TRANSACTIONS

OF THE

NEW ZEALAND INSTITUTE,

1901.

I.—MISCELLANEOUS.

Art. I.—*Presidential Address.*

By Jas. Stewart, C.E.

[*Read before the Auckland Institute, 3rd June, 1901.*]

We this night commence the thirty-fourth session of our Institute, a fact which carries our existence practically over one-third of a century; and, although it might be excusable to utilise this landmark as a peg on which to hang a retrospect of the past and anticipations more or less prophetic or imaginative in respect to the future, I prefer to touch lightly on this scope, and leave it to the occupier of this chair sixteen years hence, when the jubilee of the Institute will be celebrated in, there is no room for doubt, a manner befitting the occasion, and with the participation of, I hope, all of those whom I now see before me. Nevertheless, I am deeply sensible of the privilege I now enjoy of opening our first session in the new century, and it is pleasing to be able on such an occasion to congratulate the Institute on its solid and prosperous condition. We are able to keep up a steady, if not large, increase in all sections of the Museum, and in the ethnological section especially we may claim to lead the colony. Our roll of membership has taken a turn upwards, with every prospect of a yearly balance on the right side, the result in no small degree of the lectures, scientific and popular, which for many years past have been given, often at no small trouble and some expense, by those who have thus evinced in such a practical manner their interest in the work.

When I addressed you on a similar occasion to the present eleven years ago some of the present applications of science were in comparative infancy, and the advance that has been made since then offers a tempting opening to enlarge on what may be achieved in the future. But I have no intention of inflicting on you a tirade in the gushing style of which we have had a good deal of experience since the commencement of the century. Some of the conclusions reached in these predictions might eventuate if the law of gravitation could be repealed. But just as we have experienced the possible, so also we have a clearer conception of what is impossible; just as we have learned the possibilities of electric transmission of heat, light, and force, so have we learned the laws by which these things are governed, and which are as immutable as those pertaining to the older science of hydraulics. When one takes up a specimen of these florid predictions. such as I have now before me in a cutting from an American newspaper, and eliminates therefrom all that is equivalent to perpetual motion—and, singular to say, many things that are already in use; others, again, long known but not in use—it is wonderful how little remains of what is possible and at the same time new.

There are, however, among those who have been forecasting future possibilities the names of some who have scored their mark indelibly in the annals of time. And if, as is asserted, Nikola Tesla predicts that electric messages and power will be sent from England to Australia without wires, we have no scientific warrant for disbelief, although we have not the smallest foundation in our present experience for hoping that such a thing may be possible.

But to enter into a train of speculative thought on these and kindred subjects on this occasion would be somewhat out of place, and I shall therefore endeavour to enlist your attention in matters having a more or less practical bearing and influence on every-day life. This opens out a very extensive field of vision, far too much for either your time or patience, and I will endeavour to exhaust neither.

The advance of engineering during the last fifty years has been suggested as a theme of general interest, and it is to me in many points attractive, for it is just fifty years ago last New Year since I entered to serve my time to the work of my life, a raw youth of eighteen fresh from Ian Maclaren's Scots Grammar School. I will therefore glance at a few of the changes which have taken place in the practice of what has been happily defined as the "art of directing the great sources of power in nature for the use and convenience of man."

Sixty years ago the design of bridges adhered, with few exceptions, to the arch or suspension type. But stone or brick arches were going out, and designs in cast or wrought iron were coming in. The suspension type had been tried for railway-work and found unsuitable without such application of stiffening as led it practically to partake quite as much of the girder type as of suspension. The disastrous breakdown of the Dee Bridge, near Chester, in which a deep cast-iron girder was reinforced in a rather unscientific manner by malleable-iron ties, led to the abandonment of cast-iron for all but very small spans, and even for such it has long disappeared. With the last of the "forties" came the tubular bridges of Conway and Britannia; but with the succeeding great Victoria Bridge over the St. Lawrence at Montreal this design may be said to have been abandoned. The design is not economical, really very much the reverse, but the mathematical investigations necessary to its evolution bore immediate fruit in the inception and development of the open-girder pattern, which in some of its many modifications has become the standard of all long and short span bridges the design of which is not governed by æsthetic traditions. It will be readily granted that it is the size of the span, and not the mere length of the structure, that stamps the importance of a bridge, and the advance of engineering in this particular in fifty years cannot be more forcibly illustrated than by the comparison put forth by Sir Benjamin Baker — that is to say, the span of the Britannia Bridge, 460 ft., is to that of the Forth Bridge, 1,710 ft., as a newly born babe is to a life-guardsman. The bridge now in progress over the St. Lawrence at Quebec is to have a span 90 ft. longer than that of the Forth, and the designs of the proposed great suspension-bridge over the Hudson, between New York and Hoboken, show a span of 2,700 ft., or 60 ft. more than half a mile.

