

in both the protracted inquiries dealing with the discharge of the London sewage into the Thames at Barking and at Crossness. After the Tay Bridge disaster he was instructed by the Government to report fully on the cause of the accident, and in 1892 he was appointed by the Foreign Office to consider, with German and French colleagues, the various schemes for the drainage of Cairo submitted to the Egyptian Government.

During Mr. Law's long and varied career he was associated with many works in various parts of England, but for some years past he was more intimately concerned with works of sanitation, his latest being the drainage of Oldham and Broadstairs, and the prevention of flooding at Eastbourne. Mr. Law possessed mathematical powers of a high order, and his calculations were most refined and accurate. He was of a very inventive turn of mind, and devised for his own use, among other things, an electrical sounding apparatus and an electrical current meter. He was the author of several mathematical and engineering books, among which may be mentioned, "Examples of the Modes of Setting-out Railway Curves," "Mathematical Tables for Trigonometrical, Astronomical, and Nautical Calculations," "The Rudiments of Civil Engineering," and "The Art of Constructing Common Roads." Mr. Law took great interest in the Sanitary Institute, of which he was for many years a Member of Council, and at the time of his death Chairman of Council.

Mr. Law died at his residence in London on the 18th July, 1900, having just attained his 76th year.

He was elected a Member of the Institution on the 5th February, 1867.

WILLIAM LINDLEY died at his residence, 74 Shooter's Hill Road, Blackheath, on the 22nd May, 1900, in his 92nd year. Born in London on the 7th September, 1808, he was the younger son of Mr. Joseph Lindley, of Heath in Yorkshire, some time Assistant to the Astronomer Royal at Greenwich Observatory. When only three months old he lost his father. He was educated at Croydon, but feeling the want of stricter discipline than that afforded at home, at the age of sixteen he obtained permission from his mother to continue his studies at Wandsbeck, near Hamburg, in the house of Pastor Schroeder. On returning to England he entered, in June 1827, the office of Mr. Francis Giles as a pupil, and subsequently assisted that engineer in design-

ing the Newcastle and Carlisle Railway, now part of the North Eastern Company's system, and the London and Southampton Railway. On the latter he was entrusted with the construction of the bridges. He left the service of the London and Southampton Railway Company in 1836. During that period he had also been employed on the regulation of the River Mersey, and for a time on the works of Brunel's Thames Tunnel.

In 1837 and 1838 Mr. Lindley was engaged on railway work in Germany and Italy, and on the formation of the Hamburg-Bergedorf Railway Company he was appointed Engineer-in-Chief. Acting under the instructions of the Hamburg Government he worked out the designs for connecting that line with the great trunk-line extending to Berlin. Immediately after leaving Hamburg it passed through the "Hammerbrook," a low marshy district, which from its position in immediate proximity to the city would in all other respects have formed a most natural site for the extension. It was, however, considered to be an "unimprovable swamp," and Mr. Lindley's suggestion to lay out a systematic network of streets and canals, embracing the whole district, and thus to transform it into valuable building ground for warehouses, factories, etc., was met with opposition and even ridicule from all but a few. His proposals, made in 1840, were, however, adopted, and were carried out under his direction. An area of about 1,432 acres was successfully drained, a portion of which has become a very important part of the city of Hamburg.

In 1841 Mr. Lindley designed the long railway carriages with six wheels, which were used for the first time on the Hamburg-Bergedorf line, and afterwards became more or less typical for other continental lines. About this time, too, he was entrusted with negotiations on the part of the State of Hamburg with the British Government for introducing a cheaper rate of postage between London and Hamburg, his desire being to see established a universal rate of 2*d*.

The Hamburg-Bergedorf Railway was to have been publicly opened on the 7th May, 1842. The great fire of Hamburg, which lasted three days and nights and destroyed a considerable part of the town, broke out at 1 A.M. on the 5th of that month, and Mr. Lindley proposed energetic measures to cut off the further progress of the fire by blowing up a line of buildings in its course. Being entrusted with the direction of the operations, he at once proceeded to blow up the Town Hall, and after unremitting activity during three days and two nights, succeeded in retarding the conflagration and in limiting its

area. His life was in great danger, not only imperilled by the work itself, but by rumours which had found credence with the ignorant classes, that the English meditated blowing up and destroying the Port of Hamburg and that he was acting as chief agent of the plot. The city authorities were obliged to take strong measures to protect the lives of Mr. Lindley and his English assistants and, after the extinction of the fire, the Senate found it necessary to contradict officially the absurd rumour, and it publicly thanked Mr. Lindley for his great services. The first use made of the newly-opened railway was to transport the homeless poor out of the burning city.

