PRESIDENTIAL ADDRESS.

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(Read before the Sydney University Engineering Society, on May 9th, 1900*).*

FOLLOWING the usual custom of our Society, it is now my privilege to briefly address you, before relinquishing the office which I have had the honour to fill during the past twelve months.

First, I should like to refer to matters personal, the Society's position, and its record of achievements for the past year. As you are aware, this is our fifth anniversary, the first meeting having been held in October, 1895. At the present time there are one hundred and twenty-three members on the roll, including nine honarary members, and our income for the past year has been £43 6s. 8d., of which a balance of £8 1s. still remains available, after allowing for all liabilities, and taking no account of subscriptions still outstanding. During the year, five meetings of the Society were held, at which the following papers were read :—Presidential Address, by Mr. P. W. Rygate, B.E., L.S. Assoc. M. Inst. C.E. ; "Dry Crushing," by Mr. E. W. Nardin, B.E. ; "River Discharge Observation," by Mr. W. Poole, Assoc. M. Inst. C.E. ; "Practical Sampling" and "Some Notes on Tenacity as far as the "Elastic Limit," by C. P. Allen ; "Notes on the Cockle Creek Sulphide Works," by Mr. G. Waterhouse, B.Sc. ; "Notes on the Concentration of Ores," by Mr. N. Reid, B.E. ; and "Electrical Transmission of Power in Mines," by Mr. B. Wallach, B.E. In addition to the above, Professor Liversidge kindly delivered a lecture on "Liquid Air" to the Royal and University Societies combined, and Mr. Poole exhibited some interesting lantern views of Funafuti at the last meeting of the year; upon which occasion the Society also took the opportunity of wishing Professor Warren good-bye, on the eve of his departure for England.

A very pleasing feature of the year's proceedings has been the contribution of several valuable papers from undergraduate members, and I should like to thank that section of the Society for their consistent attendance at the meetings, even in the face of approaching examinations, when, as we know, time can ill be spared for such relaxations. At present, the disability under which our Society labours most is the lack of adequate discussion of the papers read. This is only to be expected, when the subjects treated of may be included in any of the many branches of Engineering, and when it is remembered that the graduate members are at present comparatively few, and with diverse experience, and in many cases resident in distant parts, and unable to be present at the meetings. However, this is a matter for which time will supply the remedy, and judging by the present prosperous condition of the Department of Engineering of this University, it is not too much to expect that the day is approaching when this Society will number among its members leading men in every branch of Engineering, and when the discussion on papers read will form an important item in the business of our meetings. Meanwhile I would urge upon our members, at home or abroad, to contribute from time to time, papers and notes on such works coming within their experience as will be of interest to the Society as a whole, and of value to the younger members who are passing through the University course.

Coming now to the second portion of my address, it may not be inopportune in this, the closing year of the nineteenth century, to glance back for a moment to the state of things which prevailed in the Engineering profession one hundred years ago, and compare it with what exists at the present time. "Civil Engineering as a distinct profession," it has been written, "may be said to have originated in England about the middle of the eighteenth century." The close of that period, and the first quarter of the nineteenth century, witnessed the first steps in the developments of great powers, which have since revolutionized the face of the world. Prior to the year 1800, the question of improved internal communication had been occupying the minds of Engineers like Brindley, Smeaton, Telford, Macadam and others, who, by the construction of extensive canals and the adoption of a scientific system of road making, had already done much to ameliorate the deplorable condition of things which hitherto prevailed. The early years of the nineteenth century, both in Great Britain and America, may be considered as marking the era of Canal Engineering, in contradistinction to the succeeding Railway era, which dates from the opening of the Liverpool and Manchester Railway in 1830.