In direct contrast to bridges are tunnels, and in this line an enormous advance has been made, not only in the magnitude of the works, but in the facility and certainty with which operations can be carried out under all circumstances, even to driving under the Thames at Blackwall with only a few feet of mud between the water and the lining of the tunnel. Driving railway-tunnels for miles under cities like London or Glasgow is now such an every-day occurrence as to call for no remark. During the last half-century the Mont Cenis Tunnel, seven miles and a third, and that of the St. Gothard, nine miles and a quarter, have been constructed, and at the present time the Simplon is being pierced by twin tunnels of twelve miles and a half in length.

Turning to railways, the principal departure seems to be in the direction of application to steep and mountainous countries formerly considered to be inaccessible to the locomotive. It is true that more than sixty years ago a gradient of 1 in 37½ was worked by ordinary locomotives on the Bromsgrove–Lickey Incline, between Birmingham and Oxford, but that was exceptional. Soon, however, in the period under review, it was recognised that railways must be adapted to circumstances, and not limited to conventional gradients or curves. Main lines in North and South America have now many hundreds of miles of gradients of 1 in 25 and 1 in 20. What this means may be imagined when it is considered that it is not far from double the rate of ascent of the heaviest of our New Zealand lines as worked with ordinary locomotives. It is worthy of remark that we have, in some of its phases, a renewal of the "battle of the gauges," which in the early "forties" was being fought through many parliamentary campaigns. And it is somewhat disquieting to find that there are some among us who, ignoring the lessons of the past, would calmly condemn a future generation to the trouble and expense which a break of gauge forced on Britain and America, a trouble which will loom more and more into view as a disturbing factor in the railway policy of the Australian Commonwealth. Locomotives have been practically trebled in weight and power during the last fifty years. The express speeds are somewhat, but not very much, higher—that is, on the average. But we are promised within the next two years or so the startling development of railway speed up to 120 miles per hour. Some anticipate much more. This is by the monorail system, which Mr. Behr has pushed into prominence, and which is likely to be exploited on the historic field, in railway history, of Liverpool and Manchester. Such speeds can only be attained by carriages not liable to derailment, and propelled by other than reciprocating machinery. It is possible that, for express passenger traffic and under exceptional conditions, this system may come into use. But I fear that several defects, such as shunting difficulties and others, inherent in its design will prevent its adoption otherwise.

In marine engineering we see a most marvellous advance, and it would take all the time at our disposal this night to follow up, step by step, the steady march in the direction of speed and reduction of fuel per unit of power. The double, treble, and quadruple phases of compound engines, with proportionately high initial steam-pressure and high piston-speed, have worked results which in the early "fifties" would have been declared impossible by nearly all the marine engineers in Great Britain. I say nearly all. I might extend it to all but one. In 1852 John Elder, the descendant of a race of grand old Fifeshire mechanics, and the possessor of all that can be conferred by heredity in such a case, entered into business on the Clyde. Although the compound engine had been invented and in mining use in Cornwall at the close of the eighteenth century, it was left for John Elder to see the vast possibilities of the application of the principle to marine work. Previous to his time the steam-pressure used in marine boilers was about 7 lb. per square inch, and the difficulty in introducing the compound design lay principally in the deeply rooted prejudice existing against high pressures at sea. In 1853, however, Messrs. Randolph, Elder, and Co. commenced the innovation entailing the most radical departure from former practice. I well remember the opposition set up, alike by owners and the engine-room staff, and I watched with much interest the steady, if not rapid, triumph of high initial pressure and expansion to extreme limits in separate cylinders. John Elder died in 1869, at the early age of forty-three. Had he survived to the present day, what would he have seen as the result of his sound judgment of fifty years ago? He would have seen marine boilers carrying steam at 280 lb. to the inch, and expanding in three or four stages through five cylinders, with piston-speeds of 900 ft. per minute. He would have seen the consumption of fuel at sea reduced from more than 6 lb. per horse-power per hour to less than 1 lb. And, solely as the outcome of these results, he would have seen the Atlantic Ocean virtually a ferry, crossed by more than half a million of passengers last year, and our own colony, for the Panama service of which he built the "Rakaia," served with steam-liners not one of which would have been possible under the old system. And, lastly, he would have seen the cargo-steamer "Inchmarlow" carrying 1 ton one sea mile by the combustion of one-third of an ounce of coal, which, taking the price at 15s. per ton, is equivalent to carrying 1 ton 550 miles for 1d. But the most startling innovation in the marine engine is undoubtedly the steam-turbine of the Hon. Mr. Parsons. By this means velocities have been reached of forty-three statute miles per hour, with an utter absence of that vibration which, at high speeds, is at once so distressing and destructive. Whether the steam-turbine can be applied to an Atlantic liner remains to be seen. There are several drawbacks inherent to the design, the principal of which is the impossibility of reversing the turbine, so that separate machinery has to be provided for going astern, and which is allowed to run loose when the vessel is going ahead. It is certainly not in its favour that, even in the small vessels in which this turbine has been tried, the power has to be applied through three propeller-shafts, each with three screws, the whole revolving at the enormous velocity of two to three thousand revolutions per minute.