It was this great fire which opened a wide field to Mr. Lindley's talent and led him to develop that line of municipal engineering, and especially sewerage and water-supply, with which his name subsequently became identified. While the ruins were still smouldering, he received instructions from the Senate to design the rebuilding of the city. The special committee of the Senate and Town Council nominated in consequence of the fire, appointed him Consulting Engineer, and he likewise became Consulting Engineer to the Hamburg Water Board and to the Board of Works, holding those offices till the close of 1860. He thus designed and carried out most of the great public works which marked the transformation of the town of Hamburg into an important modern city. Prominent among these are, besides the above-mentioned Hammerbrook works, the sewerage of the city, the water-supply, and the extension of the Hamburg-Berlin Railway terminus and goods station.

The sewerage works were commenced immediately after the fire, and in 1860 the network of sewers had an extent of 40 English miles. The chief characteristic of the Hamburg drainage works was the completeness of the system, as the plan was not hampered by having to embody existing sewers, and the whole network could be designed as best suited to local conditions. It was divided into an upper and a lower system: the upper system independent of the floods in the river for its outfall, and the lower system limited to the low-lying tracts, with artificial means of keeping down the water-level in the sewers during high water in the river. The sewers were laid at a considerable depth, so as to drain the subsoil and the cellars; the system was from the commencement based on the universal use of the water-closet and on carrying off all sewage in a fresh condition, catch-pits in the sewers themselves being avoided. Curves of large radius and tangential junctions were used to facilitate the flow. A complete system of artificial flushing

was adopted; all branch sewers were so connected at their upper ends as to permit flushing them from the next line of intercepting sewer; and a thorough system of ventilation was carried out for both street sewers and house drains.

These principles were to a great extent novel at the time (1842) and Mr. Lindley's proposals were severely criticised by many and pronounced to be irrational and certain to lead to failure. The Hamburg literature of that time is most interesting on these points and proves how hotly the controversy was carried on by both sides.

In conjunction with Mr. W. C. Mylne, at that time the Engineer to the New River Water Company, Mr. Lindley, in February 1844, reported on works for the water-supply of the city of Hamburg. They were carried out from 1844 to 1848 under his direction and from his designs, as were likewise the extensions of the same until the end of the year 1860, the date of his leaving Hamburg. The water was taken from the Elbe at Rothenburgsort and clarified by means of subsidence-tanks before being pumped into the town. Provision was made to raise the pressure at night in order to supply some of the higher districts and to obtain increased pressure in case of fire. This design was likewise untrammelled by previous works and could be drawn up and carried out purely with regard to the best solution for local circumstances. It was the first comprehensive and systematic water-supply on modern principles on the Continent. A characteristic feature was the careful design and disposal of the works, and especially the network of piping, with regard to their systematic extension to meet the demands of the far future. A further feature, resulting from the influence of the great fire, was the ample provision made for fire-extinguishing purposes by means of large hydrants. But above all it should be mentioned that these works formed one of the first large water-supplies carried out by a corporation for the supply of its city, and with the express object of delivering water at a very cheap rate and under exceptionally favourable circumstances to the poorer classes. In 1853 Mr. Lindley designed large extensions of the works, and sand filters to supplement the method of clarification by subsidence which had become inadequate. These works were, however, only partly carried out; the execution of the filters was unfortunately delayed and became the subject of a controversy which lasted over 30 years, and was in fact only brought to a conclusion by the construction of sand-filters at the time of the disastrous outbreak of cholera in 1892-93.

In 1860, when Mr. Lindley left Hamburg, about 11,000 houses

were supplied with a maximum quantity of 7 million cubic feet of water per week.

After the great fire Mr. Lindley proposed a complete trigonometrical survey of the city and its suburbs, and he was entrusted from 1848 to 1860 with the direction of the work.

