

sketched, however clearly they may have been described, but will go out into the fields and quarries and see them in their natural states. A farmer too perfects by experience those elements of his occupation which he acquires by reading, and so also must the enquirer gain his practical knowledge by his own experience and observation of the transaction of business.

For many ages, an absurd notion prevailed, that sound theory and sound practice were inconsistent with one another, and it is interesting, though at the same time lamentable, to observe how this idea has descended from generation to generation down to our own times, and has had a very evil influence upon the speculative sciences, but especially upon those which have to do with construction. The old Greek philosophers carried their researches far into the realms of philosophy, of poetry, of geometry and have transmitted to us many valuable treatises on these subjects. Their studies, on the other hand, in the physical and mechanical world were almost valueless. The prevailing and absorbing idea with them was that mental philosophy was the highest and noblest of all human studies, or, as one of them says, "on earth there is nothing great but man; in man there is nothing great but mind;" they therefore considered it a lowering of the dignity of science and an exhibition of inferior scholarship to resort to experimental methods for the purposes of exposition.

The idea was very general that a scientific man was wholly unfit for business, and that anything and everything gross and practical belonged especially to the province of him who had degraded himself to the exercise of some trade or profession. Their physical theories were consequently, almost entirely destitute of agreement with established facts, and were mere empty dreams, which they endeavoured to perpetuate by all possible means.

The Romans must have been eminently skilful in many of the departments of engineering and architecture, and the monuments that have come down to us, of the magnificent works they carried out, will afford many a useful lesson to every engineer. They covered Europe with those wonderful roads, which exist to the present day, and which are marvels of conception and execution, and they made those famous aqueducts and erected those edifices, which show by their construction, that their builders must have been thoroughly acquainted with all that related to masonry and practical hydraulics. We must go back again to the middle ages, for the origin of those structures perfect in symmetry and beauty, for which Europe is so celebrated, and for the production of which the engineers and architects of those times must have had a profound knowledge of the laws of equilibrium and of the proper distribution of material. And yet not a trace of the principles by which they were guided in the execution of their work has come down to us, and in very many cases even their names are lost. The fact is, the so-called scholars were altogether wrapped up in their own conceits, and were occupied in magnifying and increasing their own numerous errors, being fully persuaded that everything practical was too contemptible to be worthy of consideration, and of far too inferior a character for them to have anything to do with it.

The important study of the mechanical properties of materials certainly began at a very early date, and many traces of the effect of this study are still to be found in the first attempts in the art of construction. It must also be allowed that the pursuit of this study has tended to show that the forms and dimensions of different materials have a most important bearing on their durability and strength; and the many types of ancient architecture, in which they were guided by a mechanical instinct, which for the most part was tolerably correct, have furnished us with certain rules, which are also in accordance with the results we obtain from modern theories. It was not, however, until the 17th century that Galileo laid the foundation upon which has since been built up the whole theory of the strength of materials. He was the first to apply geometry to the solution of problems of this nature, and must therefore be regarded as the founder of the science. In one of his dialogues he remarks:—"That the strength of bodies which are geometrically similar, are by no means proportional in a like degree to their similarity," and this is the earliest indication, as far as is known, of the idea of a radical distinction between similarity in mechanism and similarity in geometry. Galileo investigated the conditions of stability of a loaded beam, and gave to the world a theory which was not, however, sufficiently in accordance with practical results to be of much value. Bernoulli slightly modifying the hypothesis which had been adopted by Galileo, hit upon the true theory, which experiment confirmed, and which is now generally maintained; and from that time to the present, the doctrine of the strength of materials has been in a continually progressive state. "Then too, under the labours of such men as Galileo, Bernoulli, and Sir Isaac Newton, it came to be acknowledged that no material object however small, no force however feeble, no phenomenon however familiar, was insignificant or beneath the attention of the philosopher; that the processes of the work-shop, the labours of the artisan, were full of instruction to the man of science; that the scientific study of practical mechanics was well worthy the attention of the most accomplished mathematician." In the 18th century, the theory of the strength of materials was cultivated by the most eminent geometers, physicists and engineers, and in our own time it has been still further developed by such men as Poncelet, Navier, Kirkaldy, Morin, Grant, Vicat, Laure, Hodgkinson, Fairbairn, and many others. Due to the remarks of these men, it has become, on the one hand, a special branch of mathematical physics, and is denoted as the General Theory of Elasticity; and on the other, the methods of the ordinary theory have at one time followed in the wake of, and at another time, anticipated the progress of construction.