Full efficiency also can only be obtained when full power is being exerted. At half and quarter speeds the loss of efficiency is very great, and as yet the efficiency is at best very considerably below that of the average ordinary marine engine of the day. But in this turbine the long-sought realisation of a successful rotary-engine has been attained.

In electrical engineering we have the third great branch of the profession; and it is one which, in its far-reaching ramifications, already exceeds the most diversified practice of the conventional civil engineer or his brother of the marine. To draw a contrast between electrical engineering fifty years ago and to-day would indeed be comparing small things with great. The electrical engineer as known to us now had no existence in those days. Electricity was employed, we may say, in only two works of commercial importance—those of electroplating and telegraphy. The original patents for both of these applications were overridden by what was called "magnetic plating" and the "magnetic telegraph." Permanent magnets were used in both cases, and it was not until it was found that electro-magnets could be substituted that the phenomenal advance in the science and practice of electricity took place. To speak in detail of the evolution of the electrical engineer is not my purpose. My endeavour is to interest you, not to weary you if I can avoid it; but I may mention one circumstance which stands out boldly in my memory in the light of present experience. My worthy old friend the rector of the Scots Grammar School aforesaid, in his lectures on electricity, held it to be impossible that the electric light should be commercially successful. His reasoning was based on the difference between the atomic weights of carbon and zinc. At that time this was given as 6 to 32, now more accurately stated as 11·97 to 64·9, but the ratios are very nearly the same. Had the electric light been possible of production only by the primary battery, in which zinc is the fuel, the old gentleman would have been right, for 1 ton of coal, or rather of carbon, would go as far in chemical combination as more than 5 tons of zinc. But the invention of the dynamo gave coal its opportunity; and yet it is at a heavy disadvantage, in so far as it cannot be applied directly in a primary battery like zinc, but must be used through the intervention of the steam or gas engine. Now, the steam-engine is the most wasteful of prime movers, so far as the conversion of the thermodynamic value of fuel into work is concerned. It has an efficiency of only from 10 to 12 per cent., and very seldom reaches 15 per cent., while the efficiency of the primary battery may be averaged at 90 per cent. or more. If, therefore, carbon could be used directly in a primary battery as zinc is, a saving of fuel of about 75 per cent. would result. With a prize like this in prospect we cannot wonder that for many years a primary carbon battery has been the dream of electrical inventors. But, although thermo cells of several kinds are known, we are practically no nearer the realisation, and I very much fear that we shall never see the boilers of an Atlantic liner replaced by electric batteries, into which a few stokers working in a cool and pleasant atmosphere will shovel one-seventh of the coal now required by steam. The difficulties attending the practical application of such batteries would be enormous, and may be clearly conceived by supposing zinc to be as plentiful and cheap as coal, and to form the fuel, in fact, as we would like to see carbon. We have only to imagine the number, dimensions, and arrangement of cells, each of a pressure of about one volt, which would have to be grouped and arranged in serried masses to give out from 15,000 to 30,000 horse power. No; I am more than doubtful of the utility, for marine purposes at all events, of the primary carbon battery, even if it does become a fact.

