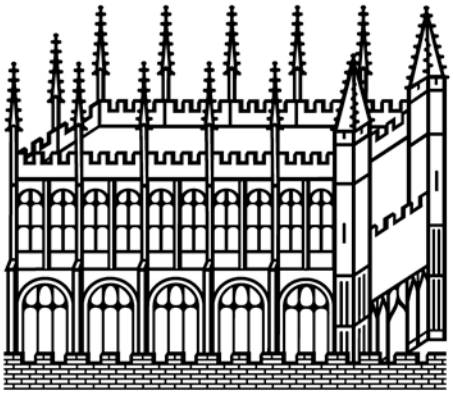

SOME REMINISCENCES

SEVENTY-FIVE YEARS WORK IN CIVIL ENGINEERING.

By

Professor HENRY ADAMS.

1861 d. 67

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LONDON.

The Institution of Structural Engineers.

MDCCCCXXV.

Price Half-a-Crown Net.

PROFESSOR HENRY ADAMS.

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Foreword.

THE Council of the Institution of Structural Engineers is pleased to publish the Memoirs written by Professor Henry Adams. Professor Adams is a member of nearly every Engineering and Architectural body of standing, and a past president of not a few, including the Institution of Structural Engineers, of which he is now an Honorary Member and the first and only Gold Medallist. His experiences extend over more years than most of us can lay claim to; and in spite of his modest disclaimer of an eventful life, there is no doubt but that the engineering world would have been a deal poorer for his absence.

SOME REMINISCENCES.—By Professor Henry Adams, M.Inst.C.E., F.R.I.B.A., P.P. and Hon. Mem.I.Struct.E., etc.

THE Editor of *The Structural Engineer* has suggested that my long career must have brought me in contact with many matters that might prove interesting to its readers and has asked for an account of my reminiscences. I have not had an eventful life, but it has been a long and busy one, and my memory being still good I have pleasure in recalling the days that have gone by.

Some of these notes may seem very puerile, but, as Anthony Hope says in " The King's Mirror," a man's *puerilia* are to himself not altogether puerile, they are parcel of the complex explanation of his existent self.

Poeta nascitur non fit is a well-worn tag, and I think it applies to followers of science quite as much as to the followers of any art. Study, application and opportunity will do much to procure the advancement of an engineer, but unless he has been born with a scientific bias he will be half hearted in his work and look upon it as more or less drudgery. It does not show a scientific mind when a man can say, as one did, that he did not believe the moon had any effect on the tides, because the tides went on just the same when there was no moon to be seen; or the other man who said " What proof have we that the planet the astronomers call Uranus is really Uranus after all "; but what are we to say when a solicitor, presumably an educated man, examining a witness at Willesden Police Court (April, 1925) in a case where a motor-cycle and a side-car met in collision, asked " Which of them struck the other first? " Heredity is certainly a strong factor in mental as well as physical equipment. I had the good fortune to come of an engineering stock, my father and grandfather both being civil engineers. My earliest recollection goes back to a house alongside the track of what is now the North London Railway, then in course of construction from Camden to Poplar and known by the cumbrous title of " The East and West India Docks and Birmingham Junction Railway," afterwards leased to the Northumberland and Durham Coal Company, chiefly for the carriage of coal from ships at the Poplar Dock, which was then known as the Collier Basin of the West India Docks, to Coal Depots at Hackney, Kingsland, Highbury, Caledonian Road and Camden Town.

My father, John Henry Adams, was one of the Resident Engineers on the construction of the railway, under Mr. J. B. Atwood the chief engineer, having his house and office at Kingsland adjacent to the railway, which was there in deep cutting. The soil consisted of gravel overlying London clay supported by heavy brick retaining walls built in lias lime mortar. My childish amusement was to make a double row of chairs and go between them pretending I was " down the cutting " and imitating the contractor's locomotive travelling backwards and forwards, which I only knew then as " Puffing Billy." The caretaker of the office, adjoining our residence, was the wife of the driver of this locomotive, and his younger brother was the fireman. One day a fall of gravel from the side of the cutting overwhelmed the engine and killed the fireman, whom I saw afterwards laid out on a table in the office. The date of this, by a memorial printed on white silk recording the event, which I still have, was July 3, 1850.

I distinctly recollect the instant when I first realised my personal identity, or, as I put it then, " That I was me." I was not four years old at the time and was in a room by myself, which I can recall vividly. It was a curious sensation, and was the commencement of a new outlook on life. Most people, I suppose, grow gradually into a differentiation between themselves and their surroundings; mine was a sudden transition. Much might be learnt as to mental development if children were studied more closely. A two-year-old daughter startled me one day; I noticed her opening and shutting her eyes two or three times, and then she said " Daddy, where does the dark go to what I see when I shut my eyes? " There was the beginning of an enquiring mind. As Descartes said, *Cogito ergo sum.*

Another early recollection is that of being taken to the Great Exhibition of 1851 in Hyde Park. I remember the overwhelming feeling at the first sight of the great glass house (now the Crystal Palace); what struck me most inside were the Koh-i-noor diamond on a table with a policeman in a tall hat at each end, a piece of sculpture (boy with a broken drum), the large crystal fountain, the Würtemburg collection of stuffed animals in comical attitudes, and a full-sized tree all alive in the building, one of those shut in during the erection.

I was extremely delicate as a child, and have been told that until I was fourteen my life seemed to hang by a thread. I do not know when I first went to school, but I remember that I used to have to lie down on a rug on the floor there for an hour every morning; notwithstanding this drawback, I could read when I was four years old.

My grandfather, John Samuel Adams, was Engineer to the East and West India Dock Co., and had his residence in the docks facing the Limehouse Basin. My visits there were great sources of enjoyment although I was not then seven years old. Among other things I saw a real Chinese junk with its curious construction, sails of matting, and native sailors in blue smocks and broad, round turn-down conical hats. Also what I understood to be the first iron ship, the *Great Britain;* at any rate, it was the first iron ship to enter the West India Docks. The other ships were all wooden, clipper built, high stems flared forward, with carved and coloured figure-heads and tall, tapering masts. The masts were so tall that I have heard them called sky-scrapers, moon-rakers and star-gazers. The working of the lock-gates, capstans and bridges, all by hand labour, roused my mechanical instincts, but what I did not like was the smell of the warehouses, especially the vaults. Unrefined castor oil is the nearest illustration of the prevailing scent, varied by that of dead rats, rum and molasses. My grandfather was rather a fussy little man, and I remember hearing him say one day he had been into the cooperage and, finding rather more than the usual smell of rum, he went to a cupboard and there found a pail containing a pretty strong decoction of rum and water. Upon further enquiry the man responsible for it explained that before starting to repair a rum cask they washed it out and mixed the liquid with the water they had for drinking to kill the " amalankers " (animalculæ).

In those days boys wore petticoats until nearly or quite seven years old, and that is one reason I can fix the date of my early visits to the Docks. I can distinctly remember, however, seeing a boy, perhaps ten or twelve years old, dressed in a large flat cap, with a short round jacket, to the outside of which his trousers were buttoned, like the pictures in " Sandford and Merton." My grandfather wore a beaver hat, not so tall as the silk hats of later days, with a rather broad brim and broad crown. I was told that my father was married in a bright blue coat with gilt buttons and white waistcoat and trousers, so that the fashions have altered considerably since those days. When I reached ten years old I had a white woven-horsehair peaked cap, a black velvet spenser and white trousers, and rather " fancied myself." The ladies wore " poke bonnets " and shawls, which were as typical of the time as the chignons and crinolines of 1860-65. I remember a tinder-box used to stand on the mantel-shelf at home, although not in use. We had large matches, dipped in sulphur and tipped with phosphorus, that made a great splutter and stifling smell when they were struck; they called them " Congreves," after the inventor. Silent and safetv matches did not come into use until many years later. We had no gas in the house, only candles and a " Moderator " lamp, which was seldom lighted. Usually we had one candle if by ourselves, and two if we had company—somewhat different from the brilliant lighting now demanded. Outdoor lighting has undergone very similar changes.

It was in one of the warehouses at the West India Docks, nearly facing the entrance next to the West India Dock Railway Station, that Perkins made his experiments on high pressure heating. I did not see either him or his experiments, but I remember my grandfather remarking that Perkins claimed to be able to work at a pressure of 1,000 lb. per square inch and make the water red hot. The system is in use right up to the present time for churches, but the application has not been very extended, perhaps because of the smell

from charred organic matter falling on the pipes and the danger of fire from the charring of wood near the pipes. It may be noted here that from my own later experiments, made with the object of ascertaining this fact, wood chars at 450 degrees Fahrenheit, which represents a steam pressure of about 425 lb. per square inch by the gauge. A steam pressure of 1,000 lb. per square inch would mean a temperature of about 532 degrees Fahrenheit.

I must have been very young when I learnt a clever dodge in mechanics from my father which I have not forgotten. I had a fair-sized humming top, the sort with a spindle at the top and a handle that slipped over the spindle. I had broken the handle and could not spin the top, because if I wound the string round the spindle and pulled, the pressure against my hand stopped it from rotating. My father took the string, doubled it over, and wound it round the spindle, beginning at the looped end. He then took hold of the two loose ends and pulled in opposite directions so that the top was balanced and at the same time caused to rotate quickly.