The old types of construction were first of all attempted on a small scale, and their dimensions were gradually increased, while in modern times, we have seen totally new types produced, as the fruit of the calculation and thought of the engineer. The Menai Straits and a St. Lawrence have been opened by tubular bridges, and iron and timber bridges of different classes have been erected in all parts of the world, a Mont Cenis tunnel has been driven, a St. Gothard tunnel is being driven, and a submarine tunnel to unite England and France has been projected with almost a certainty of success, retaining walls have been built, and docks and harbours have been closed by iron and wooden gates. I might, indeed, refer you to a multitude of such examples, but will content myself with calling your attention to that wonderful instrument of which all the world is at present talking, I mean the telephone, for the discovery of its properties seems at last to have given us the final victory over that most indomitable obstacle distance, which, indeed, may be now said no longer to have

any existence. Dr. Tyndall, in his address before the British Association, says:—"The Atlantic Cable had its small beginnings in the laboratory of the physical enquirer, but here, also, the positions of the debtor and creditor have been reversed, for the work of the engineer has called the physical enquirer to pursue his investigations with thoroughness and vigour, and has given to those investigations a scope and magnitude which, without the practical stimulus, would have been impossible. The consequence is that the practical realization of sending electric messages along the bottom of the Atlantic has been an immense augmentation of our knowledge regarding electricity itself. Thus does the human intelligence oscillate between sound theory and sound practice, gaining by every contact with each an accession of strength. These two things are the soul and body of science. Sever sound theory from sound practice and both die of atrophy; the one becomes a ghost, and the other becomes a corpse."

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(To be continued.)

PROTECTION AND FREE TRADE.

It was very correctly stated in the first number of the *SPECTATOR* by Mr. White in his article on a "National Policy" that the use of the terms "Free Trade and Protection has done much to confuse the question which above, and before all others, is important in its present and future influence upon the prosperity of the country."

The application of the principles of Free Trade to the commercial intercourse of nations is unquestionably one of the events of the age. England has taken the lead in this movement, as formerly she took the lead in the opposite policy of protection and restriction, and just as her example was previously imitated, or perhaps resented by neighbouring countries, so in the course she is now pursuing, she will be followed by her rivals, until monopoly ceases to exist, and the only practical legislation will be to leave commerce alone.

Nor can the policy which England has pursued be better illustrated than by quoting a paragraph from the great preacher "Channing" in addressing an association of American merchants in 1841:—"The time has come when you are particularly called to take yet more generous views of your vocation, and to give to commerce a universality as yet unknown. I refer to the juster principles which are gaining ground on the subject of Free Trade;—this is the plain duty and plain interest of the human race. To level all barriers to free exchange; to cut up the system of restriction root and branch; to open every port on earth to every product; this is the office of enlightened humanity. Freedom of the seas; freedom of harbours; an intercourse of nations, free as the winds. Under a wiser and more Christian civilization, we shall look on present restrictions, as we do on the swaddling bands, by which in darker times the human body was compressed."

This question of "Protection and Free Trade" is the more important now, because of the two parties contending for political power in Canada. The governing party now in power favours as far as possible the principle of Free Trade, while the opposition party advocates Protection. The latter declares, that situated as we are in Canada, protection to manufactures is a necessity, and that "cities and towns are impossible unless manufacturing industry is flourishing."

To form a correct opinion on this question it is necessary to look back on the history of trade in Canada for the last few years. It was in 1846, that England inaugurated her new commercial policy. Previous to that time Canada and all of England's colonies were protected in the markets of the mother country. In other words, the grain, flour, lumber, square timber, &c., &c., were admitted into England at a less rate of duty than the same articles from foreign countries, but on the other hand an Imperial Differential duty was collected on imports into Canada. The Canadian merchant in 1846 could not employ a foreign ship, nor could he import foreign or British goods except from the British Warehouse. The United States had not then passed their drawback, or "Bonding Bill," allowing Canadian produce or foreign merchandise to pass through the United States to the Atlantic in bond. Hence Upper Canada (now Ontario) trade was under this system forced through the St. Lawrence and centred almost exclusively in the cities of Quebec and Montreal.

When the purport of Sir Robert Peel's commercial policy became known in Canada, great were the lamentations and predictions—of the ruin and disaster which would inevitably follow the withdrawing of protection to Canada's products. Fortunately, there were a few who differed from the great majority of the merchants of that day—who held different views and rejoiced in the policy being pursued. Those few organised themselves into a Free Trade Association. They memorialized the Imperial Government, expressed satisfaction at what had been done, but as a matter of justice, prayed for a total repeal of the Navigation Laws and Differential Duties, so as to enable the Canadian merchant to compete equally with his neighbour and with other countries in trade.

Canada at that time suffered severely by the sudden change of being largely protected, and of being at once thrown upon her own resources. Canals were unfinished, and only opened in 1849. There were only some twenty-four miles of railway; but taking everything into account, is there any one to-day, who will not say, that this freedom of action in trade, and the self-reliance gained thereby, was worth far more to the people of Canada, than all the enervating influence of the previous system of Protection? Such, however, is a fair as it is a correct statement, as to Protection and Free Trade at that time in Canada.

The trade of the Western States, and of Canada West, was thus thrown open to competition, and the rivalry for the carrying trade of the West was at this time fairly begun between Canada and the State of New York, and this still continues.

How this rivalry is to end; whether the carrying trade from the West is to be swallowed up in the channels of conveyance, centring in New York, or whether the natural facilities which Canada possesses shall be so improved as to secure a share of this gigantic and ever-increasing traffic, depends on the action which