of a great conflagration. This bridge, as designed, was to have the longest span in the world. It was designed under the guidance of Mr. Theodore Cooper of world-wide reputation, and the contractors were The Phœnix Bridge Company, of Phœnixville, Pennsylvania, a firm with a splendid reputation.

It was to consist of two anchor spans of 500 feet each, and one cantilever river span of 1,800 feet, this latter being 90 feet more than the spans of the Forth Bridge. The depth of the river at the site is 200 feet, 350 miles from the sea; there is a range of tide of 15 feet, the stream flowing at a velocity of eight miles per hour. The span was made long in order to bridge the stream in one span, and to ensure that the piers should be as easily built as possible, in shallow water, and that they should be as little exposed as possible to the great force of the St. Lawrence ice. There is a depth of only 10 feet of water at the piers, the foundations of which are 60 feet below high tide. The piers were sunk by the Plenum Pneumatic process. The Forth Bridge has one pier founded 89 feet below high water.

The Quebec bridge designers seem to have been bent on teaching the English engineers some points in cantilever bridge design, but the wisdom of the late Sir John Fowler, and the late Sir Benjamin Baker in their great design of the Forth bridge has been more than justified. The main compression booms of the Forth bridge consisted of hollow cylinders 12 feet in diameter; the corresponding struts in Quebec bridge were box section 4ft. 6in. x 5ft. 6in. The former bridge was designed for a dead load 9½ times as great as the live load, whereas the proportion was 4½ to 1 in the latter.

The live loads in the British structure could be doubled before bringing up the unit stresses to the standard adopted in the American.

The former was designed for a working compressive stress of 7½ tons per square inch, as against 14½ tons in the latter. The Forth bridge calculations allow for 56 lbs. per square foot wind pressure, whereas in the other case no wind pressure is allowed, unless it exceeded 30 per cent. of the combined live and dead loads.

In the former bridge the steel had a strength of 34 to 37 tons per square inch, as compared with 28 tons in the latter.

The English engineers minimised the risk of complete failure by employing a double intersection system of trussing; the Americans adopted the single and simpler system. It might be ill-advised of us to sit in judgment on the American engineers, in view of their many contributions to our knowledge of the anatomy of bridges; but it does seem that in this case unit stresses approached dangerously near to the elastic limit, and that undue temerity was displayed in the design of the great column sections of the bridge. As far as concerns columns much investigation remains to be made, especially in experimental work on large full-sized specimens. Some one has suggested that Mr. Andrew Carnegie, having amassed his fortune in the steel industry, might, in his anixety to spend his millions for the world's benefit, contribute some to experimental research on the properties of built steel columns.

While engineering has made large advances in other parts of the world, the good seasons which this State is experiencing have made it possible for larger enterprise here.

In June, last year, a number of members were privileged by the courtesy of Mr. Walter Shellshear, M. Ins. C.E., Inspecting Engineer of the Existing Railway Dept., to witness and assist in the testing of a new railroad bridge across the Nepean River at Penrith.

This structure, while interesting to me personally, because of my having assisted to design and draft it, and afterwards for a time to superintend the foundation works in the capacity of resident engineer, is also of interest generally, as it marks the date of obsolesence for railway purposes of the existing bridge, which was opened for traffic just 40 years previously, being the second large iron railroad bridge in New South Wales, the similar bridge at Menangle on the Southern line having been built in 1863, that is, four years earlier.

A general description of the new and old bridges appeared in the New South Wales Railway Budget of January, 1907.

Suffice it to say regarding the comparative designs that the old bridge is of the plated box girder type, with bi-cellular chords, with plate web cross girders spaced three feet apart centres; the bridge is continuous over three spans of 198 feet each; the piers are of local Hawkesbury sandstone, quarry faced and margin drafted. The piers of the new bridge were built in line with and down stream from, those of the former structure.

In the new bridge the superstructure of the main spans is 193 feet 4 inches between centres of bearings, of Pratt truss type, all web members of I. section, 8 panel length of 24ft. 2in. each, cross girders 5ft., and stringers 3ft. 6in. deep, both of plate girder type.

The advances made in bridge design may be indicated by a comparison of the weights, strength, and cost of the two structures.