The railways in those days were very curious. The city terminus of the London and Blackwall Railway was at the Minories and the other terminus at Blackwall, just before reaching Brunswick Wharf. A winding engine at each end used to haul a rope through a trough laid in the " four-foot." The carriages were all " composite " and made after one pattern. The guard stood on a narrow covered platform at the front, with a brake-wheel and a gripping rod which could hold on to the rope or let it go. Behind the guard was a first-class compartment, then I think a second-class one, and at the back a compartment with standing places only. All the carriages were like this, each with its own guard. This phase of the working was just before my time, but I was told that when the train started from one end the passengers for the next station got in the last carriage, and so on in order, the hinder carriage being left behind as each station was reached, another being taken on in front; and they were picked up in the same order in returning. When I first travelled on that railway the line was continued through to Fenchurch Street and to Brunswick Wharf, Blackwall, and the same carriages were run by locomotives. The locomotives were, however, very different from those seen at the present day. They had low, squat boilers only about waist high to the driver standing on the foot-plate. The chimneys were of small diameter and very tall. The engine had no shelter or screen for the men, who were thus exposed to all weathers. Later they had a plain screen with two circular windows, which they objected to at first as the glass got obscured. They finally had the enclosed cab as at present. " Valve-setting " was not understood, so that up to about 1875 the " beats " of the engine were always irregular, with consequent loss of efficiency. The carriages must have been an advance upon those of some of the other railways, because I remember travelling from London Bridge to Greenwich in a carriage shaped like a boat-swing at the fairs, *with no top on it,* and painted in light blue. There were market gardens then just beyond London Bridge Station. Some few years later on the first main line train I travelled by I observed that the luggage was all put on the roofs of the carriages. Excursion trains were advertised as running with " covered cars "; these were ordinary wooden-seat carriages open all round, with the roofs supported on iron rods carried up from the sides, and, as one may suppose, they were decidedly draughty. A railway journey was in those days a deliberate affair, none of the officials seemed in a hurry, and suburban trains generally stayed five minutes at each station to get the passengers off and on. The omnibuses, what few there were, were equally dilatory. The blue Blackwall 'bus, the green Bow 'bus, the yellow Camden Town 'bus, the green Islington 'bus, the Camberwell 'bus, one to Edmonton, and I think one to Hammersmith, and the Royal Blue from Waterloo to Regent's Park made up the total, and they used to run about every half-hour. They all had doors with a shutter or window to let up or down according to the weather. The conductor stood on a little round step on one side of the door holding on to a strap; the three steps for the outside passengers were merely step-irons placed vertically on the other side of the door. There was a long, low centre seat on top where the passengers sat back to back, and in front were

two seats each side of the driver, which were reached by climbing on the wheel and seizing a looped strap held out by the driver. The full complement was twelve passengers inside and fourteen outside. The floors of the vehicles were always covered with three or four inches of straw, and were so narrow that it was difficult to pass the other peoples' knees. The conductors were as a body notorious for their chaffing proclivities when they met other vehicles. The fare was never taken until the passenger alighted, and everyone was delayed while change was being found. There were no orderly boys or bins in those days, and it was by no means rare to find three or four inches of mud and horse droppings in the city streets in bad weather.

As stated before, the Northumberland and Durham Coal Co. took a lease of the East and West India Docks and Birmingham Junction Railway, when they appointed my father Engineer and Manager. He had charge of the repair of the locomotives and rolling stock, and fitted up the Collier Dock with three luffing jib cranes by Sir William Armstrong's firm. He was only Mr. Armstrong then (1851), and the cranes were the first hydraulic machines fixed in London. Later on, when the North London Railway took over the line, my uncle, William Adams, was appointed Locomotive Engineer and my father Goods Manager, with permission to engage in private practice as a civil engineer. Among the locomotive drivers under the Northumberland and Durham Coal Co. was a John Scott, a short but very stout and broad man. I often rode on the engine with him, and found that he stood on a stool, so that he looked a giant when only seen from the outside. He was made the leading foreman of the Bow Works when my uncle took them over, and turned out a first-class works manager.

My first boy's school was, of course, known as an "Academy." The master was a young man, a B.A., reading for his M.A., and in common with schoolmasters of that day was a brute. Scarcely a day passed without one or more of the boys getting a thrashing, and about every half-hour, for the slightest slip in a lesson, the cry was " Brown, Jones, Robinson (or Adams), come here; hold out your hand," and whack came the cane wielded by an athlete. If a boy ever drew back his hand so that the first stroke missed, the second stroke came upwards and caught him on the back of his hand, which was rather worse. Sometimes, in addition to this, it was " Learn fifty lines of Milton." This master wrote a copper-plate hand and was adept at flourishes for title-pages so much in vogue then. He was very strict with the boys' writing, and never gave them lines to write out in punishment for fear of spoiling their style. I took some pride in my writing, and was fortunate in obtaining the school prize in that subject at ten years of age, although there were many older boys there. Some of the boys tried to " spoil the rod and spare the child " by putting a horsehair up the cane when the master was out of the room, but it did not make any difference, although tradition said that it would split the cane. In spite of his rigid discipline this master was a good teacher, and, personally, I forgave him his cruelty because he gave us a weekly scientific lecture with blackboard diagrams in some branch of mechanics, physics or physiology. We had afterwards to write out our notes at home and send them in with freehand sketches. One good point about the school was that there was no bullying except by the master. Each new boy as he arrived was matched with one that the others thought to be his equal. If he beat him he had to try the next above him until he found his equal, and then he was not allowed to fight with or bully anyone below him in skill. My difficulty was that when I reached the boy that beat me I challenged him and beat him. Then he challenged again and beat me. After several trials, in which we beat alternately, we agreed that it was silly to go on, and then became the best of friends. The school terms were at that time divided up into half-years; we had a week's holiday at Easter and Michaelmas, a fortnight at Christmas, and a month's holiday at Midsummer.

At 10 years old I was learning French, Latin and Greek, besides Algebra and Chemistry, and at 12 was reading Le Sage's *Gil Blas* in French and Xenophon's *Anabasis* in Greek. This was at the time of the Crimean war and the Indian Mutiny, and I can recall the very severe winters we had about that time, as the schoolroom had only one little fire in it at the

master's end of the room, and the boys all suffered from chilblains. Although gas was laid on it was never lighted, and we all had to provide wax tapers for lighting up after dark. We do not have such winters now except as an occasional phenomenon, although I believe the thermometer went down to zero Fahrenheit one Christmas about 1860. I well remember about 1870 seeing a man walk across the Thames on the ice at Westminster Bridge, and about 1880 a particularly heavy snow storm, during which the snow was piled up seven feet high against the houses and walls in North London facing north-west. About 1890 there was again a severe frost, during which all my pipes were frozen up for six weeks. These periodical snaps of cold are partially explained in Sir Robert Ball's *Cause of an Ice Age.*

During the Crimean war bread went up to the then unheard-of price of 1s. per quartern loaf, and there were bread riots at the East End of London. The shipwrights were making all the money then, 7s. 6d. a day was the rate, and it was considered very high, but ships were wanted, and the noise of the deck caulkers' mallets was so continuous round about the docks that I can only compare it with the noise of a stamping mill for ore crushing. In my opinion the present high costs of labour, materials, and living generally, had its origin when the munition workers during the Great War asked for more money, and the Government, instead of putting them under martial law, virtually said "Here is the money; let us know if you want any more." Naturally, when the men had more money to spend the tradesmen put up their prices, and so it went on in a vicious circle, and it is very doubtful if we shall ever recover from it. When the war broke out my eldest son, a full M.Inst.C.E., being over age for joining up, stated his qualifications and offered his services to the Government at a salary if they could utilise his engineering experience. They offered him a job as *Clerk of Works at* 30*s. per week,* which he declined. Had he been a butler or shopman they might perhaps have offered him a high salaried appointment; they seemed to have no sense of the fitness of things. It was reported after the war that a man applied to a firm for a job as labourer, when he was told that all the labourers' jobs were filled, but if he would accept a post as a manager he might in time work up to the more highly paid job of labourer. To this we may say "*Si non è vero è ben trovato,*" and typical of the relative emoluments.

About 1857, when I was living at Poplar, the building of the *Leviathan* steamship, designed by the great Brunel, was going on, and I remember walking to the further end of the Isle of Dogs to see it lying on the shore after the first attempt at launching. At that time there were one or two small factories near the Folly House on the north-east corner of the island, but otherwise it was all pasture land and marsh intersected by narrow roads and ditches. The ship, afterwards known as the *Great Eastern,* was marvellous for its enormous size and construction. It had several paddle-wheels and screw propellers with their respective engines, but was so extravagant in fuel that I believe it made only one paying voyage, and that was in laying the Atlantic Telegraph cable.

About this time, or rather earlier, a circular brick sewer was being laid along the East India Dock Road, and I was interested to note how they did it. I watched the timbering of the trench and saw the method and the object of it. On the ground, wooden troughs some four or five feet long were formed to the shape of a segment of the sewer, filled up with bricks and mortar, the segment being left to set until it could be handled and then placed in position as a part of the sewer. I passed the trench every morning on my way to school and always looked down to see how the work was progressing. Portland cement was not in use at that time, but lime mortar was strengthened by mixing pozzuolana with it.

The East End of London is very different now from what it was when I first knew it. Bow Road was then called London Road, and there was still some land in the main thoroughfare not built upon. Bow was separated by fields from Old Ford, Stratford, Poplar and Limehouse. Bromley was older than Bow, and abutted against it on the south and between there and Poplar it was quite rural. A mansion called Bromley Hall existed, standing in large grounds and surrounded by many fields. In Bromley itself was a large old

building known as Queen Elizabeth's palace, which I believe became a nunnery. In Pennyfields, Poplar, was another large house with garden and stable, where an engineer friend lived with his family. The last time I saw the house it was let out in lodgings to Chinese, and I daresay 100 of them occupied it. When I was a visitor there, there were no Chinese Colonies in the East End, not even at Limehouse, where they now abound. In the East India Dock Road were several large houses standing in their own grounds and market gardens in between, long since all swept away to make room for thousands of small houses. There was one notable feature about the East India Dock Road and its continuation the Commercial Road East, and that was a stone tramway three miles long up to the City warehouses to facilitate the hauling of the tea vans. It consisted of two lines of granite slabs about 12 inches wide and 6 ft. long laid flush with the ordinary horse track of granite setts between. The remainder of the road was macadamised.

