at home and abroad, the militia, and volunteers in the United Kingdom, and in the colonies, the British native forces in India, and other countries. This includes 10,000 Egyptian troops under a British general, but excludes the forces of the native states of India, and of the other countries politically connected with the empire. If, however, the forces of the native states of India were to be added (and they are generally available for imperial purposes), then the total of 850,000 would be raised to nearly 1,000,000. Thus the men under arms, or effectively trained to arms, are in number more than 750,000, and, under the last-named computation, would amount to nearly 1,000,000. The defensive armaments of the empire, by sea and land, cost £41,000,000 sterling annually, or twenty per cent of the total of revenue and receipts. The police for the empire numbers 560,000. Thus we have, for the whole empire, an average of one policeman to every 571 of the people, and to every sixteen square miles.

It is never to be forgotten, that one of the main reasons why the British empire is able to keep its land-forces at a comparatively low scale is its preponderance at sea. The predominance which we hope to find in the British navy will hardly be shown by the enumeration of ships. With this caution, however, it may be stated that there are 246 British war-vessels afloat, or in commission; of which 72 are sailing-ships, and 174 have steam-power. There are now 63 iron-clads, either complete or nearly complete. The number of officers and men amounts to 57,000. The number of iron-clads ready for action at the shortest notice is now 44, of which 25 are at sea.

The mercantile marine has nearly half of the steam tonnage, of the carrying power of the port of entries, and of the freight earnings of all the nations together, and two-thirds of the ship-building. The total trade of the British empire cannot be easily exhibited statistically. However, if the aliquot parts of the trade of the principal nations be computed, then 34 per cent, or one-third of the world's commerce, pertains to the British empire.

The manufactures of the United kingdom are valued at £818,000,000 sterling annually. In general terms, it may be stated, that British manufactures form one-third of those for all Europe put together. The great competitor is of course the United States, where the value appears to exceed that of the United Kingdom. The American manufactures are indeed wonderful, not only in their present magnitude, but in the rapidity of their progress, and in the prospect of their extension.

It follows from these facts, that the wealth of the United Kingdom in land, cattle, railways and public works, houses and furniture, merchandise, bullion, shipping, and sundries, valued at £8,720,000,000 sterling, exceeds that of any European state, and is just double that of Russia. But it is exceeded by the corresponding figure for the United States, namely, £9,495,000,000 sterling. The £8,720,000,000 of British wealth represent a sum seven times the annual income, namely, £1,247,000,000, which seems to be a fair calculation. According to this, the British people earn 14 per cent on their capital, which rate is about the same as that of the United States. It exceeds the corresponding ratio on the continent of Europe. But it is considerably surpassed by the ratios in Canada and Australia, — 18 and 22 per cent respectively.

The construction of public works is a test of national progress. Those works which may here be selected for mention are railways, electric telegraphs, and canals. It is calculated that 46 per cent of the railway traffic of the world is done by the railways of the British Empire: the distances run, however, are less than on the continent of Europe or in the United States. The electric telegraph does six times as much in the old country as in the new.

The total public debt, governmental and municipal, for the British Empire, reaches a total of £1,312,000,000 sterling.

He concluded this statistical summary by adverting to a group of subjects into which moral considerations largely enter; namely, thrift and education.

The decrease of crime and pauperism is satisfactory in the United Kingdom; while pauperism hardly exists in the other dominions of the empire, and the charitable funds raised in the United Kingdom are enormous. The number of patients in the hospitals, though large, is not remarkable relatively to the size of the empire.

Respecting education, there are 5,250,000 pupils at schools in the United Kingdom, 860,000 in Canada, 611,000 in Australia, and 2,200,000 in India, making up a total of 8,921,000 pupils in the British Empire. The fact is, that in India, although education has made a remarkable progress within the last generation, yet the lee-way to be made up was enormous, owing to the neglect of many centuries; and many children of a school-going age still remain out of school. But the comparison attains special interest when made with the United States, where a truly noble progress is exhibited, and where the number of pupils reaches to 10,000,000, the annual expenditure being £17,000,000 sterling. Thus the extraordinary fact remains, that in respect of educational statistics the United States are numerically in advance of even the British Empire.

The religious missions to non-Christian nationalities constitute a bright feature in the British Empire. The statistics of the Roman Catholic missions are not fully known, but their operations are very considerable. The income of the various Protestant missionary societies is hardly less than £750,000 sterling annually, and the number of European ordained missionaries maintained by them is about 900.