The close of the eighteenth century witnessed the application of steam to purposes of canal navigation, and after prolonged experiments by several engineers, notably William Symington; Robert Fulton of New York in 1807 constructed a steam vessel which travelled at the rate of five miles per hour, but it was not until eleven years later that the first vessel, the *Curacoa*, of four hundred tons burden, crossed the Atlantic using steam as an auxiliary to sail power. Watt had in 1777 discovered the condensing engine, and the expansion of steam in 1782, and in conjunction with Boulton, had erected many stationary engines prior to the end of the century, and Murdock and Trevithick, had shown that steam power might also be applied to the propulsion of vehicles along ordinary roads, but it remained for George Stephenson to bring the question of steam locomotion to a practical issue. It was to the rapid increase in the coal trade of the North of England, and the necessity for divising improved methods for transporting it to the shipping ports, that the invention of the locomotive and the railway system was principally due. Many minds were engaged upon the solution of the problem of steam communication, and this may be said to have been practically settled by the success of Stephenson's famous engine *Rocket*, at the Rainhill competition of 1829, when it was shown possible to obtain a speed more than double that of the fastest stage coach, a speed hitherto deemed absurd, by means of adhesion only, without the intervention of cog wheels or rack. Since then the improvement of steam communication has been constant year by year, until now we have locomotives weighing over one hundred tons, and working at a pressure of two hundred and ten pounds per square inch (the weight of the *Rocket* was four and-a-quarter tons, and the steam pressure, fifty pounds per square inch). Even yet the limit does not seem to have been reached.

Of the various steps in the development of Railway Engineering, it is impossible to do more than mention the names of some of the more important. First, the vexed question of gauge. We have all read of the battle of the gauges in Brunel's day, and it may be said to be still undecided, in Australia at any rate, since even in the five railway systems of this continent we have three distinct gauges. These are:—In New South Wales, four feet eight and-a-half inches; in Victoria, five feet three inches; in Queensland and Western Australia, three feet six inches; and in South Australia both five feet three inches and three feet six inches. Perhaps the unification of gauge to the four feet eight and-a-half inches standard may follow in time after the accomplishment of Federation, but at present there seems little hope of it.

The improvements in the design of permanent way and rolling stock, and the adoption of systems of signalling and interlocking, and of the continuous brake—inventions of comparatively recent years—have had, of course, a very considerable influence in bringing the railway to its present state of perfection, while the success of the light lines of railway lately constructed (to the standard four feet eight and-a-half inches gauge) in this colony, promises well for the opening up of country to which but a few years back the cost of a railway would have been prohibitive. It may be noticed in passing, that these pioneer lines, which have been designed and constructed by one of our honorary members, Mr. Henry Dean, M. Inst. C.E., Engineer-in-Chief for Railway Construction, have cost only about £2,000 per mile, and are giving considerable satisfaction. Electric locomotives, though employed with success on some few special lines in England and America, have not so far come into general use, but would appear eminently suited for short distance suburban traffic, especially for working in tunnels or in densely populated centres, where the smoke and fumes from the steam locomotives are an objection. It seems very probable that some such system will have to be adopted for our own suburban traffic, when the railway is extended into the city. On June 30th, last year, there were in this Colony two thousand seven hundred and six miles of Railway open for traffic, carrying annually twenty-four and-three-quarter millions of passengers, and five-and-a-quarter million tons of goods, and returning 3·8 per cent. on the £38,000,000 of capital invested, after paying working expenses.

These figures, though representing satisfactory progress, when it is remembered that the first railway line (from Sydney to Parramatta) was not opened in New South Wales till 1855, are, of course, inconsiderable when compared with the immense railway system of the United States, where, at the end of 1898, there were one hundred and eighty-four thousand five hundred and thirty-three miles open, carrying five hundred and fifteen millions of passengers during the year; or even with the twenty-one thousand six hundred and fifty-nine miles and the £1,150,000,000 of capital invested in the United Kingdom at the same period.

Of tramways—steam, cable, and electric—I need only remind you that our first steam tram was opened some twenty years since, to carry passengers to the International Exhibition in Sydney, and that at the present time we have in the city and suburbs, some fifty-two miles of tramway open, at a cost of £1,360,000, which will, in the near future, be entirely converted to the overhead electric system.