The seaside towns have altered more than London, as the habit of the middle classes to take a summer holiday at the seaside hardly commenced before the second half of the nineteenth century. To take two examples, in 1860 Southend consisted of a fringe of houses facing the sea in what is now called the lower town, ending at the Castle Hotel. There was the Royal Hotel on the cliff, with four new houses alongside and a few scattered up the street to the railway station. The Shrubbery was merely a rough cliff with brambles and sloe bushes. There was a library half-way down the cliff and some six or eight bathing machines at the bottom. There were three bathing machines belonging to a man named Bradley in the lower town. This comprised the facilities for sea bathing. The machines had large hoods to let down in front so that the bath could be taken in private; and it was very bad form for a woman to go outside the hood. The bathing dresses were merely a dark loose smock for the women and small bathing drawers for the men. There was no Westcliff except on paper. Leigh was a small fishing village some distance from Southend, and Prittlewell a village about 1½ miles inland. There was plenty of blackberrying within five minutes of any part of the town. Shoeburyness was a camp, with no civilians.

Then take Margate; there was no Cliftonville, nothing beyond the coast guards' cottages about where the Cliftonville Hotel now stands. In Palm Bay as late as 1880 my bathing tent was the only one to be seen there; the only other sign of life was a gipsy encampment in the far corner. Now in the season there are something like 2,000 persons bathing there daily, and the sands are crowded with bathing tents and pavilions. Other places within the Londoners' ordinary range—Clacton, Herne Bay, &c.—have grown at the same rate. Margate Jetty, when I first knew it, was a little wooden structure with an old hand-power crane on it for lowering a boat. When this jetty was burnt down the present large and handsome structure was built.

Like all boys, I pulled my toys to pieces to see how they were made, but I was constructive as well as destructive. I remember making a pump out of a round wooden pencil case, a couple of corks and the rib of an umbrella; also a winch from a reel, some firewood and another umbrella wire; a rope spinning frame with three spindles rotating on their own axes, by means of two pieces of wood and three bent wires. I used to watch the men at the rope-walk in the Commercial Road on my way to school and to see each spindle going round by itself was a puzzle for a long time, until I got inside one day and saw how it was done.

The Science lectures I heard led me to pour molten lead into a bucket of water to make all manner of fairy caskets; a pennyworth of sulphuric acid and water with some rusty nails furnished hydrogen through a piece of tobacco pipe stuck in the cork; an ordinary clay pipe with the bowl filled with coal dust and covered with wet clay made a gas retort when put in the fire, the gas from which would burn for several minutes. A piece of lead gas pipe for a siphon and shoe-leather for a sucker also furnished instruction and amusement. I experimented in a small way with electricity, rubbing with a silk handkerchief a sheet of glass supported on two books and making little figures cut out of paper dance below, also rubbing a piece of glass tube to pick the figures up, and heating a sheet of

brown paper before the fire, rubbing with india rubber and getting sparks to my knuckles. I made copies of prints by putting behind them paper soaked in nitrate of silver and dried, and exposing to the sun, but I did not know then how to fix the photographs; however, when dry plate photography superseded the collodion process I took up proper photography and experimented with all the known developers.

Shortly before the age of 13 I went to a boarding school. I arrived the evening of the day before school reopened and was introduced to the few boys who had then arrived. The questions they put were the usual ones: " What's your name? " " Who's your pater? " " How much pocket-money have you got? " They helped themselves to some of the latter, and one of them went out at once to purchase a bottle of wine and some biscuits, to " pay my footing." Nightcaps were still in fashion, and so I was sent to school with half a dozen white nightcaps to tie under the chin. Men usually wore stockingnette night-caps, to pull on the head with a tassel at the top, like the red caps brewers' draymen wore for many years after, and some seaside boatmen still wear. The boys of my dormitory discovered these in my clothes box and there was a fine scrimmage in which, fortunately, the caps were all torn to pieces as they were not in vogue at that school. This discovery did not enhance my reputation, but in my first half I got to the head of the school in mathematics, which place I kept all the time I was there, obtaining the medal for Algebra each year, not that I knew so much about the subject, but that the others knew less. I went ahead in Latin, Greek and German, reaching the top form in the two former and the head of the school in the latter, missing the medal by one mistake at the examination. I was told off to give the Greek recitation on Prize Day just before I left. I did not shine so much in French, as there were several Guernsey and Jersey boys there who filled the first class, but I had a good practical knowledge of it; in fact, at the present time (i.e., the last three or four years) I read on an average three French novels a week for recreation. What I enjoyed most was the workshop where, however, they only had a small foot-lathe and a carpenters' bench. We were only allowed there in our playtime, but I put in enough work to receive the Workshop Prize before I left. I was fond of chemistry, but they did not teach it there; however, I introduced writing in secret ink which could be developed by the application of another liquid, and a great many of the boys adopted it, until it was discovered by the masters and all the materials confiscated. It was, perhaps, this fact that induced the head master to invite me, after I had left the school, to attend a course of evening lectures in Chemistry about to be given there, which I did. A friend of mine who was in a shipping office joined me, and was so taken with the work that he gave up his business and took to chemistry entirely. He underwent a training and became an analytical chemist, continuing until his death some 60 years later. I also followed up the study, but only as a recreation, although I did take a week's engagement at a farm in Huntingdonshire to analyse the soils for the farmer. He had two varieties of land, clay and fen, and differed entirely from the usual grumbling farmer, inasmuch as when it was dry he said " this is fine for my clay land," and when it was wet he said " this is fine for my fen-land "; and when it was indifferent weather he would go off to the market and make a deal in corn.

About 1860 the Thames Ironworks and Shipbuilding Co. had constructed a floating vessel, flat-bottomed, 223 feet long and 90 feet beam, with a gigantic fixed crane and steam winches for lifting sunken ships, and I saw it with an old wooden hulk, sunk to water-level, hanging to it. It was an amusing state of things, as this vessel was not sea-going and it could only lift sunken ships *by having them brought alongside*. Messrs. William Cory & Son heard that it was for sale, and my father, on their behalf, went into the question of converting it into a floating wharf, with hydraulic cranes for unloading screw colliers moored alongside and discharging the coal into barges at the ends. Finding the scheme feasible, the vessel was bought at about a third of the cost of construction and duly converted. It was fitted with filters, steam pumping engine, Cornish boilers, accumulator, coal weighing cranes, capstans, gas works, carpenters' shop, fitters' shop, smiths' shop, cook-shop, mess-room, &c. It was then officially known as Atlas No. 1, but the river folk always called it

the Derrick. I do not know whether H.M.S. *Warrior* was built by the Thames Ironworks Co., or the date, but I remember going over it soon after it was built. It must have been about this date, and I understood it to be the first ironclad constructed.

On leaving school at the age of 15 I was taken into my father's office, where I learnt general office routine, and was chiefly engaged upon the drawings for the conversion of the vessel described above. I there learnt to work the Wheatstone telegraph, which was the instrument then in use for sending telegraph messages. There were two handles, two dials and two needles, and by the movement of the handles the needles made signs singly or in conjunction, or in opposition, to indicate the various letters of the alphabet. After a year in this office I obtained permission to enter the locomotive workshops at Bow as an apprentice. I served in the pattern shop, foundry, smiths' shop, fitting shop, turnery and erecting shop. The working day was 10 hours then, beginning at six in the morning, but occasionally I used to climb over the railings of Victoria Park and have a swim in the lake before going on to the works. I may say that at that time I had quite outgrown my delicate health and rapidly became athletic. I was the strongest lad in the works, and never thought of calling a labourer to help when I had a heavy load to lift on to the machine. When I was 18 I could lift by dynamometer 402 lb., while others trying at the same time could not lift more than 250 lb. If the machine could be relied upon, I lifted 450 lb. at a strength-testing machine at Cremorne Gardens in 1865, then still open as a place of popular amusement, but now as much forgotten as the earlier Vauxhall Gardens. I even lifted and carried four ½-cwts. at one time when I was 70.

In order to get rid of my superfluous energy and build up permanent strength I joined, in 1865, the Deutscher Turn-Verein, or German Gymnasium in St. Pancras Road, and attended evening practice there for three years. At that time there were some hundreds of German members and only a few English. All instruction was given in German. I was also fond of rowing, and used to go frequently with friends on the River Lea or on the Thames at Putney. This was interspersed with visits to the various public swimming baths. When I gave up the outdoor swimming for want of time I used to take a cold shower-bath at home every morning throughout the year, and have kept up the daily cold bath to the present time, not what a doctor calls a cold bath, 60 degrees Fahrenheit, but whatever Nature provides down to 32 degrees. Various doctors have advised me against the practice, but I have replied that if they would produce a doctor who knew from personal experience the effects of such a bath I would give his experience due consideration. One doctor asserted that he took a daily cold bath, but on cross-examination admitted that he took the chill off by the addition of a little hot water; he therefore never knew the invigoration due to cold water.