The Gas Company in 1846 called in Mr. Lindley to design and carry out the Hamburg Gas Works on the "Grasbrook." On the basis of his design, which allowed for future extensions of these great works, he carried out the first part of the same. Their characteristic features were the magnitude of the design and the systematic disposition of the factory to minimize the cost of labour and transport.

In 1851 he suggested the erection of large public baths and wash-houses at Hamburg for the poor. This model establishment was carried out according to his plans on the Schweinemarkt by voluntary subscription and inaugurated in 1854. In the same year various extensions to the Port of Hamburg were carried out by him, based on the designs prepared by Messrs. Walker, Huebbe and himself in 1845. In 1850 he was instructed by the three cities of the Hansa—Hamburg, Bremen and Luebeck—to negotiate the sale of their "Steelyard," a large wharf on the banks of the Thames. The sale was effected two years later, and Cannon Street Railway Station now stands on that site.

In February 1851 Mr. Lindley was called in by the Directors of the New River Company, London, to report on the adoption of the system of constant supply, and his proposals formed the basis of large works of extension carried out at Stoke Newington, Green Lanes, and in the district supplied by the Company.

In the same year the British Government entrusted him with various works on the island of Heligoland, including the construction of the great retaining wall "am Falm."

In 1855 Mr. Lindley supervised for the municipality of Hamburg the carrying out of the Altona Gas and Water-works, the latter of which had been designed for the owners of the undertaking by Mr. Thomas Hawksley, Past-President. The water-works draw their supply from the River Elbe, about 7 miles below Altona; it is there lifted 280 feet to an elevated plateau, filtered and stored in covered reservoirs, and thence carried to Altona in cast-iron mains. This was the second water-works on the Continent, Berlin being the first, in which sand filtration was adopted. During his residence in Hamburg Mr. Lindley was consulted and employed on numerous other extensive designs, among others the Berlin, Kiel, Stralsund, Stettin and Leipzig Water-works, and he took part in preparing

plans for bridging the River Elbe to connect the network of railways north of the river at Hamburg with those on the south at Harburg.

At the close of the year 1860, in consequence of the serious illness of his wife, whom he lost in 1862, he left Hamburg and took his family to the south of France, and thence to England.

In 1863 Mr. Lindley was invited by the authorities of Frankfurt-am-Main to report, with other experts, on the drainage of that city, and in 1865 he was appointed Consulting Engineer to the city. The sewerage works were carried out according to his designs and under his direction, his Resident Engineer till the year 1873 being the late Mr. Joseph Gordon, and till the end of 1879, the year of his retirement, his eldest son, Mr. W. H. Lindley. The Frankfurt sewerage works are characterized by a still more accentuated carrying out of the principles adopted in Hamburg; and further by the adoption of the egg-shape sewer, by the extensive use of the 2-foot by 3-foot brickwork sewer which forms about 50 per cent. of the whole network, by the great extent to which tunnelling was made use of in the narrow streets of the older parts of the town, and by the first adoption of the deep stoneware street-gully known as the "Frankfurt gully." Ventilating shafts were built where the upland sewers ended on the high lands surrounding the city, the towers of the old fortifications being in some cases utilized for this purpose, and reservoirs were constructed to collect flushing water at the top ends of the various systems. These were rendered necessary as there was not an efficient water-supply till six or seven years after the sewer works had been commenced. Great care and attention were paid to house-drainage and stringent by-laws and model plans were for the first time worked out and published. When Mr. Lindley left Frankfurt in 1879, there were about 80 miles of street sewers, serving about 15,000 dwellings, with some 19,000 water-closets.

During the execution of these works, Mr. Lindley proposed a survey of the city similar to that of Hamburg, and it was carried out under his direction by the City Surveyor, Mr Spindler. Mr. Lindley was consulted by the city authorities as to the remodelling of the railway system, and advocated the construction of a large Central Station on the site of the present well-known fine building.