International communication in this colony is necessarily limited to road and railroad. Our costal rivers are too short, and our inland river system too uncertain to admit of any extensive system of water carriage, and, with the exception of the Darling River, which, if the proposed scheme of locks is carried out, may in the future provide a more regular outlet for the trade of the West. There seems little prospect of any great improvement in this respect; it is, therefore, essential to expend a considerable sum of money annually in extending, improving, and maintaining our roads, of which there are at the present time some forty-two thousand miles under the control of the Public Works Department, exclusive of roads and streets under municipal control. As we are all aware, convict labour was used in the construction of the earlier roads; the most difficult of these was that over the Blue Mountains to Bathurst, *via* Mount York, which was opened in 1851, the route being afterwards changed to the present line through Mount Victoria, by Sir Thomas Mitchell, under whose direction the Main Northern Road was also carried out by convict labour.

Time will not admit of more than a brief glance at the improvement which one hundred years has effected in the design of bridges, but it may not be amiss to remind you that it is little more than a century ago (1776) since the first cast-iron bridge was built at Coalbrookdale. The arch and plate web-girder were the types first adopted for iron bridges; and even so late as 1859, when the design of the great Victoria Tubular Bridge at Montreal was under discussion, the truss principle was so imperfectly understood, that we have one of the most eminent engineers of that day upholding the tubular form against the lattice girder, on the ground that the web members of the latter were useless except for the purposes of connecting the booms and keeping them in position. "They depend," said he, "upon the connection with the top and bottom webs for their own support; and since they could not sustain their shape, but would collapse immediately on their being disconnected from their top and bottom members, it is evident that they added to the strain in them, and consequently to that extent reduce the ultimate section of the "bearers."

Up till 1850, the Menai Straits Bridge, which consisted of two independent tubular beams, each one thousand five hundred and eleven feet long, and weighing four thousand six hundred and eighty tons, was undoubtedly the greatest achievement in this branch of engineering, and may be noted as the outcome of extensive experiments by Fairbairn, for which a sum of £6,000 had been voted by the railway company interested, showing that even at that time, the public was alive to the commercial advantages ensuing on a right understanding of the principles of construction and properties of materials. Many larger bridges have been erected since then, of which the Forth Bridge, of one thousand seven hundred and ten feet span, and the Brooklyn Bridge, of one thousand five hundred and ninety-six feet span, are perhaps the two most notable examples. Here in Australia we have the Hawkesbury Bridge, which cost £380,000, and is remarkable as having the deepest foundations—one hundred and sixty-two feet below water level—yet carried out, but, on account of the excellence of our hardwood timbers, iron or steel bridge building is not indulged in to the same extent as in other countries. At the present time there is in course of erection over the Lane Cove River, an under-truss bridge, with a span of one hundred and sixty-five feet. This is, I believe, the longest timber span yet erected in Australia. Unfortunately, owing to the large demand for ironbark, which is now being exported in considerable quantities from this Colony, the cost of this and other classes of our best timbers has considerably increased of late years, and the time does not seem far distant, when we shall have to revert to metal for our large structures.

The increase in the size of vessels and of the volume of harbour and river traffic, has led to considerable improvement in the design of opening bridges. At the present time, two large swing bridges which will be operated by electricity, are in course of construction in our own city of Sydney, while work is in hand in connection with a small Bascule bridge of a type novel to this country for one of our coastal rivers.

In no branch of Civil Engineering has progress been more marked than in that of Sanitary Engineering. Sewerage Systems were unknown at the beginning of the nineteenth century, and, even forty years later, such drains as were in use were employed almost entirely for carrying of the rainfall only, refuse of all kinds finding its way into cesspits and other receptacles close to dwellings, so that it is not surprising to learn that a death rate of thirty per thousand was by no means uncommon in the towns of that period.

Sir. W. H. Preece, in his address to the Sanitary Institute of Great Britain at its annual meeting in August of last year, divides modern methods of sewerage treatment and disposal under three heads, (1) Mechanical, by water carriage or burial; (2) Chemical, by precipitation of the solids, filtration of the liquids, and formation of artificial manures; and (3) Biological, dealing either with crude sewage or with sewage clarified by precipitation.