I kept up the study of various subjects after my schooldays, adding Italian and Spanish to the languages and medicine and surgery to the science subjects. I learnt shorthand from Frederick Pitman, son of Sir Isaac, the originator of Pitman's system, in a little private class he held at the back of his shop in Paternoster Row, and used it to take notes of lectures I attended.

I applied myself diligently in the workshops, as my father told me if I became a good workman I might rise some day to be a foreman. If he had said it was only a preliminary to professional practice I might have shirked, as the premium pupils did, but fortunately I stuck to the work. It was intensely interesting, and I was keen on labour-saving dodges, so that I appeared to have a good deal of leisure. I remember that at one time I was in a piece-work gang where the money was pooled and divided out in proportion to our fixed rates of pay. I was then working at a lathe and by means of special devices was able to make it to some extent automatic, and am afraid that in consequence I spent more time " larking about " than was desirable; at any rate, the foreman of the gang said they were " keeping me " and complained to the office. The consequence was that a full investigation was made, when it was found that I had earned more than anyone else in

the gang, including the foreman, and I was honourably acquitted. While in the shops I thought out a new form of locomotive blast pipe, which should eject the steam through an annulus instead of as a solid jet, and thereby provide a greater frictional surface, inside and outside, for creating a draught through the tubes. I could not persuade my uncle to adopt it, as he thought it was only a juvenile idea, but twenty years afterwards when I had the opportunity to apply it for myself and prove its value, he was glad to join with me in taking out patents for it all over the world. He would not agree to form a small company of locomotive engineers to work the patents, so we soon had a dozen other patents taken out by them in opposition to us and we missed a fortune. The London and South Western Railway Company, to whom my uncle was then locomotive engineer, allowed it to be tried on several of their engines for a start, and the official return showed by its use a total saving of £60,000 in seven years. It was adopted on some other railways, but not to any great extent by reason of the subsequent patents. It was called the " Vortex " blast pipe, as the outlet from the cylinders carried up to the annulus formed a great scoop-shaped opening opposite the tube ends in the smoke-box and thus caused a rush of hot gases to the inside of the annulus while the outside acted as an ordinary blast pipe. The economy consisted in making the lower tubes equally efficient with the upper ones, steaming easier and with a reduced back pressure in the cylinders.

While I was in the shops the first train with a continuous brake was fitted up (Chambers' patent). This was worked by a chain carried over a double pair of links, attached to adjoining carriages. A sheave at each end and one at the hanging junction of the two pairs of links enabled the chain to pass over and under and remain of the same length, whether the carriages approached each other or receded. The carriages had buffers on long rods so that they were from two to three feet apart, instead of being only a few inches as at present. An amusing incident of my workshop life occurs to me. On one occasion the before-mentioned John Scott, the works manager, was severely reprimanding a workman for some dereliction of duty, and then suddenly turned on him and said " Now don't be saucy." The astonished man replied " I haven't said a word," when John Scott retorted " I know you haven't, and that's the worst part of the saucy."

After leaving the Bow works I could not give up my handicraft, and so used to work for a couple of hours before breakfast every morning until I had built a workshop for myself, 9 ft. by 6 ft., properly framed together, with framed and panelled door, four moulded sashes, floor and roof. I then made a carpenter's bench, and a lathe bench and bought a lathe to go on it. After many vicissitudes during the fifty years following I still had and used a workshop and chemical laboratory, until it was finally discarded about the time the Great War broke out.

When I commenced the study of practical Chemistry I wanted, among other apparatus, a stoppered glass retort, but had no money to spare. I had not heard of Cartesian Co-ordinates, but hit upon the method by which I could determine the relative value of different sized retorts and obtain the best return for my money. I plotted the capacities on a base line and erected perpendiculars for the cost of each; joining the extremities, I found that where the curve deflected most from a straight line towards the base was the size indicated. After this I used the same method for controlling experiments, pricing machines and many other purposes. For example, in ascertaining the most efficient loading for a given hydraulic crane or lift. It was a question of greater load and less speed, or greater speed and less load. By plotting the loads on a base line and the time in seconds taken to lift a given height as ordinates, I obtained a curve, the adjustment of which corrected the times observed; then dividing the loads by the respective times I obtained the relative efficiencies; this gave a second curve from which the maximum was easily read off. I found that the maximum work done was when the load was equal to three-fourths of the ultimate creeping load.

Applying the same method to the catalogue price of steam engines, I was met by an apparent anomaly. The curve rose more or less as a straight line for a given distance, then

made a sudden jump and again continued fairly regular. This I found was due to the same size bedplate taking cylinders larger and larger until a larger bedplate was necessary, and therefore the jump in cost. Although I used these graphic diagrams very largely from 1866 onwards it was not until about 1880 that I found them in use elsewhere, and since that time their use has extended rapidly, more perhaps in America than in England. I took an early interest in graphic statics, and remember that about 1870 I furnished Sir Corbet Woodall (then Mr. Woodall) with some calculations and stress diagrams for the first large gas-holder (two million cubic feet) at Kennington.

I was very fond of spending my summer holidays in a walking tour with one or other of my friends. These tours included Scotland, North Wales, and all round the south coast of England from Whitstable to Lands End. Of course, we got into all sorts of quarters, but I used to take a small bottle of .880 ammonia with me to sprinkle the sheets and keep off the *pulex irritans* when they got too lively. While stopping at Penzance we spent one day on the hills, and returning at night, as we thought to Penzance, found ourselves at St. Ives on the wrong side of the hills, and had to tramp all the way back, some ten miles. We were not afraid of walking. Earlier, on the same holiday, reaching Exeter overnight, we went round the town early next morning, over the cathedral and park, and then walked on round the coast through Exminster, Starcross, Dawlish, Teignmouth, Shaldon, and Babbacombe to Torquay, 30 miles by the winding road we took. In the Welsh tour we saw plenty of women in red cloaks and tall, tapering hats, and in many villages where we enquired our way the best answer we could get was " No English." We heard occasionally an open-air Welsh choir, or, rather, group of men, who sang singly or together with most musical and melodious voices. My Scotch tour was a geological one with knapsack and hammer. Arthur's Seat, Edinburgh, is not so high as it was before I went, as I brought away the highest point of it, where the red serpentine cropped out.

The present generation will be surprised to hear that public hangings took place at the top of the Old Bailey in front of St. Sepulchre's Church, after I went to business, but I had no wish to see them. On one occasion I remember there were five men hanged at the same time.

In 1865 I entered the London office of Sir W. G. Armstrong & Co., and in a very short time became assistant out-door manager, looking after the erection of engines, boilers, accumulators, cranes, lifts, capstans, bridges, caissons, lock-gates, sluices, &c. Among the larger establishments fitted out with hydraulic machinery under my supervision were the Cannon Street Hotel, the Inns of Court Hotel, the Midland Grand Hotel, St. Pancras, the St. Pancras Goods Station, the Broad Street Goods Station, Blackfriars Goods Station, Whitecross Street Goods Station, the whole of the underground work of the Smithfield Markets, the Millwall Docks, extensions at the Surrey Commercial Docks, Regent's Canal Entrance, &c. At one time I had 14 foremen and 400 men under me. At all these places I learnt what I could of building and everything else, I also had the opportunity of studying the drawings connected with all these buildings, and began to pick up details of architecture, land and quantity surveying. When first I went to Westminster I used during my lunch hour to study the architecture of Westminster Abbey almost daily, so that I got a good grasp of English ecclesiastical architecture from the Norman to the Perpendicular.

On my first visit to Broad Street Goods Station, then in course of construction, I was accosted by an Irish labourer, " Sure and I would like to drink your honour's health." Being young and green, I gave him sixpence. The next time I went there the same man spotted me and said, " Sure, and I'm so mighty dry I can't thank your honour for the saxpence you gave me last time you were here." I thought that was almost worth another, but forebore. Another taste of Irish humour occurred to me in Dublin. I took a side car to the station, and on my way asked the jarvey the fare; he said " Three-and-sixpence, your honour." I replied that I should have thought one-and-sixpence was more like the fare— " so it is, your honour." However, I gave him two shillings, which amply satisfied him, as he parted from me with a hearty " Thank ye, sorr, you're a gintleman." While in

Dublin I saw the spot in Phœnix Park where Sir Frederick Cavendish was murdered, and this reminds me of another instance of the native wit of Irishmen. When Carey, the Informer, turned Queen's evidence, he admitted that on a certain occasion he had ducked his head to avoid being shot, and counsel asked him if that was not a cowardly thing to do, and his reply was " Sure, and I'd sooner be a coward for five minutes than a dead man for the rest of my life."

It was about the time of my going to Westminster when the first Thames Embankment was being constructed, at the same time as the Metropolitan Railway. The contractors for the latter gave a price for excavation, but did not know what to do with the material; just then the contractor for the embankment wanted material to fill in at the back of the retaining wall, and so the first contractor was able to dispose of his material at an unexpected profit. Contracting in the old days was much more speculative than at present. It is reported that one of the old school of prosperous navvys was considering the amount he would put in for a given job, but thought he would consult his wife first. She advised him to double it, and after getting back to the office he thought there was little or no competition, and so he doubled it again—and got the contract.

There was no railway between the City and Westminster; the quickest way was by hansom cab over Southwark Bridge and over Westminster Bridge, but the penny Steamers were almost as quick. There was an omnibus with a 6d. fare that took about three-quarters of an hour, but it was quicker to walk. The wide flats of mud between Westminster Bridge and Waterloo used to be infested by boys, known as " mud-larks," who shouted for pennies from the passengers in the boats and on the bridges.