In electric traction the last decade of the century has furnished probably the greatest revolution ever witnessed in the realm of applied science, although so far as Great Britain and the Continent of Europe are concerned it has only just commenced. There are many reasons for this great success, but I have no intention of entering into them in detail at this time. I hope that before our meeting next year on a similar occasion to the present we shall have a practical illustration of electric traction in our midst. The scale on which it is being installed in America is immense. The New York elevated street railway is now being transformed from a locomotive to an electric system, and the traffic with which it has to cope may be imagined when the record of two consecutive days' work is looked at. On these days 1,700,000 passengers were carried. During the heaviest rush of traffic 280 trains, or 1,280 cars, were run per hour, and during twenty-four hours 4,820 trains were despatched on the various sections. The electric power on this system, when the installation at present in progress is complete, is stated to be eight units of 8,000-horse power, or a total of 64,000-horse power. In London the work of transformation of the metropolitan and metropolitan district railways is in progress, and it will be a welcome change from the smoky dungeon-looking holes they are now to the white walls and clear air they will in a short time present to a vastly increased traffic. While on the question of electric traction it may be mentioned that a discussion has arisen in all sincerity respecting the possibility of replacing locomotive traction on railways in general by electric power. It is held by some that power-stations located at regular distances along the lines could, by the three-phase system, transmit energy at a more economical rate than is obtained with locomotives. The question is indeed a large one, but is bound to be threshed out to a finality. It is like the question of change of gauge. The enormous sacrifice of plant involved delayed that for many years, but it had to be faced in the end, and so it may in this instance also.

During the last fifty years, but at somewhat long intervals, the subject of wireless telegraphy has come before the public. The first exponent of this, so far as I know, was a native of Forfarshire, Mr. J. Bowman Lindsay. I well remember his experiments in transmitting signals across the River Tay, near Perth, during the year I left Home, now just forty-two years ago. Later Mr. Lindsay essayed to transmit signals between Dundee and the southern shore near Newport. His method was by conduction, making the earth or water, in fact, act as conductors between pairs of earth-plates on either side of the space over which he wished to communicate. The possibilities of wireless telegraphy under this system are extremely limited and of no practical value, and it is not hard to understand why the labours of Lindsay—one of the most earnest and self-sacrificing workers in practical science the country has ever known—were not taken up for actual use.

Towards the end of the century the experiments of the late lamented Hertz demonstrated the existence of a medium which, ever since the days of Newton, was suspected as the agent by which the laws of gravitation and light act in force throughout all space. This medium has usually been designated the "ether," and now the tendency of thought is towards identifying it with electricity itself. Whether this is so or not, it is certain that, in accordance with the number of billions of vibrations or etheric waves per second, there appear to our senses the component parts of light as separated by a refracting prism. Beyond the range of vibrations which give out the spectrum are the Rontgen or *x* rays, which have the power of penetrating many otherwise opaque substances, as the solar rays do glass. And, curiously enough, the Hertzian waves are in frequency placed far below those of the dullest red, the lowest of the spectrum, and yet they have the power of vibrating through solids, or what we have hitherto been calling solids. Had Hertz survived he most certainly would have followed up his discoveries to the point of controlling the despatch and receipt of the etheric waves, and by reinforcing them by an ordinary relay effect what is now known as wireless telegraphy. This work has been taken up by Marconi, Dr. Lodge, F.R.S., and others; but to Marconi seems to be due the form of coherer which appears to be the most sensitive and practical method of catching vibrations in the ether set in motion by powerful sparks discharged it may be a hundred miles distant.

The question now arises, To what extent, from a commercial point of view, is wireless telegraphy likely to come into use? Gushing writers, in crowding together the coming achievements of the century, take for granted that all wires, alike for telegraph and telephone, will be abolished. Granted that perfection is reached in practice, and that it is possible to dispense with telephone-wires between any two instruments, it will be readily admitted that a system by which a receiver could respond to and translate into speech all or any of the etheric vibrations set up by thousands of instruments would be of no value, to say the least of it. Hence Marconi endeavoured to devise means by which the vibrations could be reflected, or, at all events, very much strengthened, in a given direction. But it is hard to conceive Hertzian waves, which are supposed to be able to pass through stone walls, being reflected by anything. This reflection idea, therefore, has not been much in evidence of late. But it is asserted that a receiver may be tuned so as to syntonize with a particular transmitter, and that signals would be intelligible only between these two. Granted again, what follows in practice? Each subscriber must be supplied with instruments tuned to those of every other member of the Exchange. This, of course, is unthinkable, and therefore for telephony wires cannot be superseded. For telegraphy it might be possible to use a cryptograph, by which messages might be deciphered only by those holding the key. It may be objected that all ciphers are solvable by scientific methods, but there is one very simple instrument, known as the Wheatstone Cryptograph, which is absolutely unsolvable without the key, and that key may be varied through millions of commutations.