The Northern Main Outfall sewer of Sydney which was commenced in 1880, is a notable example of the first system, the dimensions of this sewer at the outlet being eight feet six inches by seven feet six inches. The sewerage of London is now treated by the second or Chemical system, and over two million tons of sludge are conveyed away every year from the works, and deposited fifty miles distant in the sea. Sewage farms have been employed to a considerable extent where the sea is not available, as in the case of some of the Continental capitals, uch as Berlin, and in that of the Southern and Western sewerage systems of this city, while extensive works are now in progress on this principle for the sewerage of Melbourne. With regard to the Biological system, the authority before quoted, states that "it has clearly come to stay, but is still, however, in the experimental stage. No great town has committed itself to its general use." It may be noted in connection with sewerage in this Colony, that a septic tank has recently been completed at Rookwood, where the sewage from the Asylum, with one thousand two hundred inmates, is being most successfuly treated under the Biological system.

Many patents have been taken out of late years for Refuse Destructors for the destruction of garbage by fire, and the City Council has recently decided upon the erection of three, each of eight cells, of these on the Pinhoe principle, so that the objectionable and obsolete practice of tipping the rubish of the city may soon be expected to become a thing of the past.

The immense strides made in Marine Engineering, especially since 1850, when iron began to supersede timber in the building of vessels, may be ascribed to the discovery of the screw propeller, the increase in boiler pressure following on the use of steel in boiler construction, and the improvements in the design of Marine engines. By these means, the coal consumption has been so considerably reduced from the nine pound per h.p. per hour, which obtained in the early steamships, and the speed has been increased to such a degree, as to render economical the consiruction of such giant vessels as the North Atlantic Liners *Kaiser Wilhelm der Grosse* (fourteen thousand three hundred and forty-nine gross tonnage), the *Deutschland* (sixteen thousand gross tonnage), and the *Oceanic* (seventeen thousand gross tonnage). This latter vessel, which is the largest constructed up to the present time, is seven hundred and four feet long, sixty-eight feet beam, and twenty-eight feet six inches draught. The rapid increase in the size of vessels during the past few years is leading to the reconstruction of many harbour entrances, graving docks, and canals, which, when originally constructed were judged large enough to meet any probable developments. The Suez Canal, for instance, when opened in 1869, had a bottom width of seventy-two feet and a depth of twenty-six feet, but has since been considerably widened, and it is now intended to deepen it to thirty feet.

The introduction of sand pump dredges has enabled a reformation to be effected in the cost of dredging river bars, and reclaiming swampy foreshores. Two of these dredges, now employed on the Mersey River bar, England, have each a dredging capacity, under favourable circumstances, of six thousand tons of sand per hour, at an average cost of about 7d per ton. As examples of successful sand pump dredging in this Colony, of a rather different class, the work done by the recently built "Antleon" may be quoted. This vessel is self loading, and is designed for dredging sea bars carrying only five feet of water, and has proved herself capable, under such circumstances, of removing two hundred and fifty tons of sand per hour while steaming slowly over the bar.

Breakwaters and retaining walls are in progress at many of our river entrances, where it is to be hoped that the excellent results obtained by such means at Newcastle Harbour may be repeated.

In the matter of Water Conservation in this Colony, a large number of surveys of our river systems have been carried out, and some progress has been made in the construction of weirs and other works, while considerable further expenditure is contemplated in this direction, and in the sinking of artesian bores.

The engineer's workshop has necessarily kept step with the march of progress, rendering possible the many great structural works, which one hundred years ago it would have been idle even to contemplate. Even so late as 1837 we read (Sir G. P. Bruce, in P.I.C.E., Vol. 91) that in the shops of the Stephensons', the most up-to-date of that day, there were no steam hammers, machine riveters, nor a single crane, while manual labour was entirely employed in the smith's shop and boiler yard and the only wood cutting machinery was the circular saw. It must also be remembered that the choice of materials was much more limited then than it is now. Prior to the invention of Bessemer and Siemens, steel was made only from high-class wrought iron, and the price (about £60 per ton) was naturally prohibitive ; it was not till about 1860 that steel first began to come into use in structural work and ship building. Steel wire rope come into vogue with the construction of the Brooklyn Suspension Bridge in 1876, where its successful application first attracted general attention. Portland cement—in its infancy fifty years ago—has, almost as much as steel, had its influence on engineering work of all classes, while even the humble glazed stoneware drain-pipe, without which, house connection to the sewer would be a costly luxury, is an invention of comparatively recent date.