When the Metropolitan Railway was first opened the heat and smoke from the steam locomotives rendered travelling by it very unpleasant, the worst part being between Portland Road and Kings Cross. A slight improvement was made by ventilation between these points, but it remained so bad that passengers were apt to modify Dr. Watts' hymn and say " I have been there and still *won't* go, 'Tis like a little *oven* below." The District Railway when first opened was advertised as the " daylight route," but afterwards altered to the more appropriate designation of the " daylight station route."

The streets of London in those days were only beginning to prove inadequate. There was the narrow Strand and Fleet Street, St. Martin's Lane and the rest, and still the obstruction of Temple Bar, the Poultry, Fen Church making a bottle-neck at the corner of Fenchurch Street, the block of buildings at the foot of Parliament Street, and many others. Holborn dipped down at Snow Hill to the level of Farringdon Street, there was no Holborn Viaduct; many City churches have disappeared. There was one opposite my offices in Queen Victoria Street when I took them 46 years ago, since pulled down. In the thickness of Temple Bar on the north side was a house of two rooms occupied by a hair-dresser named Buckingham, rather a humorous sort of man, and when the Strand was to be widened and Temple Bar removed to make room for the Law Courts he refused to budge, as he said he was neither in the Strand parish nor Fleet Street parish, and it was reported that a special Act of Parliament was passed to turn him out. The Law Courts were at that time held in an annexe to Westminster Hall, which was removed when the Strand Law Courts were erected. It was there I learnt the routine of law cases in preparation for the time when I should have to give evidence.

I heard John Stuart Mill make an election speech at the hustings at Charing Cross, in front of Northumberland House, before voting by ballot came in. The state of the poll used to be announced every hour by placards affixed to the polling booths, and although there was some excitement the disturbances were not so great as one might have expected. Northumberland House stood facing Morley's Hotel and Trafalgar Square. The building the public saw with the figure of a lion on top was, I believe, only a screen to the house itself, which was some distance back. This lion was somewhat noted; it stood with its tail straight out, and not infrequently a crowd used to gather when one man would say he saw the tail move, and upon straining the eyes to watch, it was difficult sometimes to believe

that it did not; many persons were quite sure they saw it. Another notable feature of this front was the porter who used frequently to stand in the gateway. He was enormously stout, even stouter than the proverbial Lord Mayor's coachman, but he passed away with the old buildings when all the neighbourhood was remodelled.

In 1866 I joined the evening classes at the City of London College, and a little later those at King's College and elsewhere for the special subjects I wanted. In the chemistry class at the former place three students were one evening selected to take a dose of "laughing gas." The first one after inhaling immediately buried his face in his hands and laughed immoderately for a long time; in fact, I went home with him afterwards and he continued laughing at intervals and said he could not help it. The second one only strutted about, saying "I feel of much greater importance now." I was the third one and, losing my native shyness, I went at once to the head of the table and described my sensations for the benefit of the class. I had cause to remember the examination in Building Construction particularly, because it was held at South Kensington from 7 to 11 p.m., and when it was over I had to walk to Bow where I then lived, carrying a heavy imperial-size drawing board, tee square and box of instruments, arriving home about 2 a.m. Students at the present day have no conception of the difficulty there was 60 years ago in carrying on their studies after leaving school. In three years I took nine prizes, including a Queen's Medal and twenty-nine certificates, covering almost every branch of study. I added one to the number later on, the certificate of efficiency given by the St. John Ambulance Association. The last time I went on the platform as a student the prizes and certificates were distributed by the Bishop of London. Upon handing me a somewhat bulky parcel he said rather pompously, "I suppose, sir, you have now completed your education." I promptly replied "I hope not, my lord." The fact is, an engineer's education is never completed. At the Science and Art Department examinations in 1868 I took the third place in honours in Applied Mechanics and in 1869 the first place in honours in Applied Mechanics and also in Machine Construction and Drawing. Thereupon I was appointed on the staff of Professors at the City of London College, and created the Engineering Department which in after years became somewhat famous, the students reaching high positions in various parts of the world. This evening work I carried on for 35 years in addition to my daily work at the office. I also founded the Art Classes at the Bow and Bromley Institute and acted as Art Master for three years, and lectured occasionally elsewhere, as at the Royal Polytechnic, the Crystal Palace School of Engineering, the Architectural Association, &c. I was the first on record to hold evening classes in land surveying, and the first to hold any classes in quantity surveying. When I left the College in 1904 it is no boast to say that I was acquainted with every detail of building construction and the complete preparation of quantities, according to the London system. The largest survey I have made was an estate of 420 acres of hilly ground in Essex, including farms, woods, &c. In town work I made the survey of the site for the Ritz Hotel, Piccadilly, and afterwards set out the lines of the building; also the site of the "Morning Post" building in the Strand.

There are many pleasing recollections connected with the College. One student was a working fitter at Maudslay's' when he came to me, but after training for a year or two I sent him as a leading draughtsman to a firm of Marine Engineers. In another year or two he was Superintendent Engineer of the Kiangnan Arsenal at Shanghai, where he designed and built the first steel works and the first locomotive in China, and retired on a competence. Another was a boat-builder, but applied himself diligently to the study of civil engineering and bridge work, so that a year or two later I recommended him to a railway company who applied to me for a draughtsman; I advised them to engage this one, although he had no previous experience, and the result was quite satisfactory. When last I heard of him he was one of the Assistant Engineers, and has designed some of the largest bridges. Another student was engaged in the shoe trade, technically a "clicker." He had no education until he was 21, when he went to a night school and learnt all they could

teach him in one session. He then joined the College; there I came across him. A year or two afterwards I recommended him as Science Master to a school, which post he filled with satisfaction. After two or three similar appointments he went out to Australia, and was the first man to take the B.Sc. degree there. He was appointed lecturer in Chemistry at the Prince Alfred College at Adelaide, and has remained there ever since. All the students were not so clever. One evening, at the close of one of my lectures on land surveying, a student came up to me and asked " What is a contour." I replied " I have been trying to tell you that for the last hour; if you want a brief definition you might look in a dictionary." He said " I have already done that, but it was not spelt as you spell it; it was ' C-e-n-t-a-u-r.' " This was quite genuine on his part. Another surveying student, who was a local preacher in his off-time, told me he thought it was dishonourable of surveyors to enlarge from Ordnance Maps instead of making their own surveys—he was caught referring to a book at the examination and excused it by saying it was only to find something he had forgotten—his papers were cancelled.

One of my earliest jobs with Sir Wm. Armstrong's firm was to go round London and obtain particulars of all the passenger and goods lifts then in existence, without exciting too much attention. This I did ostensibly as a man in the street actuated by simple curiosity. I had a good eye for measurements and a good memory for details, and found a shilling to the lift attendant or engineer procured me a sight of all the mechanism. I took no notes at the time, but directly I got outside I made sketches in my note book, with full dimensions, diameter of rams, construction of valves, safety gear, guides, &c.

Naturally, in my out-door experience I came upon many noticeable things. At the Millwall Docks the new drawbridge worked all right for some time, then suddenly in the summer one day it refused to land on the opposite abutment, the guiding arm at the nose of the bridge had sunk too low to enter the space for it. It was thought that the foundations had given way, and it was only after some hours' delay that they could get the bridge closed. This happened again, and it was discovered that the heat of the sun on the dark-painted bridge had expanded the top flanges and caused a downward curvature. The bridge was then painted white and no further difficulty occurred. This reminds me of the account given of the opening of the Forth Bridge, when H.M. King Edward VIIth, then Prince of Wales, was going to put in the last bolt and it would not pass, the hole being what is technically known as " partly blind." However, the sun came out and the warmth expanded the bridge so that the hole came true and the bolt was duly driven.

In going about I observed at one of the Docks, where one side was bounded by a sloping bank down to the water level, a brick retaining wall was being put in. The wall was properly designed for stability, but the surface of the bank was not benched out before the filling in took place. I observed at the time to the foreman in charge that the wall would fail from this neglect, and twenty years afterwards the failure took place. A celebrated engineer was called in, who had the wall demolished, replacing it at enormous expense by large cast-iron cylinders, sunk in a line and filled with concrete. He was not going to endanger his reputation by another failure, but in my opinion any independent, conscientious engineer would have been horrified at the waste of money. It has been said that " An engineer is a man that can do for a pound what any silly fool can do for two." Another saying is " It is a poor rule that won't work both ways." The above case would seem to be an illustration of the reversal. Another failure came to my notice where a dock retaining wall was pushed out by dredging too near its base. This was done by a newly-appointed engineer to the Company, who might have known what would happen if he had referred to the drawings which were still in existence.

Among other work with Armstrong's firm was the connection of the hydraulic pressure mains between the East India Docks and the West India Docks. The connection was to be made along the Blackwall Railway, but a difficulty occurred in passing Poplar Station which threatened to stop the work altogether, and it was not until a happy thought occurred to me that we got permission. I suggested that we should carry the pipes along the back

of the platform and cover them with a continuous seat for the passengers, which was done. The firm erected a small hand-power swing bridge over the canal in Woolwich Arsenal, on cast-iron screw pile cylinders sunk in the bed. After it was completed it was desired to put in diagonal braces between the piles, but this could only be done when the water was drawn down in the canal to its lowest level. This was arranged for one Sunday, and I undertook to see it carried out. It was in the depth of winter, the canal was covered with ice and there was a strong north wind blowing right up the canal. On my arrival the men had got a raft upon which to work to remove a flange bolt from each pile, but the joint was some six inches below the water level and the bolt had to be driven upwards. They tried it for some time, but the bolt held firm, and they struck work, saying it was too cold. I was determined it should be done if possible, so I took off my coat and laid down on the raft with the water spurting up between the joints and freezing on the top. I got the bolt started, and the men thus encouraged completed the removal. We then found the tie-rods as sent from Newcastle were too long, so that the next step was to send out into the town and find a smith to come in, cut and re-weld them. This was done for a reasonable payment and the work was completed the same afternoon. It was a chilly experience, but I had another sort some years later on, to counterbalance it. This was the examination of the reinforced concrete foundations under some electric furnaces in Scotland, also in the depth of winter. The outside temperature was 26 deg. Fahr., but in the vaults under the furnaces where I stayed for twenty minutes taking measurements and making sketches, the temperature was 176 deg. Fahr., only a rise of 150 degrees!