It is thus more than doubtful if wireless telegraphy may become commercially useful. But there is a large and very important field of usefulness otherwise open. At sea especially, both in peace and war, it must become of immense importance. We all remember the long search that took place some time ago after two disabled steamers. Had they, and also those engaged in the search, been supplied with Marconi's instruments, the work would have extended to days instead of weeks or months, and been one of system instead of chance. So, also, for enabling an admiral to communicate with his fleet during foggy weather, or with detached ships or squadrons, and for lighthouses and lightships communicating with shore stations, the invention appears to be perfect. It is stated that, owing to some atmospheric conditions, this system has not been a conspicuous success in South Africa. If so, it would seem that there is some subtle connection between the ether and the atmosphere that is rather disturbing to the ideas we have been forming on the subject. But wireless telegraphy as yet is only effected by bold and explosive discharges which generate the waves, and who can say that the new century may not see the same effect produced by vibrations as mild as those set up between the transmitter and receiver of an ordinary telephone circuit? Those vibrations represent an electric current so feeble that no known galvanometer can even detect their presence, and yet they effect the most delicate reproductions of the human voice. Nothing is known of the still more feeble currents circulating in the human brain; but that in the cells of that organism currents are transmitted through the nerves, and having performed the behests of the will are returned, much in the same manner as in ordinary electrical work, can hardly be doubted. And, further, it only requires the supposition that among the millions of human-brain batteries two may be now and then found so accurately syntonized as to respond without the conducting nerves being physically joined, and that Hertzian waves may in this manner be the foundation of thought-reading, of the possibility of which many very startling demonstrations have been given. It is also possible that by much training and practice certain individuals may acquire the power of syntonizing the transmitting cells of their brains with the receptive cells of others, who may be already nearly in syntony with them, and thus the phenomena of hypnotism may yet be elucidated.

I have, I fear, allowed this rather jerky and disjointed disquisition, if I may presume to use the term, to extend to undue length, and I will endeavour to utilise the remaining time at my disposal by touching on one or two subjects having general interest, and which are calculated to affect the well-being of our colony. Foremost among these stands technical education. I observe with pleasure that this subject has been engaging the attention of the Chief Justice, Sir Robert Stout, and, after his master-mind and perspicuity of diction, I might well let the matter rest. But if only to add my testimony to the truth of his line of argument, and recall a few illustrations within my experience, I have the temerity to follow on. The first thing that strikes me is what is commonly understood by the term "technical education." We have had a technical school in our midst for some years, and towards gaining an insight as to what the term is understood locally to mean I very gladly availed myself of an opportunity of visiting it and seeing for myself. Well, I saw a school in which various handicrafts were practised and taught, together with the elements of machine-drawing. The workmanship was in most cases very good, in some cases perfect. A great deal of attention was devoted to carving in wood, and many very creditable productions were to be seen finished or in progress. The whole reflected much credit on the promoters of the institution so far as the scope of teaching went. But that does not represent what technical education in its true sense means, which, as it happens, has been defined by Act of Parliament. I have had many opportunities of observation, and have come to two conclusions bearing on technical teaching. The first is: A youth cannot be taught a given trade at any such school in a manner to enable him to take his place among those who have served a regular apprenticeship to that trade. Nothing can take the place of, or effect the same results as, an apprenticeship, regular or not, but in any case comprising, say, four or five years of actual work and earnest application. Of course, there are exceptions, as now and then there may arise a Nasmyth, who was self-taught and served no apprenticeship and yet was perfect in his workmanship. The second point I note is that, of all things a youth can try, the use of his hands in mechanical handicraft is the easiest to acquire, notwithstanding the length of time it takes to perfect his workmanship. This must be understood as in comparison with anything requiring the use of his brains. I cannot too strongly emphasize the difference that exists between a mechanic and a mechanical workman. Hugh Miller's friend, David Fraser, who was so expert a stone-cutter that he could easily do, and regularly did, as much work as three ordinary men, was a mechanical workman of the first order, but nothing more—a human machine, in fact. On the other hand, the late Lord Armstrong, who began life as a solicitor, was no workman, and never even acquired the art of the draughtsman, but he was by nature a mechanic, and became one of the foremost mechanicians of the age.