The old one was designed for a live load of 1¼ tons per foot run on two lines of way. The heaviest engine in use on the Great Western Line in 1867, was of the 2-4-0, locally known as the G class. The weight in steam on engine and tender was 50 tons 18 cwt. 3 qrs., total wheel base 37ft. 2in. The heaviest axle load at the time was 12 tons 6 cwt. on the driving wheel of an 0-4-2, locally known as E class engine.

The modern bridge is designed to carry a live load of two tons per foot run on two lines of way, with the usual allowance for wind pressure. The heaviest engine in use to-day is the T class consolidation engine of the 2-8-0 type, weighing, with tender, 107¼ tons in steam, on a total wheel base of 51ft. 10¼in., the heaviest axle load being 15 tons 10 cwt. The weight of three main spans of the old bridge—they were, by the way, imported ready for erection—594 feet length is 1,100 tons, while three corresponding spans of the new bridge weigh 822 tons, a reduction of over 25 per cent.

Present day foundation work is also considerably lighter; four piers and two abutments of the new bridge containing 4,353 cub. yds. of masonry as against 5,529 cub. yds. in four piers of the original structure.

The comparative costs are about £100,000 for the old structure, as against about £40,000 for the new.

En passant, it may be said that this type is being adopted for the large bridges necessary on the North Coast Railway, tenders for the construction of the first section of which were called for to-day. The manufacture of the bridges required for this portion of the railway has been contracted for and is in progress.

The old bridge at Penrith, of which only one track has been used for the railroad purposes, has been taken over by the Department of Public Works for highway traffic exclusively, and is being decked with Monier plates.

One of the most important problems of the day in railways and shipping is that of the bulk-handling of materials such as grain and coal. With regard to the former I indicated in former paper* some steps taken by the Sydney Harbour Trust and the Railway Commissioners to deal with this matter. Since then a record wheat season led to the building of a new jetty 150ft. wide x 500ft. long, at a cost of £23,000. On this jetty was erected a commodious grain shed 50ft. wide x 500ft. long, equipped with a modern system of conveyors and elevators for stacking or loading grain in sacks.

The shed is fed from three lines of way on each side. The wheat may be taken from the shed or direct from the truck and conveyed into the ship's hold by means of traveller gantries equipped with elevators and conveyors.

From an engineering as well as a practical and commercial point of view the method of dealing with wheat in sacks is undesirable. It is to be hoped that that now famous institution, the "Chapman" sack, will expedite the advent of bulk handling. The chief difficulty in the way is, of course, the cost of providing the proper carriage.

* An experiment in elevating and conveying wheat in sacks.—Journal S.U.E.S., Vol. ix., 1904.

Another pressing problem lies in the handling of coal for locomotives and for shipment. The Railway Commissioners have erected several elevator plants for automatically coaling locomotives, a typical and pioneer plant being that erected at Penrith. The shipping of coal requires larger plant. For years past the coaling of large and small vessels at Sydney and Newcastle has been accomplished by means of steam and hydraulic cranes. It has been found necessary to devise a means of speeding up largely the rate of coaling. This has been done at Pyrmont Jetty, Sydney, by the installation of twin electrically driven elevators, which are each capable theoretically, of handling 200 tons of coal per hour.

In one of these elevators the truck of coal is drawn up an inclined road to a position over a hopper into which the coal is dumped, and the truck passes away on the down grade. The coal falls into an endless bucket elevator-conveyor, the buckets of which are 3ft. square x 18in. deep, by which it is elevated into a steel building. From the horizontal portion of the bucket conveyor coal is dumped on to and into a drag plate conveyor, which is so hinged and built that it can be raised or lowered and traversed to suit the position of the bunkers of the large vessels visiting Sydney Harbour. This conveyor is pivoted to a feeding hopper running on a track on a bridge between the elevator houses about 32 feet above the wharf level, and at a third of its length from the outer end has a hinge at the attachment of its lifting shackle, there being another lifting shackle to the extremity, so that when the conveyor is traversed back between the buildings the outer portion may be hoisted clear of the passing shipping.

The power for the installation is supplied by the Ultimo Tramway Power House.

This plant has been rendered necessary at Sydney, partly because large vessels, such as those of the White Star Line and similar lines, are unable to enter Newcastle Harbour because of its shallowness, etc.

At Newcastle the Railway Commissioners are having installed a McMyler Coal Hoist, at a cost of £15,000, exclusive of freight, duty, cost of foundations, etc., and capable of loading 800 tons per hour.