When hydraulic wagon lifts were first used to pass railway trucks from a higher to a lower level, or vice versa, there was great danger of the truck running into the liftway, being only checked by chocks on the rails or by sprags thrust in the wheels. I devised a self-acting arrangement of buffer beams against the framing, for both levels, worked by the movement of the lift-table, so that when the lift was down a truck could run on, and when the lift rose the lower buffer beam came down into position and the upper one rose clear of the truck to let it come off. This was worked out with a cardboard and thread model, and was adopted first at Blackfriars Goods Station and afterwards at Broad Street. Another idea I had was for an eduction pump with no valves or moving parts, worked by a jet of high-pressure water, something after the style of a steam injector. My father had one made in 1874 to my design for pumping out the bilge of Atlas No. 1 by means of the accumulator pressure, and it acted satisfactorily. Among my other inventions were an improved safety fusible boiler plug to extinguish the fire in case of shortness of water; an electric warning for over-pressure in a boiler, that would ring in the office; a bicycle pedal with increased leverage on the down stroke; a floating wharf with all appliances for unloading ships into barges; an extending arm to hydraulic cranes to give increased range; and a revolution counter to indicate up to a thousand revolutions a minute. Some of these were duly patented and sold, but inventors do not always obtain success. In 1875 the Society of Arts offered their gold medal for the invention of an apparatus for ships, to give the mean revolutions or actual revolutions per minute of the engines as might be desired, day or night, in the engine room and on the bridge, without the use of a counter or light. I sent in a design that conformed to all the conditions, but the medal was awarded to a machine that was invented beforehand and did not conform to the conditions. One of the competitors who sent a model complained that it had not been removed from its case, and the feeling generally was that the result was fore-ordained. Those who know the present magnificent building of the Patent Office will be surprised to hear that when I first made searches there, the whole establishment was contained in a narrow ground floor passage in Southampton Buildings, Chancery Lane, with a very restricted staff.

I only sat for a Civil Service Examination on one occasion (1872), and that was for "Practical Mechanician to the Inland Revenue Department." The examination lasted five days and, fortunately, I only came out second among the 17 candidates who reached the final stage, or I might have been bound up in red tape for the rest of my life.

I was the first in England to take indicator diagrams under hydraulic pressure of 700 lb. per square inch. Finding that an indicator diagram had been taken from a hydraulic capstan at Marseilles Docks in 1864 I applied to Elliott Brothers to add a special cylinder to my indicator to suit this work, but their manager said it would not be safe and he could not undertake it. This manager died shortly afterwards, and I immediately made application to the new manager and supplied him with all dimensions for a new cylinder and plunger, which were duly made and fitted. With this I indicated force pumps, accumulators, capstans, suction pipes, lifts, &c., and learnt a great deal about the dynamics of water pressure.

At one of the hotels in London where I supervised the erection of boiler, steam engine, pump and lifts, complaint was made two or three years afterwards that the machinery was in a bad condition, and wanted immediate attention. The managing director called it " rotten." It appeared that a firm of gas-fitters and hot-water engineers had been called in who had made alterations that caused all the trouble. On entering the engine room I found the engineer (who was not a mechanic) holding a stick against the strap of the pump eccentric which was fixed on the crank shaft. He said he had to do that all the time the engine was running to prevent it coming off. Upon examination I found that the rebated brass liner between the cast-iron sheave and strap had been disconnected from the sheave and fastened to the strap, leaving only plain surfaces to work together instead of the rebated surfaces. They had also disconnected the delivery pipe from the bottom of the air vessel and carried it from the top, so that the air vessel was inoperative as such. In another case, at a carpet warehouse in the City, a tank on the roof and a low-pressure goods lift were installed. Complaint was made some time afterwards that the lift worked very stiffly and slowly. Upon examination I found that no part had been lubricated since erection, and explained that to the proprietor, who said he would see to it. The next time I called I found that the lubrication had been overdone, and the liftman had carefully oiled the outside of the lifting cylinder all over. He had oiled the sheave pins and bearings as I had instructed him, but he thought " as the cylinder did the work it wanted most oil."

Tall hats and frock coats were the everyday dress of the business man, 1870-1880, but what would one say now-a-days to see a man dressed thus perched upon the jib-head of a weighing crane with an umbrella in his hand, as I have been many a time when examining the knife edges of the steelyards. I generally carried an umbrella with me and took it wherever I went, up ladders or down wells. I lost three umbrellas the first week I went to business, and have not lost one since. Of course, I had to make an exception when I was inspecting boilers; I then put on a boiler suit of overalls and left the other things outside.

In some warehouses goods are taken in on one side and delivered on the other. The delivery cranes are usually worked by hand-power, the goods being merely lowered on the brake. I found that in many cases a second man was required to help lift the load off the floor before it was swung out for lowering, and I suggested that a small hydraulic cylinder might be attached to the crab frame to force a ram into a bight of the lifting chain until the load was clear, but it was not adopted. When the new south dock of the West India Docks was built on the site of the old Timber Pond I suggested an overhead runway to carry goods from the ships or barges into the warehouse; this also was not adopted. I was not aware of any such thing in existence at the time, but it has since been very largely used in many places.

During the construction of one of the London Goods Stations the architect had two of the girders tested to destruction, and I saw them after the test while the load was still on. They were riveted plate girders 35 ft. long, 2 ft. deep; to carry 2 tons per ft. run including their own weight. The distributed breaking load was 175 tons on the pair, showing a factor of safety $\frac{175}{140} = 1\frac{1}{4}$ only. It was not my business, but I wanted to know all about it, so I took dimensions and made my own observations. The load was a heterogeneous collection

of railway material and included 3584-lb. rails, 21 ft. 11 in. long, 301 ditto 21 ft. long, 767 cast-iron 36-lb. railway chairs and 24,000 bricks at 62 cwt. per 1,000. I made a drawing of the girders and applied the including parabolas of bending moment when I found that the girders failed from not having the outer plates carried far enough. Some text books show the outer plates terminating where the parabola cuts the elevation; I always insist on half-cover length beyond this. A more usual method of testing such girders is to fasten the ends together by plates and bolts and to place a hydraulic jack in the centre to act equally upon both, the load being estimated from the pressure in the cylinder of the jack. The objection to this method is that the bending moments from a central load do not give the same curve as those from a distributed load.

I was much impressed by a book I read when I was about 16, the life of Robert Houdin, a French prestidigitateur; he used to take his son past a shop window, say a toyshop or any other with a variety of articles on show, and tell him to look at the things displayed, then taking him away at once he would ask him to describe everything he saw. It seemed to me that this was an admirable way of forming what I call " eye-memory," and having adopted a similar mode of study I have found the result of great use in my professional career, of which I could give many striking examples. Francis Galton in his book *Human Faculty* calls it the power of visualization, and says one may test himself by trying to picture the breakfast table as it was this morning, &c. I heard Prof. Stokes, the " Memory Man," with his wonderful boys, lecture with illustrations at the old Coliseum, Regent's Park. His recommendation was " Observe, reflect, link thought with thought, and . . . ? " My memory fails me, but it was nearly 70 years ago. As a lad I used to go to all the conjuring entertainments I could and always offered myself when any of the audience were requested to step up. I wanted to see how it was done. I remember particularly Prof. Anderson, the so-called " Wizard of the North," Dr. Lynn, who always made pretence of showing the spectators " how it was done," Maskelyne and Cooke, the Davenport Brothers, and Pepper's Ghost. I heard Prof. Pepper give a lecture once in a room where there was a temporary platform, when he made several striking experiments. Among other things, I saw him dip his hand in molten lead. In another experiment he had two glasses with different coloured liquids in, he said that when he poured one into the other the colour would disappear. It did, and so did he, as the plank of the platform on which he was standing gave way at the same time. I always wanted to get to the bottom of any mystery, and when opportunity offered in 1868 I joined " The Dalston Association of Enquirers into Spiritualism." I attended the meetings for some months but saw nothing that could not have been simulated. Florrie Cook, one of the party, afterwards became a celebrated medium. She is referred to in Florence Marryat's book, *There is no death.* My failure to find any distinct proofs in spiritualism does not lead me to deny the possibility, or in face of Sir Oliver Lodge's *Raymond* one should perhaps say the probability, of some occult phenomena taking place. I have had many proofs of telepathy, some of which may be explained by the analogy of wireless telephony, where the brains of the projector and recipient may be connected by etheric waves, but other cases that I have had of pre-vision cannot be so explained, and the instances were too full and definite to admit of mere coincidence as an explanation. It is a great pity scientists do not take up the study systematically instead of pooh-poohing it as the majority do. When I started practice on my own account my first client was named Rich and my first pupil named Gold; what a future some would have built upon that omen! I believe more in work than in omens. At the Crystal Palace at one time they were showing a weird illusion. A member of the audience was asked to step on the platform and place himself in a coffin that stood upright and open before the audience. By some kind of reflection the body was gradually changed into that of a skeleton, and after a minute or two back into its original appearance. Of course, I went up and went through the performance, but the light was too strong for me to see how it was manipulated. My wife, who was in the audience, was, I think, more impressed by my casting off this mortal flesh than I was.