There are, of course, some handicrafts ever so much more difficult to acquire than others; but I am safe in estimating, as the result of a lengthened and close observation of a good few representative trades, that not more than one in five hundred of good workmen gets further than that stage by the exercise of mental capacity. I have, to be on the safe side, taken the above proportion; but I fear that were a close investigation possible the result would be much more unfavourable. This is under the system of no higher education than that to be obtained at the bench; and the work of joinery plumbing, &c., which I saw at the technical school goes very little further. I need not say that such is not the system of technical training which has worked so great a change in

Germany and elsewhere. There the great aim is to prepare the intellect to receive and master the scientific basis of all construction or other process of manufacture. Under such a course a very large proportion of the students, who depend on the workshops for their skill and expertness with their hands, rapidly learn to become more than mere human automata. I know that I am treading on much-debated ground, but I feel sure that a little observation of the results of this dual training will support my conclusions, which are in accordance with those of the Chief Justice and a host of eminent men who are devoting much time to the study of ways and means towards the elevation of the masses.

The late Sir Joseph Whitworth left a very large endowment for the establishment of technical scholarships. The conditions of entry therein were very clearly outlined by him and formulated by the trustees, and are in principle very simple. An intending student who has acquired an elementary knowledge of any of the sciences—say, of chemistry, geometry, or other branches of mathematics—may be a workman in any of the trades allied to engineering; or he may be a scientific or mathematical student who has acquired a certain well-defined but not severe degree of expertness in the use of hand-tools. I am speaking from memory of the first regulations for the scholarships. There may be alterations in some respects since, but in any case the degree of Wh.Sc. carries great weight in the scientific and technical world. I have mentioned this foundation particularly because it was the creation of one of the small minority I speak of—one who, not content with being unsurpassed as a workman, used his great abilities towards the perfection of tool and machine design and manufacture, having a clear intuition of the possibilities of the advancement of the British workman with the necessary educational facilities at his command. But in addition to the Whitworth endowment and schools—such as the Owens College, at Manchester—there is in Great Britain the Department of Science and Art, under the Board of Education, with a disbursement of nearly £600,000 per annum. The scope of this department is very large, and embraces schools of science and art, museums, training and technical schools scattered throughout the three kingdoms, with examining functions in thousands of provincial and colonial places, including New Zealand.

I have alluded to the parliamentary definition of technical education. It is defined by "The Technical Instruction Act, 1889," to mean the principles of science and art applicable to industries; the application of special branches of science to specific industries; and a further and rather elastic definition embracing any other forms of instruction, including modern languages, commercial and agricultural subjects, which may in the opinion of the local authority be required by local circumstances. During about ten years County Councils and other local authorities have administered this Act. A special tax on beer and spirits provides the funds, supplemented in some cases by local grants. In this way two years ago very nearly a million pounds was disbursed. It will be admitted that this is not a large expenditure in a population of forty millions—about 6d. per head, in fact. Probably the whole of the technical education in the United Kingdom does not exceed 1s. per annum per head of population. It must be admitted that this is not likely to effect the desired end if we are to keep—or shall we say regain—our commercial and manufacturing supremacy.

Great and manifold, from a social and literary point of view, are the advantages of a classical education, but by itself it is not on the lines required for the subject in hand. There is an amusing preface by an engineer, the author of a work on bridges which has become a standard. He details his classical education, and the time, trouble, and expense he spent in acquiring a proficiency in the Latin language. And in all his after-experience in his profession he pathetically relates that he found not one instance in which his accomplishment served him for good. But that it should not be always so he entitled his book "De Pontibus," and proudly points to this as one instance in which he has been able to air his Latin in his profession.