This system is apparently much preferable to that just referred to, as the operations consist only of hoisting and emptying the truck or trucks into a hopper from which the coal emerges on a shute, and is led thereby into the ship's holds. There is this, however, to be said, that the McMyler Hoist is not suited for bunkering purposes.

Another event of interest and importance as far as this State is concerned was the completion on May 15th, 1907, of the first locomotive manufactured by the Clyde Engineering

Co., under their contract with the State Government. This engine and others since placed on the rails have proved to be of excellent workmanship. During the year the Railway Commissioners have been making preparations at their Eveleigh Workshops for building their own locomotives.

During the next few years, what with the building of the North Coast Railway, and the various extensions of other lines, and of enlarged coal and goods sidings, a large increase in engines will be needed, and if the State is to produce its own locomotives, whether by State or private enterprise or by both, a busy time of manufacture should be anticipated.

On April 30th, 1907, the first cast was made from the modern blast furnace erected at Lithgow by William Sandford, Limited. The official opening took place on May 13th, 1907. Some members of this Society were present last year on a visit made to Lithgow by various engineering and scientific societies of Sydney. The new blast furnace is capable of producing from 750 to 1,000 tons of pig iron per week; the cost of installing is stated to have been £120,000.

The old time methods of manufacturing iron by rule of thumb process have been entirely superseded; the proportions of the materials to be smelted are nicely calculated and carefully obtained, and economy of method and material is sought after.

The waste gases are utilised to raise steam in the battery of Babcock and Wilcox boilers for the turbine driven air blower, and numerous other engines attached to the furnaces.

The pig iron turned out is converted into steel in Siemen's open-hearth furnaces, of which there are three in operation, one of 15 tons capacity having been installed just prior to the opening of the blast furnace. For the production of wrought iron, pig iron from the bast furnace is puddled in existiing furnaces.

As regards the raw materials, coke is made at the site of the works, the iron ore is brought a distance of 95 miles, and the limestone flux 25 miles. This is an almost ideal condition of affairs from the point of view of the ironmaster, while making for constant revenue to the State in the matter of railway freights.

The amount of steel required in this State is from 2,000 to 3,000 tons a week; the blast furnace last week made a record so far, by producing 800 tons of pig iron, and is capable of producing 1,000 tons; so that the prospects are that it should have to work to its utmost capacity in future.

The history of the attempts to found the iron and steel industry in Australia is largely a story of heroic efforts resulting in failure. Sixty years ago, in 1848, Messrs. Neale, Holmes, and Burton, erected a small blast furnace near Mittagong, and the Fitzroy Works were established. Seventeen years later Mr. Hampshire turned out in a month about 60 tons of pig iron at a cost of £5 17s. 6d. per ton, and subsequently in 36 weeks made 2,394 tons, an average of under 70 tons per week, some of this material having been used as girders in Vickery's Chambers, Sydney, and in the Gundagai Bridge over the Murrumbidgee River; but Dame Fortune would not smile on the enterprise.

The first blast furnace at Lithgow was brought into use late in 1875, and produced 100 tons per week. From 1875 to 1882, when its use was abandoned, it produced 8,844 tons of pig iron.

Owing to the perseverance and energy of Mr. William Sandford, the establishment of the present works is due, and it is a matter of regret that after many years of arduous work in practically pioneering the native iron industry of this continent he should through financial stress, be obliged to relinquish his ownership of the Lithgow Ironworks. The regret is somewhat tempered by the knowledge that he had accomplished his ambition of producing steel from native ore, and that he has founded an industry which already affords a livelihood for some thousands of persons. The inception of this industry is not without its irony—to insure the peace of the Commonwealth and State a small arms and ammunition factory is to be established by the military authorities—the peaceful giant steel may become your fearsome enemies' agent—your tireless slave, the locomotive, is not loth to become a bloodthirsty Juggernaut, if you adopt wrong relationships thereto.