ON THE RELATION OF MECHANICAL SCIENCE TO OTHER SCIENCES.[1]

THERE are those who object that section G deals too little with pure science, too much with its applica-

[1] Abstract of an address to the mechanical science section of the British association at Montreal, Aug. 28, 1884, by Sir F. J. BRAMWELL, F.R.S., V.P.Inst.C.E., president of the section.

tions. It may be, as the members of section G might retort, that it is possible to attend so much to pure science as to get into the unchecked region of scientific speculation, and that, had the members of section G been debarred from the application of science, the speculation of Dr. Lardner might to the present day have been accepted as fact.

The speaker thought all men, even though they be followers of science in its purest and most abstract form, must concur in the propriety of section G dealing with engineering subjects generally, as well as with abstract mechanical science. This admitted he would ask — certain what the answer must be — whether there is any body of men who more appreciate and make greater use of the applications of pure science than do the members of this section. Surely every one must agree that the engineers are those who make the greatest practical use, not only of the science of mechanics, but of the researches and discoveries of the members of the other sections of this association.

It would be the purpose of his address to establish the proposition, that not only is section G the section of mechanical science, but it is emphatically the section, of all others, that applies in engineering, to the uses of man, the sciences appertaining to the other sections of the association, — an application most important in the progress of the world, and an application not to be lightly regarded even by the strictest votaries of pure science; for it would be in vain to hope that pure science would continue to be pursued, if from time to time its discoveries were not brought into practical use. The connection between this section and that of mathematical and physical science (A) is most intimate. Without a knowledge of thermal laws, the engineer engaged in the construction of heat-motors will find himself groping in the dark. He anticipated, from the application of thermal science to practical engineering, that great results are before us in those heat-motors, such as the gas-engine, where the heat is developed in the engine itself. Passing from heat-motors, and considering heat as applied to metallurgy: from the time of the hot blast to the regenerative furnace, it is due to the application of science by the engineer that the economy of the hot blast was originated, and that it has been developed by the labors of Lowthian, Bell, Cowper, and Cochrane. Equally due to this application are the results obtained in the regenerative furnace, in the dust-furnace of Crampton, and in the employment of liquid fuel, and also in operations connected with the rarer metals, the oxygen-furnace and the atmospheric gas-furnace, and, in its incipient stage, the electrical furnace. To a right knowledge of the laws of heat, and to their application by the engineer, must be attributed the success that has attended the air-refrigerating machines, by the aid of which fresh meat is at the end of a long voyage delivered in a perfect condition; and to this application we owe the economic distillation of sea-water by repeated ebullitions and condensations at successively decreasing temperatures.

Coming to the mathematical side of section A, whether we consider the naval architect preparing his design of a vessel to cleave the waves with the least resistance at the highest speed, or whether we consider the unparalleled series of experiments of that most able associate of naval architects, the late William Froude, carried out as they were by means of models which were admirable in their material, their mode of manufacture with absolute accuracy to the desired shape, and their mode of traction and of record, we must see that both architect and experimenter should be able to apply mathematical science to their work, and that it is in the highest degree desirable that they should possess, as Froude did, those most excellent gifts, science and practical knowledge.

Passing from section A to section B (chemical science), the preparation from the ore of the various metals is, in truth, a branch of engineering; but to enable this to be accomplished with certainty and economy, it is essential that the engineer and the chemist should either be combined in one and the same person, or go hand in hand.

Reverting to the water-engineer, the chemist and the microscopist have their sciences applied to ascertain the purity of the intended source; and, as in the case of Clarke's beautiful process, by the application of chemistry, water, owing its hardness to that common cause, carbonate of lime, is rendered as soft as the water from the mountain lake.

With regard to the subjects treated by section C (geology), the speaker instanced the Channel tunnel as a case in which, without the aid of geology, the engineer would not be able to give an opinion on the feasibility of the enterprise. The engineers said there is a material, the compact non-water bearing gray chalk, which we have at a convenient depth on the English side, and is of all materials the most suitable. If that exist the whole way across, success is certain. Then came geological science, and that told the engineer that in France the same material existed; that it existed in the same position in relation to other stratifications as it existed in England; that the line of outcrop of the gault lying below it had been checked across; and that, taken together, these indications enabled a confident opinion to be expressed that it was all but certain this gray chalk stratification did prevail from side to side.

To come to section D (biology), the botanical side of it is interesting to the engineer as instructing him in the locality and quality of the various woods that he occasionally uses in his work. With regard to that most important part of the work of D, which relates to 'germs' and their influence upon health, the engineer deals with it thus far: he bears in mind that the water-supply must be pure, and that the building must be ventilated, and that excreta must be removed without causing contamination.

In conclusion, reference was made to the relations of the engineer to the geographical explorer and the student of economic science. The great works, the results of engineering skill, enable the geographer to reach his field of exploration the more readily, and are called into existence by the dictates of the economist.