I came across some time ago a simile intended to indicate a degree of condescending patronage, a certain supercilious bearing not unmingled with a shade of contempt. It was likened to the bearing of an Oxford don towards an engineering professor in a northern university. This sort of thing, no doubt, has some foundation in fact, and has to be reckoned with. It is hard to get out of a deeply scored groove in conventionalism. I recall an incident in my own experience. I was at one time in the course of my public duties much interested in the subjects prescribed for the Senior Civil Service examinations, in so far as they concerned the admission of cadets into the Public Works Department. I found that Latin was compulsory, while trigonometry or statics was not. Now, Latin was of no manner of use in the Public Works Department, while trigonometry was indispensable. In response to a vigorous protest on my part the subjects were altered to this extent: It was made optional for a candidate to substitute trigonometry for Latin. This practically met the case in point, but it would still allow of a young man permeated with classical lore, but with only the most hazy idea of trigonometry or mechanics, entering a profession where it is essential that a knowledge of these things should be like a second nature.

Another conventionalism to be reckoned with is the depreciation implied in the comparison of theory and practice. An ounce of practice is said to be equal to a ton, I think it is, of theory. If there is any foundation for this at all it must be infinitesimal. Theory which is held so cheap cannot be theory in fact. By theory I mean scientific deduction, and not hypothesis merely. The three angles of any triangle are in theory equal to 180°, but if in actual measurement they amount to more or less, then practice is wrong. If, however, it is held to be theoretically possible that the angles may be so carefully measured with an instrument so absolutely perfect that they may sum up exactly to the known figure, then practice will show that this theoretical supposition is wrong, and that only by accident can such absolute perfection be attained. An incident in point came under my observation in the Old Country very many years ago. One of the best workmen I ever knew—a foreman fitter—was marking off on a circle the centres of six bolt-holes. As usually happens, the dividers, opened to the radius of the circle, did not, on stepping round, exactly close on the commencing-point. My friend remarked that it never did—that the radius of a circle did not divide the circumference exactly into six, but only very near it. Of course, I said that it was a geometrical fact that such a division was exact, but was met with the remark that it might be so in theory, but practice showed the contrary.

A good many years ago the Messrs. Denny, of Dumbarton, recognised that among the thousands of their workmen there ought to be much latent talent for the invention of improvement in tools and methods of application, only requiring some incentive to bring it into action. The firm accordingly instituted a scheme by which rewards were to be given in proportion to merit for any improvement by which time could be saved or better work performed than was possible with previous appliances. This scheme has proved very successful, and for many years numbers of important improvements of all kinds, large and small, were the result of an incentive to the use of their heads as well as their hands by men who had nothing to learn in mere workmanship.

Among those misguided searchers after perpetual motion, of which we have evidence even to this day, there is not one true mechanic. Either they are workmen more or less expert or mere mathematicians, in neither case with any knowledge of or capacity to acquire true mechanics. I have met several of both classes, and found in all cases their craze incurable. I noticed very lately that a gentleman informs the *Winton Record* that after forty years' experimenting he has succeeded in attaining perpetual motion, and protected the invention over the world. It is hard to conceive what sort of intellect could labour for forty years at a mechanical impossibility without discovering it to be so.

But even the primary-school master must be abroad now and then, and I am tempted to give one or two instances of a rather comical nature. I dare say many here present have observed that the terms "square feet" and "feet square" are often used indiscriminately, evidently under the impression that they are synonymous. In a description which appeared lately in a local newspaper of the Duke of Cornwall's apartments on board the "Ophir" the drawing-room was stated to be 1,200 ft. square! Even in these days of big ships this is rather startling, for it means that that room has an area of more than 33 acres; 1,200 square feet, which, of course, was meant, would still indicate a good-sized room at sea, and might mean 40 ft. by 30 ft. Another local paper told us that it is interesting to know that the late Queen's walking-stick was one that had belonged to her "ancestor," King Charles II.

I have taken up more space than I intended when I touched on technical education, but I cannot conclude without mentioning, if I do little more, two or three subjects of economic importance to our community. The first is the drainage of towns and cities, which has always been a subject of first importance; but the recent plague scare brought it more to the front, and showed us unmistakably what a genuine visitation may mean. It is possible that very few could be found who would own to a belief that plague ever entered Auckland, and it is certain that not one would care to deny the importance of being prepared for combat with the pestilence. What such a visitation would mean to Auckland some may know, but not many actually realise. But with our commerce destroyed, and the influx of all visitors—and their money—stopped, together with the stampede of that large section of our residents who are here for the sake of health, all would soon become alive to the reality. And is anything being done to meet such a contingency? Practically nothing, so far as the first requirement—complete and thorough drainage—is concerned. Without that no amount of cleaning of back yards and slums will be of any use. Such measures without perfect drainage only serve to distribute filth over a wider area than it before occupied.