The Iron Age upon which we are entering promises to be more conducive to our welfare than the Golden Age which began half a century ago. The advent of the Iron Industry is without excitement; it has not set all the world in a frenzy of excitement and dreams of avarice as did the discovery of gold in the early fifties; but he would be bold who would affirm that it holds less potentialities of general good to the community. To the Golden Age we owe largely the spirit of adventure, self-reliance, and independence combined with great qualities of imagination which are found to-day in the descendants of the immigrants of fifty years ago—a spirit which is surely a feature of Australian character. There seems no good reason why, in the years to come, this continent should not sustain the same relationship to the Southern Hemisphere that in the past Great Britain has held to the Northern.

Before vacating the position in which you placed me a year ago, I feel it incumbent upon me to make some remarks upon some other matters which closely interest each of us.

It is a curious search which one makes in striving to arrive at some conclusion as to what constitutes the engineering mind. Years ago it was wont to be impressed upon me that no talent for engineering could exist in the mind of one who could not become ecstatic over a steam engine, or upon whom a piece of steel could not procure an effect akin to hypnotism. The steam engine and the piece of steel were right in their place; but the ability to work or to machine them does not constitute the engineer. Indeed the engineering mind can, and does, exist independently of all the so-called materials of construction. While the possession of artisanship does not constitute the engineer; on the other hand the possession of a highly technical training, while excellent in itself, may not produce any nearer approach. The engineering mind is firstly that soul within us which impels us throughout the term of our natural lives to mentally conceive, and crave the opportunity for building, something. It dreams in marble and steel and all sorts of materials, and builds castles in the air that it may bring them into actual being. In a great sense it is the creative mind of mankind. Aflame with imagination, undeterred by countless reverses, faint yet persuing, the years and the centuries behold in it that wonderful inventive genius, which daily is finding out new laws of being. new fields of enterprise, new ways of utilising the resources of Nature, to add to the sum of human wealth and happiness.

In the discharge of his functions in the economical world the engineer's mind must be particularly well balanced if he would achieve any but ephemeral success. For example, an engineer is placed—often places himself unwisely—in a position of being his own judge. The specification in his contract often appoints him the sole and final judge in a question between himself and the other party. In consequence, he must often be a little more than human, in order to be impartial to himself, and do absolutely right.

This mind is not created in a University or other School of Engineering. The possession of the University degree, which to some of the younger members of this Soicety may seem a consummation devoutly to be desired, is not, in itself, a certificate of the possession of the faculty; it merely indicates that, for some seasons, one's mind has been undergoing an instructive process in technical knowledge, and that one has passed certain tests of his power to acquire the knowledge.

One object of the training, if it be worth the name, is the development of independence, together with a finely critical judgment. No theory, however plausible, deserves acceptance merely because of its projenitor's position.

The engineering mind, whilst quite open to conviction, will accept nothing from hearsay, but must travel over the whole road of scientific research for itself. There is no justification for thoughtlessly using a method or formula because it happens to be in your text books. Keep these, if you will, as works of reference. In the world of science they soon become, as it were, moss-covered, and may fittingly become the nucleus of a museum —cherished, may be, because of associations. In that wider world in which, as a graduate, you will find your energies utilised, a man who thinks for himself is invaluable as compared with the man with the memory and little thinking power. In other words, it is essential to success that you develop an individuality and a personality. To this end the teacher must possess a personality, and be able to communicate something of it to his pupils. Whatever questions would-be employers may ask a young graduate seeking employment, there is one which ever recurs to their minds: "Who is his teacher?" The esteem in which the teacher is held as a man among men will, in the majority of cases, count for far more than either his own or his pupil's attainments, until the latter has established a reputation for himself. Wherefore, as we declaim that "Second to none is the engineer," we are sensible of the anxiety to be always able to truthfully proclaim that the individual members of our teaching staff are in personality as in attainments in the first rank of the community. Now, to develop that personality which is so essential, the best training consists in experimental research where one has perforce to form conclusions from one's own personal observations. In this field the student learns to regard theories as needing proof, in the process of which his own judgment is called into requisition. Regarded in this light, too much importance cannot be attached to the encouragement of original research in any scheme of engineering education.