In 1868 Mr. Lindley was called in by the city of Pest to report on the water-supply. He indicated a comprehensive design for the supply, but as the necessary funds were wanting, only a part was executed. Before the end of the year these works were opened and with the revenue they gave further sums were raised

and the works extended. He was also consulted on water-supply questions by Düsseldorf, Chemnitz, Basel, Galatz, Braila and Jassy, and on sewerage questions by Düsseldorf, Basel and Crefeld. His last professional work was the general design for the sewerage and waterworks of the city of Warsaw, and for the sewerage works of St. Petersburg, in the years 1878-79. The latter have not yet been constructed, but the Warsaw sewerage and water-works were carried out under the direction of his sons, William, Robert and Joseph, whom he left to continue his work on his retirement at the end of 1879.

The greatest works of Mr. Lindley are those at Hamburg, more especially the Hamburg and the Hammerbrook drainage, and the sewerage of Frankfurt-am-Main. The so-called Hamburg-Frankfurt system has become more or less typical for sewerage works in Germany and Austria, while the drainage of many large cities in America has been modelled after the Frankfurt works. The chief characteristics of Mr. Lindley's works were the thoroughness and far-sightedness of his designs which were always based on the demands of a far future, the care spent on details of construction, and their conscientious execution, his great resource and inventive genius ever finding practical solutions for difficult questions. His simple, straightforward thoroughness of purpose, his indefatigable energy, and his kind genial nature always won and retained the confidence of those who sought his advice, and the willingness and devotion of his assistants. He was a true friend to his workmen, and one of his main objects and greatest pleasures in life was to further the well-being of others. His reports bear witness to the conscientious and painstaking manner in which he tried to place a subject clearly in all its salient points before the authorities who had to decide upon it, and he had a peculiar way of making technical questions, even when of an intricate nature, clear to those with whom he had to deal, and of convincing them of the correctness of the views he advanced. One of his marked traits was a constant good humour, which carried him through many a difficult situation. He had a wonderful intuitive knowledge and judgment of men. He was not only an engineer, and did not limit himself to the technical side of the questions submitted to him, but generalised and looked at them from all points of view; and in fact the success of many of his works was due to his clear judgment and advice on the financial side of the subject.

After his retirement from active life in 1879, Mr. Lindley devoted his time to travel and reading. He had been a Fellow of the Geological Society from 1841, and from 1844 a Member of

the Smeatonian Society of Engineers, of which body he acted as President in 1864. He was the recipient of many interesting letters of recognition for services rendered, among others from the authorities of the City of Hamburg after the great fire, and again in 1892 on the occasion of the fiftieth anniversary of that fire; and at the news of his death the cities of Hamburg and Frankfurt-am-Main sent last messages of grateful acknowledgement of the services he had rendered them. How long he outlived his contemporaries is evidenced by the fact that he enjoyed the personal friendship of Cobden, John Stuart Mill, Professor Fawcett, Sir Rowland Hill, Professor Wheatstone, Sir Charles Lyell, Justus von Liebig, Sir George Gilbert Scott, Joseph Prestwich, Edwin Chadwick, Sir John Hawkshaw, Sir Joseph Whitworth, William Chadwell Mylne, John Frederic Bateman, Thomas Hawksley and Sir Robert Rawlinson.

Mr. Lindley was one of the oldest Members of the Institution, having been elected on the 1st February, 1842.

THOMAS DAVID LITTLE was born at Reading on the 19th December, 1842, and was educated at Caversham House Academy. After serving articles to the late Mr. J. B. Clacy, County Surveyor for Berkshire, he was engaged for about eighteen months in the Engineering Department of the Great Western Railway.

In 1861, as the result of competitive examination, Mr. Little was appointed an Assistant Engineer in the Bombay Public Works Department. After being stationed successively at Poona, Ahmedabad, Surat and Panch Mahals, he was posted to Kaira in 1869 and placed in charge, as Executive Engineer, of that large district, in which, during the following eighteen years, he designed and carried out many important works, including upwards of 150 miles of metalled roads, numerous tanks and other irrigation works, and a large number of masonry and iron bridges, besides being instrumental in securing the construction of branch railways. In 1887 he was transferred to Khandesh, and in 1889 was promoted to the rank of Superintending Engineer, 1st class. From December, 1889, to May, 1890, and again from 1894 till his retirement in December, 1896, he served as an Additional Member of the Council of the Government of Bombay for making Laws and Regulations. Mr. Little was promoted to be Chief Engineer of the Bombay Presidency in