Increased knowledge of the properties of materials has had much to do with their use in building construction. Prior to the year 1800, practically no experiments on the strength and properties of materials has been made, and though in the succeeding fifty years, "great progress was made in the theory of elasticity, and a slow growth took place in knowledge of the properties of materials under stress, it was not until after 1850 that large testing machines for special purposes began to be built, and elongation and ductility began to be carefully studied. Soon after 1870, it was recognised by many manufacturers, that physical tests of metals were imperatively necessary in order to secure uniformity of product." (Address by Prof. Merriman, at the Annual Meeting of the International Association of Testing Materials, August, 1899.)

In order to render the results of testing by different authorities comparable, the International Association of Testing Materials was formed in 1895. Its Congress meets this year in Paris, when there are nineteen technical questions proposed for discussion—viz., six on iron and steel, eight on cement and mortars, and one each on such diverse subjects as stone and slate, tile pipe, paints, lubricants, and dry rot.

Although the scope of this address is not intended to cover any more than a few scattered notes on the progress in the Branch of Civil Engineering, I may say in passing, that our knowledge of electricity may be held to reckon back almost exactly one hundred years, for it was only last year that an exhibition was held at Como, the birth-place of Volta, to celebrate the centenary of the Voltaic pile discovered in 1799, from which dates the whole modern science of applied electricity. I take this opportunity of saying that I consider it a matter for great congratulation that our Senate has recently made provision for a course in Electrical Engineering in connection with the Engineering Department of this University. I am thoroughly convinced that the wisdom of this step will be fully and amply justified by the results, even as it has been in the case of the course in Mining Enginering, a branch which, though only established a comparatively short number of years, has far outstriped in popularity—for the time, at any rate—the parent branch of Civil Engineering. Owing to the munificence of our Patron, Mr. P. N. Russell, expenditure is now possible in connection with the Engineering Department in general which otherwise the Chancellor, as Chancellor of the Exchequer of the University, would have been compelled to veto, and our Engineering School has never been in such a flourishing condition as it is at present.

Before concluding these somewhat disjointed remarks, I should like to call to your minds once more what has been so often dwelt upon before—I mean the advantages under which the science of Engineering can now be studied, compared with the difficulties with which the forefathers of the profession were accustomed to meet one hundred years ago, and indeed for many years later than that. The early engineers were almost without exception self-educated men (such education as they had being acquired in some cases under very exceptional difficulties), equipped with a limited knowledge of the laws of Mechanics, with practically no engineering literature, and with a circumscribed choice of materials and tools for working them. They had, in addition, to battle in many instances against popular prejudice, and in the face of public opinion, to take the risk of carrying out schemes of a novel character, the failure of which would have meant ruin and defeat. Take for example, the opposition to the early railways, where, in carrying out the survey for the Liverpool to Manchester Railway, the farmers stationed men at the field gates with pitchforks and guns to drive the surveying party back, and a powerful fellow, a noted bruiser, was hired to carry the thoedolite, which appears to have been a particularly unpopular instrument. In the United States the early Engineers were often Judges as well, a quaint combination of professions, due to the fact that "in almost every frontier settlement could be found some man more gifted than his fellows, who laid out farms, settled petty controversies in his county, and became a Judge, thus uniting surveying with a knowledge of the law.

At the present time, instruction in Engineering forms part of the curriculum of almost every University in the civilized world, while for the artisan technical education, of a quality which a century ago would have been eagerly welcomed by even the foremost Engineers, is now almost universally provided. According to the last report of the Commissioner for Education, there are now twenty-eight thousand students of Engineering receiving instruction in the Universities, Colleges, and Schools of Technology in the United States alone.

It now remains for me, gentlemen, to thank you once again for the honour you did me a year ago in electing me as President of our Society, an office which I am afraid I have but unworthily filled, and to testify to the great assistance I have received from the Honorary Secretary and the members of the Council. In vacating the Chair, to which I now have the pleasure of welcoming my successor, Mr. W. M. Thompson, M.A., B.E., I wish him a continuance of the kindly support which I have invariably received, and the Society a prosperous year under his able direction.