The engineering mind is marked by restless activity, impressing itself upon, and being impressed by, the world about us. This is an age of travel. Less than a century ago Robert Stephenson conceived the prospect of land locomotion by means of steam engines and railroad at a speed of 15 miles per hour; to-day one hears with little wonder of speeds six and eight times as great. Thanks to scientific pursuits, we can telegraph across the oceans and speak across the continents. Yet this unsatisfied age is turning attention to flying. Small success has as yet attended the attempts hitherto made, but there is great hope for the future of these attempts. To this present day engineering activity has been laid the charge of conducing to the gruesomeness of war. The increasing activity of life and growing facilities for locomotion and intercourse, while lengthening life by intensifying it, conduce to make the world seem smaller, and to annihilate the mental and social gulfs which have separated nations, so, with increasing knowledge, leading to mutual respect. Perhaps in no domain of human activity is this mutual appreciation so manifest as in the realm of science and engineering. Modern warfare may entail a terrible strain on the combatants, but who shall say that it is more gruesome than the hand-to-hand slaughter of bygone ages? And, at any rate, it cannot be so very wrong to employ inventive genius for the protection of our country and homes. The charge is confidently met, on the other hand, by such common occurrences as the salvation of those who go down to the sea in ships by the receipt of a timely marconigram, and the fact, overlooked because of its familiarity, that by irrigation, sanitation, etc., tens of thousands of lives are being saved yearly from the clutches of pestilence and disease.

I have a great admiration for that type of mind of whom the engineer-philosopher Swedenborg was a type. As one calls the curve the line of beauty, one may regard the cube as the symbol of compact unchanging strength. And with due apology to the votaries of a certain craft, I like to regard the ideal engineer as a square man, absolutely honest and honourable in his dealings with men, many-sided in his interests and sympathies, designing and constructing in truth and substantiality, impartial and broad-minded, and standing four-square against every temptation to bemean his profession by producing inferior work or to defraud his fellows and those who place their lives in his keeping.

Popular opinion pictures the engineering mind as being as devoid of beauty as the cube. Certain it is that he must be largely ulitarian in his tendencies. The criterion of his professional skill is his ability to design to obtain the greatest efficiency with the least expenditure of wealth. But in thus building true to natural laws the beauty of truth and strength must manifest itself.

The engineering mind develops along the lines of search and research. Every discovery leaves one less for the future, and the question naturally arises as to what is the limit of possibility in this direction. I am convinced that the possibilities of the future are only limited by human aspirations. The spirit which implants a desire in our minds does not do so in mockery. The realisation must follow on the desire.

Within the last few weeks you will have heard of the reported successful attempt made by Kamerliggh Ohnes, of Leiden, Holland, to convert helium into a solid.

This marks a further step towards the attainment of that magic condition which obtains at the absolute zero of temperature, at which one stands at the death of matter. What secrets there await discovery? The discovery of the great secret of the universe is even contemplated by the scientist. Like a mighty chorus the achievements of the past world seem to proclaim: "Seek, and ye shall find."

This everlasting searching, the marshalling of facts and scheming the disposal of men and material to obtain the best results, leads to the development of administrative capacity which engineers often possess in a most marked degree.

The engineer has not, in practice, the leisure to verify every advance in scientific knowledge for himself. He is compelled to make use of and adapt the discoveries of others. His art is to direct the resources of nature for the services of men, and he is thus so much engaged among the material things around him that he is liable to forget the philosophical utility of knowledge in the quest of the physical, and his mind is apt to be absorbed in the material things to the exclusion of those which are unseen and eternal.

There is, therefore, to my mind, a need of some balancing interest in life, for the sake of others as well as ourselves. I have said that the existence of the engineering mind is independent of the so-called materials of construction. The mind is superior to matter, and the spirit of construction must find other channels of energy if it is to accomplish its highest purpose in life. The world needs the help of the engineer in its social and political life, to imagine and design and build for it in those matters which are for its highest good.

And in these realms he must be a leader. His mental culture affords him an overwhelming advantage in the attempt to mould the thought of his fellow-man. The great complaint one has concerning the average citizen is that he needs this leadership, because of his reluctance to think for himself. Perhaps it is a development of this mechanical age in which nearly everything except thinking can be done by machinery. Be that as it may, I feel that citizenship calls upon us, with our unique opportunities for acquiring a sympathetic understanding of men of every class, to fill a greater place in the social economy than mere slaves to minister to its material requirements and mechanical necessities.

It may entail self-sacrifice to obey this call; but in so far as in response thereto we bring our engineering mind, instinct, and genius to deal with that which is greater than the material world, and build in the mental and spiritual for the highest good of our fellow-men, so far will we be able to give full expression to, and justify the dominating spirit of, our lives.