But measures that are sufficient in one town may not be applicable to another. Sydney carries the sewage out to the rock-bound coast of the Tasman Sea. London, after allowing the sewage to settle in tanks, runs the effluent, more or less clear, into the Thames, and employs a fleet of steamers to carry the sludge practically out to sea. In both cases nature is left to finish the work. It is an axiom in engineering, as it should be in every calling, not to fly in the face of the working of nature, but to assist nature and nature will assist you. So, as there are means provided by which the refuse of the world is turned to good account, we have only to make use of them and the mysterious operations of nature will do the work. The septic treatment of sewage therefore seems to offer to us more prospect of dealing with the drainage of towns which have not the advantage of being able to discharge it into the open sea. Much has been already achieved in this direction, but much remains to be added by experience. Nevertheless, I anticipate that within a very few years the treatment of sewage will be as certain and successful as that of any other process or manufacture.

The utilisation of natural sources of power must always be of importance, and the question seems to be now occupying a good share of attention. Water-power from rivers is usually the first in such schemes, and, in conjunction with long-distance transmission of energy by electrical means, offers a good field; but the scope and results are more restricted than are usually believed. It is very seldom that river rapids or falls can be harnessed into work except at a very large cost, and even where in more favourable cases power can be got in hand cheaply the distance over which it must be conveyed rapidly absorbs the efficiency, and it is wonderful how soon the economy of water-power is overtaken and surpassed by steam-power with all its low efficiency.

The harnessing of the tides is another scheme oftener talked about than practised. There is probably no power in nature at once so vast, so visible, and so difficult to utilise as that of the tides. There are exceptional cases where tidal power has been economically used, but as yet they are very few. It seems to me, however, that much more might be done in this direction, and that there are places where a very considerable amount of energy might be made available by a judicious arrangement of floating wheels, dynamos, and secondary batteries, all under automatic control. The harnessing of wave-power on the sea-coast has been less often proposed, and, with the exception of bell-buoys, still more seldom put in practice. It may be found, however, that there are by this means greater facilities for gathering up and storing energy than by the tides. There appear to be situations peculiarly adapted for such an installation, such as at some breakwaters which have been designed by flying a good deal in the face of nature. At these places I believe the wave-power might be so used that it would effectually keep down the accumulation of shingle by conveying it beyond the harbour and leaving it free to resume its travel along the coast.

I think it unquestionable that before very long a large amount of power will be generated at our coalfields by the use of slack coal, nearly all of which goes now to waste. Either by the use of steam, or by producer gas, electrical energy could be generated and sent with economy certainly to a distance of about a hundred miles.

Our thermal springs form, I believe, an asset in the capital account of the Auckland Provincial District the value of which it is difficult to estimate, and I am sure this is even now not sufficiently recognised. Looked at from the lowest point of view, the amount of hard cash brought into the country year by year by foreign tourists must amount to a very large sum, so large that it would take an immense area of the finest agricultural lands to produce profits equal to it. I speak in general terms, because I have no data on which to found estimates of tourist expenditure. But, taken on a social and humane basis, the value of the several thermal centres, although more generally recognised, can never be stated in money. It is very satisfactory to observe that the Government seems at last to be fully alive to the importance of fostering the traffic; but very much yet remains to be done in this direction. One essential line of action has never been attempted—I allude to the compilation of an authoritative list of all that can be procured of the very remarkable cures effected during, say, the last twenty years. There is yet time for this; and, now that the tourist traffic has become a branch of a special department of administration, we may hope that it will not be lost sight of. It is now over twenty-three years since I first knew Rotorua, and ever since I have had exceptional opportunities of observation, and have known of many cures of a most startling character. Many of these, no doubt, are on record at the Sanatorium, but numbers of others—indeed, the great majority—were never treated there. The principal cases are, no doubt, well remembered by residents and business people, and a systematic inquiry might easily furnish authentic material, which, compiled and issued under official authority, would carry weight wherever published, which should be the world over.

I have thus endeavoured to enlist your interest in a few subjects of economic importance, and if I have been successful in respect to even one of them in any degree I shall feel more than repaid for the effort.