acting injuriously upon health, unless consumed in the state described day after day for a considerable period of time. But the experience of Whitehaven and Inverness removes, in our judgment, all grounds of anxiety on this point.

THO. GRAHAM.

A. W. HOFMANN.

LONDON, 13th March, 1855.

From Supplementary Report by DR. ALFRED S. TAYLOR.

From the results of these further inquiries it is therefore my opinion—

1. That the Katrine water, although (like that of the Ness and other sources) it is liable to act upon lead under certain circumstances, may be safely used in leaden cisterns and pipes as they are supplied by the plumber.

2. That there will be no danger in the use of this water delivered through cisterns and pipes that have been already employed for the supply of other waters, and have thereby acquired a slight protecting coat.

3. That as a matter of precaution, and to meet the views of those who apprehend danger, tinned lead pipes might be laid down where new service pipes are required: although the fact that Inverness has been supplied with similar water, without danger to the health of the inhabitants during the long period of twenty-four years, shows that such a precaution is really not absolutely required.

The state of the water supply to Inverness appears to me to throw a more important light on the supposed danger or safety of

using pure water through leaden pipes and cisterns than the case of any other town in this country or abroad. It cannot be disregarded or overlooked, as it is a question affecting public health, and is well calculated to test the value of all chemical theories regarding the action of water on lead, and the dangers which are supposed to attend the use of such water. The facts already elicited respecting the properties of the water supplied to Inverness must be equally applicable to Glasgow. If it be clearly established that this water is supplied to Inverness through leaden pipes or cisterns, and that no lead-diseases have been observed in the large population of this town during the very long period of twenty-four years, it is evident that chemists have hitherto greatly overrated the danger arising from the use of a water that is found, *at the source whence it is taken*, to act "strongly" upon lead. If there has been, during a period of twenty-four years, safety to Inverness, there is no reason to apprehend danger from the supply of a precisely similar water to Glasgow. If, on the other hand, there are valid reasons to apprehend danger from the proposed use of Loch Katrine water in Glasgow, then there can be no doubt that the supply of the River Ness water should be immediately withdrawn from Inverness. Danger from this cause in one locality implies equal danger in the other.

ALFRED S. TAYLOR, M.D., F.R.S.

15 ST. JAMES'S TERRACE,
REGENT'S PARK.
14th March, 1855.

*From Additional Report by DR. THOMAS ANDERSON, Professor
of Chemistry in the University of Glasgow.*

GLASGOW, 15th March, 1855.

In conclusion, I may once more express it as my decided opinion that no injurious effects are likely to be produced by the Loch Katrine water in actual practice.—I remain, dear Sir, yours truly,

THOMAS ANDERSON.

ARTHUR FORBES, Esq.

*Additional Report by DUGALD CAMPBELL, Analytical Chemist
to the Brompton Hospital in London.*

LONDON, 27th March, 1855.

The water supplying the town of Inverness I have further examined, and my experiments confirm my former opinion, that in every respect it is a water similar in character to the water of Loch Katrine. As formerly stated, it has been furnished to the inhabitants for upwards of twenty years invariably through leaden pipes, and, with rare exceptions, through leaden cisterns also. No injurious effects to health have been noticed to result from its use. Indeed, this action upon lead was unknown to the inhabitants until recently, when it was pointed out to them.

The supply of water to the city of Manchester I have again examined. There are six sources of supply; and under certain circumstances I found all the waters to act upon lead, some of them with much more vigour than the Loch Katrine water; but the water as supplied in the city was found *practically* to have lost all action upon lead.

I have also investigated the water supply of the city of New York. When the Croton water, which very much resembles the Loch Katrine, was first proposed as a source of supply for the city of New York, it met with the most violent opposition because it was a remarkably soft water, and was shown by laboratory experiments to act powerfully upon lead. It was, however, introduced and supplied in the ordinary way through lead; and although I have made many inquiries, I have not heard of any injurious effects upon the inhabitants from its use. My own experiments prove that, as delivered in the city of New York, it has practically no action upon lead.

Some other large towns in America are supplied with water of a similar description, and distributed through lead pipes, and no injurious effects are known to have arisen from their use.

I conclude from these results—

1st. That the Loch Katrine water may be distributed through lead pipes, from the iron mains, to the inhabitants of Glasgow, without any injurious effects.

2d. That although the Loch Katrine water acts to a slight extent upon new lead in open vessels, it does not do so to a danger-

ous degree; and after a short time this action ceases altogether, especially if the water is changed, as would be the case in a house service. It might therefore be supplied through lead cisterns, as well as lead pipes, without any dangerous effects.

3d. That the Loch Katrine water may be distributed with the most perfect safety through the old lead pipes and cisterns now in use for the present supply in Glasgow.

4th. That lead alloyed with 5 per cent. of tin, or even less, is not acted upon by the Loch Katrine water.

5th. Judging from my experiments upon Manchester, New York, and many other supplies of water which from time to time have come under my notice, I am of opinion that the Loch Katrine water will be so materially altered in its passage to Glasgow as to be incapable of acting upon lead of any description.

DUGALD CAMPBELL.

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H.C.