I have not been up in a balloon, but I have been down in a diving bell, and down what was then the deepest coal mine in England, the Monkwearmouth Pit, near Sunderland. It was the upcast shaft, where the heat and fumes were considerable, and passing the furnaces with their flames and smoke was literally " going to blazes," and reminded one of the " bottomless pit." I have also spent a night on the top of Snowdon to see the sun rise, but it did not rise that morning so far as I was concerned, not that I overslept myself and found it setting, like one of the " Innocents Abroad " did, but the summit was completely enveloped in the clouds. I walked through the Thames Tunnel during its early days when a bazaar was held there, also through the little Tower Subway under the Thames during the short time it was open to the public. I visited the interior of the Great Globe at Leicester Square; Cremorne Gardens with its al fresco dancing; Rosherville Gardens and other resorts of festive Londoners of those days.

Whenever a steamship is sunk the daily Press repeats the fallacy that the boilers burst. I have always countered that opinion as I saw no reason why they should burst, and considered that the steam evolved arose merely from the quenching of the furnaces. I have had a proof in one instance of a tug under my supervision being sunk while steaming in the river, with the usual statement that the boiler had burst. On the tug being lifted and cleaned the boiler was examined and found intact, being put into work again without any repair.

I was one of the rapidly thinning number of those members of the Institution of Mechanical Engineers who went to Birmingham in 1877 to vote for its removal to London, where from a small local body it has expanded into a world power with its army of seven thousand members.

The " Spanish prisoner " fraud by this time must be pretty well known, although quite recently I saw by the newspapers that it was still going on. About 1885 I received the usual application, but did not become a victim. It was a long letter in French dated from a supposed Spanish prison stating, as nearly as I remember, that the writer was unjustly detained, but before his incarceration he had buried his treasure in England at a certain spot known to his daughter, a beautiful and accomplished girl, but without means now that he was locked up; and that if I would send a certain amount to an address given to enable her to travel to England she would lead me to the *cache* and I should share the fortune with them.

Upon the death of my father in 1877 I took over his engineering practice and left the firm of Sir Wm. Armstrong & Co. I also took over his position with Messrs. Wm. Cory & Son as their Superintending Engineer, having charge of the two Atlas Floats, the unloading berths at Victoria Docks and Lambeth, and six screw tugs. The latter were more like tubs than tugs, and though built of iron were heavily sheathed in wood to protect them from damage. I designed for this firm a new type of tug, the first being the *Retort,* followed by the *Rotifer,* the *Romulus,* and the *Remus,* with high-pressure non-condensing engines; the *Rex* and the *Regina* with condensing engines. By attention to details I brought down the coal consumption per I.H.P. by 58 per cent. between the years 1878 and 1890. When the *Rotifer* was proposed, mild steel was just coming in and I wanted to use it. The firm objected, and said they were perfectly satisfied in every way with the iron-built *Retort,* and that they supposed if they would let me I should prefer to use platinum. This sarcasm showed the view people took of mild steel when it was first introduced, but I carried my point and saved both money and weight by the substitution.

The testing of materials was a comparatively rough operation until about 1880, when the Buckton machine was introduced. The ordinary testing machine held the specimen horizontal, with a hydraulic plunger at one end to put on the tension and regulate the position, and a system of levers at the other end terminating in a scale pan. The operator seated at the latter had before him ordinary grocers' weights of say 7 lb., 4 lb., 2 lb. and brass weights for the smaller sizes. His object was, as the beam and scale pan rose, to get as many of these weights on as he could, taking off the smaller ones and putting on a

larger one as the required load increased. He was very expert as the load neared the breaking point, and the manipulation was very like a game of " knucklebones." Seeing that the properties of the steelyard had been known for many hundreds of years one would have thought that, in an engineering factory at least, the lever and scale pan would have given place to a steelyard and moving weight.

When I had an address of my own in the Post Office Directory I received the usual daily flow of circulars, but none exceeded in humour one from a Frenchman who had invented a semi-portable pump. He described it fully in what he thought was English, and the final paragraph was " It don't must to be forgotten that it cans be moved if it wants but it's no a mobile machine."

In 1880 I was called in by " The Committee of the Coal Meters Office " to examine and report upon all the Seaborne Coal Weighing Machines in the Port of London, mostly weighing cranes which weighed the coal as it was lifted in half-ton buckets. This Committee was an official body maintaining and supplying men (coal-meters) for weighing out the coal cargoes, as umpires between the coal factors and the merchants. I found some very erratic machines and methods in use, but being afterwards appointed consulting engineer to the Committee I gradually introduced standard methods of construction and use for the weighing apparatus. I became consulting engineer to all the principal firms on the Coal Exchange and designed machinery, buildings and vessels for them. One rather amusing case occurred when the manager of a coal firm required weighing apparatus fitted to a steam luffing crane. A design was prepared and submitted, with an estimate for its construction and guarantee of its satisfactory working. Upon seeing the drawing the manager objected to pay £50 for " a bit of a thing like that," and he would get it made himself. Upon being told that he could not as it was a patent he said he would design his own. He did so. It cost him £140 and *would not work.*

Among my notable experiences I may mention that I heard Jenny Lind (Madame Lind-Goldschmidt), a soprano of world-wide reputation, sing at the Poplar Town Hall about 1855, and at the same place I saw Tom Thumb and Minnie Warren, the celebrated dwarfs and their miniature brougham. I have since seen the three notable giants who came before the public as Chang (a Chinaman), Anak, and a female whose name I forget. They were all said to be about 8 feet high. I saw the celebrated Dundreary with his eyeglass and " Piccadilly weepers," also Cole, the great ventriloquist. I thought him very clever, and he was certainly the best I have heard; I endeavoured to imitate him, and by practice found I could talk without moving my lips or face muscles, but the letters b and p were rather difficult. I also heard Clara Novello sing at the first Handel Festival at the Crystal Palace about 1857-60. Later I heard Adelina Patti in the opera of Martha soon after she came to London, Zara Thalberg on her first appearance in opera, Romer, the Christy Minstrel bass who took the lower C. I heard Madame Antoinette Stirling sing her own composition, " The lost chord," and Sims Reeves, Santley and Christine Nilssen in a trio, " The magic wove scarf." Other delightful recollections are Madame Norman Neruda on the violin, Herr Joachim on the 'cello, and Wells on the flute. I several times heard the Rev. J. C. M. Bellew, the highly talented reader and born actor, and, of course, many other noted actors. I saw Edward Lloyd, the great tenor, at his first appearance in public when he was a thin young man with a beard, very different from the stout man with moustache only that he became later. Elizabeth Stirling, the composer of some charming part songs, taught the piano for some time at the City of London College while I was there. I was fond of music, and for many years (1862-1900) belonged to one or more choirs and choral societies at the same time.

I had tea with Charles Dickens at Wright's Coffee House, Charing Cross, about 1870. I remember Sir Benjamin Baker in his early days when he was working as a draughtsman in Sir John Fowler's office. He was well appreciated at that time, as one day he was not looking well and Sir John (then Mr. Fowler) said to him, " Here's a cheque for £50 take a month's holiday with it." About 1882 Sir John Lubbock (afterwards Lord Avebury)

showed me over his collection of ants and flint implements, and I had tea with his family. I went from there to see Charles Darwin, who lived near, but as he was at dinner I would not disturb him; I am a great admirer of his books and his patient investigations. I met Prof. J. Macquorn Rankine at the first Conversazione of the Institution of Civil Engineers that I attended.

In 1880 I moved to Bexley Heath, in Kent, 1½ miles from the railway station. It was then not much more than a village on the London and Dover Road, surrounded by open fields of strawberries and bush fruit. There was generally a man patrolling the fields on Sundays to warn off the visitors, but there was no occasion for this precaution on week-days as the inhabitants all grew fruit for themselves. I spent seven years there and had a delightful time, as I used to cycle with my wife all over the county, and sometimes further. We only did 1,000 miles a year as I had not much spare time. It was a good district for roses, and I took a prize for some specimen blooms at the local flower show, the only time I exhibited.

I visited Belgium with the Society of Architects in 1891. We were received by King Leopold at Ostend and invited by him to visit his palace at Laeken. We visited also Antwerp, Blankenburg, Bruges, Brussels, Courtrai, Ghent, Louvain, Malines, Mons, Oudenarde, Tournai, Ypres, &c., being received generally by the mayor and the head of the Church in each town. I took many photographs of places that have since been destroyed in the Great War. These were converted into lantern slides and shown at a meeting of the Society of Architects after we got home again. I also spent a fortnight in Norway and took an open-air photograph of the Naerodal Pass at Stalheim on midsummer day at 11.30 p.m., the latitude and season allowing sufficient light for the purpose. I noticed a curious custom in Norway to make the most of the short summer. When the hay is cut it is not left on the ground and tossed about as with us, but is hung on hurdles so that the grass can continue growing as the mowing proceeds, and in this way they get two crops in the season. I went over a Norwegian farmhouse of the olden style, which consisted principally of a large hall with a gallery on each side, in one of which the men slept and in the other the women, while the cattle were stalled on the ground floor. Also a saetar, a small building on the steep hillside, about 10 feet square, where the cow-keeper (in this case a girl) slept in the upper part, with the cows below it. The warmth from the cows was appreciated in the winter. I have visited Calais, Boulogne, Dieppe and Paris, and although I cannot by any means call myself a traveller I find on looking through Bradshaw I have visited some 164 of the towns and larger villages in England. I once arranged to have a fortnight's tour up the Rhine and had fixed upon my stopping place each night, when the Franco-German war in 1870 broke out three days before I had intended to start, so that as far as I was concerned it was fortunate that it did not happen a week later.

The more prominent work upon which I have been professionally engaged beyond that previously described includes the steelwork of theatres, picture palaces and factories; roof work for town halls and other large buildings; water towers and tanks; heavy foundations; tall chimneys; bridges and jetties; sea walls; and a battery of eight 160-ton hydraulic presses. Among other things I was responsible for the steel reconstruction of the interior of Drury Lane Theatre; groined vaulting for a cathedral, and also for that required in the restoration of an abbey; a steel-framed steeple 87 feet high, and a brick water tower 80 feet high. I was commissioned by the Editor of the *Daily Mail* in 1907 to make an independent investigation into the stability of St. Paul's Cathedral, particularly with regard to the effect of the tides, rainfall and underground water. I found no direct connection between them, and attribute the cracks solely to want of strength in the piers. My report, with diagrams, was published in the *Daily Mail* on 10th December, 1907.

In 1906, on the appeal of the Municipal Reformers in the neighbourhood, I stood for election to a Borough Council. I did not canvass or attend any meeting, but I polled only two votes short of the highest number obtained by any of the six candidates elected, all of my party. I was appointed Chairman of the Works and Highways Committee in 1907,

but proved too independent to please the party leader. He endeavoured to dictate to me on several occasions as to engineering matters, and one evening I remember ruling him out of order at the meeting and refusing to hear him. After the meeting he came up to me and suggested that I had a limited experience of Committee work. I then reckoned up and was able to tell him that at that moment I was on thirty different councils and committees, and in the chair of thirteen. One of his contentions was that a new bridge then about to be built could be moved to another position that he favoured, because the limit of deviation gave an area of five acres, and he was with difficulty convinced that the limit of deviation was a linear measurement only. At one time he got a special committee appointed to consider the question of maintaining the existing horses and stables or hiring. He and his nominee chairman showed that the cost of maintenance, including all charges, was greater than the charge for occasional hire, and produced a balance sheet. I pointed out that not only would the charge for hiring go up directly we had disposed of our own horses, but that he had made several omissions from the balance sheet that told against the hiring, but was assured from the chair that they were all included. After the meeting I challenged the chairman that he had knowingly made false statements; his reply was, " I know I did, but I had to make my case good." I retired at the next election.

In 1909 I took my eldest son into partnership, when we extended the practice by adding specifically water supply, sewerage and central heating. Although I lectured for many years on Architecture I have not made a leading feature of it in practice. I was for over 30 years a member of Council of the Society of Architects and about 20 years their superintending examiner. Upon the amalgamation of the Society with the Royal Institute I became automatically an F.R.I.B.A.

After I gave up the College in 1904, still keeping on my practice at Queen Victoria Street, I devoted my spare time chiefly to reading and horticulture. I raised several new varieties of fuchsia, geranium and begonia by hybridisation and selection, and among them some curiosities, one of which was a three-storied geranium. Observing a green leaf among the blossom, I picked off the latter and grew a new plant on top of the flower stalk. The next year among the blossom of the " first floor " geranium was a green leaf, and this again I grew on to a plant. I was not able to go any further with it as by some means it died during the next winter. Besides the usual domestic cat, dog, and canary, I have kept fowls, pigeons, rabbits, guinea pigs, white mice, a squirrel, hedgehog, tortoise, cockatoo and silkworms, so that my experience has been somewhat extended in the natural history line.

In 1913 I was appointed on a Committee of Scientists gathered by the *Sanitary Record* to test the claims of professional Water Diviners. A series of tests was arranged at Guildford when seven of the most noted diviners were in charge of seven Committee men, and independent tests were made at three different sites where water was known to exist at certain spots. The result was that the diviners failed to discover the known water, in one case a spring of 50,000 gallons per hour, and no two gave records alike. I made my own experiments and discovered exactly how the dowsing rod was moved, and devised a holder for the rod which compelled the diviner to move his hands definitely to get the rod to move and disproving the statement they make that the rod moves up or down of its own accord. The full account of this will be found in the pages of the *Sanitary Record* during April, 1913.

I saw the great Silvertown explosion take place, 19th January, 1917, from Honor Oak Park Railway Station, just five miles off and in the direction of the railway at that point. It appeared to me that there were two explosions with not more than about a second between them, the first rather less in volume. Later on I had an opportunity of visiting the spot. I found a lake of considerable extent on the actual site surroundered by an embankment of the earth thrown up by the explosion. The houses for an area of about a square mile had been demolished by it, but the tall chimneys in the neighbourhood were still standing like gaunt sentinels; I have heard many theories to account for this, but none

satisfactory. I was appointed by the Ministry of Munitions to value the machinery damaged or destroyed at some of the neighbouring works, for which a claim of £90,000 was made by one firm only. I heard the great explosion at Erith about 1864; I was in the Bow Works at the time and thought it was a train off the line and coming through the wall behind me. Although it was ten miles away some of the windows in Bow were blown in by it. I also heard the explosion on the Canal at Regent's Park where a barge of gunpowder blew up. That must have been about 1875.

The largest dinner I have presided at was that of The Engineers-in-Charge, when there were 396 members and guests sat down. Judge Rentoul was one of the number and surpassed himself in the facetiousness of which he was a born master. Among other anecdotes he told us of a man living on the borders of Mexico and the United States at a time when the Mexican dollar was worth sixpence less in the United States and the United States dollar sixpence less in Mexico. The man had a United States dollar and went over the border, had a drink and got a Mexican dollar in exchange. Then he went back, had another drink and received a United States dollar in exchange. He repeated this as long as he could walk steadily and left off with his original dollar. " Now," said Judge Rentoul, " I want to know who paid for the whisky." He said the man could not have been a Scotchman because a Scotchman only takes drink on two occasions throughout the day, " when he is thirsty and when he is not."

Talking of dinners, the following amusing conversation between the President in the chair and the Toast master took place in my hearing in 1889:—

P. to the toast master: " Announce that I shall be happy to take wine with them."

T.: " Gentlemen, the Chairman will be happy to take wine with you."

P. (a stickler for propriety): " No, the President."

T.: " Gentlemen, the Chairman will be happy to take wine with the President."

P.: " No, you fool, the President will take wine."

T.: " Gentlemen, the President will be happy to take wine with the Chairman."

P. (thrusting toast master back): " Gentlemen, I shall be happy to take wine with you."

I have been engaged in many law cases as an expert witness; at one time I had five in hand in different stages of progress. They were mostly dull, but sometimes very amusing. In one case I told my Counsel I could not support him, it was a case of a broken railway coupling where the material was defective and the railway company was resisting a claim for injuries received. At the crucial point in the cross-examination the opposing Counsel was putting his briefs end to end to represent a train and was about to put a very awkward question when my Counsel made a remark that threw ridicule on his opponent and convulsed the court, so that the question was not put and we won the case. In another case, of a broken chain, the experts on the other side were particularly unfortunate, the first one stuttered so badly that it was difficult to obtain his evidence; the second one was very deaf so that the usher had to stand beside him and shout every question; and the third one was a chain maker from the North who spoke with such a broad dialect that it was extremely difficult for the court to understand him. I was the only expert for the defence, and when Counsel started his cross-examination he said " Now you have heard what this chain maker has said, a practical man who knows all about it." I replied quietly " Yes, but you had the wrong man." " Wrong man, wrong man, what do you mean? " I replied " He has had experience with new chains only, and this is entirely a question of the maintenance of an old chain." This virtually clinched the matter and we won the case. It is much easier to meet the cross-examination of leading Counsel than that of juniors. The latter ask so many silly questions that one gets annoyed, and in the examination-in-chief one cannot easily bring out the main points of the case unless the junior has been previously coached. There are, of course, some brilliant exceptions which only go to prove the rule.

I was the only expert retained by the Home Office when they formulated their Regulations for Docks and Warehouses with regard to cranes and lifting machinery, and at the inquiry at Caxton Hall I had to withstand cross-examination from a large proportion of the thirty-

six Counsel present representing the Dock and Warehouse Owners throughout the Kingdom. Many other experiences might be related, but it is time these reminiscences came to a finish.

Since I first entered the service of Sir Wm. Armstrong & Co. I have kept a note book of data and formulæ on any matter that might be useful to engineers. This was published first as *Notes in Mechanical Engineering*. It went through four editions and was then taken over by Messrs. Cassell, who issued the fifth edition of 12,000 copies under the title of *Engineers' Handbook*, as it had by that time extended far beyond Mechanical Engineering. Another large edition was published by them, and it was then handed over to the Waverley Book Co., who issued it in two volumes, forming the seventh edition, which was reviewed in these pages.*

I said to begin with that my life had been a busy one, and this will be acknowledged when I say that I have written over 40 books and papers and given over 10,000 lectures, besides attending to my daily office work. From the positions held by so many of my old students I feel that I may have been of some use in the world, and without any other genius than the capacity for hard work, I have been able to leave some impress upon my generation that will continue to bear fruit.

I must not close without recalling the greatest honour I have received, that of the Gold Medal of the Institution of Structural Engineers. I have worked hard for the Institution, but it has been a labour of love, and the medal is far beyond any recognition that I may have merited. It is sufficient reward to see that the Institution is progressing so rapidly and firmly and to be able to look forward with confidence to its future position.

* *Structural Engineer, Nov. 1925, p. 393.*